AN APPLICATION OF THE PROPERTY RIGHTS THEORY OF MANAGERIAL BEHAVIOR TO THE WATER UTILITY INDUSTRY

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THEORY OF MANAGERIAL BEHAVIOR TO
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PREFACE

The intention of this study is to derive a utility maximization model of managerial behavior and to apply it to the water utility industry. Certain behavioral implications of the model are investigated in order to assess the effect of alternative property right structures on managerial behavior. Specifically, the effect of alternative ownership rights on managerial efficiency, rate-making, and product quality decisions are the focus of most of this study.

I would like to thank Dr. Joseph M. Jadlow, Jr., my major adviser, for the timely guidance and assistance he has given me throughout the duration of the study. Further, I would like to express thanks to the other committee members, Dr. Kent W. Olson, Dr. Ronald L. Moomaw, and Dr. P. Larry Claypool, for their helpful comments and encouragement; and to both Kay Bois and Sandi Ireland for the excellent preparation of the final draft and final copy of the dissertation.

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CHAPTER I

INTRODUCTION

Introduction

The theory of the firm is solidly grounded in the works of Augustin Cournot and Alfred Marshall. It is from these individuals that price theory obtained some of the mathematical and geometric models of profit maximizing behavior. Marshall had a well developed theory of monopoly, but chose to devote his energies to a study of firms operating in markets characterized by ". . . freedom of industry and enterprise" (93, p. 345). Cournot was the first to develop a mathematical model of monopoly. Since Cournot and Marshall, most works in price theory have been refinements of the marginalist ideas they advocated. Predictions regarding managerial behavior were based upon the assumptions of profit maximization and the particular structure of the market in which the firm operated. Thus the works of Arthur C. Pigou, Joan Robinson, Edward Chamberlin, and Heinrich von Stackelberg presented alternative models of profit maximizing behavior under the assumption of different market structures. Later, economists recognized that not only does market structure affect market conduct which, in turn affects market performance, but they also recognized the importance of feedback effects of conduct and performance on market structure.

While these developments in economic theory have been indispensible in analyzing managerial behavior, price theory has not gone unchallenged.

Economists began to challenge the profit maximization model. Some suggested that the maximand was naive. Output and revenue maximization models were formulated as alternative theories of the firm, but these models appeared to have less predictive content than the profit maximization model. In the late 1950s and early 1960s, economists began to infer from the works of Becker (12), Alchian and Kessel (4), and Coase (20) that there may be a more general model of decision-making behavior than that described by the theory of the firm. These pioneering works cumulatively implied that managerial behavior is a utility-maximization process whereby managers maximize utility subject to a set of costs and rewards. Under certain assumptions, the utility maximization theory of managerial behavior reduces to the standard profit-maximization model. Consequently, the traditional theory of the firm can be conceived of as a subset of a more general utility-maximization theory of managerial behavior.

The essence of the economic theory of property rights is that decision-makers maximize utility by consuming both pecuniary and nonpecuniary income subject to an opportunity set function. This constraint on managerial behavior is conceived to be some function of the market environment in which the firm operates, the technological characteristics of the firm, general laws and mores regarding behavior, and profit requirements of the owners of the firm. An analysis of any industry will generate a set of characteristics unique to that industry. These characteristics shape the opportunity set constraining managerial behavior.

In order to avoid interpersonal comparisons of utility functions, managers are assumed to have the same tastes and preferences for things that provide satisfaction. Organizational theorists have provided property rights theorists with a long list of things considered to be likely sources of managerial satisfaction. Once certain sources of utility are related to certain managerial activities, testable implications of the property rights theory of managerial behavior can be generated for a host of managerial activities by altering cost-reward (property rights) structures. In defending this approach, Alchian and Kessel (4) note that meaningful implications of property rights theory can be generated by postulating what variables affect managerial utility. "This leads to meaningful implications refutable, in principle, by observable events" (p. 158).

Many of the empirical investigations of the property rights theory of managerial behavior have been tests of firm efficiency and have been extended to a number of industries: savings and loan associations (81), airlines (27), hospitals (19), insurance companies (39), electric power companies (74), and water utilities (69, 79, 23, 48). For reasons noted in Chapter II and again in Chapter IV, tests of the efficiency predictions of the theory of property rights are incomplete. Further, very little property rights analysis has been done for other aspects of managerial behavior such as pricing and product policies, particularly product quality. Many studies have not distinguished between ownership rights and other factors that affect the manager's opportunity set. There has been virtually no attempt to isolate ownership from other noneconomic influences on opportunity sets. Nor have there been attempts, with the exception of Mann (66), to try to isolate political effects on managerial behavior.

The theoretical models employed by property rights theorists range from heuristic models to geometric and constrained optimization models. Each of these models differ somewhat depending on the aspect of property rights theory being analyzed. There appears to have been no attempt to formulate a general model of managerial behavior that can incorporate the relaxation of a number of ownership rights as well as other factors unique to the industry under investigation.

Objectives

It is the intent of this dissertation to formulate a geometric model of a manager's utility maximizing behavior. In particular, the model will allow for the relaxation of the set of ownership rights that describe the "classical" firm. The model will also be useful in describing the expected effects on managerial behavior when considering other industry characteristics that shape the constraints faced by managers. The model is then used to generate testable implications regarding managerial behavior for the water utility industry.

The water utility industry was selected for several reasons. First, there are both investor- and publicly-owned firms which allow for the test of implications under conditions of alternative ownership rights. Second, there are other characteristics of the water industry that are expected to affect the manager's opportunity set and as a result managerial behavior. One such characteristic is the industry's regulatory structure. Ideally, these other industry characteristics should be controlled for when trying to isolate the effect of ownership on managerial behavior. Third, until recent years there has been little economic analysis of the water utility industry. Fourth, there are testable implications of the theory of property rights that have been developed here and elsewhere that either have not been applied to the water industry or have been applied but involve methodological problems that make the results of such tests less than conclusive. Finally, results of hypotheses regarding firm efficiency and product quality may have important policy implications regarding water conservation and water quality.

The hypotheses to be tested for the water utility industry entail hypotheses relating to (1) firm efficiency, (2) product quality, and (3) rate-making policies. Specifically, it will be hypothesized in Chapter IV that public water agency managers relative to private water managers will employ more labor and capital, incur higher costs, combine inputs less efficiently, incur more input waste, charge lower prices for all customer groups, price discriminate less, give preferential treatment to the high-usage relative to low-usage customers and residents relative to non-residents, and produce a higher quality product. Additionally, tests relating to the local regulatory-political effects on managerial behavior will be conducted, in part, to determine if ownership is an important non-economic determinant of managerial behavior after controlling for these effects.

Organization

Following the introduction, Chapter II presents the property rights theory of managerial behavior by first discussing the set of assumptions which underly the "classical firm" and the seminal analyses that relaxed these assumptions. The largest part of Chapter II, however, consists of a derivation of a geometric model of managerial behavior. Chapter III discusses the characteristics of the water utility industry, some of which constitute important constraints on a water manager's behavior. Chapter IV consists of an application of the property rights model to the water utility industry. In this chapter, testable implications are produced with respect to firm efficiency, rate-making practices, and product quality.

Chapter V presents the sample, data, method, and empirical results of the firm efficiency and product quality hypotheses. Similarly, Chapter VI formulates statistical tests and presents results for the rate-making hypotheses. Chapter VII discusses the empirical tests and results of hypotheses relating to the effect that local regulatory-political influence has on managerial behavior. Finally, Chapter VIII presents conclusions and suggestions for further research.

CHAPTER II

THE THEORY OF PROPERTY RIGHTS

Introduction

The recent interest in the theory of property rights has resulted, in part, from dissatisfaction with the traditional explanations of market performance. The traditional approach to explaining market behavior has been to investigate the relationship between market structure, market conduct, and market performance. While this paradigm has been indispensible to the economist's understanding of the economic behavior of the firm, there is a growing realization that the theory of the firm is but a subset of a more general theory of decision-making behavior. The traditional theory of the firm is based upon certain restrictive assumptions to be discussed below that are unlikely to obtain in modern-day markets. A more general theory of the firm would allow for the relaxation of these assumptions. It is the relaxation of these assumptions which constitutes much of the work in property rights theory. The purpose of this chapter is to describe the economic theory of decision makers within firms. This will be accomplished by relaxing the set of assumptions that constitute the "classical" ownership characteristics.

Characteristics of the Classical Firm

Alchian and Demsetz (3) pointed out that the "classical" firm has certain important characteristics:

1. the owner-manager is the claimant to the residual income of the firm;
2. the owner-manager has the right to observe the behavior of inputs and, through being the central party to all contracting, can revise and terminate input employment contracts; and
3. the owner-manager has the right to transfer or sell the rights in (1) and (2) above.

If these ownership rights are fully assigned and transactions and policing costs are zero, property rights will guide incentives such that externalities are internalized. According to Demsetz (34),

> (1) . . . the value of all harmful and beneficial effects of alternative uses of property rights will be brought to bear on their owners;
> (2) (if) . . . owners of property rights are utility maximizers, property rights will be used efficiently; and,
> (3) the mix of output that is produced will be independent of the distribution of property rights among persons except insofar as changes in the distribution of wealth affect demand patterns (p. 62).

Given the above set of ownership characteristics and assumptions regarding transactions costs, owners' policing costs, and the degree to which property rights are assigned, a utility-maximizing owner-manager would behave in ways consistent with the theory of the firm.

Relaxation of Assumptions

The conclusion above depends upon a restrictive set of assumptions that are unlikely to be met is present-day markets. The assumption of zero transactions costs was first relaxed by Coase (20). He noted that the initial partitioning of property rights would not affect the allocation of resources as long as transactions costs are zero. Property rights are partially transferred or partitioned via the contract. Coase observed that, even if contracts are able to fully assign property rights, resources may be misallocated if transactions costs are positive. As a result, managerial activities may no longer be consistent with those predicted by the theory of the firm.

Traditional economic theory has dealt, however, with the problem of externalities. If has been shown that the assumption of zero externalities is incorrect to the extent that private marginal benefits and costs diverge from social marginal benefits and costs. Property rights theorists such as Cheung (17, 18) have shown that the extent to which private and social marginal benefits and costs diverge can be explained by individuals not having the right to contract, or to contracts with incomplete stipulations. For example, the common pool problem in natural resource economics is an example of markets participants having a non-exclusive contract with high transactions costs. Both McKean (72) and Posner (91) have done work in the area of transactions costs, externalities, and contracts. McKean analyzed product liability contracts. He explains that different liability assignments result in different transactions costs and therefore cause different uses of resources. Posner's work is in the area of a property rights analysis of the law. In sum, positive transactions costs and contracts incomplete in the assignment of property rights often result in externalities. The market mechanism may not internalize these in the firm's decision-making resulting in a suboptimal allocation of resources.

Most property rights studies, however, have been concerned with a relaxation of the ownership characteristics of the classical firm. The ownership characteristics of the classical firm mentioned above are not applicable to many of our present-day enterprises. That is, owners and management are separated in both the modern corporation and in the public firm. Owners in regulated industries have an attenuated right to the firm's residual income. Owners of public firms have no right to the residual income of the firm nor do they have a right to transfer ownership of the public firm. Because the characteristics of many present-day decision-making units diverge from the characteristics of the classical firm, an understanding of the institutional, market, and political environment in which these units operate is a necessary step in analyzing modern economic behavior.

Managerial Objectives

Traditional economic theory assumes that the firm's objective is to maximize profits. Economic theory therefore predicts price-output policies of profit maximizing firms that operate at some point within a range of possible market structures. Observed firm behavior does not always conform to that predicted by economic theory. Furthermore, the behavioral implications of profit-maximizing models are somewhat limited. As a result, it has been suggested that firms pursue goals other than profit-maximization such as output maximization, profit satisficing, and revenue maximization (64, 57). These objective functions, however, seem to be even more limited in terms of their predictive content than the standard profit maximizing model.

An alternative explanation as to why firms seem to behave in ways inconsistent with profit maximization theory is that the behavior of firms results from rational responses by utility-maximizing managers.

Becker (12) was one of the first to explain managerial behavior as a utility maximization process. He incorporated tastes for discrimination as a nonpecuniary source of income in the manager's utility function to explain, among other things, why some firms would forego profits in order to hire less efficient but socially-attractive employees. The first systematic description of the economics of property rights was by Alchian and Kessel (4). They argued that the firm's observed behavior was the result of managers maximizing utility subject to the various constraints that are imposed by the firm's owners and market environment. Managers maximize utility by pursuing those activities that increase their pecuniary and nonpecuniary income. In terms of analyzing market behavior, Alchian and Kessel state, "What is important is not a matter of differences in tastes between monopolists and competitive firms, but differences in terms of trade of pecuniary and nonpecuniary income" (p. 163).

This suggests that in order to describe firm behavior, the analyst must determine what factors affect the relative actual or imputed prices of pecuniary and nonpecuniary sources of income. Once it can be shown that certain factors affect relative prices in consistent directions or alter the constraints imposed on the utility-maximization process, demand theory can be used to predict changes in the composition of these sources of managerial utility and therefore the effect on managerial behavior.

Efficiency, Costs and Property Rights

An approach that many economists have used in property rights studies has been first to identify those managerial activities that increase pecuniary and nonpecuniary income. Next, the institutional and market environment in which the firm operates is analyzed and the important variables which have an impact on the exchange ratios of pecuniary and nonpecuniary income sources as well as the constraints that are imposed on managerial utility-maximizing behavior are identified. Predictions of managerial behavior with respect to the consumption of utility-generating activities are then empirically tested.

The first rigorous empirical test of the property rights theory was by Williamson (111). In a model that extended Alchian and Kessel's model, Williamson suggested that the firm's (manager's) objective was to maximize utility subject to the constraint that reported profits be greater than or equal to the minimum profit requirements of the owners. Utility was a positive function of the size of the firm's staff, managerial emoluments, and discretionary profit. According to Williamson, a larger staff not only meant a possible increase in salary for the manager, but it was also a source of nonpecuniary income such as power, security, status, professional excellence, and prestige. Managerial emoluments were the ". . . fraction of managerial salaries and perquisites that are discretionary" (111, p. 1035). In other words, this was organizational slack absorbed as costs. Discretionary profits were the profits in excess of the minimum return to owners and were assumed to be used by managers for expenditures on staff and discretionary investment. The minimum return to owners was considered a return that was sufficient to maintain the manager's effective control of the firm. It was a function of the owner's perception of the costs and benefits involved in policing managerial behavior.

A geometric interpretation of Williamson's model can be represented by Figure 1. As can be seen in that figure, a firm owned and managed by the same individual would produce at the standard profit maximization level of output, S_π, where $\partial TR/\partial Q = \partial TC/\partial Q$. With the separation of ownership and management in the modern corporation, there are positive policing and monitoring costs borne by the owners. Owners will engage in less policing of management and will be content with a lower level of profit. This leaves discretionary profits available to management to increase staff and discretionary investment. Managerial consumption of organizational slack reduces reported profits below potential profits whereas the consumption of discretionary investment expenditures exhausts any remaining excess of reported profits over minimum profits. As a manager spends the discretionary profits, total costs increase from TC to TC1, but Williamson assumes that marginal costs are unaffected. Williamson assumes that increases in staff expenditures, however, will increase product demand and thus both marginal and total revenue as TR shifts upward to TR1. Staff expenditures are assumed to increase demand because staff expenditures are assumed to contain an advertising component. Williamson's first-order conditions require the firm to equate marginal revenues and marginal costs, but staff will be employed inefficiently--where the marginal value product of staff is less than the marginal cost of staff. This clearly implies that the firm will operate at a higher level of output than would be the case for the traditional profit maximizing firm. At S_π in Figure 1, discretionary managerial behavior results in an increase in marginal revenue relative to marginal cost. Marginal revenue and marginal cost can only be equated at a higher level of output such as staff and size level, S_u.

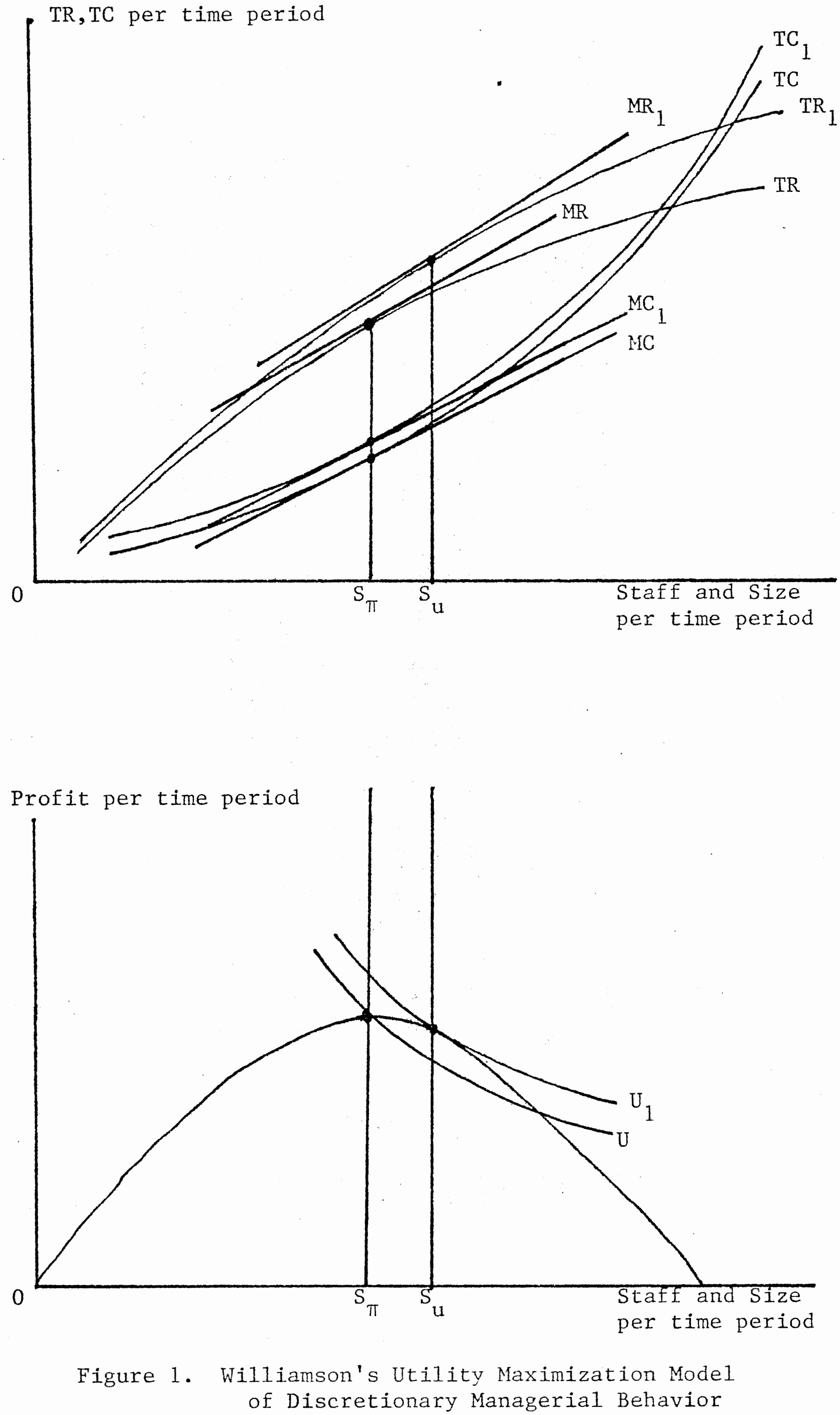

Figure 1. Williamson's Utility Maximization Model of Discretionary Managerial Behavior

Here the manager attains a higher level of utility as given by indifference curve, U_1.

The most obvious implication of Williamson's analysis is that the greater the cost to owners of monitoring managerial performance, the less effort that owners will put into policing management. Owners will be content, therefore, with smaller minimum profit thus leaving more funds for managers to use to maximize their utility. This activity is expected to result in higher firm costs at a given scale of output.

An alternative explanation of the effect of the owner's monitoring costs on the firm's costs has been offered by Alchian and Demsetz (3). They point out that for most firms, resources jointly produce the firm's output rather than output being a simple sum of each individual's productive effort. Because of this nonseparability of output among factors, it is a difficult task for managers and owners to meter performance and marginal product, and thus pay a reward equivalent to the marginal product of the resource. Labor resources thus have a tendency to be free riders in the production process. As long as detection, policing, monitoring, and metering costs are positive, the price of leisure relative to the price of productive work is lower than if these costs are zero and the worker will purchase more leisure time relative to work time--labor will "shirk" on the job. This implies lower productivity and higher costs for firms faced with additional policing costs which exceed the expected additional benefits from greater monitoring effort. Whether higher firm costs are due to shirking by labor or discretionary behavior by managers or some combination of the two, property rights theory strongly suggests that to the extent that owners are faced with greater policing costs, the firm will incur higher costs at a given level of output.

There have been a number of studies which have tested this fundamental proposition. Most of these studies assert that public firms, for reasons to be discussed later, are less efficient than are comparable private firms. Nichols (81) investigated stock versus mutual saving and loan associations and found that the mutuals were less efficient. Davies (27) found that private Australian airlines were more efficient than their public counterparts. Clarkson (19) found that non-proprietary hospitals were less efficient that proprietary hospitals. Frech (39) extended the property rights theory to an analysis of the efficiency of private insurance companies versus nonprofit mutual and Blue Shield firms in the processing of Medicare claims. He found that the private companies were more efficient. The property rights efficiency hypothesis has also been extended to the electric power (74) and water utility industries (23, 48, 69, 79). The only study to find results contrary to those predicted by the property rights theory of firm behavior was the Mann and Mikesell (69) study. Mann and Mikesell found that private water firms had higher per unit costs than public water utilities. Crain and Zardkoohi (23) attribute this to the failure of Mann and Mikesell to control for input price differentials. Price differentials are expected to affect input choices and thus costs.

It should be noted, however, that the results of most of these studies should be considered tentative. All of the studies suffer from the absence of disaggregated cost data. In addition, Morgan's study (79) can be criticized because of the nonrandomness of the data sample, Nichols (81) and Davies (27) did not use statistical testing, and all of the above studies with the exception of the Crain and Cardkoohi (23) article failed to control for input price differentials. Nevertheless, the weight of the evidence to date is consistent with the efficiency predictions of the utility maximization model.

A Property Rights Theory of Managerial Behavior

Legal ownership is a sufficient but not a necessary condition for a decision-maker to have command over certain resources or assets. The right, legal or implicit, to use, sell, or to change the quantity or quality of a resource or asset determine one's property rights. Depending on the particular industry, form of government, laws and regulations, social mores, and transactions costs, a decision maker is confronted by different constraints on his ability to "use" resources. These different constraints attenuate property rights to different degrees and thus are expected to have a systematic impact on managerial behavior.

The manager's utility function has both pecuniary and nonpecuniary sources of income as arguments. Utility is derived from the services that goods and services provide. Pecuniary income, e.g., salary and stock options, allows the consumption of marketable goods and services. Nonpecuniary income is the positive utility received from the consumption of goods and services that are not directly purchased with pecuniary income. The work of organizational theorists has suggested that a manager may receive utility from activities that increase the manager's prestige, power, the attractiveness of the work environment, job security, the public's perception of his contribution to the community's welfare, and from the absence of conflict with customers, regulators, and politicians (13, 41, 64, 99). A number of managerial activities could increase these possible sources of nonpecuniary income. For example, greater prestige might result from a higher quality product, an increase in sales or profits, or community service. The feeling of greater responsibility or power might result from increasing the size of the firm in terms of sales, capital, labor, or from administering a larger discretionary budget.

More formally, the problem is to maximize the manager's utility function subject to an opportunity set function. That is, the manager maximizes U(P,N) subject to O(P,N) where U(P,N) is a strictly concave and differentiable utility function with pecuniary, P, and nonpecuniary, N, income as arguments. P and N are substitutes in consumption. O(P,N) defines the opportunity set faced by the manager. It is concave to the origin, reflecting increasing opportunity costs associated with the consumption of additional sources of utility. It represents the possible combinations of P and N available to the manager given the market and regulatory environment, production technology, laws, and the property rights structure. The marginal condition that results from the maximization of the manager's utility is $dP/dN = -Un/Up$. In other words, the rate at which the manager is required to give up P to obtain N is just equal to the rate at which he is willing to give up P to obtain N. For normal goods, consumer behavior theory predicts that demand curves are downsloping. Therefore, as the price (actual or imputed) of N changes relative to the price of P, or if the opportunity set shifts as constraints are relaxed, managers will alter their consumption of P and N.

Utility Maximization and the Classical Firm

Three important characteristics constitute the basic structure of property rights for the classical firm. First, the owner-manager is a single individual who has the right to be the central party to all contracting. Second, the owner-manager is the claimant to the residual income of the firm. Third, the owner-manager has the right to transfer ownership of the firm. Given the above rights, the owner-manager will maximize utility at point P_m (see Figure 2) where his indifference curve, U_1, touches the opportunity set function at the maximum level of profits, π_m. Because pecuniary income and profits, π, are equal to one another in the classical firm, the manager-owner can increase his consumption of nonpecuniaries only by reducing profit, ceteris paribus.

In the classical case, however, the manager-owner has no tastes or preferences for nonpecuniary income. The manager-owner has no incentive to take income in-kind when pecuniary profits can be used entirely at the owner's discretion. Thus, the owner-manager's indifference curve, U_1, is horizontal reflecting preferences only for profit. The classical owner-manager, therefore, maximizes both profit and utility simultaneously at P_m. For the classical case, the constraint on the owner's ability to maximize utility, $\pi_m D$, is some function of the technological factors associated with the firm and the market environment in which the firm operates.

The set of classical property rights does not adequately describe many of today's productive enterprises. Property rights theory, however, provides an explanation of what kinds of changes in managerial behavior can be expected to take place when the above classical characteristics are altered. In the following section, the separation of ownership from management will be analyzed. The effect of attenuated returns will be considered next. Finally, the effect of the absence of the right to transfer ownership shares will be described.

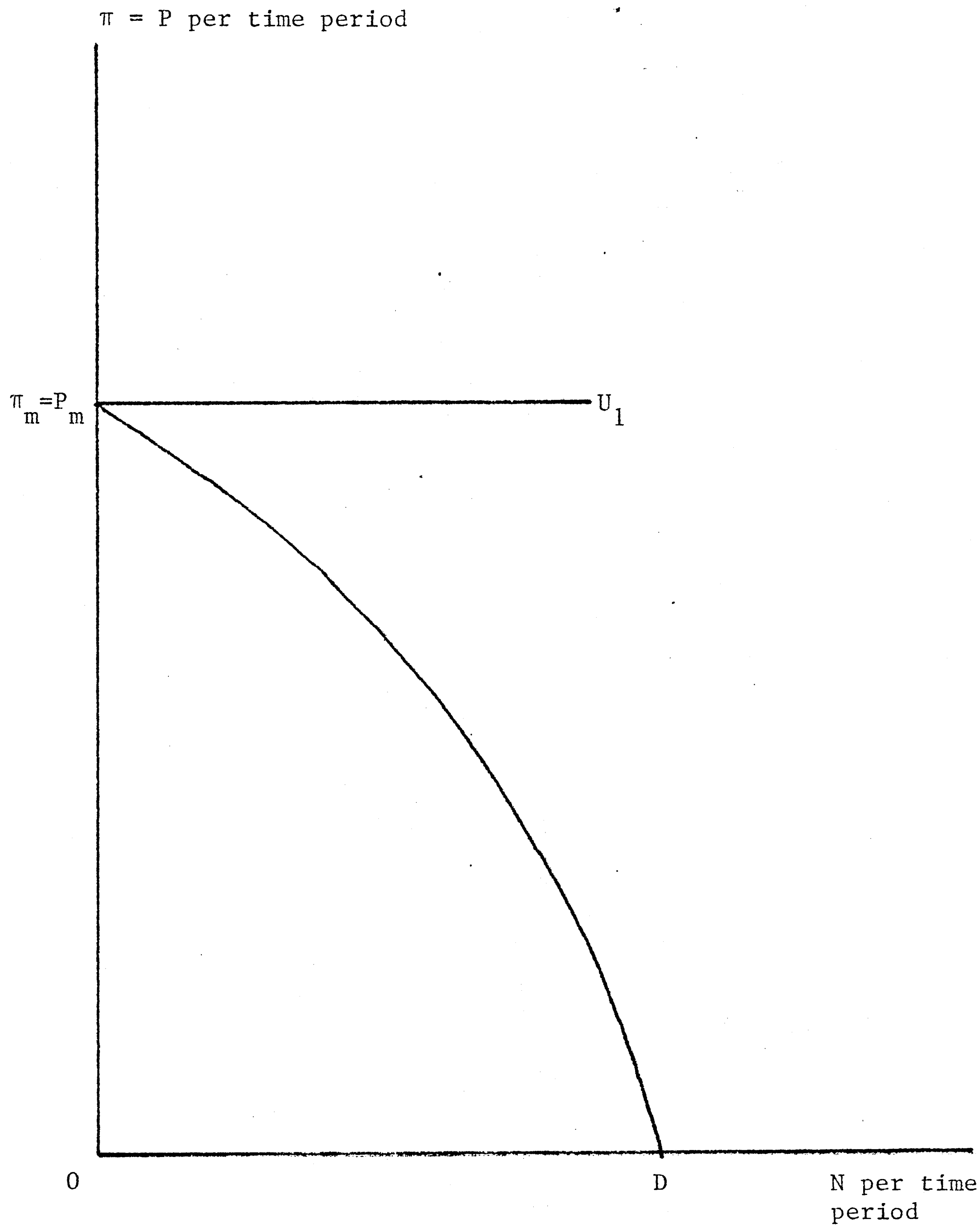

Figure 2. The Owner-Manager's Maximization of Utility

The Separation of Ownership from Management: A Geometric Derivation of a Utility Maximization Model

In corporate enterprises, ownership and management are separated. The owners, stockholders, are no longer the central party to all contracting. Day-to-day operations of the firm are handled by management. With the relaxation of the assumption that the owners and the manager are the same individual, the utility maximization process can no longer be described by Figure 2 for two reasons. Owners are now faced with positive policing costs of management. Secondly, the manager's pecuniary income no longer equals the owner's wealth.

Management is constrained to pursue, in part, the goal of owner's wealth maximization. But because of positive policing costs, owners engage in "optimal" monitoring where the benefits from additional monitoring are just offset by the additional costs. Of course, if monitoring was costless, owners would constrain management to a course of full profit maximization. Owners require a minimally-acceptable return on their investment which is expected to be at least equal to what they could earn elsewhere. The minimal profit requirement is partially a function of policing costs. The greater the cost to owners of policing management, the less the minimally-acceptable return will be. Since monitoring is costly, owners engage in less monitoring thus allowing management greater freedom in decision-making. As a result, the implicit price of managerial goals falls relative to the implicit price of the owner's goal of wealth maximization. Consumer behavior theory predicts that the manager will consume more of the sources of utility that have declined relatively more in price. The implication is that managers can be expected to pursue more managerial goals at the expense of the owner's wealth.

A second reason why the utility maximization model has to be altered for the case of incorporation is that the manager's pecuniary income no longer equals the owner's wealth. There is no longer a one-to-one relationship between profit and managerial utility. Therefore, there is no reason to expect a utility maximizing manager to make decisions that are exactly consistent with profit maximization. The model that will be derived in the next section is based upon the plausible assumption that the compensation of the top executive officer is more a function of measures of firm size than of profits. The empirical evidence supports this proposition (98, 94). Even if the manager's pecuniary income is some positive function of reported firm profits, the directional hypotheses generated in the next several sections remain unaltered. A discussion of this is offered in the next section.

It has been suggested by Alchian (2), de Alessi (28, 29), and others that for the case where ownership and management are separated, a utility maximization model should include a utility function which has both pecuniary and nonpecuniary sources of income as arguments. The constraint on the manager's maximization of utility, the opportunity set function, is a function of the technological characteristics of the firm, the market, legal, and regulatory environment in which the firm operates, and the minimum return to equity required by owners. Other things constant, the corporate manager can increase P and N only at the expense of the owner's wealth. Whereas in the classical case (where $P = \pi$), the tradeoff was just between P and N.

<u>Derivation of the Manager's Opportunity Set</u>. A three dimensional graph can be used to show the relationship among P, N, and potential profit (see Figure 3). The manager's pecuniary income per unit of time, P, is plotted on the vertical axis; his nonpecuniary income per unit of time, N, is on the horizontal axis; and potential profit per unit of time is on the diagonal axis. The relationship between potential profit and N is expected to be inverse as it was for the classical case. For a given level of P, the manager can increase N only by reducing profit assuming all other things constant. The opportunity cost of increasing N at the expense of potential profit is assumed to increase as more N is consumed. Similarly, for a given level of N, the manager can increase P only at the expense of owner's wealth. Thus, the relation between profit and P is also expected to be inverse and concave to the origin reflecting the increased opportunity costs associated with additional quantities of P consumed. Therefore, the opportunity sets in potential profit-N space and potential profit-P space are inverse and concave to the origin.

In the classical case, the manager-owner maximized utility in the profit-N space. The corporate manager, however, maximizes utility in the P-N space. Based on the previous assumptions that potential profit and P, and potential profit and N are inversely related, i.e., managers can only increase P and N at the expense of the owner's wealth, it can be shown that the expected relationship between P and N is also inverse and concave to the origin.[1] For a given level of profit, a corporate manager will choose some combination of P and N. A manager must reduce P

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[1]The assumption of concavity, increasing opportunity costs, while realistic is not necessary for the directional hypotheses derived from the model to hold. The assumption of concavity will be useful, however, in explaining what happens to the ratio of the manager's consumption of P to N as constraints are relaxed.

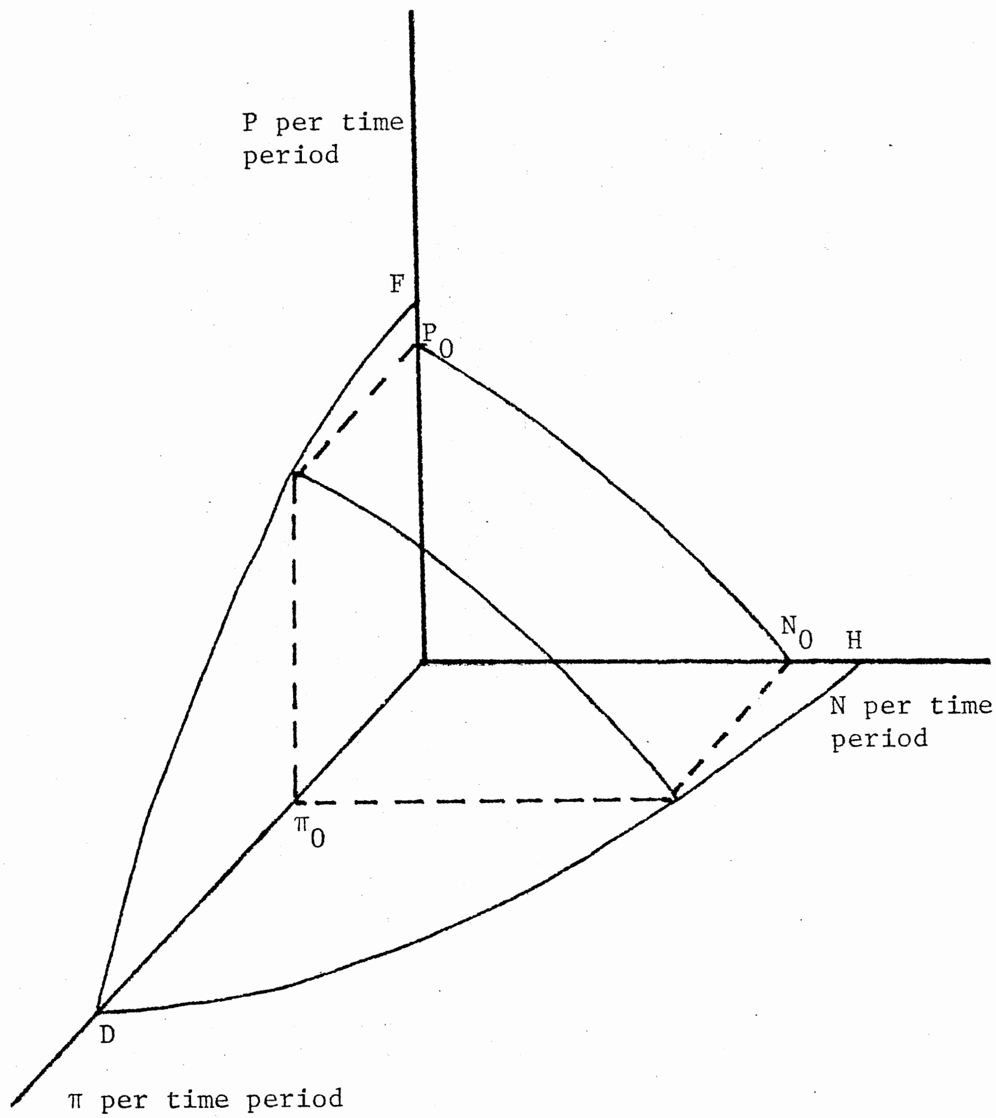

Figure 3. Derivation of the Manager's Opportunity Set

in order to have more N and vice versa. Other things constant, the manager can have more of both P and N only at the expense of owner's wealth. Given the potential profit-P and potential profit-N constraints of Figure 3, the P-N constraint can be easily derived. Assume that the minimally-acceptable return to owners is π_0. If the manager's tastes were such that only P were desired, and if he had complete discretion over the size of his salary, that manager could consume P_0 pecuniary income and still generate the level of profit necessary for his survival. At the other extreme, a manager desiring only nonpecuniary income could consume N_0 with a given level of profit, π_0. Because the opportunity set surface in potential profit, N, and P space is assumed to be concave at the minimum level of profit, π_0, the downward sloping concave function, P_0N_0, represents the constraint imposed on the manager's utility-maximizing activities. In this model, the constraints on the manager's maximization process involves the technological and market constraints on potential profits as well as the constraint imposed by owners in the form of a minimally-acceptable profit.

Shifts in the Opportunity Set. This model assumes that potential profits, as determined by the firm's technology and market environment, are constant. If, for example, potential profitability were to increase as a result of an increase in product demand, then the manager's opportunity set would shift outward from the origin. An increase in potential profits, holding the minimal profit to owners unchanged, provides management with access to more funds with which P and N can be purchased. The point of intersection of the potential profit-P and potential profit-N constraints with the potential profit axis represents the potential level of profits when both P and N are zero. If potential profits increase, this point of intersection moves down the diagonal axis to point E from point D (see Figure 4). If the increase in potential profits is entirely absorbed as an increase in P, then the intersection of the potential profit and P constraint with the P axis will increase from point F to some point G. Likewise, if the increase in potential profits is completely absorbed as an increase in N, then the potential profit-N constraint will intersect at a higher point on the N axis such as at point I. Given the minimum profit, π_0, the manager can consume P_1 (where N = 0) or N_1 (where P = 0). The manager's new oppotunity set, therefore, becomes P_1N_1. Thus, the potential profit-N, potential profit-P, and P-N constraints all shift outward from the origin.

The P-N constraint also shifts outward from the origin when owners lower the minimal return acceptable to them. Suppose that owners, due to an increase in the monitoring costs of management, lower their minimally-acceptable return. Assuming potential profits unchanged, managers will have access to more resources which can be diverted to utility-generating activities. If for example the owner's minimum return were to fall from π_0 to π_1, (see Figure 5), the pecuniary income intercept of the P-N constraint would increase from P_0 to P_1 (where N = 0) and the nonpecuniary income intercept would increase from N_0 to N_1 (where P = 0). Thus, the P-N constraint would shift outward to P_1N_1.

Utility Maximization Subject to the P-N Constraint. As was discussed earlier, the corporate manager maximizes his utility subject to an opportunity set function. In Figure 6, the opportunity set function is given by P_0N_0 under the assumption that owners require a minimum profit of π_0. Consumer behavior theory predicts that utility maximizing managers will consume some combination of P and N where the

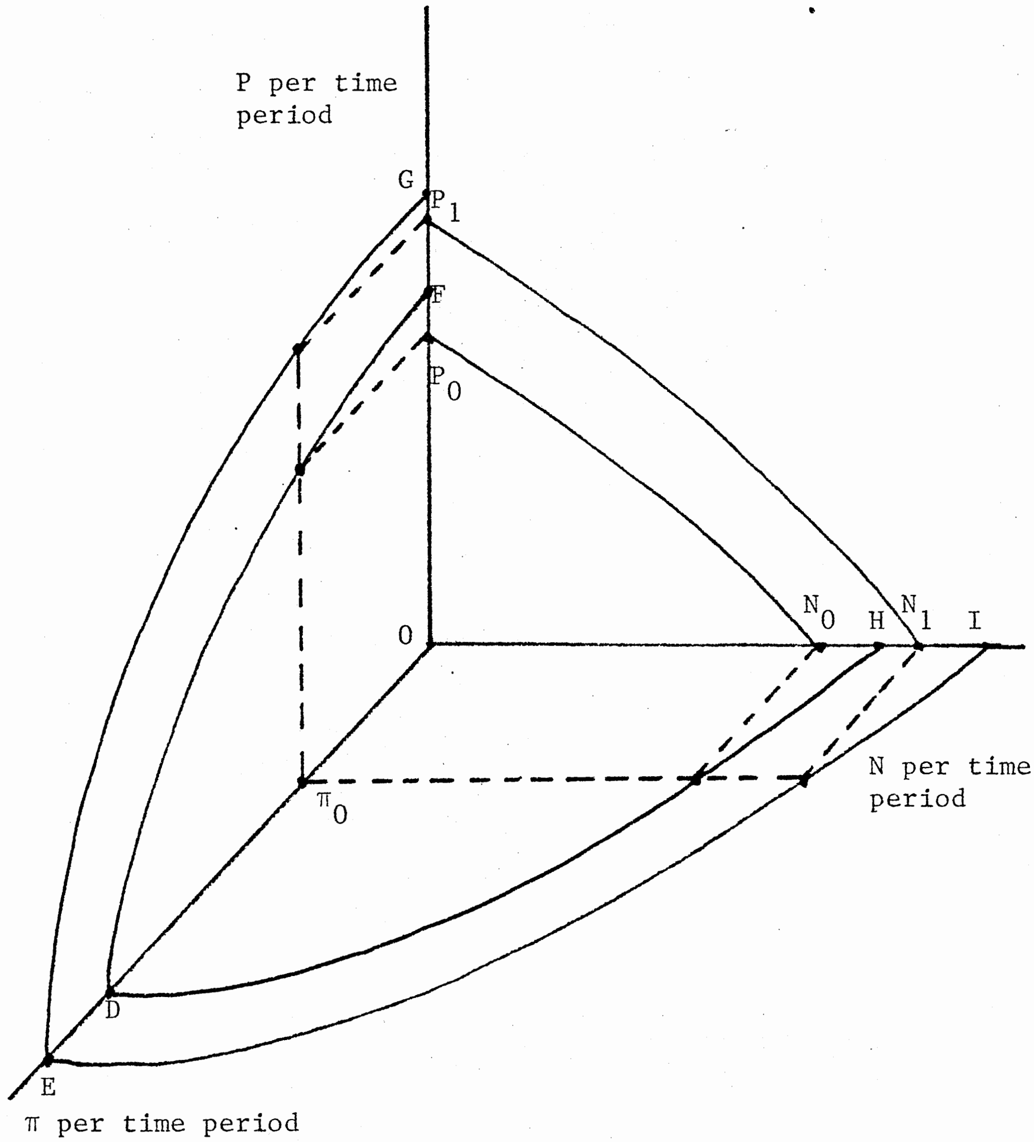

Figure 4. The Effect of an Increase in the Firm's Potential Profit

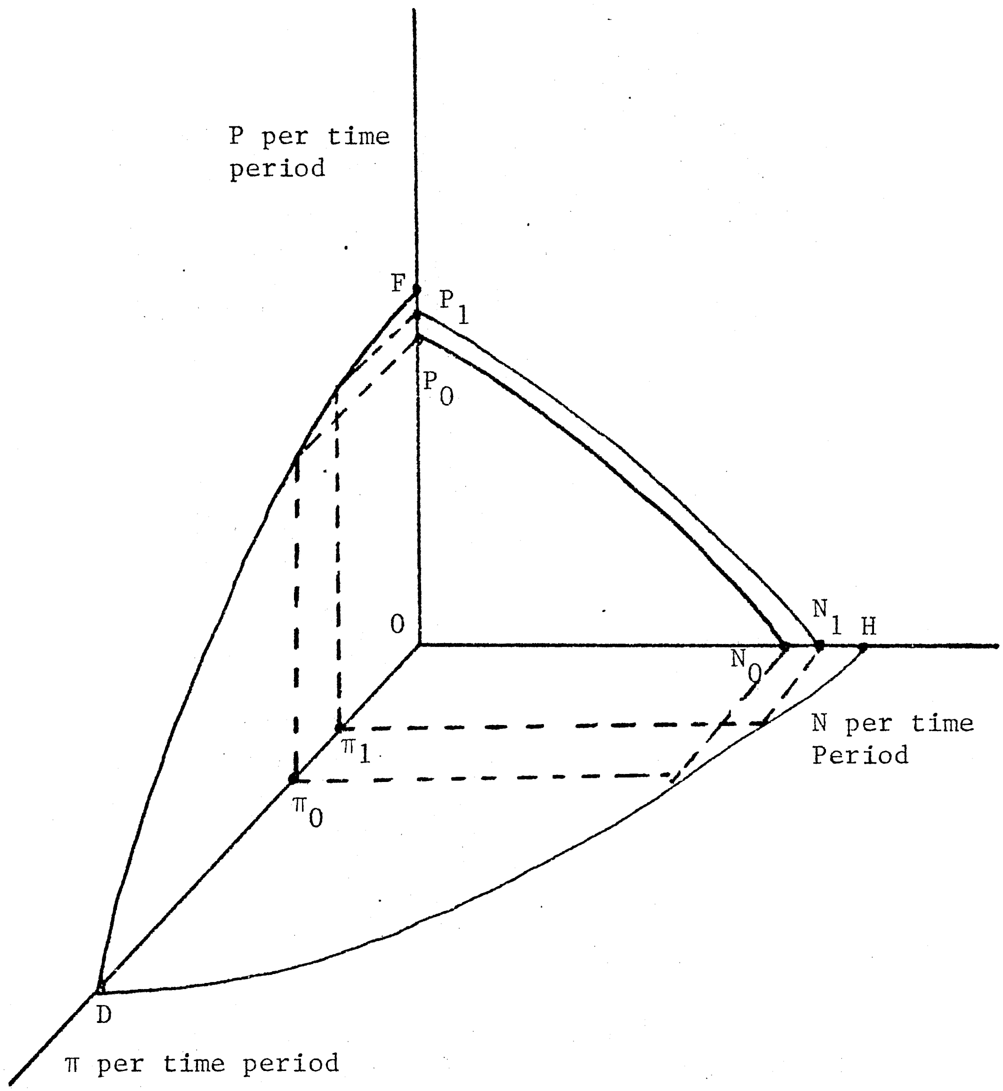

Figure 5. The Effect of a Reduction in the Owner's Minimally-Acceptable Return

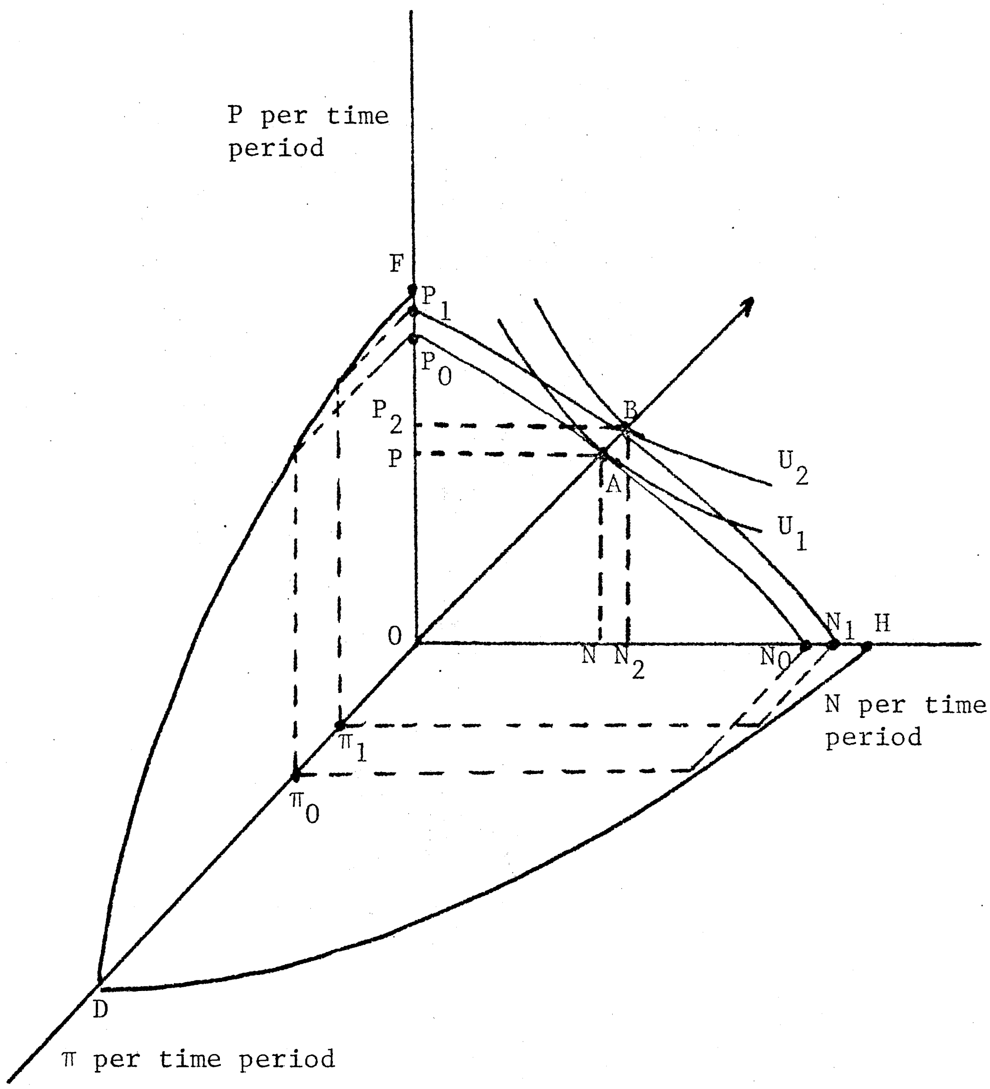

Figure 6. The Manager's Maximization of Utility and the Effect of Increased Monitoring Costs

marginal rate of substitution of N for P, MRS_{NP}, is equal to the marginal rate of transformation of N for P, MRT_{NP}. Because the MRT_{NP} equals the ratio of marginal costs of N to P, the slope of the opportunity set function can be interpreted as the ratio of the opportunity cost associated with the consumption of P to the opportunity cost associated with the consumption of N. Given an indifference map, the manager maximizes utility at point A where total utility is given by the indifference curve, U_1. The manager consumes OP pecuniary income and ON nonpecuniary income subject to the constraint that owners receive a profit no less than π_0.

The manager's constraint in Figure 6, P_0N_0, is based upon the assumption that all discretionary profits are used for the consumption of P and N. The only association between profit and managerial utility is the P and N received from the manager's use of discretionary profits. Meeting the minimum profit requirements ensures the manager's survival and thus a continued flow of P and N. A manager, however, may receive an increase in utility specific to meeting the owner's minimum profit requirements. For example, it has been argued that managers desire tenure (30). If greater job security is expected to be associated with managers consistently meeting the owner's profit requirements, managers will have an incentive to make sure that the minimal return to owners is met.

The manager may get an additional source of N from reporting profits in excess of that which is required by owners. The manager may feel more successful or have a heightened sense of worth as a result of reporting profits in excess of the owner's minimum profit requirements. But this is only one of several sources of N and the manager would not be expected to consume this particular source of N to the exclusion of all others. Furthermore, even if in the manager's employment contract, managerial compensation was positively related to reported profits, it is unlikely that the association between reported profits and executive compensation would be so close as to induce the manager to forego all N in excess of that required for the efficient operation of the firm. Indeed, the works reported earlier conclude that measures of firm size are more important factors than profits in determining the level of executive compensation.

The only effect on the model from introducing a positive relationship between the excess of reported over minimum profits and managerial utility is that, in equilibrium, the manager will have less discretionary profits to purchase P and the N not specifically related to reported profits. As long as reported profits are less than potential profits, a proposition which seems highly likely, the manager will have positive discretionary resources to engage in the utility maximizing process described earlier.

This utility maximization assumes that managerial tastes and preferences are identical, so that all of the managers will have similar tastes for reporting profits in excess of minimum profits as well as for the other sources of P and N. As a result, the important factors for deriving directional hypotheses involve the changes in the relative prices of the sources of utility and the changes in the position of the P-N constraint. Whether it is assumed that the manager receives utility from reported profits in excess of minimum profits or not, the directional changes in the slope and position of the P-N constraint that are hypothesized in this chapter remain unchanged. Thus, the directional hypotheses regarding managerial behavior discussed in this chapter and Chapter IV will remain unchanged as well.

The Effect of Increased Monitoring Costs on Managerial Behavior. If the classical assumption of zero monitoring costs is relaxed, it can be shown that the higher the owner's monitoring cost of management, the greater will be the manager's consumption of P and N. With positive monitoring costs, the minimally-acceptable profit falls to a lower level such as π_1 (see Figure 6). Given that all factors influencing potential profit remain unchanged, the manager finds that his opportunity set, P_0N_0, shifts outward to P_1N_1. Assuming that just an income effect is present, the manager moves to a higher indifference curve, U_2. The new equilibrium occurs at point B where the manager is consuming OP_2 pecuniary income and ON_2 nonpecuniary income. The manager, therefore, consumes more P and N at the expense of owner's wealth as policing costs increase.

The manager is likely, however, to consume more N relative to P from an increase in monitoring costs. This is because consuming N is much less visible than increasing salaries (109). The ability with which managers can exchange profit for N is expected to be greater than their ability to exchange profit for P. The cost to managers of increasing P at the expense of profit is greater because this type of managerial behavior is visible to owners and if carried too far might result in managerial reprimands or firings. Increases in N however, can often be hidden in the form of administration costs or production costs. Thus, for a given reduction in the owner's minimum profit, managers can be expected to increase N more than P because the costs to managers (the probability of reprimands or firings) are expected to be lower when the less visible utility-generating activities are undertaken. Furthermore, the salaries of top management are generally determined by a board of directors. Therefore, the transactions costs to top management associated with an increase in P is much greater than it is for an increase in N. This creates an upward bias in the ratio of opportunity costs associated with consuming P relative to N.

The model can be altered to reflect these propositions by ensuring that the potential profit-P constraint is more concave to the origin that the potential profit-N constraint. That is, the rate at which managers can exchange profit for P is expected to be less than the rate at which profit can be traded for N. For a given reduction in the owner's minimum profits, managers will consume more N relative to P because of the lower implicit price or opportunity cost of doing so. As can be seen in Figure 7, as increased monitoring costs reduce the owner's minimally-acceptable return, the manager's opportunity set shifts outward and become flatter. Thus, there is an income and substitution effect that results from the separation of ownership and management. The substitution effect, in particular, causes the manager to consume more N relative to P. The clockwise rotation of ray OR indicates that managers consume more N relative to P as monitoring costs increase. While this assumption makes the model somewhat more realistic, it does not affect the directional hypotheses of the model. Its main effect is to show that the manager will alter the composition of P and N consumed in addition to consuming more P and N as constraints are relaxed.

In sum, the separation of ownership from management entails positive policing costs of management which results in management consuming both N and P with N increasing relatively more than P. The model also implies that if the owner's minimal profit requirement remains unchanged, anything that causes the firm's potential profitability to

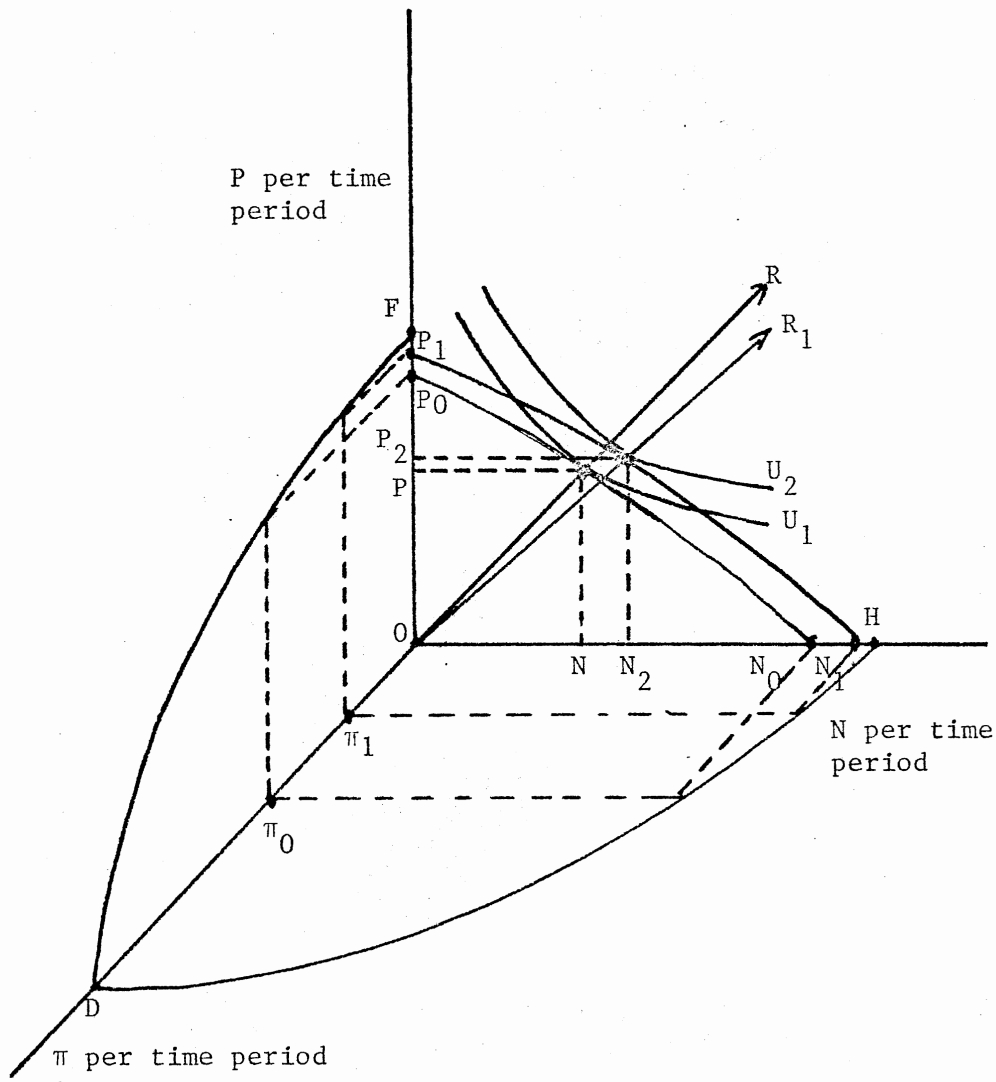

Figure 7. The Effect of an Increase in Monitoring Costs Under the Assumption that Managers Can More Easily Increase N than P with Increases in Discretionary Profits

increase will result in an outward shift in the P-N constraint thus allowing management to increase their consumption of P and N.

The Regulated Private Firm: Attenuated Returns

In the previous section, the effect of separating ownership from management was analyzed. This separation eliminated one of the major classical property rights--owners were no longer the central party to all constracting and decision making. In this section a second classical property right will be altered and the effects of the change will be analyzed. In particular, the owners of some productive enterprises such as utilities have an attenuated right to the residual income of the firm.

Utilities, by virtue of the necessity of the good produced and the scale-economy requirements necessary for efficient production, are natural monopolies. Governments recognize that competition can be ruinous to some of these industries. In order to ensure continued and adequate supplies of the goods and to promote the efficiencies associated with large-scale production, governments grant these utilities monopoly status. Utility rates are regulated, however, to prevent monopolistic pricing. The dominant form of rate regulation involves average-cost pricing where a "fair" rate-of-return to equity is included in the average-cost concept.

If owners are limited in their right to keep the profits of the firm, the returns to owners from encouraging efficiency in the operation of the firm cannot be fully captured. As a result, owners will have less of an incentive to monitor managerial behavior. As discussed in the previous section, owners will lower their minimally-acceptable return (in this case to the regulated level) and the P-N constraint will shift outward. This allows managers to consume more P and N at the expense of the owner's wealth (see Figure 8). If the effect of rate regulation is to reduce profit from π_1 to the regulated level of profit, π_2, the manager's opportunity set will shift outward to P_5N_5. A utility maximizing manager would consume more P and N.

The expectation that managers will consume more pecuniary and nonpecuniary income as a result of rate regulation suggests that the economies of large size associated with natural monopolies are not all passed on to utility customers in the form of lower rates nor are the economies captured entirely by the owners. After the regulated rate of return is met, much of the excess residual income which may potentially result from large-scale production is probably captured by management (31). In comparison to the private unregulated firm, the regulated private firm will be less efficient. Its managers will consume more P and N thus increasing the firm's per unit administration and operating costs.

The Public Firm: The Absence of the Right to Transfer Ownership Claims and to Keep the Residual Income of the Firm

The public firm differs in two important respects from the private firm. One, the owners are taxpayers and generally have no right to any of the residual income of the firm. Thus, they have little, if any, incentive to encourage efficiency within the firm. Second, ownership cannot be transferred, or can be transferred only with substantial transactions cost (transfer of public ownership can only be achieved by the taxpayer moving from the community).

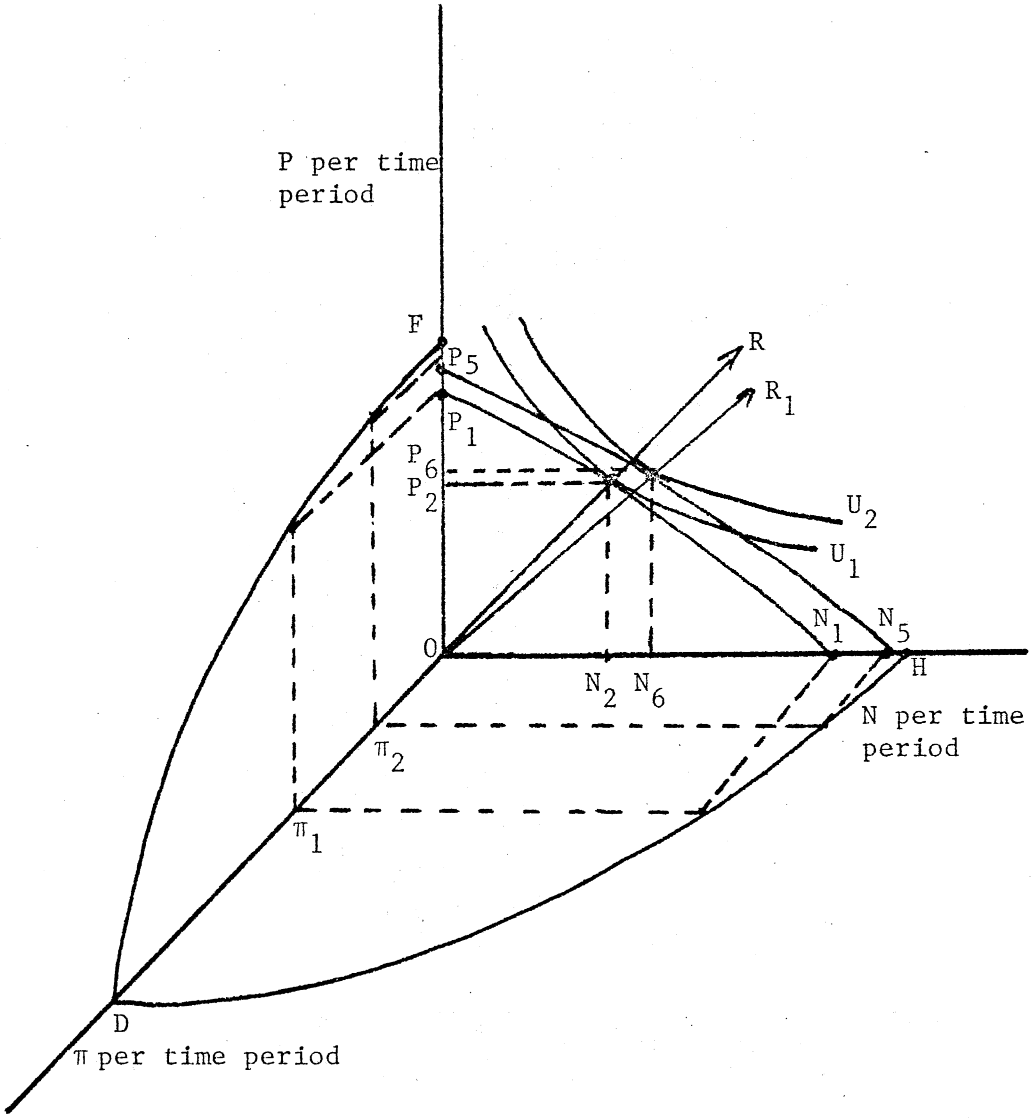

Figure 8. The Effect of Rate Regulation on Managerial Behavior

The more readily that rights to ownership can be exchanged, the greater the owner's ability to capitalize the rewards from efficiency into the present value of ownership shares. Owners of private firms, therefore, have an incentive to monitor the behavior of managers to ensure that the owner's profit goals are being met. If it is difficult or impossible to exchange ownership rights, as is the case with the public firm, owners will have less of an incentive to police managerial behavior (2).

The case of the public firm can be represented by Figure 9 where the level of profit received by the owner-taxpayers, π_3, is equal to zero. If the owner-taxpayers have no right to the firm's profit, potential profit can be absorbed entirely as pecuniary income (where N = 0) or as non-pecuniary income (where P = 0) at point F and H, respectively. The P-N constraint shifts outward to FH and managers consume more of both P and N.

In many instances, however, statutory constraints are placed on the salaries of public managers (31). If the statutory salary, OP_s, is assumed for simplicity to equal OP_6, the pecuniary income of the manager of the regulated-private firm, the effect of lowering the owner's required profit from π_2 to π_3 is to cause the manager to spend the entire increase in discretionary profits on N. The manager's consumption of N would increase to ON_7 (see Figure 9). Thus, the public firm is expected to be less efficient (to incur greater per unit costs) than its regulated private counterpart. Public managers are expected to consume more N than managers of comparable, but regulated-private firms.

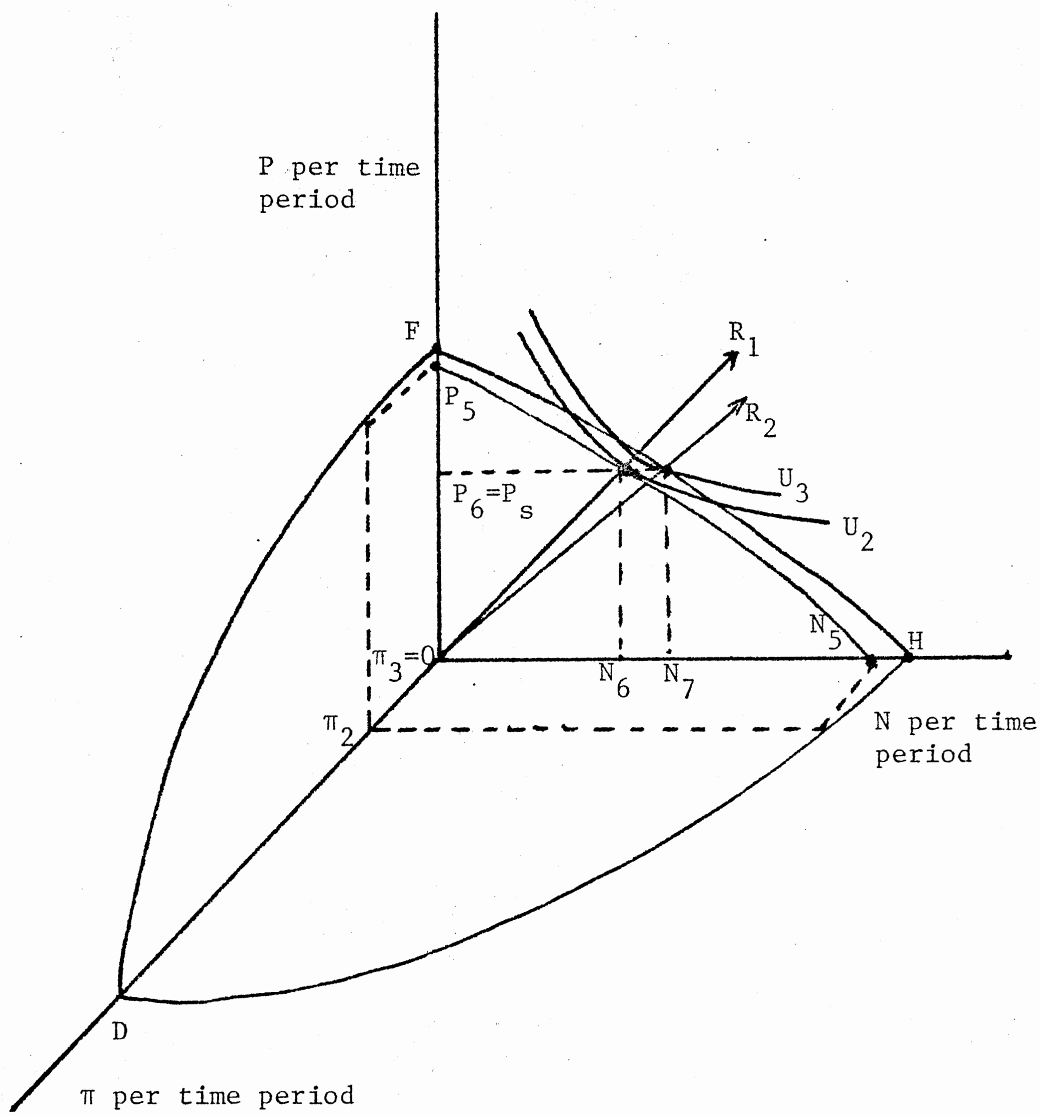

Figure 9. The Effect of Public Ownership on Managerial Behavior

Conclusion

Utility maximization theory was used to show that managerial behavior within the classical firm, the corporation, the regulated-private firm, and the public firm will differ because of different property rights structures. For instance, the manager of a regulated private firm is expected to consume more P and N than the manager of a comparable unregulated private firm, but less P and N than the manager of a comparable public firm. The public firm, therefore, is expected to be less efficient (to have higher per unit costs) than a comparable private, but regulated firm. This is a testable implication of the theory of property rights that has been the focus of much of the empirical work to date.

The theoretical approach used in Chapter IV involves identifying those major managerial activities that give rise to pecuniary and non-pecuniary income, and then observing how the manager's consumption of these activities differs when different property rights structures are analyzed. In Chapter IV, the property rights theory of managerial behavior is extended to an analysis of the water utility industry. Two different sets of property rights are identified within this industry--one set is associated with investor-owned utilities and the other set is associated with publicly-owned utilities. Testable implications of the theory are developed with respect to firm efficiency, pricing, and production policies. But first, an overview of the water utility industry and certain important aspects of that industry will be presented in Chapter III.

CHAPTER III

CHARACTERISTICS OF THE WATER UTILITY INDUSTRY

Introduction

The purpose of this chapter is to describe various aspects of the water utility industry. Some of the characteristics discussed in this chapter impose important constraints, in addition to ownership rights, on managerial behavior. Part of Chapter IV is devoted to outlining the effects that some of these characteristics have on the manager's opportunity set.

The first section presents a brief history of the water utility industry in the United States followed by sections on water utility management, the production process and capital intensity, costs and economies of scale, utility financing and linkages to local government, and rate-making practices. The last two sections present a discussion of water quality and the regulatory structure of the industry.

Characteristics of the Water Utility Industry

Brief History of the Water Utility Industry

The water utility industry had its inception during Colonial times. The first water system was built in 1652 to serve Boston residents (5).

It was a very crude system consisting of wooden pipes which transported spring water to a wooden holding tank from which area residents filled their buckets. The first water supply system designed specifically to serve an entire community was built in 1746 in Shaefferstown, Pennsylvania (5). It took another century before there were as many as 16 water systems. By 1800, there were 16 water systems of which 15 were privately-owned (48). Privately-owned water systems represented the majority of water systems until the latter 1890s (48).

From 1890 to the present, the number of water systems has increased dramatically (see Table I). In 1890, some 1878 utilities served a population of 22,678,000 (5). By 1976, it was estimated that some 34,631 water systems served a population of 192,200,000 (see Table II). Over 18,000 of these water suppliers served populations of less than 500 people. The table reveals that roughly 8 percent of the water systems serve 80 percent of the population and 80 percent of the water systems serve only 8 percent of the population (108). Further, it was estimated that in 1976, 84 percent of the population was served by public water firms whereas private water firms served only 16 percent. The composition of public and private firms in 1976 is comparable to what it was in 1896. Public water firms accounted for 56 percent of the total number of water firms in 1976 (108) and 53 percent in 1896 (48).

Water Utility Management

Water utility managers are subject to state regulations and the profits requirements of owners in the case of privately-owned utilities. Public water managers are responsible for carrying out the directive of local ordinances or state regulations. The section on regulation in

TABLE I

UNITED STATES WATER UTILITY GROWTH, 1800-1976

Year	Utilities	Estimated Population Served
1800	16	
1825	32	
1850	83	
1875	422	
1880	598	11,809,231
1885	1,013	
1890	1,878	22,678,350
1896	3,196	
1924	9,850	
1934	10,790	
1939	12,760	81,243,480
1948	16,439	93,455,135
1958	17,808	133,126,310
1963	19,236	150,602,164
1976	34,631*	192,200,000

*Utilities are defined as all community water systems (a) serving 25 or more (15 or more connections) fixed resident populations, (b) which are privately-owned systems or publicly-owned local and state systems, and (c) which are located in the contiguous 48 states. All federally-owned and wholesale firms are excluded.

Sources: American Water Works Association (5), p. 769; Environmental Protection Agency (108), p. II-4.

TABLE II

NUMBER OF WATER UTILITIES AND POPULATION SERVED BY SIZE CATEGORY, 1976

	Population Category									
	25-99	100-499	500-999	1000-2499	2500-4999	5000-9999	10000-99999	100000-999999	> 1 Million	Total
Number of Water Systems*	6,308	11,714	4,932	4,850	2,496	1,646	2,442	232	11	34,631
Percent	18%	34%	14%	14%	7%	5%	7%	<1%	<1%	100%
Population Servied (millions)	0.4	2.8	3.4	7.6	8.7	10.4	73.8	58.9	26.2	192.2
Percent	<1%	<2%	2%	4%	4%	5%	38%	31%	14%	100%

*System definition is given in footnote of Table I.

Source: Environmental Protection Agency (108), pp. II-4.

this chapter will discuss in greater detail the regulatory structure of the industry. Beyond the legal constraints on managerial behavior, there are informal operating standards put forth by the American Water Works Association (AWWA). The following is a policy statement of the AWWA regarding general operating standards.

> Delivered water should as a minimum meet United States Public Health Service drinking water standards. In addition, it should be free of objectional taste and odor, color, turbidity, and staining elements, and as noncorrosive as practicable. It should be adequate in quantity for all sanitation and other domestic uses; safe and desirable for industrial and commercial use; adequate for fire protection services, and available on an uninterrupted basis with a minimum of fluctuations in pressure (5, p. 769).

Water utility management is comprised of formulative and administrative management (96). The formulative level of management establishes goals and general policies of the utility. For a private water utility, the owner or a corporate board of directors perform this function. City fathers perform this function for municipally-owned water systems. The city fathers generally do not have the technical expertise that the corporate boards have. Further, city councilmen are subject to political influence much in the manner that corporate boards are subject to stockholders' influence. Public managers are often directed to conform to certain social and political policies which are not necessaily in the best interest of the utility.

The administrative level of management is comprised of the chief executive officer of the utility and the management engaged in

> (1) . . . forecasting future needs; (2) making plans concerning the resources and methods necessary for best meeting forecasted needs; (3) acquiring and organizing the necessary resources--financial, physical, and human--to carry out the plans; and (4) actually operating these financial, physical, and human resources (96, p. 496).

It is the behavior of the administrative manager which is the concern of this dissertation. The private administrative manager must perform according to the wishes of the owner or stockholders. The public manager is usually hired by the city council, city manager, or appointed or elected local water boards or commissions. Only rarely is the position of the chief executive office an elected position (58). The public manager is usually directly responsible to politicians or political appointees.

The closeness of public management to local political influence often causes problems for the public manager in operating the utility (58). For example, a community may use the water system to further community goals such as to ". . . further economic development, to relieve property taxes, or to subsidize eleemosynary institutions" (58, p. 217). In a 1968 survey of problems experienced by public water managers subject to local political control, the most common complaints were that the utility was required to give free water to other city departments and to make contributions to the municipality's general fund (58). In a 1974 AWWA survey of public water agencys' financial linkages to the local government, it was found that out of 218 responding public water utilities, 19 percent of the water agencies provide free water to the local government, 45 percent made cash contributions to the municipality's general fund for administrative and staff costs, and 38 percent made cash contributions to the general fund in lieu of sales, property, and franchise taxes (7).

Production Process and Capital Intensity

The major components of a water system are source of supply, collection works and transmission mains, treatment facilities, and the distribution network (5). Surface sources of water consist of ponds, lakes, and streams. Groundwater sources come from wells, springs, and infiltration galleries. In a recent survey sponsored by the Environmental Protection Agency (EPA), it was found that 75 percent of all water systems use ground sources of water whereas 13 percent used surface sources and 12 percent purchased water from wholesalers (108). Large water utilities rely more heavily on surface sources of supply. The EPA survey shows that while 13 percent of all systems used surface water, these surface sources provided water for 49 percent of the total population served by all utilities (108).

Collection and transmission facilities consist of ". . . intakes, pumping stations, and pipelines necessary to collect and transport . . ." water to the treatment plant (5, p. 767). Treatment plants involve anything from minimal treatment such as disinfection to more extensive treatments which require using chemicals and mixing, filtration, settling, and flocculation systems. Once the raw water has been treated, it is delivered to the distribution system. This component of the production process includes storage and pumping stations, water mains, hydrants, valves, service connections, and meters.

Water industry technology has changed very little over the past several decades particularly when compared to the technological advancements of the communication, electric power, and natural gas utility industries. New water technology has been employed, but this has been largely to meet upgraded water quality standards. Pumping is no longer powered by steam and ". . . there have been improvements such as increased filtration rates and better system dependability through control development" (5, p. 556). Larger systems are becoming increasingly automated, but ". . . water systems today are basically the same as those 30 years ago" (5, p. 556).

Of all the utility industries, the water utility industry is the most capital intensive and has the highest investment per dollar of revenue (5). A common measure of capital intensity used when comparing various industries is the ratio of gross annual revenue to total investment (or the capital-turnover ratio). Hanke and Boland (44) report that the capital-turnover ratio has been estimated at 4 to 6 for wholesale and retail trade enterprises, 2 for manufacturing, .3 for electric utilities, .2 for water utilities, and around .4 to .6 for other utilities. Compared to other utilities and industries, the water industry is one of the most capital intensive industries. One reason for the high investment relative to revenues is the durability of the assets of water utilities. Many investments in the water industry have useful lives of 50 years or longer (108).

Costs and Economies of Scale

Because of the highly capital intensive nature of the water industry, a considerable portion of water system costs is fixed (see Table III). Fixed costs are defined as the sum of depreciation and interest expenses, taxes, and payments to the local government in lieu of taxes. It has been estimated that these expenditures comprise roughly one-third of total system costs. The other two-thirds of total systems costs are variable costs which include fuel and electricity for pumping, chemicals for purification, labor and administration expenses.

TABLE III

ESTIMATED VARIABLE AND FIXED COSTS BY SIZE CATEGORY, 1976

	Population Category								
	25-99	100-499	500-999	1000-2499	2500-4999	5000-9999	10000-99999	100000-999999	> 1 Million
Variable Costs[a] (Percent of Total)	.78	.68	.53	.69	.64	.56	.57	.60	.43
Fixed Costs[b] (Percent of Total)	.22	.32	.47	.31	.36	.44	.43	.40	.57

[a]Defined as operation and maintenance expenditures.

[b]Defined as the sum of depreciation expenses, interest expenses, taxes, and in-lieu payments.

Source: Environmental Protection Agency (108), p. II-12.

Hanke (43) estimated that the acquisition and distribution capital costs accounted for 38.7 percent and 35.5 percent of total capital costs. Of total acquisition costs, transmission capital costs accounted for 80.4 percent of the total with the remainder used for source of supply capital costs. Distribution mains accounts for some 76 percent of total distribution capital costs. Treatment facilities account for 14.3 percent of total capital costs.

In the summary of EPA's 1976 community water system survey (108), the authors declare that there are ". . . clear economies of scale in total system operating expenses (O & M, depreciation, taxes, and miscellaneous other expenses)" (p. II-15). They report that economies of scale exist also for interest expenses. For a national sample of water utilities used in Chapter V of this dissertation, estimates of returns-to-scale presented in Table VIII imply that variable costs decrease with increases in scale. The evidence regarding economies of scale in the water industry is somewhat mixed, however, when considering economies of scale for various components of a water utility such as production and distribution systems (51), transmission (61), and treatment (52, 87).

Hines (51) found economies of scale in water production (specifically for surface water production) but not for the distribution of water. When both the production and distribution systems were combined, he found the presence of constant returns to scale. Linaweaver and Clark (61) found economies of scale present for transmission costs as water is transported through larger pipe sizes. Orlob and Lindorf (87) and Hinomoto (52) found economies of scale in the costs of water treatment.

Utility Financing and the Municipal Firm's Financial Linkage to Local Government

Privately-owned water systems are self-supporting in that they try to generate revenues sufficient to cover operation and maintenance costs, taxes, interest payments, depreciation as well as the regulated return on investment. Revenues should also be sufficient to provide funds necessary for capital additions and to be able to attract external debt financing. Publicly-owned utilities may be either self-supporting or tax-supported enterprises (5). Self-supporting enterprises

> . . . receive sufficient revenue through rates, charges, and fire protection tax levies to meet all expenses, maintain and expand the system, and contribute funds to the utility in lieu of taxes (5, p. 773).

These enterprises finance large capital additions by issuing revenue bonds. Revenue must be sufficient to pay the interest and redemption on these bonds.

A tax-supported utility

> . . . is budgeted and accounted for within the city's overall operations. Revenues from water sales are deposited in the general municipal fund together with other receipts, including tax receipts, out of which the expenditures for all city operations, including the water utility, are made. In such cases, taxes are levied to meet payments on bonds issued to expand the water system. The bonds would be general obligation bonds backed by the taxing powers of the municipality (5, p. 773).

Many variations of public utility financing exist. For instance, a city may finance capital additions by using exclusively general obligation bonds subject to voter approval, issuing special assessment bonds in which assessments are levied only against benefitting properties, issuing revenue bonds, applying for federal aid funds from federal agencies such as the Farmers Home Administration (71), or using a a combination of these methods (76). Most city water supply systems, however, are financed by revenues with some additional support from special assessments and general obligation bonds (76). In a 1974 survey by the AWWA, it was found that 82 percent of the responding 210 public water systems receive approximately 80 percent of their revenues from water sales; 16 percent receive a tax-subsidy from property taxes for debt-service, capital, and operation costs; and as was noted in the section on utility management, 38 percent of the responding utilities make contributions in lieu of taxes to the locality's general fund (7).

Rate-Making Practices

A traditional concept in water utility rate-making is that water rates should be cost-based (16, 59) and equitable (63). Little attention has been given to demand relationships (44, 68). The method which utilities generally use to establish rates is to first determine annual revenue requirements. Second, a cost-of-service study is done to determine the cost of serving each customer group. Finally, rates schedules are constructed such that revenues are generated by each customer group sufficient to cover their cost of service.

According to Keller (59), revenue requirements are generally determined on a cash-needs basis for 5 to 10 years into the future. One method of projecting future cash needs is to obtain future population estimates and multiply these times per-capita cost estimates (44). Required revenues should meet all the utility's cash needs. For the municipally-owned utility, cash needs consist of estimated inflation-adjusted operation and maintenance costs, debt service, capital additions financed from revenues, developer refunds, and in-lieu payments. The ordinary means by which a private utility determines its cash needs is to project future operation and maintenance expenses, taxes, depreciation and return-on-rate base. In order to determine the additional revenues that must be recouped via the rate structure, projected revenue requirements are compared to the projected revenues associated with the current rate structure.

In order to determine how to adjust the rate schedules to generate the additional required revenues, a cost-of-service study is done to determine the estimated cost of service of each customer group. MacEwen (63) notes that there are two methods commonly used to allocate estimated costs: the commodity-demand and the base-extra methods. Two steps are involved. First, costs are disaggregated by function--commodity, demand, and customer costs in the case of the commodity-demand method or base, extra capacity, and customer costs in the case of the base-extra technique. The next step is to allocate these costs to the various customer classes in accordance with their water use characteristics. Commodity costs are those costs that vary in direct proportion with output such as treatment chemicals and power for pumping. Customer costs include operating and maintenance costs associated with meter reading, billing, and the installation of meters and lines. Demand costs are variable and fixed charges associated with the extra plant capacity that is needed to meet peak-period demands.

The rate structure most commonly used in the water industry is the declining block rate (42). After a minimum charge, average prices decline with increases in discrete quantities. The first block is the minimum water wate and is designed to cover the ". . . cost of meter reading and billing and the fixed charges on the customer facilities, as well as base water costs for minimum use customers" (59, p. 11).

The next block generally covers the average cost of residential water consumption. This residential water rate also covers the costs associated with demands imposed on the water system by peak residential irrigation use. The last blocks are designed for the highest-use customer, e.g., industry, and are designed to recover base costs and demand costs associated with peak-day or peak-hour use. Base costs are defined in a similar manner to commodity costs defined earlier except that base costs include a cost for water system capital used in serving customers during average load conditions (59). The customer-class groups are ordinarily comprised of residential, commercial, industrial, public, wholesale, and customer groups outside the city limits.

Other water rate designs which have been used or suggested for use are flat rates, uniform rates, step rates, demand and peak-load rates, inverted block rates, time-of-day rates, seasonal rates, value-of-service rates, social rates, utility stamps, and lifeline rates (68). Arguments for and against these price policies revolve around simplicity, implementation costs, stabilizing load factors, economic efficiency, local income redistribution, and water conservation.

Water Quality

Until the last decade, it was generally assumed that adequate steps were being taken by water suppliers to produce a product free of chemical and bacteriological contamination. It was a ". . . shock to laymen and professionals alike" (102, p. 22) to discover that there were serious quality problems nationwide. The extent of the problems were revealed in a 1969 survey of community water supplies--The Community Water Supply Study - Analysis of National Survey Findings, 1969 (107).

Sonnen reports that the survey reveals that 41 percent of the water systems sampled did not meet the 1962 drinking water standards, 25 percent did not meet recommended contaminant limits, and 16 percent exceeded some of the mandatory limits (101). Stacha notes further that the water supply survey indicates that 56 percent of the utilities had problems with disinfection capacity, 77 percent had plant operators with insufficient training in water microbiology, 85 percent did not take bacteriological samples frequently enough, and 69 percent of the systems only analyzed half of the samples required by the public health service (102). In a recent committee report by the AWWA (9) on quality control practices in microbiology laboratories, it was found that 8 to 33 percent of the 226 responding utilities were unaware that quality control problems existed.

Nationally, most small utilities use groundwater and large utilities use surface sources or a combination of ground and surface sources of water. For a sample of 248 Oklahoma water suppliers used in Chapter V, approximately one-half of all water systems used groundwater with the other half using surface sources. The same relationship holds for private and public water suppliers. Stacha (102) says that surface water generally at least requires turbidity removal and disinfection. Other problems encountered with surface supplies are poor taste, color, and odor; the presence of inorganic contaminants, pesticides, industrial and other wastes; and treatment problems associated with the seasonal effects on humic acids, mineral content, and turbidity. Groundwater problems vary from disinfection to removal of extensive quantities of iron, solids, hardness, manganese, hydrogen sulfide, carbon dioxide, radionuclides, and inorganic matter.

Water is disinfected by either the use of chlorine, ozone, or chlorine dioxide. Suspended solids contributing to turbidity problems can be eliminated by filtration, sedimentation, and coagulation (102). The EPA's 1976 community water system survey indicates that the typical treatment used by utilities employing groundwater is disinfection whereas surface source systems employ a wider range of treatments including disinfection, corrosion control, filtration, coagulation, and sedimentation (108). As was reported above, treatment costs account for 14.3 percent of total capital costs with variable treatment costs consisting of chemical costs, employee compensation, and energy.

All public and private water suppliers serving fixed resident populations of 25 (or 15 connections) or more are subject to the maximum contiminant limits established as a result of the passage of the Safe Water Drinking Act of 1974 (PL 93-523) (95). These limits are imposed on 10 inorganic constituents, turbidity, coliform organisms, six pesticides, and radionuclides (102). Monitoring, sampling, and public notification requirements are also established in the Act with the responsibility for such activities being imposed on the owners of the utility. States are given the primary promulgation and enforcement responsibilities of the Act. Failure of public water systems to comply with the Act can potentially result in civil suits against the water utility with the citizens bringing the suit being awarded cost for such litigation (49).

Regulation

In addition to federal and state clean-water regulations, various aspects of a water utility's operation are regulated by either state regulatory commissions or various types of local government regulation. The extent of regulation varies from none in the case of Georgia and Nebraska (state regulation) (62), to fairly extensive review and regulation of rate levels, rate structure, debt-capital structure, accounting and depreciation practices, annual reports, rates of return, rates to outside customers, service extension, and so on.

Investor-owned utilities are almost exclusively regulated by state regulatory commissions. According to Hansman, a study (no date), funded by the Department of Interior, of state regulatory practices by Fristoe, Goddard, and Keig shows that of 50 states, 46 have the power to regulate investor-owned utilities, 41 can regulate retail and wholesale rates, 43 prescribe rates of return, 42 require mainline extensions to franchised areas, 31 regulate the financing of mainline extensions, 36 regulate pricing to governments, 43 require certain accounting practices and reporting forms, 12 require a fair-value estimation of the rate base, 25 require original cost less depreciation to be used in valuing the rate base, and 26 require the straight line method of depreciation (45).

Based upon a 1968 survey of 252 publicly-owned water utilities, Keig, Fristoe, and Goddard (58) found that there was a variety of forms of local regulation. Of the total number of utilities sampled, 68.6 percent were regulated by city councils, 5.6 percent by state commissions, 12.3 percent by appointed or elected boards, and 13.5 percent by combinations of city councils, boards, or commissions. State regulation of municipal water agencies varies from regulation of outside city service only to regulation of accounting and reporting practices, main-line extension, and both outside rates and inside retail and wholesale rates.

Five states regulate municipal inside rates whereas 10 states regulate inside and/or outside public water rates (45).

City council regulation is the dominant form of public regulation in all locally-regulated states except Tennessee. Primary control by city councils does not preclude some state regulation. States may require specific accounting procedures and regulate outside services. In general, city councils control the water utility's budget, water rate policies, and other policies not controlled by state regulation. The city council may also appoint a board or commission to oversee rates or capital expansion. The decisions of these boards and commissions are often subject to the council's veto power.

Some public water utilities are under the jurisdiction of elected or appointed commissions or boards which usually have the power to determine rates, improvements, and extension policies. In the case of elected and state-appointed boards, statutes limit the discretionary powers of the board members. Often, the chief water executive is appointed by the board or commission and is responsible to these groups. In some cases, state law empowers the city manager to employ the chief water manager. The last major form of local regulation is joint regulation by city councils and regulatory commissioners. The division of power between these two groups takes many forms--the appointed or elected commissioner may have to submit plans to the city council for approval or an elected manager may have to self-regulate activities in conjunction with local politicians. In sum, ". . . the predominant pattern of control over publicly-owned water utilities is that in which the city council must approve the budget, rate structures, and other major policies" (58, p. 217).

Conclusion

Both the number of water utilities and the total population served have grown rapidly, particularly since the late nineteenth century. Little has occurred, however, over the past few decades in terms of technological innovation.

The industry is composed of both private and public firms subject to state and various forms of local regulation. Other characteristics of the water industry are that (1) water firms appear to be one of the most capital intensive industries; (2) economies of scale seem to occur when overall systems costs are considered and in the case of water treatment, but are less clear when considering other components of the production process; (3) roughly one-third of all system costs are fixed costs with acquisition and distribution capital costs accounting for most of a system's capital cost; (4) many public utilities are self-supporting, but there are a considerable number of public firms which are tied closely to municipal government and rely on operating and investment subsidies; (5) price policies apparently still adhere at least in word to the traditional concept of water utility pricing that rates should be cost-based and equitable. The dominant form of pricing used in the water industry is the declining-block rate policy, but varies from utility-to-utility depending on cost allocation techniques, the number of blocks, and other considerations; and (6) there is some evidence to suggest that water suppliers may be producing water which does not conform to drinking water standards.

The intent of the next chapter is to apply the utility maximization model of managerial behavior to the water utility industry. Important industry characteristics other than ownership are analyzed as to their effect on the manager's opportunity set and testable implications are derived with respect to managerial behavior in the water industry.

CHAPTER IV

AN APPLICATION OF A PROPERTY RIGHTS THEORY OF MANAGERIAL BEHAVIOR TO THE WATER UTILITY INDUSTRY

Introduction

The water utility industry is an important industry for an application of an economic theory of property rights for at least three reasons. One reason is that there are both investor-owned and publicly owned water utilities which makes an analysis of different ownership rights as well as differences in other institutional characteristics of the industry possible. Second, with the exception of rate studies, there has been very little economic analysis of the water utility industry. By contrast, there has been much more economic analysis of the electric power industry in the areas of rate-making, investment strategies, the effect of regulation, and even in the area of property rights and managerial behavior. A third reason for analyzing the behavior of privately-owned water utilities (IOUs) and publicly-owned water utilities (POUs) is that there may be important implications regarding which ownership form is preferable in terms of addressing pressing regional issues such as water shortages and water quality.

In Chapter II, the general effects on managerial behavior of attenuated ownership rights were analyzed. It was concluded that any attenuation of the owner's rights to be the central party to all contracting, to exchange freely the ownership shares of the firm, and to keep the residual income of the firm would result in managers consuming both more pecuniary and nonpecuniary income sources at the expense of the owner's wealth. It was also concluded that these rights are more attenuated for public utilities than for regulated private utilities largely because taxpayers do not have the right to the residual income of the firm nor can they exchange ownership shares in the public firm without incurring high transaction costs. Managers of POUs can be expected to consume more of all pecuniary and nonpecuniary sources of income than managers of comparable IOUs. This conclusion was subject to the restriction that if the public manager's salary was statutorily fixed, the public manager will consume mostly nonpecuniary income as the constraints on the opportunity set are relaxed.

Differences in the behavior of public and private managers are not affected exclusively, however, by differences in the rights of owners. Other factors influence the manager's opportunity set. A study of any industry will yield a set of characteristics unique to that industry. These characteristics influence the manager's ability to use resources. In other words, ownership rights and other institutional factors shape the structure of managerial property rights.

Because the effect of ownership rights on managerial behavior has been discussed in Chapter II, the purpose of this chapter is to first identify and explain the effects that other important industrial characteristics have on the structure of managerial property rights. Next, the effect of different managerial property rights on managerial behavior will be analyzed. Specific consideration will be given to managerial actions that affect the firm's efficiency, price-output decisions, and product quality.

Important Institutional Characteristics of the Water Utility Industry

In the context of the model developed in Chapter II, both ownership rights and other institutional characteristics affect the manager's ability to consume pecuniary and nonpecuniary sources of income. Differences in these ownership rights and industry characteristics will produce a shift in the manager's opportunity set or a change in the actual or shadow prices of one argument in the utility function relative to another. This, in turn, induces the manager to alter the level or composition of the pecuniary (P) and nonpecuniary (N) sources of utility. Several of the more important industry characteristics are discussed below in terms of their effect on the manager's opportunity set and utility maximization.

Property Tax Liability and In-Lieu Payments

Investor-owned water utilities are, for the most part, subject to local property taxes. Public water utilities are rarely subjected to local taxation, but some POUs do make payments to the local government in lieu of taxes or provide free service to other city departments (5). Taxes affect net income and as a result the residual or discretionary component of that net income available to management. Other things constant, the effect of taxes on the private manager's opportunity set is to constrain it inside of that opportunity set that would exist in the absence of taxes. Because POUs are generally not subject to taxation, public water managers are expected to have access to greater discretionary net-of-taxes profits and thus are expected to consume more pecuniary and nonpecuniary sources of income than managers of comparable IOUs.

Capital Financing

Investor-owned water utilities must obtain capital funds in the same manner as any other private firm by either issuing additional stock and bonds, borrowing from financial institutions, or generating the funds internally. Small investment projects are usually funded internally whereas large projects necessitate borrowing from commercial banks, insurance companies, and other financial institutions as well as issuing stocks, bonds, and debentures (76). Stocks, bonds, and debentures are usually issued ". . . in proportion to debt ratios prescribed by state public service commissions . . ." (5, p. 775). An IOU must earn a positive rate-of-return if it is to have the ability to attract capital. A strong earnings record is often associated with a higher bond rating and thus lower interest rates on bond issues. Higher rates of profit also attract equity capital. Low profit rates or frequent losses make it difficult for the manager of an IOU to acquire capital.

This is not necessarily the case, however, for publicly-owned water utilities. Even though most POUs are self-supporting in that they use revenue bonds to finance large capital additions, many POUs rely on subsidies from the local government (5, 76). POUs can indefinitely operate at a loss and still acquire capital if subsidized by the local government. Of the total value of bonds issued in 1964 for municipal water works construction, 64 percent were general obligation bonds and

36 percent were revenue bonds (5). General obligation bonds are backed by the fiscal creditability of the municipality. In other words, local taxes are used to service the general obligation debt and thus constitute a subsidy. The tax-free status of municipal bonds usually results in lower interest rates than would be the case for comparable private bonds. Furthermore, public water agencies, particularly rural water systems, receive federal grants and special low-interest loans for the construction of capital facilities (71). The capital funds acquired by the POU are acquired, therefore, at a lower cost per unit of capital than the capital funds acquired by the IOU.

The public manager's right to use or employ capital is also influenced by whether or not the public manager has the "authority to borrow" or is subject to public bond referenda (76). Also, major investment decisions are made, not at the level of administrative management, but at the formulative level (97). For IOUs, the formulative decisions are made by a board of directors which often includes top management. The POUs' formulative investment decisions are often made by local politicians--city councilmen that have no technical expertise in water resource management. Thus, the public manager has an additional constraint placed on his capital acquisition activities in that local political or social considerations may weigh heavily in particular investment decisions.

Other things constant, the POU is expected to employ more capital per unit of output than a comparable IOU, in part, because of the lower per unit cost of capital. In terms of the model developed in Chapter II, plotting capital as a nonpecuniary source of income on the horizontal axis and all other sources of pecuniary and other nonpecuniary sources of income on the vertical axis would suggest that the lower cost of capital relative to the price of other N and P, the flatter the manager's opportunity set. Thus, if capital is a normal good, the substitution and income effects of the price change imply that the public manager will consume more capital and "other" N and P with the ratio of capital to the "other" N and P increasing. A salary constraint implies that the income and substitution effects will primarily favor the additional consumption of capital and "other" nonpecuniary sources of income relative to pecuniary sources of income.

Property Taxation and Special Assessments as a Source of Additional Revenue

There is some evidence that some POUs do not generate sufficient revenues to cover the cost of production and thus the POUs have to rely on subsidies from local government (7, 89). There is also evidence that many POUs generate surplus revenues which go to the local government coffers (7) and therefore constitute cross-subsidization of other governmental functions by utility customers (21). It is not clear which way the causation runs between municipal finance and water agency revenues (48).

To the extent that the local government subsidizes the POU, managers of POUs have less of a need to operate the firm efficiently and therefore can further bias the costs of the firm upward by consuming more nonpecuniary sources of utility. POUs are rarely evaluated on the basis of efficiency, but on the basis of abundant and high-quality services at low prices. The 1974 AWWA Committee Report shows that of 218 responding water utilities, 38 percent make payments to the municipality in lieu of taxes, 45 percent make cash contributions to the city's general fund for administration and staff expenditures, 16 percent receive a cash subsidy from property taxes for operations, capital, and debt-service expenditures, 19 percent contribute free service to other city departments, and 41 percent do not bill the city for fire protection services (7).

Some water agencies even have the right to tax property and to levy special assessments such as front-footage assessments (47). These additional revenue sources suggest that the POU has access to more discretionary profits than would be the case in the absence of subsidies, property tax revenues, and special assessments. Because the additional discretionary profits are available only to managers of some POUs and not to any IOUs, the public manager's opportunity set is expected to lie even further outside that of the private manager's opportunity set.

Regulation

Regulation is perhaps the most important institutional characteristic in terms of its effect on managerial behavior for several reasons. One, regulation within the water industry has a major impact on managerial behavior through its effect on ownership rights. Also, regulation affects managerial behavior due to the additional constraints that it places on the various aspects of operation such as price-output policies, capital structure, product quality, accounting and depreciation methods, and service extensions. Finally, noneconomic factors, in the form of local political and social influences, can affect managerial decisions via regulation (66). The effect that political influences have on managerial treatment of the various customer classes is still an unresolved issue.

The Nature of Water Utility Regulation. There are two distinctly different types of regulation in the water utility industry: state commission regulation of most IOUs and local regulation of POUs. Although there is a variety of types of public regulation, the most prevalent type, 69 percent, is city council regulation (58). Federal regulations regarding water quality constrains managerial product decisions, but the Safe Water Drinking Act of 1974 (PL 93-523) applies equally to both POUs and IOUs. Because the act is not a source of variation in managerial behavior, the purpose of the remainder of this section is to consider the possible effects that state and local regulation may have on the behavior of private and public water managers.

Indirect Effects Via Ownership Rights. The most important effect of regulation in the water utility industry is on ownership rights. As mentioned in Chapter II, owners of IOUs do not have the right to the full residual income of the firm. Also, it was stated that public owners have no right to the residual income of the firm nor can they transfer ownership rights without bearing high transactions costs. Furthermore, the break between ownership and management is more acute for the POUs than it is for the IOUs. These differences in ownership rights led to the previous conclusion that managers of POUs could consume more nonpecuniary income at the expense of the owner's wealth than could the managers of IOUs.

Direct Effects of Regulation: Political Motives. Differences in regulation can also have a direct effect on managerial behavior in addition to the indirect effects via the structure of ownership rights. Differences in the incentive structure of regulators affect regulatory behavior (38) which, in turn, imposes constraints on the water operator's ability to maximize utility. Eckert argued that the behavior of regulators is strongly influenced by (1) how close reward is associated with regulatory responsibilities, and (2) the prospects of survival in office. The less closely that reward and regulatory responsibilities are correlated and the greater the probability that the regulator will have a short stay in office, the more likely that the regulator will prefer a regulatory structure which emphasizes industry self-regulation.

Eckert compared an appointed regulatory commissioner to a civil servant heading a bureaucratic regulatory agency. For the water industry, the appropriate comparison is between a state regulatory commissioner and a politician--the city councilman. To the extent that state regulatory commissioners and city councilmen face a different set of costs and rewards, differences in their regulatory behavior will place different constraints on the manager's opportunity set. If it is assumed that lower monetary rewards are received by councilmen relative to state commissioners and that these rewards are less closely tied to regulatory effort, councilmen are expected to have less of an incentive to regulate effectively. Excluding political motives, the implication is that councilmen relative to commissioners will prefer to engage in less extensive review and regulation of utility operations and to pursue policies designed to reduce the probability of controversy and conflict.

If the councilman's objective is re-election, then the councilman will suggest and support proposals for activities that the councilman perceives as being desirable by the politically-active constituency. Peltzman (90) argued that the politician will favor those constituencies that are associated with the highest probability of political support.

The probability of this support depends upon the cost to the constituency of organizing a political coalition and the wealth at stake by the individuals or firms within the constituency. The smaller the number of politically-active individuals or firms, the lower the cost of organizing a coalition among them.

For the water industry, it is expected that the constituencies to which the councilmen are responsive with respect to water utility activities are high-income residents and particularly to business firms that use large quantities of municipally-supplied water. Although for most families, water expenditures comprise a small percentage of total household expenditures, high-income residents usually own larger homes on larger lots which often require large quantities of water for residential irrigation. High-income households, therefore, have an incentive to influence water policy because they have greater wealth at stake. Similarly, only those commercial and industrial firms that use large quantities of municipally-supplied water would have an incentive to organize coalitions for the purpose of influencing municipal water policy. These groups comprise a small number of individuals and firms relative to the more numerous small water users. This reduces the transactions costs of forming political coalitions. Furthermore, the individual members have more wealth at stake. They can, therefore, more easily organize politically-effective coalitions.

There is some evidence to support the argument that water policies are disproportionately shaped by the influence of high-income customers and water intensive industries. Curran (25) and Smith (100) both suggest that water resource management may not be conducted in the public interest because politicians are influenced by the opinions of special interest groups that are not representative of the opinions of the general community. Beatty and Pierce's (11) study of the effect of political linkages on water policy formulation found that the interests most overrepresented were those of the better educated, white-collar workers, high-income groups, those who use water for business, and heavy water users.

In contrast to the councilman's drive to be re-elected, it is argued that the appointed state commissioner cannot evaluate reappointment very highly because the commissioner's office is often a political appointment and the length of that appointment is often longer than the term of the governor who appointed him (50). A commissioner, therefore, has an incentive to avoid the political environment surrounding him (83, 50). Hilton (50), Noll (83), and Stigler (103) suggest that the commissioner will institute policies favorable to the regulated industry in return for less conflict and therefore less regulatory effort as well as the possibility of future employment within the regulated industry. Eckert (38) hypothesized that the commissioner will prefer self-regulation by the regulated industry to minimize disputes and to reduce the regulatory workload. De Alessi (31) suggests that commissioners will favor large users (industry) in an effort to reduce conflict and the regulatory workload.

An elected commissioner in contrast to an appointed commissioner would be expected to behave in a similar manner to a councilman in that preferential treatment would be given to those users that provide the highest probability of political support. In general, it would be expected that the transactions costs to water utility customers of organizing effective political coalitions are higher at the state than at the local level. Even with a regulatory structure where both state and local regulators are elected, political influences are expected to be more important at the local level because of the greater ease with which local political coalitions can be formed. In sum, the councilman relative to the commissioner will likely engage in less economic regulation, but will advocate and support water policies beneficial to the politically-active users of water.

The Effect of Regulatory Behavior on Managerial Behavior. As previously mentioned, a manager's maximization of utility is constrained by the structure of ownership rights and other important characteristics of the industry in question. The public manager is less constrained than the private manager by the structure of ownership rights, but is more constrained by local regulatory and political influences. All managers have an incentive to increase their time-stream of benefits or rewards in order to increase the present value of the pecuniary and nonpecuniary sources of income (28). Private managers can do this by running the firm in accordance with the desires of the owners. This ensures longevity in office. A public manager's survival depends not only on performing according to explicit managerial contracts, but it also depends upon the pursuit of policies favorable to the local politicians. Given that managers of POUs are hired essentially as municipal civil servants, they can be expected to isolate themselves from the political process by simply fulfilling managerial contracts and carrying out the suggestions and directives of the local politicians who are currently in office. This is expected to be the case unless a political machine is dominant in which case all public agency managers will be expected to support and contribute to the survival of the dominant party (66, 67).

If an unregulated POU were suddenly subjected to city council review and hence to political pressures and if certain managerial activities not favored by local politicians were continued, it would be highly likely that in time the public manager would be replaced. In other words, the opportunity cost of politically-unfavorable managerial activities would be expected to increase. Consumer behavior theory would predict that the manager would consume fewer of these activities. Likewise, the opportunity cost of managerial activities favored by politicians would fall because the manager could consume more of these activities without fear of termination. If the opportunity cost is lower for politically-favored managerial activities, more of these activities will be undertaken. Because political factors are expected to be more important at the local level of government and because most POUs are regulated by city councils, the opportunity cost of consuming politically-preferred nonpecuniary income is expected to be lower for the public manager than for the private manager. The implication is that the public manager relative to the private manager will consume more of these politically-favored managerial activities.

Implications Regarding Managerial Behavior

Certain implications of the property rights theory of managerial behavior can be deduced without regard to the nature of the manager's utility function. This is the case for some hypotheses regarding firm efficiency and is probably why much of the work in the area of property rights has been in this area. But beyond hypotheses relating to per unit costs of production and other measures of efficiency, the testable implications are limited unless content is given to the composition of the arguments included in the manager's utility function. This is the approach suggested by Alchian and Kessel (4) in their early pioneering work in property rights theory and is the approach adopted here. Alchian and Kessel state:

> And so in utility maximization, one must similarly add a postulate stating what variables affect satisfaction or utility. This leads to meaningful implications refutable, in principle, by observable events (p. 158).

In Chapter II, it was stated that the organizational theorists have indicated that the manager's utility is probably a function of things such as power, prestige, job security, absence of conflict, and so on. The sources of utility that cannot be purchased directly with pecuniary income are "purchased" with nonpecuniary income via managerial activities. The task is to identify those managerial activities that would most likely to associated with given sources of utility.

It is assumed that both private and public managers have identical utility functions. They differ only in terms of the constraints imposed upon their utility-maximizing activities. The different constraints on the activities of public and private water managers imply that different quantities of the various sources of utility will be consumed. It is argued, therefore, that the hypothesized differences in public and private managerial activities constitute ". . . meaningful implications [of the property rights theory of managerial behavior] refutable, in principle, by observable events" (4, p. 158).

Firm Efficiency

In Chapter II, two explanations were given regarding the effect that alternative property right structures have on a firm's costs. To the extent that one structure of property rights is associated with fewer constraints on managerial behavior than another structure, managers faced with fewer ownership constraints on decision-making will consume more utility-generating goods and services than comparable managers faced with more ownership constraints. In other words, the costs per unit of output will be greater for the firm managed by managers having greater control over discretionary resources than for firms managed by managers having less discretion (4, 109). A second reason for greater inefficiency of some firms was the possibility of shirking by labor (3). Shirking reduces the average product of labor and thus increases the component of average costs that can be attributed to labor.

The issue of firm efficiency may be treated best by developing production function-cost models and then assessing the effect that alternative property right structures have on costs. This is essentially what was done by Morgan (79), Mann and Mikesell (69), and Crain and Zardkoohi (23) in their independent studies of the water utility industry. None of these studies can be considered as conclusive tests of the property rights theory of firm efficiency because of the presence of sampling errors (Morgan's study), misspecified models (the Morgan and Mann-Mikesell studies), and aggregation problems (the Morgan, Mann-Mikesell, and Crain and Zardkoohi articles).

What is needed is a cost function derived from a technical production function. The production function and the resultant cost functions should ideally be disaggregated by the major functions within the water firm: source, treatment, distribution, and administration. Economies-of-scale may be present in one function and not in the other. In order to isolate the effect that alternative property right structures have on costs, it is necessary to control for the effects of scale. Greater insight into the relationship of costs and property rights can be gained through disaggregation. Unfortunately, disaggregated cost data are not available for the water utility industry.

Given the above data constraints, the Crain and Zardkoohi article is the best study to date of the effects of alternative property right structures on water firm costs. They found, as did Morgan, that public ownership of water utilities is associated with higher costs for a given scale of operation than is the case with privately-owned water firms. Only Mann and Mikesell found evidence to the contrary--that public firms relative to private firms are associated with lower average costs. But, as Crain and Zsrdkoohi note, Mann and Mikesell's results are inconclusive because of their failure to control for input-price differentials. Because the evidence regarding the efficiency hypothesis for the water utility industry is mixed, other tests should be formulated using other measures of firm efficiency for which data are available. Specifically, the intent of this section is to consider the efficiency hypothesis regarding the employment of labor and capital, the average products of labor and capital, the efficiency with which inputs are combined, and the extent to which input waste occurs.

The Demand for Labor and Capital: The Private Manager. Both private and public managers have an incentive to expand operations over which they have responsibility. De Alessi (28) argued that this is due to the increase in the size and duration of the pecuniary and nonpecuniary streams of income that results from such activities. Up to some point, private managers can increase both pecuniary and nonpecuniary rewards by this activity. According to De Alessi (28, 31), the manager's marginal product (actual or apparent) and thus his pecuniary income will increase with an increase in capital (70), staff (109), and the budget (82). Increases in capital, staff, and the budget will also increase various nonpecuniary benefits. For example, an increase in staff reduces the manager's workload and provides a vehicle for spreading responsibilities in the event that there are errors in decision-making. An increase in the budget allows managers to exercise control over more funds that could be used for discretionary purposes. An increase in capital may increase the manager's prestige, power, and reduce the likelihood of confrontations with regulators and users that can result from production shortages.

An alternative explanation of why private managers desire additional capital was advanced by Averch and Johnson (10). A regulated, profit-maximizing firm can increase its profit by expanding its rate base, i.e., by expanding capital. Holding the minimally-acceptable return to owners constant, this activity increases both potential profits and the manager's discretionary profits. Thus, the property rights theory of managerial behavior explains the Averch-Johnson hypothesis as a rational response by utility-maximizing managers to increase the discretionary resources over which they have control.

The Demand for Labor and Capital: The Public Manager. Similarly, the public manager receives pecuniary and nonpecuniary sources of income from increasing capital, staff, and the budget. De Alessi (28) argued that the public manager has a higher time preference than a private manager because of the uncertainties regarding future tenure. Therefore, public managers prefer current and near-term flows of income to future flows. De Alessi argued further that public managers have an incentive to invest earlier, build larger and more durable capital facilities, and to use a lower discount rate to justify the shift of resources from the future to the present. These incentives are reinforced by the fact that public managers are rarely evaluated on the basis of efficiency, but on "visible" indicators of success such as output, the size of the capital facilities, the number of employees, and the price and quality of the product.

In Chapter II and earlier in this chapter, it was hypothesized that public managers would consume more of all nonpecuniary sources of income than managers of comparable IOUs. It was hypothesized that this was particularly true for those politically-preferred managerial activities. Capital acquisition is expected to be a politically-favored activity for at least two reasons. One, it is a visible indicator of what the politician has achieved while in office. This is especially the case when it is recognized that councilmen are cast in the role of formulative management (97). Second, Sampson and Farris (97) and De Alessi (28) note that politicians generally give a low priority to the long-run because the benefits that accrue from long-run decision making cannot be fully captured during the politician's stay in office. Thus, politicians also have an incentive to redirect capital resources from the future to the present. This can be accomplished by lowering the discount rate or utility prices. If employment in the public sector is used as a means of rewarding campaign workers, as Crain and Zardkoohi (24) infer from the works of Tullock (105), Stigler (103), and Demsetz (36), then local politicians might have an incentive to support the public manager's labor-increasing activities as well.

Because public managers face fewer constraints on their utility-maximizing behavior than do private managers, public managers can be expected to consume more of all nonpecuniary sources of income including the politically-preferred sources of income. It is hypothesized that the public manager will consume more labor and capital per unit of output than a manager of a comparable IOU. Thus, the average factor requirements of labor and capital are expected to be greater and the average products of labor and capital lower for the public relative to the private firm.

The Variability of Input Proportions. Another measure of firm efficiency is the variability of input proportions used in producing a given homogeneous output. A competitive wealth-maximizing firm will produce in the long-run with an optimal plant and therefore with an optimal capital-labor ratio. All firms within the competitive industry would be forced to employ similar techniques of production in an effort to minimize costs. Therefore, less variance in the capital-labor ratio would be expected among firms which necessarily had to be concerned with efficiency. If public water firms are less efficient than their private counterparts, public water firms would be expected to exhibit a greater variability of input proportions than would be expected for private water firms.

Clarkson (19) tested this proposition for the health care industry. Clarkson's central proposition

> . . . is that the effective constraint facing decision-makers in proprietary hospitals differ from those in nonproprietary hospitals producing similar products and that observed differences in the combinations of inputs used in production are a direct consequence of differing constraints (p. 363).

His empirical evidence supports his hypothesis that the variance of input proportions will be greater for nonproprietary hospitals than for proprietary hospitals.

Input Waste: Water Loss. Still another measure of efficiency is the extent to which water is lost within the distribution system. Water loss is expected to result from aging distribution facilities or facilities in disrepair. That is, deficient replacement and repair of old or leaking joints, connections, or water lines will result in greater water loss per customer. Because water loss is invisible to the public owner-taxpayer and because efficiency is not a major concern of public owners, correcting a problem which is invisible to the voter-owners may provide little in the way of an additional stream of pecuniary and nonpecuniary income to the public manager. Private managers, on the other hand, must be concerned with efficiency at least up to the point where the owner's minimally-acceptable return is assured. Private managers, up to this point, have an incentive to minimize input waste. Public firms relative to private firms, therefore, are expected to incur greater water loss per population served. In sum, public water firms relative to comparable private water firms are expected to employ more labor and capital, to have lower average products of capital and labor, to employ input combinations less efficiently, and to incur a greater degree of water loss per population served.

Water Rates

Utility rates are essentially a compromise among cost of service, value of service, and certain non-economic considerations. In every bargaining situation there are both economic and political factors which are important (66). It has been suggested by Mann (66) that regulators have historically been more concerned with rate levels than with the rate structure. This may be the case for state-regulated IOUs, but for POUs regulated primarily by city councils, the budget, rate structure, and other major water policies are usually subject to council approval (58). Mann notes that cost-of-service considerations are the most important determinant of rate levels, but political leverage is probably more important in determining the rate structure. One would expect political influence to have more of an effect on the POU's water rates than on the IOU's water rates. The purpose of this section is to assess the effect of alternative property right structures on the level and structure of water rates.

Rate Level Studies. Most utility rate analyses have been electric power rate studies. There have been a number of studies that have assessed the effect of regulation on the levels of electric rates. Stigler and Friedland (104), in analyzing regulated and unregulated electric power utilities, interpret their results as indicating that regulation has no effect on utility rate levels. Jackson (55), using Stigler and Friedland's model but with firm data instead of state averages, found that regulation is associated with lower electric rates. Jackson's findings are consistent with T. G. Moore's (78) 1970 study of privately-owned, but state-regulated electric utilities. Moore found that regulated electric power firms charge between 5 to 6 percent below the wealth-maximizing price. However, a 1975 study by C. G. Moore (77) found that electricity regulation raised prices during the 1947 to 1966 period. C. G. Moore interprets this result as an attempt by state regulators to cross-subsidize residential users by charging industrial customers a higher price.

T. G. Moore's results also indicate that political firms charge lower prices than private firms. Rather than charging a price 5 to 6 percent below the wealth-maximizing price, as was found for IOUs, POUs charge approximately 10 to 22 percent below the wealth-maximizing price. Peltzman (90) hypothesized and found that municipal power rates are lower than IOU rates. He hypothesizes that this is the result of the political manager's use of price policy to buy political support. He notes also that virtually all of the difference between public and private power rates can be attributed statistically to the tax exempt status of public firms.

For the water utility industry, there appears to be very few analyses of the effect of non-economic factors on water rates. Hansman (45), in her 1976 unpublished doctoral dissertation, hypothesized that political firms will charge lower prices because lower prices will make the regulator, politician, and water manager look good; will minimize confrontations with customers; and will please voters. In a 1974 unpublished doctoral dissertation by Hennigan (48), rate regressions were estimated for the residential customer class by firm ownership. He concluded as did Hansman, that IOU water rates are more cost-specific than those of POUs. Peltzman (90) found the same result with respect to the electric power industry. This result is consistent with the efficiency hypothesis discussed in the previous section of this chapter. Hennigan also found evidence contrary to Peltzman's result that virtually all of the difference between POU and IOU rates can be attributed to the tax exempt status of POUs. Hennigan argues instead that is cannot be concluded that the level of taxes is the main difference between POU and IOU prices. Taxes are a significant determinant of the difference, but not the major determinant. Mann (66) investigated the effect of political influences on municipal residential water rates. Following Peltzman, Mann hypothesized that political managers would lower rates to residential users in order to purchase political support. The coefficient on his political variable was inverse as hypothesized and it was statistically significant at the one percent level only for the minimum water rate regression. The variable was not significant, however, for other residential water rate regressions (66).

Mercer and Morgan (73) believe that Mann's results are inconclusive because his model is misspecified and the particular political variable used is inadequate. Mercer and Morgan argue that the correct specification for an average cost pricing model should include an average revenue variable in place of the water rate variable used by Mann and should include a non-operating revenue variable which Mann excludes. Furthermore, they suggest that it is improper to use county-wide data for the political variable when city data is more appropriate.

In sum, there has been little work done in analyzing the effect that non-economic factors have on water rates. Indeed, an extensive review of the public utility literature by Mann (66, p. 976) yielded the conclusion ". . . that little empirical evidence exists as to the exact influence of various socio-political factors on the regulatory process (and thus on managerial behavior)."

Managerial Behavior and the Rate Level. Earlier it was suggested that power, prestige, the absence of conflict, among other things, entered the manager's utility function and that increasing the size of the firm was a means by which a portion of these sources of utility could be acquired. It was mentioned that increases in capital, staff, and the budget produced streams of pecuniary and nonpecuniary sources of utility. Acquisition of these things is facilitated by increasing the sales of the firm. Public firms are not evaluated on the basis of efficiency but on visible signs of success--one such measure of success is output (80, 57). One way that output can be increased is by reducing prices for all water users as long as the elasticity of demand is not perfectly inelastic. Demand elasticity estimates for the water utility industry indicate that while most types of water demand exhibit price inelasticity, the elasticity coefficients are certainly not zero (26, 40).

In Chapter II, it was stated that a public manager is expected to have access to more discretionary profits than the manager of a private utility. Lowering prices as a utility-increasing managerial activity will exhause discretionary profits from the revenue side just as additional consumption by managers of capital and staff exhausts it from the cost side. The incentive to lower prices is reinforced by the manager's expectation that lower prices are also consistent with the motives of local politicians. Lower prices result in greater output and is a justification for expansion of capital, staff, and budgets all of which might be considered visible indicators of the politician's achievements. Low prices please voters and are thus attractive to politicians. Furthermore, lower rates can be used for other political goals such as inducing water intensive firms to locate in the municipality. Lower prices necessitate earlier investment in capital facilities than would be the case with higher water rates (53). If, as was suggested previously, politicians are motivated to redirect resources from the future to the present, lower water rates will complement the politician's desire to invest earlier in time and to build larger and more durable capital facilities.

As long as there is sufficient excess capacity to avoid shortages, lower prices means less customer conflict and are visible signs of what the local politician has achieved. Thus, lowering prices is a politically-preferred managerial activity. Pashigan (88), in assessing the effect of regulation in the transportation industry, found that local government regulation was more severe than state regulation in that lower fares were associated with local regulation.

The private manager likewise has an incentive to expand operations and to lower prices, but is constrained to a price-output policy which at least ensures that the minimally-acceptable return to the owners will be met. Because public managers are not required to generate a profit and are confronted by local politicians that prefer low to high prices, the public manager relative to the private manager will charge lower rates for all customer classes.

<u>Ownership Constraints and Rate Structures</u>. Because private and public managers are assumed to have the same preference functions, differences in their cost-reward structures account in part for differences in the treatment of the residential, commercial, and industrial customer classes. Ownership, regulatory structure, and political influence all shape these costs and rewards.

Differences in ownership rights result in a different emphasis on owner's wealth maximization and therefore in different degrees of price discrimination. Assuming separable markets, a manager of an unregulated private utility will engage in more price discrimination than managers of regulated private utilities or public utilities because of the greater emphasis placed on wealth maximization by owners of the unregulated firm (32, 90). Any manager, private or public, has an incentive to price discriminate to some degree. More complete price discrimination increases the firm's potential profits and thus the manager's pool of discretionary funds. It also results in greater output, which as suggested earlier results in greater streams of pecuniary and nonpecuniary income. Because public firms are not concerned with efficiency to the extent that private firms are, public firms relative to private firms would be expected to engage in less price discrimination.

The price discrimination hypothesis has been tested by Peltzman (90), Hansman (45), De Alessi (32), and Primeaux and Nelson (92). Both Peltzman and De Alessi found evidence of greater price discrimination in private electric utilities than in public electric utilities. Hansman found the same result for the water utility industry. With the exception of the Primeaux and Nelson article, none of the above studies controlled for cost-of-service differentials. Primeaux and Nelson tested the price discrimination hypothesis controlling for cost differentials and found that private electric firms price discriminate. For the water industry, Hansman found that private water firms employ more steps within each rate block than do POUs and that the slope of the rate-step schedule within a block is steeper for the IOU than the POU. There was no analysis of price-marginal cost ratios, however. While the evidence suggests that private firms price discriminate more completely than public firms, there has yet to be a test of this hypothesis for the water utility industry which analyzes price-marginal cost ratios.

Political Influence and the Rate Structure. A major unresolved issue for which there is little evidence is the effect of political and regulatory influences on the rate structure. In addition to the ownership effect mentioned above, the design of the rate structure is also influenced by the effect that regulation and political factors have on the manager's opportunity set. Earlier in this chapter, the hypothesis was advanced that both state commissioners and local politicians favor large users relative to small users. It was also maintained that political influences are expected to have a greater effect on the managerial activities of locally-regulated POUs relative to state-regulated IOUs. The implication for water rate design is that the public water firm will design a rate structure that is relatively more beneficial to high usage customers within the city and more beneficial to residents relative to nonresidents than is the case for the state-regulated IOU. In order to isolate the ownership effect on the rate structure, some attempt should be made to control for the regulatory-political effects.

Jackson (55) was one of the first to investigate the role of political power on private electric power rates. He argued that due to the greater political power of high-usage customers, these users would be able to extract lower rates from the utility. He found that industrial power rates were lower than residential power rates. Stigler and Friedland (104) hypothesized that electric rate regulation would favor the residential user, but they found evidence to the contrary. Peltzman (90) argued that the political incentives for re-election would result in electric rates that were lower for the residential class relative to other user classes and would be lower for voters relative to nonvoters. His results seem to suppo . the latter hypothesis, but Peltzman concluded that his evidence did not support the former hypothesis. Primeaux and Nelson (92) concluded that industrial electric customers receive preferential treatment relative to residential users, but they could not conclude that industrial user political pressure via the regulatory structure was the cause. Mikesell (75) also found evidence that high-usage users are given preferential electric rates. He found that high-usage residential customers are favored over low-usage residential users. The weight of the evidence for the electric power industry at least seems to support the hypothesis that high-usage customers are preferred to low-usage customers.

It appears that there has been no attempt, other than Mann (66), to assess the effect of political factors on the structure of water rates. Mann's political variable did not perform as expected except in his minimum rate regression. If water rates are used to buy votes, then following both Peltzman and Mann's reasoning, a political strength variable would be expected to have a negative effect on all residential water rates. Mann found that this was only the case for the minimum water rate. One reason for the poor results, other than Mercer and Morgan's criticisms mentioned earlier, might be that the political influences to which public regulators are responsive are those that originate not from the more numerous low-usage residential customers, but from high-income residential users and water intensive firms.

Product Quality

There has been virtually nothing done in the area of property rights and product quality. Newhouse (80) and De Alessi (31) were two of the first to assert that managerial utility and product quality were positively related. De Alessi says that both private and public managers have a desire to increase product quality because this is an output-increasing strategy. Newhouse, in his economic model of a non-profit hospital, postulates that nonprofit institutions will emphasize quality. He also says that a manager's pecuniary income is positively related to the prestige of the institution. The institution's prestige is a function of the quality and quantity of the product. With respect to the water industry, Hennigan (48), however, felt that water quality differences between POUs and IOUs would be minimal because federal clean-water regulations apply equally to both types of firms. He did not test this proposition. Water quality regulations may set the minimal quality standards, but the minimal standards do not imply that public and private water firms will produce a product of exactly the same quality.

There are at least two reasons to expect a manager with discretionary resources to consume a higher quality product. If a manager's objective function includes such things as status, a desire to serve the public, professional excellence, absence of conflicts with regulators and customers to name just a few of those things considered important by the organizational theorists, then producing a higher quality product is one of several managerial activities consistent with these objectives. That is, management will produce a higher quality product as a means of acquiring additional sources of utility.

A second reason was pointed out by De Alessi (31). A higher quality product can increase the manager's pecuniary rewards if the increase in quality increases the demand for the product and thus output. Greater output facilitates the acquisition of more capital and labor and would be expected to increase the manager's marginal product and therefore his income. Households are sensitive to the taste, smell, and color of water as well as to the water pressure at the tap. MacEwen (63) lists water quality as an important factor affecting water demand. He cites some evidence that suggests that there appears to be a relationship between water quality and the industrial demand for water.

In the context of the model of managerial behavior discussed in Chapter II, it was noted that anything that increases potential profits will shift the manager's opportunity set outward. If an increase in product quality increases the demand for the product and if the resultant additional revenues exceed the additional costs of providing the higher quality output, potential profits would be expected to increase. The increase in the discretionary funds available to the manager implies that the manager would be expected to consume both more pecuniary and nonpecuniary income. Up to a point, it is expected that qualitative product improvements would increase potential profits. Thus, up to a point, private managers will have an incentive to increase product quality.

For the water industry, POUs can acquire water treatment facilities at a lower per unit cost than can IOUs. This is because municipalities often use municipal bonds to finance capital facilities. POUs are also eligible for federal grants and low-interest loans for the construction of water treatment facilities. Because the additional cost of new treatment facilities is less for a POU than it is for a comparable IOU, the manager of a POU would be able to expand water treatment and thus product quality to a degree greater than could a manager of a comparable IOU.

POUs will also provide higher product quality than comparable IOUs because of the differences in the position of the opportunity sets facing the public and private managers. If the manager's utility function is in any way an increasing function of quality, as was asserted by De Alessi and Newhouse, the property rights theory of managerial behavior predicts that the POU will produce a higher quality product than the IOU. This is because the manager of the POU relative to the manager of the IOU has access to more discretionary resources to purchase more of all nonpecuniary sources of utility, including product quality. In sum, the POU relative to a comparable IOU is expected to produce a higher quality product as reflected in a water quality index to be discussed in the next chapter.

Conclusion

Differences in ownership, the regulatory structure, political factors, and other industrial characteristics shape the opportunity sets that constrain the choices of public and private water managers. Based upon the unique set of managerial property rights associated with the water utility industry, it was hypothesized that public managers relative to private water managers would employ more labor and capital per unit of output. Public firms relative to private firms, therefore, would be expected to have lower average products of labor and capital. Public firms are also hypothesized to incur greater water loss per customer and to employ a less efficient combination of inputs relative to comparable private water firms.

With respect to rate-making, the public firm relative to the private water firm will charge lower prices for all water users, will price discriminate less, but will give preferential treatment to large-usage customers relative to low-usage customers and to residents relative to those that live outside the city limits. Finally, it was hypothesized that the POU will produce a higher quality product than a similarly-situated IOU. In addition to presenting the results of tests of the above hypotheses, the purpose of the next three chapter is to describe the data, samples, and statistical methodologies used in testing each of the above hypotheses.

CHAPTER V

FIRM EFFICIENCY AND PRODUCT QUALITY

Introduction

In Chapter IV, it was hypothesized that a POU relative to an IOU would (1) employ more labor and capital for a given level of output, (2) employ a combination of inputs that would diverge more from the cost-minimizing combination, (3) have lower average products of labor and capital and a higher incidence of input waste, and (4) produce a higher quality product. The first hypothesis is tested by estimating reduced-form input demand functions employing a binary variable for ownership. A further implication of hypothesis (1) is that POUs will incur higher costs at a given level of output than IOUs. A reduced-form cost function consistent with the underlying input demand functions is used to test this additional implication. A test of hypothesis (2) entails estimating a "cost-minimizing" capital-to-labor ratio for each water utility and then comparing it to the firm's actual capital-to-labor ratio. Hypothesis (3) is tested by using the appropriate parametric or nonparametric tests to determine if there are differences in these measures of firm efficiency by ownership. Finally, in the last section of this chapter, regression analysis is used to assess the effect of ownership on three measures of water quality.

Firm Efficiency

The Demand for Labor and Capital

The empirical models used to test for the effect of firm ownership on the demand for labor and capital are of the log-linear constant elasticitiy type (54). The input demand functions are derived from a minimization of cost subject to a production function. This is equivalent to a Lagrangean maximization of output subject to a cost constraint.

Let

$$Z = Q(L,K) + \lambda(C - wL - rK) \tag{5.1}$$

where Q = output,

L = labor,

K = capital,

C = costs,

w = price of labor, and

r = price of capital.

Substituting a Cobb-Douglas production function

$$Q = AL^{\alpha}K^{\beta} \tag{5.2}$$

where A = constant,

α = output elasticity of labor, and

β = output elasticity of capital.

for the general production function in (5.1) and maximizing Z subject to the cost constraint yield the first-order conditions for a maximum.

$$\partial Z/\partial L = \alpha Q/L - \lambda w = 0 \tag{5.3}$$

$$\partial Z/\partial K = \beta Q/K - \lambda r = 0$$

Combining the first-order conditions produce the familiar marginal condition for a cost-minimizing combination of inputs.

$$(\partial Q/\partial L)/(\partial Q/\partial L) = w/r \;, \qquad (5.4)$$

which can be rewritten as

$$rK/\beta = wL/\alpha \;. \qquad (5.5)$$

Solving (5.5) for the capital-to-labor ratio yields the cost-minimizing capital-to-labor ratio,

$$K/L = \beta/\alpha \; w/r \;. \qquad (5.6)$$

Solving (5.6) for K, substituting this expression for K in (5.2), and making a logarithmic transformation on (5.2) results in the derivation of a log-linear constant elasticity capital demand function

$$\ln K = a - \alpha/(\alpha + \beta) \ln (r/w) + \frac{1}{\alpha + \beta} \ln Q \qquad (5.7)$$

where $a = \ln[A(\alpha/\beta)^{\alpha}]/\alpha + \beta$

Similarly, a labor demand function can be derived as

$$\ln L = a' - \frac{\beta}{\alpha + \beta} \ln (w/r) + \frac{1}{\alpha + \beta} \ln Q \qquad (5.8)$$

where $a' = \ln[A(\beta/\alpha)^{\beta}]/\alpha + \beta$

The test of hypothesis (1) involves estimating equations (5.7) and (5.8) separately with a binary variable for ownership. The equations to be estimated are presented in (5.9) and (5.10) below.

$$\ln K_i = a + a_1 D_i - \frac{\alpha}{\alpha + \beta} \ln (r/w)_i + \frac{1}{\alpha + \beta} \ln Q_i + U_i \qquad (5.9)$$

$$\ln L_i = a' + a_1' D_i - \frac{\beta}{\alpha + \beta} \ln (w/r)_i + \frac{1}{\alpha + \beta} \ln Q_i + U_i \qquad (5.10)$$

where i = 1, 2, ..., n where n equals the number of private and public water utilities included in the sample,

D_i = binary variable for ownership type (1 if municipally owned, 0 if privately owned), and

U_i = a residual term for the ith water utility.

The advantage of estimating equations (5.9) and (5.10) is that output is treated as an exogenous variable. As Crain and Zardkoohi note, water utilities do not have control over the provision of their output in that they are required to produce sufficient quantities of water to meet all water demands (23). Further, the relative input price variable can be treated as an exogenous variable because the interest rate, r, is determined by competitive capital markets and wage rates, w, are fixed by public employees' contracts in the case of POUs or union contracts in the case of IOUs (54).

Sample, Data, and Methodology. The sampling population consists of a survey by the American Water Works Association (AWWA) of water utility operating data for 1970 (8). The survey provides data on 768 water utilities representing 48 states and serving a population of 85,581,070 (7). No utilities serving communities of less than 10,000 population are reported in the AWWA survey. A 1976 survey of community water systems by the Environmental Protection Agency estimates that of an estimated 34,631 water systems, only 8 percent of the systems serve populations in excess of 10,000 (108). Thus, the AWWA survey comprises roughly 28 percent of the total number of water systems in the over-10,000 population size range.

The sample chosen for testing hypothesis (1) as well as hypotheses (2) and (3) include all water firms in the AWWA survey for which adequate data are available. Some of the firms included in the AWWA survey are purchase-only firms. Purchase-only firms have primarily distribution facilities. Because of the absence of production facilities and the labor needed for its operation, these firms were omitted from the analysis. The largest investor-owned utility in the sample serves a population of 1,251,000. In an effort to control for scale effects, all public water agencies are excluded that serve populations in excess of the largest investor-owned water firm. The largest POU serves a population of 1,230,000. The sample used in the following analysis consists of 125 water utilities of which 87 are POUs and 38 are IOUs.

The data on capital, labor, price of capital, ownership, and output were taken from the AWWA 1970 survey. The wage rate variable is constructed from data on wage rates provided in the AWWA's committee report, Water Utility Salaries and Wages, 1968 (6).

Let

K_i = net book value of the ith utility in thousands of dollars.

$L_i = L_{Fi} + \frac{1}{2}L_{Pi}$ where L_{Fi} and L_{Pi} equal full and part-time labor, respectively, for the ith utility.

r_i = price of capital of the ith utility defined as the bond yield, dividend yield, or loan rate applicable to capital investments put in place in 1970. Some utilities report more than one of these rates. In most of these cases, the rates did not differ markedly. It was decided to keep the sample size as large as possible by retaining those utilities that reported multiple financing methods. For these utilities, a simple average of these rates is used. The data do not allow for the computation of a weighted-average rate.

w_i = weighted-average annual wage for the ith utility by region and ownership. The weights are based on the importance of each of 17 different occupational classifications relative to total water utility employment. The weights are multiplied by each occupation's average annual wage and income and summed across all 17 occupations. The weights and specific occupation wage levels vary by ownership and the nine regions defined in the 1968 wage survey.

Regions

1. Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
2. New Jersey, New York, Pennsylvania
3. Illinois, Indiana, Michigan, Ohio, Wisconsin
4. Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
5. Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
6. Alabama, Kentucky, Mississippi, Tennessee
7. Askansas, Louisiana, Oklahoma, Texas
8. Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
9. Alaska, California, Hawaii, Oregon, Washington

Q_i = millions of gallons of water produced and purchased annually by the ith utility.

D_i = binary variable for the ith water utility ownership (1 if municipally owned; 0 if privately owned).

Descriptive statistics are presented in Table IV below.

TABLE IV

DESCRIPTIVE STATISTICS OF VARIABLES USED IN ESTIMATING EQUATIONS 5.9 AND 5.10

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
Capital (K)					
Pooled	125	21,926.70	35,892.10	132.00	210,374.00
POU	87	22,887.90	29,811.90	260.00	210,374.00
IOU	38	19,725.90	25,023.50	132.00	88,147.00
Labor (L)					
Pooled	125	116.88	200.79	5.50	1,540.00
POU	87	114.78	219.27	6.00	1,540.00
IOU	38	121.70	152.75	5.50	526.00
Price of Capital (r)					
Pooled	125	6.08	1.92	1.70	10.00
POU	87	5.17	1.28	1.70	8.00
IOU	38	8.19	1.42	4.95	10.00
Price of Labor (w)					
Pooled	125	6,386.88	649.06	4,981.00	7,763.00
POU	87	6,215.23	620.73	5,136.00	7,763.00
IOU	38	6,779.87	537.03	4,981.00	7,431.00
Output (Q)					
Pooled	125	10,021.80	15,395.30	304.00	70,976.00
POU	87	8,811.94	15,119.90	304.00	70,976.00
IOU	38	12,791.80	15,862.90	326.00	54,507.00

Total Population Served	N	Mean	Total
Pooled	125	164,918.00	20,614,699.00
POU	87	134,733.00	11,678,298.00
IOU	38	235,168.00	8,936,401.00

Both of the input demand functions are estimated using ordinary least squares (OLS). A check for multicollinearity was done by inspecting the diagonal elements of the $(X'X)^{-1}$ matrix, the determinant of the (X'X) matrix, and the simple correlation coefficient matrix. For both intput demand functions, there did not appear to be any serious problems with multicollinearity. Tests for heteroskedasticity were conducted for all regressions using a test attributed to Glejser (65). For all of the regression equations estimated in this section on firm efficiency, the null hypothesis of homoskedastistic disturbance terms could not be rejected. Therefore, the regression estimates presented below are OLS estimates.

Regression Results. The results of the capital and labor demand regressions are shown in Table V. The coefficients on all variables including the binary variables for ownership in both the capital and labor demand regressions have the expected signs and are statistically significant with the exception of the coefficient of $\ln(r/w)_i$ in the capital demand equation. The coefficient on $\ln(r/w)_i$ is positive, but statistically not significant. Thus, the regression results support the alternative hypothesis that after controlling for levels of output and relative factor prices, municipal water agencies relative to private water firms employ more capital and labor.

A comparison of the regression estimates for (5.9) and (5.10) suggest that cost-minimizing considerations are more important in the demand for labor than in the demand for capital.[1] The theoretical

[1]Differences in the regression results may also be the result of measurement error. The variable used as a proxy for capital is net book value which depends, in part, on the accounting treatment of the valuation of the capital base.

TABLE V

OLS REGRESSION ESTIMATES OF EQUATION 5.9 AND 5.10

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level
Capital Demand Equation				
D_i	.5900	.1803	3.272	.0014
$\ln(r/w)_i$	.1236	.2659	.465	.6429
$\ln Q_i$	.9334	.0529	17.645	.0001
(Constant)	1.7461	1.9648	.890	.3759
R^2 = .740	F = 114.31	N = 125		
$\bar{R}^2$ = .733	MSE = .5955	dF = 121		
Labor Demand Equation				
D_i	.3009	.1126	2.672	.0086
$\ln(w/r)_i$	-.3393	.1661	-2.043	.0432
$\ln Q_i$	.8539	.0331	25.830	.0001
(Constant)	-1.0285	1.2270	-.840	.4040
R^2 = .862	F = 252.82	N = 125		
$\bar{R}^2$ = .858	MSE = .2323	dF = 121		

economic variables, relative factor prices and output, seem to explain much of the water utility's demand for labor, but only output is an important economic determinant of the demand for capital. The overall F statistic and adjusted R^2, $\bar{R}^2$, is much larger and the mean square error, MSE, much smaller for the labor demand regression than it is for the capital demand regression. In both regressions, ownership is an important noneconomic explanatory variable. It might be inferred that in addition to ownership, noneconomic considerations such as the community's desire for residential, commercial, and industrial development may be more important in explaining the water firm's demand for capital than its demand for labor.

Operation, Maintenance, and Administrative Costs

A much-tested implication of the theory of property rights is that publicly-owned firms have higher per unit costs than privately-owned firms. The weight of the empirical evidence to date and the results of the capital and labor demand regressions above support this hypothesis. As noted earlier, there have been few attempts to test this hypothesis for the water utility industry. The Crain and Zardkoohi study (23) was the best of the cost studies because of their use of a reduced-form cost function which accounted for factor price differentials. Intriligator (54) notes that Nerlove employed this same type of cost function in analyzing the electric power industry. Because the sampling technique and wage data employed by Crain and Zardkoohi differ from that used in the previous section, a reduced-form constant elasticity cost function is estimated using the sample used previously for the capital and labor demand regressions.

Crain and Zardkoohi made use of the same 1970 operating data for water utilities used in this study, but used wage data from a 1974 survey of water utility salaries and wages by the AWWA even though 1968 wage and salary data were available. Because Crain and Zardkoohi did not provide regional rankings by ownership for their wage variable (which is a weighted-average wage rate constructed for their study), no comparison can be made to the 1968 weighted average wage variable used in this study.

Crain and Zardkoohi used the same price of capital variable as is used in this study, but they chose to eliminate all firms which reported more than one source of capital financing. The effect of doing so was to eliminate from their sample most of the larger private water systems (from 500,000 to 1,251,000 population served). The 1970 operating data reveal that IOUs tend to use mulitple methods of finance more frequently than do POUs. Because Crain and Zardkoohi eliminated all public firms serving populations larger than the largest IOU, they effectively excluded most large water systems in excess of a half-million population.

Empirical Model. Adding the cost condition

$$C = wL + rK \tag{5.11}$$

to the first-order conditions and production function in (5.3) and (5.2), respectively, a reduced-form constant elasticity cost function can be derived as (54)

$$C(w,r,Q) = A'(w^{\alpha}r^{\beta}Q)^{1/(\alpha+\beta)} \tag{5.12}$$

or

$$C = A'w^{\alpha/(\alpha+\beta)}\, r^{\beta/(\alpha+\beta)}\, Q^{1/(\alpha+\beta)} \tag{5.13}$$

where $A' = (\alpha+\beta)(A\beta^{\beta}\alpha^{\alpha})^{-1/(\alpha+\beta)}$

The cost equation to be estimated can be derived first by making a log-linear transformation on (5.13) and then adding a disturbance term. The result is given below in (5.14).

$$\ln C_i = A' + \frac{\alpha}{\alpha + \beta} \ln w_i + \frac{\beta}{\alpha + \beta} \ln r_i + \frac{1}{\alpha + \beta} \ln Q_i + U_i \tag{5.14}$$

It is necessary to impose a restriction on the above equation that the sum of the coefficients on $\ln w_i$ and $\ln r_i$ must equal 1 (23). This can be achieved by dividing $\ln C_i$ and $\ln w_i$ by $\ln r_i$. The result is as follows:

$$\ln C_i - \ln r_i = A' + \frac{\alpha}{\alpha + \beta} (\ln w_i - \ln r_i) + \frac{1}{\alpha + \beta} \ln Q_i + U_i \tag{5.15}$$

Adding the binary ownership variable, D_i, gives the regression equation to be estimated in (5.16).

$$\ln C_i - \ln r_i = A' + \frac{\alpha}{\alpha + \beta} (\ln w_i - \ln r_i) + \frac{1}{\alpha + \beta} \ln Q_i + D_i + U_i \tag{5.16}$$

All of the variables used to estimate the above equation remain the same as those used in estimating the capital and labor demand functions with the exception of the new variable C_i. C_i is defined as the sum of operating, maintenance, and administration costs and is obtained from the 1970 AWWA survey of water utility operating data. Taxes are excluded from costs because of the bias that would be introduced due to the fact that municipal firms are rarely subject to taxation. Debt service and depreciation expenses are also excluded because of sporadic reporting of these variables and because omitting observations for which these expenditures are absent results in a sample that is no longer consistent with the sample used in estimating the capital and labor demand functions.

Regression Results. The coefficients of the economic explanatory variables are positive as hypothesized in (5.16) and are significantly different from zero at the .01 level.[2] The ownership binary variable, D_i, is positive as expected and significantly greater than zero at a .06 level (see Table VI below). These results confirm the results presented by Crain and Zardkoohi (23) and add additional support to the general hypothesis that municipal water agencies are less efficient than private water firms. Although regression estimates of (5.16) and Crain and Zardkoohi's regression estimates are not directly comparable because of differences in data and sampling, it can be noted that regression (5.16) provides a better fit to the data and the relative input price variable using the 1968 wage data has a higher t ratio than is the case for Crain and Zardkoohi's estimates.

Input Combinations

As discussed in Chapter IV, if POUs are less efficient than IOUs, POUs are expected to be associated with greater variability of input proportions than IOUs. This was the central proposition of Clarkson's study of proprietary and nonproprietary hospitals. Clarkson tested the hypothesis by testing the null hypothesis that the variances of input combinations are equal for proprietary and nonproprietary hospitals against the alternative hypothesis that the variances of nonproprietary hospitals are greater than those of proprietary hospitals (19). The

---

[2]Note that the coefficient on ln Q, $\frac{1}{\alpha + \beta}$, is comparable in size and significance to the same coefficients for the capital and labor demand functions. $\frac{1}{\alpha + \beta}$ equals .8412 for equation (5.16) and .9334 and .8539 for equations (5.9) and (5.10), respectively.

TABLE VI

OLS REGRESSION ESTIMATES OF EQUATION 5.16

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level
D_i	.1334	.0838	1.59	.1139
$\ln Q_i$	.8412	.0246	24.21	.0001
$\ln w_i - \ln r_i$	.7528	.1235	6.09	.0001
(Constant)	-7.4979	.9128	-8.21	.0001
R^2 = .907	F = 394.95	N = 125		
$\bar{R}^2$ = .907	MSE = .1285	dF = 121		

	N	Mean	Standard Deviation	Minimum Value	Maximum Value
C_i					
Pooled	125	1540.06	2152.94	78.00	8877.00
POU	87	1305.49	1905.26	83.00	8656.00
IOU	38	2077.08	2582.87	78.00	8877.00

same test applied to the water industry (see Table VII) using the sample described above supports Clarkson's hypothesis that the variability of input proportions among public firms exceeds that of private firms.

TABLE VII

EMPLOYMENT OF CAPITAL AND LABOR, F TEST FOR EQUALITY OF VARIANCES, AND DESCRIPTIVE STATISTICS

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
Capital-to-Labor Ratio (K/L)					
Pooled	125	216.24	159.54	4.63	1254.29
POU	87	235.54	173.25	13.64	1254.29
IOU	38	172.03	112.49	4.63	491.23
For H_0: Variances are equal					
$F_{86,37} = 2.37$*					

*Significantly different from zero at a .01 level.

Note that the mean levels of (K/L) are greater for POUs than IOUs. A Mann-Whitney U test (22) of the null hypothesis that the capital-to-labor ratios are equal for POUs and IOUs can be rejected in favor of an alternative hypothesis that POUs are <u>more</u> capital intensive relative to IOUs at a .01 level of significance. This result is in contrast to Crain and Zardkoohi's 1980 argument that ". . . the public sector will operate with relatively less capital and more labor than privately owned firms in performing roughly identical activities" (24, p. 1075). Some doubt, therefore, is cast upon the theoretical model which underscores their hypothesis.

Although the results in Table VII are suggestive, the assumption that underlies Clarkson's hypothesis is that both private and public water firms face a competitive environment which out of necessity requires the use of a single cost-minimizing combination of inputs. Water utilities operate in sheltered markets and they face different input prices rather than single market-determined wage rates and capital prices. Thus, the cost-minimizing capital-to-labor ratio would be expected to differ for each water firm. A more rigorous test of the efficiency hypothesis with respect to input combinations involves the estimation of a cost-minimizing capital-to-labor ratio for each firm and a comparison of this ratio to the firm's actual capital-to-labor ratio. Greater divergences of a firm's actual from its cost-minimizing capital-to labor ratios imply less efficiency in the employment of input combinations.

In the first section of this chapter, a cost-minimizing capital-to-labor ratio (5.6) was derived from the first-order conditions (5.3). Let (5.6) be defined as CK_i, the cost minimizing capital-to-labor ratio, where

$$CK_i = (\beta/\alpha)(w/r)_i \tag{5.17}$$

and

$$A_i = |CK_i - (K/L)_i| \tag{5.18}$$

where CK_i = cost-minimizing capital-to-labor ratio for the ith utility,

$(K/L)_i$ = actual capital-to-labor ratio for the ith utility, and

A_i = the absolute value of the difference between the ith utility's actual and cost-minimizing capital-to-labor ratio.

All other variables and constants are defined as before.

The null hypothesis to be tested is that the POUs' actual capital-to-labor ratio will diverge by the same amount in absolute value from its cost-minimizing capital-to-labor ratio as is the case for IOUs. The alternative hypothesis is that A_i is greater for POUs relative to IOUs. The hypothesis is stated below in (5.19).

$$H_0: A_{POU} = A_{IOU} \quad (5.19)$$

$$H_1: A_{POU} > A_{IOU}$$

In order to test for differences in A_i, estimates of α and β have to be obtained. Unique estimates of α and β can be obtained from the cost regression estimated previously. The coefficient on $\ln Q_i$, $\frac{1}{\alpha + \beta}$, can be divided into the coefficient on $(\ln w_i - \ln r_i)$, $\frac{\alpha}{\alpha + \beta}$, to give the output elasticity of labor, α. Because $\alpha + \beta$ must equal the returns-to-scale, β can be derived as the reciprocal of $\frac{1}{\alpha + \beta}$ less α. The cost regression was estimated for the entire sample, a sample of IOU firms, and a sample of POUs without the binary ownership variable. A test for differences in estimated coefficients between regressions (60), the Chow test, was used to determine if there were statistically significant differences in the slope coefficients and thus estimates of α and β by ownership. The results of the test indicate that there are no significant differences in estimates of α and β by ownership. Therefore, the parameter estimates of α and β (see Table VIII) will be taken as the estimates for both private and public firms and will be derived from the estimates of equation (5.16) reported in Table VI.

TABLE VIII

ESTIMATES OF α, β, AND RETURNS-TO-SCALE

Coefficient on ln Q_i	Coefficient on ($\ln w_i - \ln r_i$)	Returns-to-Scale	$\hat{\alpha}$	$\hat{\beta}$
.8412	.7528	1.189	.895	.294
(.0246)*	(.1235)*			

*Standard errors are in parentheses and are significantly different from zero at a .01 level.

If A_i is a normally distributed random variable, a t-test for differences in sample means would be an appropriate parametric test of (5.19) (46). If A_i is not normally distributed, the t-test will give invalid results. Using a test for normality, the Kolmogorov-Smirnov one-sample test (22), it was found that the null hypothesis that A_i is a normally distributed random variable can be rejected. As a result a nonparametric test, the Mann-Whitney U test (22), is used to test the hypothesis in (5.19). This test determines whether or not the two independent ownership samples have been drawn from the same population.

As was reported previously, POUs are significantly more capital intensive than IOUs. This can be explained in part by the higher ratio of the price of labor to the price of capital experienced by POUs relative to IOUs (see Table IX). The cost-minimizing capital-to-labor ratio, CK, is correspondingly higher for POUs as well. The results of the Mann-Whitney test for differences in A_i by ownership are presented below in Table IX.

TABLE IX

INPUT VARIABILITY HYPOTHESIS, DESCRIPTIVE STATISTICS AND MANN-WHITNEY U TEST RESULTS

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
$(w/r)_i$					
Pooled	125	1166.10	472.19	646.12	4566.47
POU	87	1301.89	496.16	763.20	4566.47
IOU	38	855.19	180.12	646.12	1378.66
CK_i					
Pooled	125	362.79	146.90	201.01	1420.68
POU	87	405.03	154.36	237.44	1420.68
IOU	38	266.06	56.01	201.01	428.92
$(K/L)_i$					
Pooled	125	216.24	159.54	4.63	1254.29
POU	87	235.54	173.25	13.64	1254.29
IOU	38	172.03	112.49	4.63	491.23
A_i					
Pooled	125	201.19	161.21	4.07	1242.35
POU	87	229.49	179.89	4.07	1242.35
IOU	38	136.38	75.37	6.83	265.48

	N	Mean Score (A_i)	Mann-Whitney U Z Statistic*	Level of Significance
POU	87	69.93	Z = -3.23	.001
IOU	38	47.16		

*Standard Normal Statistic.

The results above indicate that the null hypothesis in (5.19) can be rejected at a .01 level of significance in favor of the alternative hypothesis that POUs relative to IOUs combine inputs less efficiently. Thus, noneconomic factors such as ownership are important determinants of not only the quantities of labor and capital employed, but also the proportions in which they are employed.

Other Measures of Firm Efficiency

In Chapter IV, it was hypothesized that POUs would have lower average products of labor and capital and would be associated with a higher incidence of input waste than would be the case for IOUs. The average products of labor and capital for the ith utility are defined as $AP_{L_i} = \frac{Q_i}{L_i}$ and $AP_{K_i} = \frac{Q_i}{K_i}$, respectively. Input waste is more difficult to define given the nature of the data. Water loss in the transmission and distribution system per population served would be a good measure of input waste, but the data provide information only for the difference between total water produced and purchased and total water sold. This difference includes not only water lost in the transmission and distribution system, but also water used in the treatment plant and water supplied without charge to certain municipal agencies. However, the data can be used to construct a proxy variable for input waste defined as nonrevenue-producing water per population served.

Let

$$NPW_i = (Q_i - RPW_i)/POP_i \tag{5.20}$$

where NPW_i = nonrevenue-producing water per population served by the ith utility in millions of gallons,

RPW_i = revenue-producing water produced by the ith utility in millions of gallons,

POP_i = population served by the ith utility in thousands of people, and

Q_i is defined as before.

If POUs relative to IOUs are less efficient, it is expected that POUs will have lower average products of labor and capital and greater input waste per population served relative to IOUs. The null and alternative hypotheses are stated below in (5.21).

$$
\begin{aligned}
&H_0:\ AP_L^{POU} = AP_L^{IOU},\ H_0:\ AP_K^{POU} = AP_K^{IOU},\ \text{and} \\
&H_1:\ AP_L^{POU} < AP_L^{IOU}\quad H_1:\ AP_K^{POU} < AP_K^{IOU} \\
&H_0:\ NPW^{POU} = NPW^{IOU} \\
&H_1:\ NPW^{POU} > NPW^{IOU}
\end{aligned}
\tag{5.21}
$$

The same sample is used in testing the hypotheses in (5.21) as has been used throughout this chapter. The results of the Kolmogorov-Smirnov test for normality again indicate that a nonparametric test should be used. The results of Mann-Whitney U test of the hypotheses in (5.21) and related descriptive statistics are reported in Table X.

The results in the table below allow for the rejection of the null hypotheses that there is no difference in the average products of labor and capital by ownership type in favor of the alternative hypotheses that IOUs have higher average products of labor and capital than POUs. These results are consistent with the results of the capital and labor demand regressions presented earlier. The Mann-Whitney Z statistic is significant for a one-tail test at the .027 level for the average product of labor hypothesis and at the .001 level for the average product of capital hypothesis. The null hypothesis that there is no difference in nonrevenue-producing water per population served by ownership cannot be rejected, however. It may be that NPW is measuring something other than input waste. For instance, some of the nonrevenue-producing water may be used to increase in-system storage. This hardly constitutes input waste. There are no data on the quantity of nonrevenue-producing water that goes to increasing stocks of finished water. In sum, POUs relative to IOUs employ more labor and capital, are more capital intensive, use less efficient combinations of inputs, incur higher variable costs, and have lower average products of labor and capital.

TABLE X

MANN-WHITNEY U TEST RESULTS AND RELATED DESCRIPTIVE STATISTICS OF HYPOTHESES IN (5.21)

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Z Statistic (One-Tail Significance)
AP_L						
Pooled	125	94.18	58.67	20.80	459.57	Z = 1.93
POU	87	87.06	48.42	20.80	315.67	(.027)
IOU	38	110.48	75.47	42.31	459.57	
AP_K						
Pooled	125	.82	1.80	.08	17.11	
POU	87	.61	1.10	.08	7.59	Z = 4.19
IOU	38	1.27	2.79	.24	17.11	(.000)
NPW						
Pooled	125	.0090	.0119	0.0000	.0954	
POU	87	.0080	.0060	0.0000	.0246	Z = -.23
IOU	38	.0121	.0196	0.0000	.0964	(.411)

Product Quality

The final hypothesis advanced in Chapter IV was that POUs would produce a higher quality product than IOUs. This hypothesis was originated elsewhere (80, 31), but has yet to be tested. One difficulty in testing such a hypothesis is measuring product quality. What makes the water industry attractive as a test case is the extensive chemical contaminant data available from some state health commissions for finished water--water within the municipal distribution system. It is possible to construct an index of water quality using this data.

Because there is no published source of contaminant data for the nation as a whole, it was decided to test the product quality hypothesis using data for just Oklahoma. The chemical contaminant data to be discussed in greater detail below are from <u>Public Water Supplies for the State of Oklahoma: 1979 Annual Report</u> (85). Data on investor-owned and municipally-owned water systems were obtained from the master computer information file--the <u>Model State Information System, Public Water System Inventory Subsystem: Comprehensive Report--Selection Extract File</u> (86). All utilities for which chemical contaminant and other data were available were selected. In order to control for scale effects, municipal water systems were limited to approximately the same size range in terms of population served as investor-owned water systems. All state- or federally-owned systems and purchase-only systems were omitted. Finally, for a water system to be selected, it had to serve full-time residents. Systems exclusively serving nonresident or transient populations such as resorts were omitted because different monitoring and water sampling requirements apply to these water suppliers relative to systems serving fixed residential populations (1).

Theoretical and Empirical Model

In order to determine if ownership affects water quality, it is necessary to control for other factors that may affect water quality. Jeffrey and Singley (56) suggest that water quality is a function of surveillance, source of raw water supply, treatment, and water operator competence. It is expected that environmental and regional factors are important influences as well. For example, Sonnen (101) reports that the National Academy of Science's 1972 committee on water quality criteria recommended that contaninant criteria vary with temperature. Further, precipitation would be expected to affect water quality in terms of its affect on total dissolved solids and the quantity of herbicides and pesticides that wash into surface sources of raw water. Regions may also differ with respect to soil characteristics, the intensity of agriculture, and community attitude with respect to the maintenance and preservation of raw water supplies.

Water utility data are not available with respect to the grade level of the water system operator nor are they available with respect to the type and extent of treatment. Population served will be used as a proxy for the extent of water treatment. Larger systems are expected to engage in more treatment because these systems generally have better laboratory procedures for identifying quality problems and the resources necessary to install treatment facilities. Adams (1) notes:

> The large utility that employs chemists will have little trouble sampling, but the small system will need some trained individual to collect samples. Some tests, such as turbidity and chlorine residuals, must be done by operating personnel. These personnel must be trained sufficiently to do these tests and have the required equipment (p. 231).

In a 1980 AWWA committee report on quality control practices in water bacteriology laboratories, there is some evidence to suggest that larger water systems do a better job sampling water and thus determining its quality characteristics (9). Thus, population served is expected to be positively related to water quality.

Surveillance data is not available with the exception of whether or not monthly monitoring takes place for the water system. Virtually every water system reported the occurrence of monthly monitoring. Thus, with no variation in this variable, there is little if any explanatory value. A binary variable for ground versus surface raw water supplies is available as a raw water variable. Both Morgan (79) and Hennigan (48) suggested that surface sources may require more treatment and therefore result in greater system costs. If surface sources of raw water are of lower quality relative to ground water sources, the incidence of surface sources is expected to be inversely related to water quality. This variable, however, was not used because of its high degree of association with the regional binary variables to be discussed below. For example, of 68 water suppliers selected from the eastern region, only one system made use of ground water. Regional binary variables, as a result, are expected to pick up much of the effect that a raw-water source variable would have on water quality.

Binary variables are also used to indicate the type of ownership and the region within the state of Oklahoma that the utility is located. Several regional breakdowns were tried. The regional breakdowns that seemed to be the most heterogeneous and resulted in the smallest simple correlation coefficients among the other regressors was an east, west, central breakdown. The Eastern Region is comprised of Oklahoma's State

Water Quality Laboratory's Southeast and Northeast Regions. The Central Region is comparied of the North Central and South Central regions, and the Western Region is comprised of the Southwest and Northwest regions.

Because the contaminant data were collected for different months in different regions, monthly average rainfall and temperature were obtained for the county in which the utility is located and for the month is which the contaminant data were collected. These environmental variables were obtained from National Oceanic and Atmospheric Administration data (84). In order to minimize problems with multicollinearity, only temperature was used as an environmental variable. It was found that temperature and precipitation were strongly positively related. Further, preliminary regressions indicated that termperature was more important in explaining water quality than precipitation.

There is not a water quality index available for Oklahoma water suppliers. A search for water quality indices did not produce one which made use of the data which were available for Oklahoma. It was decided to create an index of water quality using the maximum chemical contaminant limits reported in the EPA's Primary and Secondary Drinking Water Standards (85) as a means of assigning weights to the various contaminants. The derivation of the quality index is described in the next paragraph.

The water quality index (WQ) measures the deviation of a water supplier's actual contaminant levels for eight health- and aesthetic-related chemicals from the maximum contaminant levels allowed in EPA's Primary and Secondary Drinking Water Standards weighted by a relative weight of importance.

Let

$$WQ_i = \sum_{j=1}^{8} W_j(MCL_j - ACL_{ji}) \qquad \begin{array}{l} i = 1, \ldots, n \text{ water suppliers} \\ j = 1, \ldots, 8 \text{ chemical contaminants} \end{array} \qquad (5.22)$$

where WQ_i = the water quality measure for finished water at some point in the distribution system for the ith water firm,

ACL_{ji} = actual chemical contaminant levels for the jth chemical of the ith water firm,

MCL_j = EPA's maximum contaminant level for the jth chemical contaminant, and

W_j = relative weight of importance for the jth chemical contaminant.

W_j can be constructed by inference from EPA's Water Quality Standards. It can be inferred from the EPA's Primary and Secondary Drinking Water Standards that the higher the maximum contaminant level allowed for a given chemical contaminant, the less important is that chemical relative to the other chemical contaminants in terms of harmful impacts on water quality.

Let

$$A_j = \frac{MCL_j}{\sum_{j=1}^{8} MCL_j}$$

where MCL_j is EPA's maximum contaminant level for the jth chemical contaminant. The larger the value of A, the less important is the jth chemical contaminant relative to the other seven contaminants in terms of a detrimental impact on water quality.

Let

$$W_j = \frac{(1/A_j)}{\sum_{j=1}^{8} (1/A_j)}$$

where W_j is the relative weight of importance of the jth chemical contaminant relative to the other contaminants in terms of a harmful impact on water quality. A chemical is a more harmful contaminant if it is associated with a higher value of W. W_j summed over all eight chemical contaminants equals one.

WQ_i will equal zero if the ith utility is exactly meeting the drinking water standards with respect to the eight chemical contaminants. Positive (negative) values of WQ_i indicate that the ith water system is producing water of higher (lower) quality than that which would result if the water system was just meeting the maximum contaminant levels. There is a slight qualification to the interpretation of WQ_i offered above. Discussion of this will be postponed until later, however. The null hypothesis of interest is that water quality is unaffected by the type of water system ownership. The alternative hypothesis is that POUs relative to IOUs produce higher quality water as measured by WQ. Regression analysis is used to test the above hypothesis. The regression model to be estimated is as follows:

$$WQ_i = a + a_1D_i + a_2POP_i + a_3TEMP_i + a_4R_{1i} + a_5R_{2i} + U_i \qquad (5.23)$$

where WQ_i = a water quality measure for the ith water system,

D_i = 1 if the ith utility is municipally owned and 0 if it is privately owned,

POP_i = population served by the ith water system,

$TEMP_i$ = mean monthly temperature in degrees for the county in which the ith water system is located and for the month in which the contaminant data was collected,

R_{ni} = 1 if the ith water system is located in the nth region as defined by the Environmental Health Services of the State Water Quality Laboratory and 0 otherwise; where n = 1--Eastern Region and 2--Western Region, and

U_i = residual term for the ith water supplier.

Checks for multicollinearity and heteroskedasticity are the same as those used in the previous sections. While the selection of regressors minimized problems with multicollinearity, heteroskedasticity appeared to be a problem--particularly with respect to the regional binary variables. Problems with heteroskedasticity are dealt with by estimating (5.25) using weighted least squares (WLS). WLS coefficients are unbiased, consistent, and efficient whereas the coefficient estimates of a heteroskedastistic OLS model are only unbiased and consistent. Confidence intervals produced from OLS estimates are no longer correct for given levels of significance (60). Thus, tests of significance should be made using WLS estimates. Both OLS and WLS estimates are reported in Table XII.

Data and Results

Using the sampling method discussed at the beginning of this section, 255 water systems were selected for the sample to be used in estimating regression (5.23). Upon investigation of the data, seven firms were omitted because of very unusual values for the water quality variable relative to the other 248 water suppliers. These outliers were dropped to reduce any bias that would be created by special characteristics or events unique to these utilities that could have affected their water quality. It is also possible that these outliers resulted from incorrect contaminant data reported by the Oklahoma Water Quality Laboratory. The sample of 248 water firms represents approximately 23 percent of all water suppliers in Oklahoma serving a total population of 341,206. The sample consists of firms serving populations ranging from 36 to 11,000. Seventy-seven percent of the water systems are municipally owned whereas 23 percent are privately owned. Data used in estimating equation (5.23) are presented in Table XI.

Note that the use of regional binary variables impounds the Central Region into the constant term of equation (5.23). For the entire sample, 29.1 percent of all firms are located in this region. For the POU and IOU samples, the percentages are 17.7 and 11.4 percent, respectively. OLS and WLS estimates of equation (5.23) are presented in Table XII.

The results from Table XII indicate that after controlling for other influences on water quality, public ownership is positively associated with water quality. The ownership coefficient is significantly greater than zero at a .10 level for the OLS estimates and a .033 level of significance in the WLS regression. For both the OLS and WLS regressions, coefficients on the regional binary variables are positive and significant and the coefficient on the temperature variable is negative and significant.

Six of the eight chemical contaminants that are used in constructing the water quality index are toxic in that they are associated with health hazards. The other two contaminants are from the secondary drinking water standards and affect the aesthetic qualities of finished water but have little health related effects. Contaminants listed in the secondary drinking water standards affect the smell, taste, and color of the water (85). If public managers and politicians desire higher quality water and the absence of conflict or confrontation with water customers, it might be hypothesized that public ownership is more

TABLE XI

WATER QUALITY REGRESSION: DESCRIPTIVE STATISTICS

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
WQ					
Pooled	248	6.841	1.490	-1.947	8.734
POU	192	6.940	1.409	-1.947	8.734
IOU	56	6.502	1.711	- .397	8.206
POP					
Pooled	248	1375	2059.248	36	11000
POU	192	1647	2112.321	36	10500
IOU	56	445	1551.864	50	11000
D					
Pooled	248				
POU	192	.774			
IOU	56	.226			
TEMP					
Pooled	248	53.546	17.721	26.100	82.900
POU	192	54.579	17.014	26.100	82.900
IOU	56	50.004	19.709	28.100	81.900
R1					
Pooled	248	.274			
POU	192	.194			
IOU	56	.081			
R2					
Pooled	248	.435			
POU	192	.403			
IOU	56	.032			

TABLE XII

OLS AND WLS ESTIMATES OF THE WATER QUALITY REGRESSION, (5.23)

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level
OLS				
D	.309	.242	1.283	.2009
POP	.106 E-04	.455 E-04	.232	.8166
TEMP	-.018	.005	-3.241	.0014
R1	.825	.239	3.447	.0007
R2	.750	.242	3.104	.0021
(Constant)	6.970	.361	19.30	.0000
R^2 = .132	F = 7.377	N = 248		
$\bar{R}^2$ = .114	MSE = 1.967	dF = 242		
WLS				
D	.373	.203	1.841	.0669
POP	.622 E-05	.383 E-04	.163	.8710
TEMP	-.013	.005	-2.533	.0119
R1	.832	.237	3.503	.0005
R2	.779	.259	3.016	.0028
(Constant)	6.672	.377	17.702	.0000
R^2 = .98	F = 1423.84	N = 248		
$\bar{R}^2$ = .972	MSE = 1.069	dF = 242		

strongly positively associated with a water quality index that comprises only "visible" contaminants than the index used previously which comprised both toxic and aesthetic contaminants. Color, taste, odor, and the staining of fixtures can be traced directly to the finished water supply, but it is more difficult to associate diseases such as kidney infection, sclerosis, nephritis, and nephrosis with water quality (56).

Another water quality measure (WQM) was constructed for each water supplier using the method outlined earlier but using two of the chemical contaminants that are listed in the secondary drinking water standards. Equation (5.23) was estimated using WQM_i in place of WQ_i as the dependent variable. Because of the presence of heteroskedasticity, both OLS and WLS estimates are reported in Table XIII.

Note that the t-values are higher and levels of significance lower for the ownership coefficient in the regression employing WQM rather than WQ. Again, ownership is found to be positively related to a water quality measure and significantly greater than zero at the .058 level for the OLS regression and the .009 level for the WLS regression. While the coefficients of the other regressors in general had the same signs for the WQM regressions as for the WQ regressions, only the temperature variable was significantly different from zero.

One difficulty with the water quality measures constructed above is that one water supplier could have higher water quality as measured by WQ and WQM relative to another water supplier, but have violations of the drinking water standards whereas the latter utility may not. The water quality measure used here weights contaminants according to how harmful they are. A water supplier may be violating maximum contaminant limits on less harmful chemical contaminants, but if the

TABLE XIII

OLS AND WLS ESTIMATES OF THE WATER QUALITY REGRESSION USING (WQM) AS THE DEPENDENT VARIABLE

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level
OLS				
D	12.166	7.695	1.581	.1152
POP	.362 E-03	.00145	.25	.8029
TEMP	-.634	.172	-3.685	.0003
R1	10.067	7.628	1.320	.1882
R2	2.711	7.699	.352	.7250
(Constant)	62.39	11.505	5.423	.0000
R^2 = .073	F = 3.81	N = 248		
$\bar{R}^2$ = .054	MSE = 1996.97	dF = 242		
WLS				
D	14.488	6.113	2.370	.0186
POP	-3.42 E-03	.0012	-.285	.7756
TEMP	-.298	.169	-1.768	.0784
R1	10.709	7.148	1.498	.1354
R2	5.519	8.859	.623	.5339
(Constant)	42.205	11.979	3.523	.0005
R^2 = .584	F = 56.706	N = 248		
$\bar{R}^2$ = .574	MSE = 3.074	dF = 242		

TABLE XIII (Continued)

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level

WQM	N	Mean	Standard Deviation	Minimum	Maximum
Pooled	248	42.316	45.943	-259.94	82.176
POU	192	44.495	43.561	-259.94	81.89
IOU	56	34.846	53.066	-227.23	82.176

supplier has very small concentrations of the more harmful contaminants, the water quality indices could possibly indicate a high degree of water quality. In order to ensure that there is little if any bias created by this aspect of the water quality indices, another measure of water quality was used that is independent of the weighting scheme used in constructing the other two indices.

For each water supplier sampled, the chemical contaminant data contained the number of violations of the drinking water standards incurred for the date in which the contaminant data were collected. For every instance where actual contaminant levels exceeded maximum contaminant limits, a violation was recorded. The number of violations (V) was regressed on the same independent variables as used previously. Because the number of violations and water quality are expected to be inversely related, all of the coefficients of the regressors are expected to have signs opposite of those reported in Tables XII and XIII. In particular, if public ownership relative to private ownership results in higher water quality, the ownership binary variable is expected to be inversely related to the number of violations. Because heteroskedasticity was found to be present, both OLS and WLS estimates are presented in Table XIV.

Ownership has an inverse and statistically significant relationship with the number of violations. These results are consistent with those reported for the WQ and WQM regressions. Besides ownership, only population served (POP) and the Eastern Region variable (R1) have signs opposite of those in the WQ and WQM regressions. Based upon the results of the regressions employing the three measures of water quality, it appears that after controlling for regional, environmental, and scale

TABLE XIV

OLS AND WLS ESTIMATES OF THE WATER QUALITY REGRESSION USING (V) AS THE DEPENDENT VARIABLE

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level
OLS				
D	-.288	.132	-2.181	.0301
POP	-.329 E-04	.249 E-04	-1.322	.1874
TEMP	-.005	.003	-1.585	.1143
R1	-.100	.131	- .766	.4446
R2	.249	.132	1.888	.0602
(Constant)	.909	.198	4.605	.0000
R^2 = .086	F = 4.546	N = 248		
$\bar{R}^2$ = .067	MSE = .589	dF = 242		
WLS				
D	-.261	.149	-1.754	.0806
POP	-.332 E-04	.198 E-04	-1.676	.0951
TEMP	-.003	.003	- .937	.3497
R1	-.266	.113	-2.354	.0194
R2	.192	.118	1.633	.1038
(Constant)	.857	.241	3.563	.0004
R^2 = .344	F = 21.14	N = 248		
$\bar{R}^2$ = .328	MSE = 1.548	dF = 242		

TABLE XIV (Continued)

Variable	Coefficient	Standard Error	T-Value	2-Tail Significance Level	
V	N	Mean	Standard Deviation	Minimum	Maximum
Pooled	248	.472	.794	0	5
IOU	56	.661	1.049	0	4
POU	192	.417	.697	0	5

effects, public ownership is significantly positively related to water quality.

Conclusion

The evidence reported in this chapter is consistent with the alternative hypotheses that POUs relative to IOUs are less efficient, but produce a higher quality product. In particular, POUs relative to IOUs were found to employ more capital and labor, to be more capital intensive, to employ input combinations less efficiently, to have lower average products of labor and capital, to incur higher variable costs, and to produce higher quality finished water. The next chapter will test hypotheses related to rate-making practices.

CHAPTER VI

WATER UTILITY PRICING: RATE LEVELS AND STRUCTURES

Introduction

Property rights theory predicts that managers of publicly-owned enterprises have an incentive to charge lower prices for a given quantity and quality of a good or service than managers of privately-owned enterprises. Further, both private and public managers have an incentive to price discriminate, but private firms are likely to price discriminate to a greater extent than public firms. Finally, it was hypothesized in Chapter IV that regulatory-political influence is an important noneconomic determinant of utility pricing and will be more important in explaining public utility pricing than in explaining private utility pricing. With regard to regulatory-political influences on rate-making, it was hypothesized that (1) high-usage customers would be "preferred" to low-usage customers: high-usage residential customers are preferred to low-usage residential customers; industrial customers are preferred to residential customers, and (2) customers inside the city boundaries are preferred to those outside.

The intent of this chapter is to test hypotheses relating to the rate level and rate structure and to describe the data, sample, and methodology employed in the rate analysis. Chapter VII will focus on the effect of local regulatory-political influences on managerial behavior. First, an average-cost pricing model is derived and estimates of the model are obtained using regression analysis for the residential, commercial, and industrial user groups. The last half of Chapter VI is concerned with the derivation of long-run marginal costs and the use of average price-marginal cost ratios for testing hypotheses related to price discrimination.

Rate Levels

The null hypothesis to be tested is that there is no difference between public and private water utility pricing with respect to rate levels. The alternative hypothesis stated in Chapter IV is that, other things constant, POUs will charge lower water rates for all customer classes relative to IOUs. First, an average-cost pricing model is developed. The next section discusses the sample, data, and methodology used in testing the above hypothesis. The last section presents the regression results and conclusions.

The Empirical Model: An Average-Cost Pricing Model

The empirical model is a variant of that suggested by Mercer and Morgan (73). Mercer and Morgan's model is an average-cost pricing model. They assume that the total revenue (TR) of a public utility is a function of utility sales (R) and non-operating revenue (T) such as subsidies from the city's general fund. Total utility costs (TC) are assumed to be a function of operating expenses (OMA), output (Q) and output squared (Q^2), outstanding debt (DT), ". . . and other variables (X) which reflect the agency's specialized cost characteristics" (73, p. 1302). Further, they assume that the utility is required to generate revenues sufficient to cover costs. The latter assumption provides the relationship

$$TR = TC \tag{6.1}$$

and by substitution

$$R + T = a + bOMA + cQ + dQ^2 + eDT + fX \tag{6.2}$$

Solving for R and dividing by Q gives

$$R/Q = a' + b(OMA/Q) + dQ + e(DT/Q) + fX - T/Q \tag{6.3}$$

where $a' = (a+c)$.

Thus, the average revenue of a public utility is a function of an average cost variable, output, debt per unit of output, specialized cost variables, and subsidies per unit of output.

It appears that the only attempt to investigate private versus public water utility rate-making for the residential, commercial, and industrial user groups was by Hennigan (48). Hennigan, however, investigated the extent of cost-based pricing by ownership, a hypothesis first advanced by Peltzman (90), rather than the effect of ownership on rate levels. Hennigan's empirical model was similar to the one above in that he hypothesized that water rates were a general function of water system average costs, output, as well as some specialized cost variables. But his model was dissimilar from the one above in that specific water rates for select survey quantities were used as the regressands in his rate regressions rather than the theoretical average price variable derived in (6.3). In criticizing Mann's 1973 study (66) of political influence on residential water rates, Mercer and Morgan (73) argue that

> . . . the replacement of average user revenue as the dependent variable in [Mann's equation] with one rate for a specific quantity . . . implies that the value of one rate is independent of the remainder of the rate schedule. Clearly, under the assumption that total costs must be covered, the determination of one specific rate is also a function of the quantities of water purchased at that rate as well as the level of other rates and the quantities purchased at those rates (p. 1304).

While the model in (6.3) refers specifically to POUs, a variant of the model will be used for both POUs and IOUs. As was discussed in Chapter III, a traditional concept in water utility pricing has been that water rates should be cost related. Keller (59) notes that cost-based pricing is still a valid premise for both POUs and IOUs. One of the main differences in estimating revenue requirements for POUs relative to that of IOUs is that IOUs' rate requests involve a return on the rate base whereas this element is missing from POU revenue requirements (59).

Subsidies per unit of output (T/Q), is omitted from (6.3) because data are not available for this variable and a proxy such as municipal property taxes cannot be used because as was discussed in Chapter IV, it is not clear which way the causation runs between water rates and municipal property taxes. The empirical model to be used in testing the rate level hypothesis is as follows:

$$(R/Q)_{ji} = a' + b\left(\frac{OMA}{Q}\right)_i + cMGD_i + e\left(\frac{DT}{Q}\right)_i + fX_i + gD_i + U_i \qquad (6.4)$$

where $(R/Q)_{ji}$ = average user revenue of the jth customer group and ith water utility in dollars per thousand gallons annually; j = residential, commercial, and industrial.

$\left(\frac{OMA}{Q}\right)_i$ = average operating, maintenance, and administration costs for the ith water utility in dollars per thousand gallons annually.

Q_i = million gallons of water produced or purchased per year by the ith water utility,

MGD_i = million gallons of water produced or purchased per day for the ith water utility,

$(\frac{DT}{Q})_i$ = debt service costs per unit of output per year for the ith water utility in dollars per thousand gallons annually,

X_i = a vector of three specialized cost variables for the ith utility:

$(\frac{TTX}{Q})_i$ = total tax liability per unit of output per year for the ith water utility in dollars per thousand gallons,

$(\frac{SR}{Q})_i$ = surface source production as a percent of total output per year for the ith water system,

$(\frac{RPW}{Q})_i$ = revenue producing water as a percent of total output per year for the ith water system,

D_i = binary variable for ownership for the ith water system (1 if publicly-owned and 0 if privately-owned), and

U_i = residual term for the ith water system.

The relationship between average user revenue (R/Q) and average variable costs $(\frac{OMA}{Q})$, average debt service costs $(\frac{DT}{Q})$, and total taxes per unit of output $(\frac{TTX}{Q})$ is expected to be positive. Average operating costs $(\frac{OMA}{Q})$ as well as average debt service costs $(\frac{DT}{Q})$ are important in computing revenue requirements for both the POU and IOU. The greater these costs, the higher will be the revenue requirements and thus the rate request. The greater the tax liability $(\frac{TTX}{Q})$ the higher will be overall system costs and thus the revenue requirements. The scale variable, millions of gallons per day (MGD), is expected to be inversely related to average costs and consequently average prices. The relationship between ownership (D) and average revenue (R/Q) is expected to be inverse, i.e., POUs will be associated with lower average prices relative to IOUs. Surface sources of water are expected to be more costly than groundwater sources because the costs of treatment and the cost of the surface impoundment itself are expected to be greater than similar costs for groundwater sources. Thus, the greater the ratio of surface source production to total production $(\frac{SR}{Q})$, the more costs that will be incurred by the water utility and therefore the higher the rates that must be charged to cover these costs. Finally, revenue producing water as a percent of total production $(\frac{RPW}{Q})$ is a measure of utility efficiency in that the lower this ratio, the more free water and/or distribution system leakage experienced by the utility. Free service and system leakage entail costs that must be covered by revenue producing sales. Thus, as $(\frac{RPW}{Q})$ decreases, revenue requirements and user rates are expected to increase.

Sample, Data, and Methodology

The sampling population consists of all private and public water systems (serving a population in excess of 10,000) for which adequate data are available. The data source used here is the same as that used in the first half of the previous chapter on firm efficiency--*Operating Data for Water Utilities 1970 and 1965* (8). The sample construction is the same as that used previously in that "purchase only" systems are omitted and an effort is made to keep the population size *range* approximately the same for both IOUs and POUs. In addition, five water utilities were omitted from the sample because of highly implausible values for certain variables. No explanation can be offered for these outliers other than the possibility of recording error in the 1970 survey. The sample consists of 126 water firms serving a total population of 16,049,770. Ninety-five of the water agencies are POUs serving a total population of 9,913,001 and 31 of the water firms are IOUs serving a total population of 6,136,769. Descriptive statistics are presented in Table XV.

Ordinary least squares (OLS) is used in estimating equation (6.4). A t-test is used to test the directional hypotheses of the individual regression coefficients. A second basis for rejection of the null hypothesis that ownership has no effect on average prices will consist of a Chow test for differences between regression coefficients of two subsample regressions (60). The null hypothesis in the Chow test is that each coefficient in a POU regression is equal to its counterpart in an IOU regression. The alternative hypothesis is that for at least one of the sets of coefficients, the coefficients are not equal to one another. Checks for multicollinearity and heteroskedasticity are performed as discussed in the previous chapter on firm efficiency.

There was no indication of significant collinearity between the regressors with the exception of ownership (D) and total taxes per unit of output, $(\frac{TTX}{Q})$. The simple correlation coefficient between total taxes per unit of output and ownership was -.776. It was decided to retain the tax variable, however, because it has been suggested previously (90) that an important difference between POU and IOU rates is the difference in their respective tax liabilities. In order to isolate as best as possible the effect of ownership on water rates, it is necessary to control for taxes. The rate regressions were run with and without the tax variable. In both cases, the ownership variable was significant and negative as hypothesized. Whereas in the average price regressions run with and without the ownership variable, the tax variable was generally only significantly different from zero when the ownership variable was missing. These results suggest that ownership is an

TABLE XV

DESCRIPTIVE STATISTICS OF REGRESSION VARIABLES USED IN AVERAGE PRICE REGRESSIONS

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
(R/Q) Residental					
Pooled	126	.632	.275	.139	1.529
POU	95	.550	.220	.139	1.529
IOU	31	.883	.278	.376	1.505
(R/Q) Commercial					
Pooled	126	.431	.179	.115	.938
POU	95	.385	.161	.115	.938
IOU	31	.574	.159	.249	.902
(R/Q) Industrial					
Pooled	126	.256	.113	.039	.667
POU	95	.236	.113	.039	.667
IOU	31	.315	.089	.164	.522
$(\frac{OMA}{Q})$					
Pooled	126	.188	.091	.049	.645
POU	95	.178	.092	.049	.645
IOU	31	.219	.083	.116	.463
MGD					
Pooled	126	22.657	38.815	.852	211.455
POU	95	19.794	34.316	.852	194.455
IOU	31	31.430	49.821	1.633	211.455
$(\frac{DT}{Q})$					
Pooled	126	.069	.061	.000	.385
POU	95	.074	.068	.000	.385
IOU	31	.053	.031	.003	.132
$(\frac{SR}{Q})$					
Pooled	126	.578	.460	.000	1.000
POU	95	.573	.464	.000	1.000
IOU	31	.592	.455	.000	1.000

Table XV (Continued)

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
$(\frac{RPW}{Q})$					
Pooled	126	.855	.105	.433	1.246
POU	95	.861	.102	.611	1.246
IOU	31	.836	.111	.433	1.000
$(\frac{TTX}{Q})$					
Pooled	126	.040	.059	.000	.258
POU	95	.014	.027	.000	.133
IOU	31	.119	.059	.008	.258
Total Population Served	N	Mean	Total		
Pooled	126	127,379	16,049,770		
POU	95	104,347	9,913,001		
IOU	31	197,960	6,136,769		

important explanatory variable and a test of significance on the ownership coefficient is not expected to be appreciably biased by the inclusion of the tax variable.

Tests for heteroskedasticity revealed that only for the residential average price regression could the null hypothesis of homoskedasticity be rejected. Both OLS and weighted least squares (WLS) estimates will be presented for the residential regression.

Before reporting the results of the average price regressions, several caveats should be noted. First, because of the various interdependencies that exist in a regulated environment, there is always the potential for simultaneous equation bias when a single equation such as (6.4) is estimated. Average prices are a function of costs and costs are a function of output. But output is a function of average prices. A solution to the problem involves the construction of a sophisticated simultaneous equation system. The data requirements for such a system go beyond what is available in the AWWA 1970 survey. Mann (66) suggests that these interdependencies can be minimized and a single-equation approach used by a judicious selection of regressors. Simple correlation coefficients do not suggest strong correlations between average costs $(\frac{OMA}{Q})$ and (MGD) and between average prices (R/Q) and (MGD). Thus, if there is a feedback effect of prices on MGD and as a result on costs, this effect is expected to be minimal.

A second point is that estimating model (6.4) for IOUs may involve a possible misspecification problem. IOU rate making is not identical to POU rate making in that for IOUs ". . . return-on-rate base plus depreciation expense is the usual means of determining revenue requirements is excess of operation and maintenance expense and applicable taxes" (59, p. 10).

For POUs, return-on-rate base is not applicable and depreciation is not that important in determining revenue requirements--particularly for growing public water utilities (59). Depreciation expense was not included in (6.4) because of the sporadic reporting of this variable in the 1970 survey. A dividend variable was tried as a proxy variable for the return-on-rate base in an eximation of (6.4) for just the IOU subsample and was found to be not significant.

Finally, in order to isolate the effect of ownership on rate levels, one must control for the effect of regulation. As will be noted in Chapter VII, the simple correlation between ownership and a state versus local regulation binary variable for the sample used in testing the efficiency hypothesis is quite high, .88. Most POUs are locally regulated. To ensure that the ownership variable (D) is not measuring the effect of regulation, a subsample was formed consisting of all POUs and IOUs for which state regulatory agencies regulate rates inside municipal boundaries. If the ownership variable is indeed measuring the effect of ownership, it is expected to be significant in an estimation of (6.4) for the subsample mentioned above. This approach would generally be preferred to incorporating in (6.4) a state versus local regulatory binary variable because of the significant collinearity that would be introduced between the ownership and regulatory variable.

Regression Results

First, both the OLS and WLS estimates for the residential average price regression will be presented. Second, OLS estimates for the commercial and industrial regressions will be reported. Third, subsample regressions will be reported as well as the results of the Chow test.

TABLE XVI

OLS AND WLS RESIDENTIAL AVERAGE PRICE REGRESSIONS

Regression	Variable	Coefficient	Standard Error	T-Value	1-Tail Significance Level
OLS	$\frac{OMA}{Q}$	.583	.205	2.850	.0026
	MGD	-.0013	.0004	-3.120	.0011
	$\frac{DT}{Q}$	1.643	.292	5.625	.0000
	$\frac{TTX}{Q}$	.969	.423	2.292	.0118
	$\frac{SR}{Q}$	.119	.034	3.450	.0004
	$\frac{RPW}{Q}$	-.528	.147	-3.589	.0002
	D	-.241	.058	-4.125	.0000
	(Constant)	.964	.148	6.619	.0000
R^2 = .645	F = 30.69	N = 126			
$\bar{R}^2$ = .624	MSE = .028	dF = 118			
WLS	$\frac{OMA}{Q}$	.550	.189	2.910	.0021
	MGD	-.0011	.0004	-2.529	.0063
	$\frac{DT}{Q}$	1.562	.253	6.164	.0000
	$\frac{TTX}{Q}$	.237	.514	.461	.3226
	$\frac{SR}{Q}$	.092	.031	2.932	.0020
	$\frac{RPW}{Q}$	-.481	.138	-3.485	.0003

TABLE XVI (Continued)

Regression	Variable	Coefficient	Standard Error	T-Value	Significance Level
	D	-.316	.098	-3.214	.0008
	(Constant)	1.032	.161	6.422	.0000
R^2 = .938	F = 221.97	N = 126			
$\bar{R}^2$ = .933	MSE = 13.44	dF = 118			

TABLE XVII

COMMERCIAL AND INDUSTRIAL AVERAGE PRICE REGRESSIONS

Regression	Variable	Coefficient	Standard Error	T-Value	1-Tail Significance Level
Commercial	$\frac{OMA}{Q}$	.813	.156	5.202	.0000
	MGD	-.0002	.0003	-.704	.2413
	$\frac{DT}{Q}$	.495	.223	2.218	.0142
	$\frac{TTX}{Q}$	.292	.323	.904	.1339
	$\frac{SR}{Q}$	.030	.026	1.151	.1260
	$\frac{RPW}{Q}$	-.311	.112	-2.771	.0032
	D	-.129	.045	-2.895	.0022
	(Constant)	.584	.111	5.244	.0000
R^2 = .513	F = 17.77	N = 126			
$\bar{R}^2$ = .484	MSE = .017	dF = 118			
Industrial	$\frac{OMA}{Q}$	.531	.112	4.734	.0000
	MGD	-.00004	.00023	-.169	.4331
	$\frac{DT}{Q}$	.266	.160	1.659	.0498
	$\frac{TTX}{Q}$	-.161	.232	-.695	.2441
	$\frac{SR}{Q}$	-.005	.019	-.270	.3938
	$\frac{RPW}{Q}$	-.118	.018	-1.459	.0736
	D	-.077	.032	-2.401	.0089
	(Constant)	.306	.079	3.832	.0001
R^2 = .367	F = 9.76	N = 126			
$\bar{R}^2$ = .329	MSE = .009	dF = 118			

A fourth set of OLS estimates will be reported for the state-regulated subsample mentioned above.

The signs of all the regression coefficients are as hypothesized in all the regressions with the exception of the industrial average price regression (see Tables XVI and XVII). Both total taxes per unit of output $(\frac{TTX}{Q})$, and surface source production as a percent of total production, $(\frac{SR}{Q})$, have negative signs in the industrial regression. These coefficients, however, were not significantly different from zero. In general, ownership, (D), average costs, $(\frac{OMA}{Q})$, average debt-service costs, $(\frac{DT}{Q})$, and revenue producing water as a percentage of total water produced, $(\frac{RPW}{Q})$, were significant in all regressions at a .01 one-tail level of significance. The exception is again in the industrial regression where $(\frac{DT}{Q})$ and $(\frac{RPW}{Q})$ are significant at the .05 and .10 levels, respectively. Million gallons per day, (MGD), total taxes per unit output, $(\frac{TTX}{Q})$, and surface source production as a percentage of total production, $(\frac{SR}{Q})$, were only significant in the residential regression.

The evidence presented above is consistent with the alternative hypothesis that public ownership exerts a negative effect on user group average prices. Note also that based upon a comparison of overall F values, adjusted R^2s, and the size and significance of individual regression coefficients, cost-based pricing appears more important in explaining residential rates than in explaining the average prices of higher-use customer groups such as commercial or industrial user groups. The implication is that non-cost influences appear to be more important in explaining the average prices of high-usage customer groups than low-usage customer groups. It was hypothesized earlier than an important non-cost influence on utility pricing is regulatory-political influence.

The effect of regulatory-political influence on rate making will be addressed in the next chapter.

A second basis for rejection of the null hypothesis that ownership has no effect on utility rate levels is to estimate (6.4) without the onwership variable for the entire sample as well as for both the ownership subsamples and to perform a Chow test. The OLS estimates for the pooled, POU, and IOU samples are presented below (Table XVIII).

Considering first the residential regression, all of the parameters in the pooled, POU, and IOU residential regressions have the expected signs. All coefficients are significant except for the tax variable in the POU model. The calculated F statistic for the Chow test is large enough to reject the null hypothesis that the POU and IOU residential regression are structually the same at a .01 level of significance. In the commercial regression, $(\frac{OMA}{Q})$, $(\frac{DT}{Q})$, $(\frac{SR}{Q})$, and $(\frac{RPW}{Q})$ have the expected signs in all three regressions with only $(\frac{SR}{Q})$ being statistically not significant. (MGD) has the hypothesized negative sign for both the POU and IOU regressions, but the coefficient on (MGD) is not significant. The tax variable, $(\frac{TTX}{Q})$, is significant at the .01 level and positive as hypothesized in both the pooled and IOU equations, but is negative in the POU regression. Again, the calculated F statistic allows the rejection of the null hypothesis that no differences exist between the POU and IOU commercial average price regressions at a .01 level of significance.

The industrial regressions are similar to the binary variable industrial regression presented in Table XVII in that only $(\frac{OMA}{Q})$, $(\frac{DT}{Q})$, and $(\frac{RPW}{Q})$ have the correct signs. $(\frac{OMA}{Q})$ is the only variable significant in both the POU and IOU industrial regressions. $(\frac{RPW}{Q})$ is the only other significant variable in the IOU model. Whereas, in the POU regression, $(\frac{DT}{Q})$ and $(\frac{TTX}{Q})$ are both significant at the .10 and .05 levels,

TABLE XVIII

POOLED, POU, AND IOU AVERAGE PRICE REGRESSIONS AND CHOW TEST F STATISTICS

Regression					Independent Variables					
Residential Regression										
	N	F	$\bar{R}^2$	(Constant)	$\frac{OMA}{Q}$	MGD	$\frac{DT}{Q}$	$\frac{TTX}{Q}$	$\frac{SR}{Q}$	$\frac{RPW}{Q}$
Pooled	126	29.06	.574	.762	[a] .725 (.215)	[b] -.0009 (.0004)	[a] 1.546 (.310)	[a] 2.296 (.293)	[a] .123 (.037)	[a] -.603 (.155)
POU	95	17.15	.508	.718	[a] .553 (.216)	[b] -.001 (.0005)	[a] 1.544 (2.87)	.043 (.619)	[a] .089 (.036)	[a] -.478 (.158)
IOU	31	6.01	.500	.915	[b] 1.088 (.516)	[b] -.002 (.0008)	[b] 2.764 (1.38)	[a] 1.896 (.661)	[b] .224 (.097)	[a] -.872 (.344)
Calculated $F_{7,112}$ = 4.296										
Commercial Regression										
	N	F	$\bar{R}^2$	(Constant)	$\frac{OMA}{Q}$	MGD	$\frac{DT}{Q}$	$\frac{TTX}{Q}$	$\frac{SR}{Q}$	$\frac{RPW}{Q}$
Pooled	126	18.20	.452	.475	[a] .889 (.159)	.00002 (.0003)	[b] .443 (.229)	1.003 (.216)	.033 (.027)	[a] -.352 (.115)
POU	95	8.74	.331	.393	[a] .798 (.184)	-.0003 (.0004)	[b] .399 (.245)	[c] -.688 (.522)	.031 (.031)	[c] -.210 (.134)
IOU	31	10.23	.649	.686	[a] 1.095 (.247)	-.00003 (.0004)	[a] 1.809 (.660)	[a] 1.233 (.316)	.034 (.046)	[a] -.736 (.164)

Calculated $F_{7,112}$ = 3.188

TABLE XVIII (Continued)

Regression					Independent Variables					
Industrial Regression										
	N	F	$\bar{R}^2$	(Constant)	$\frac{OMA}{Q}$	MGD	$\frac{DT}{Q}$	$\frac{TTX}{Q}$	$\frac{SR}{Q}$	$\frac{RPW}{Q}$
Pooled	126	10.02	.302	.242	[a] .576 (.113)	.0001 (.0002)	[c] .235 (.163)	[b] .262 (.154)	-.004 (.019)	[b] -.142 (.082)
POU	95	7.23	.285	.207	[a] .542 (.134)	-.0002 (.0003)	[c] .239 (.178)	[b] -.761 (.384)	.012 (.022)	-.089 (.098)
IOU	31	2.62	.244	.355	[a] .513 (.204)	.00014 (.00032)	.416 (.546)	.241 (.261)	-.049 (.038)	[c] -.214 (.136)

Calculated $F_{7,112} = 1.748$

Note: Standard errors are in parentheses; Table values of $F_{7,112}$ are $F_{.05} = 2.090$ and $F_{.01} = 2.805$; One-tail levels of significance are as follows: a=.01; b=.05; and c=.10.

respectively. However, in the POU regression, $(\frac{TTX}{Q})$ has a negative sign which is inconsistent with a priori expectations. In the case of the industrial average price regressions, the null hypothesis that the POU and IOU regressions are structurally the same cannot be rejected.

In terms of explanatory power, the adjusted R^2 for the residential and industrial regressions are similar for the POU and IOU subsamples. For the commercial regression, the adjusted R^2 for the IOU sample is .649--almost twice as large as the POU adjusted R^2. Considering utility pricing in general, it is difficult to conclude (as do both Hansman [45] and Hennigan [48]) from the estimates presented here that IOU pricing is more cost-specific than POU pricing except possibly in the commercial regressions. With respect to low- versus high-use customer groups, the POU regressions reflect the same relationship noted previously that cost-based pricing is apparently less important and by implication non-cost variables more important in explaining rate-making for high-usage relative to low-usage customers. However, note that such a relationship is less apparent for the IOU regressions. In the IOU regressions, cost-based pricing appears to be more important in explaining commercial average prices than in explaining the average prices for the residential group.

The results of the Chow test for the residential and commerical regressions suggest that ownership has a significant effect on some of the parameters of the average price regressions. This does not seem to be the case for the industrial regressions, although the estimates reported for the industrial equation with the binary ownership variable (see Table XVII) does indicate that a significant intercept shift can be attributed to ownership. Some caution should be used in making strong conclusions from the Chow test presented in Table XVIII. The degrees of freedom in the IOU equations are less than the recommended minimum of 30. Thus, it is possible that not all of the assumptions of classical linear regression model hold and the estimators for the IOU regressions may therefore not be the best linear unbiased estimators.

In an effort to isolate ownership from regulatory influences, a subsample was constructed that consisted of all POUs and IOUs from the pooled sample for which municipal inside rates are regulated by state regulatory commissions. All 31 IOUs and 24 of the 95 POUs are state regulated. The states in 1968 that regulated municipal inside rates were Indiana, Maine, Montana, West Virginia, and Wisconsin (58). With the exception of Montana, all of these states are represented in this sample. If the ownership variable (D) is measuring the effect of ownership rather than regulation, ownership is expected to be significant and have the hypothesized inverse sign in these regressions. The results are presented in Table XIX.

These results show that ownership has a significant and inverse relationship to average prices even after controlling for regulatory influences. The t-ratios on the ownership coefficient are only marginally affected by controlling for regulatory influences. It is also of interest to note that the explanatory power of the cost-based pricing model is greater for the state regulated subsample than for the entire sample of state and locally regulated water utilities.

In sum, the evidence presented in this section on utility pricing is consistent with the alternative hypothesis that relative to IOUs, POUs charge lower average prices for all customer groups. This result obtains even after controlling for the tax differential between POUs and

TABLE XIX

AVERAGE PRICE REGRESSIONS FOR STATE REGULATED WATER UTILITIES

Regression	Variable	Coefficient	Standard Error	T-Value	1-Tail Significance Level
Residential	$\frac{OMA}{Q}$	.939	.361	2.598	.0062
	MGD	-.002	.0006	-2.514	.0077
	$\frac{DT}{Q}$	2.607	.929	2.806	.0036
	$\frac{TTX}{Q}$	1.239	.459	2.696	.0048
	$\frac{SR}{Q}$	.124	.053	2.353	.0114
	$\frac{RPW}{Q}$	-.715	.239	-2.987	.0022
	D	-.225	.067	-3.350	.0008
	(Constant)	.966	.219	4.395	.0000
R^2 = .743	F = 19.41	N = 55			
$\bar{R}^2$ = .705	MSE = .027	dF = 47			
Commercial	$\frac{OMA}{Q}$	1.175	.241	4.873	.0000
	MGD	-.0001	.0004	-.251	.4014
	$\frac{DT}{Q}$	.959	.620	1.546	.0642
	$\frac{TTX}{Q}$	.707	.307	2.305	.0128
	$\frac{SR}{Q}$	.079	.035	2.243	.0148
	$\frac{RPW}{Q}$	-.545	.159	-3.410	.0006

TABLE XIX (Continued)

Regression	Variable	Coefficient	Standard Error	T-Value	1-Tail Significance Level
	D	-.093	.045	-2.069	.0220
	(Constant)	.592	.147	4.036	.0001
R^2 = .720	F = 17.27	N = 55			
$\bar{R}^2$ = .678	MSE = .012	dF = 47			
Industrial	$\frac{OMA}{Q}$	.691	.146	4.728	.0000
	MGD	.0002	.0003	.662	.2554
	$\frac{DT}{Q}$	.230	.376	.613	.2714
	$\frac{TTX}{Q}$	.205	.186	1.103	.1378
	$\frac{SR}{Q}$	.007	.021	.346	.3653
	$\frac{RPW}{Q}$	-.202	.097	-2.090	.0210
	D	-.068	.027	-2.495	.0081
	(Constant)	.286	.089	3.216	.0012
R^2 = .649	F = 12.46	N = 55			
$\bar{R}^2$ = .598	MSE = .004	dF = 47			

IOUs and state versus local regulation of inside water rates. Further, the results imply that non-cost factors tend to be more important in explaining the average prices of high-usage groups relative to low-usage groups and in explaining utility pricing in an environment of local regulation relative to state regulation.

Water Utility Pricing: Rate Structure

As was discussed in Chapter IV, both economic and property rights theory predict that investor-owned utilities price discriminate. In addition, property rights theory has been used to develop the hypothesis that municipally-owned utilities have an incentive to price discriminate, but less completely than their privately-owned counterparts (90). For both POUs and IOUs, this price discrimination is expected to favor high-use relative to low-use customer groups. That is, industrial customers are expected to have lower price-marginal cost ratios relative to residential customers. Commercial customers are expected to have higher price-marginal cost ratios than industrial customers, but lower ratios than residential customers. The intent of this section is to determine (1) if both POUs and IOUs price discriminate in the water utility industry; (2) which customer group is "preferred" in the sense of having the lowest price-marginal cost ratio; and (3) the extent to which price discrimination differs by ownership.

The null hypothesis to be tested is that the price-marginal cost ratios of the residential, commercial, and industrial user groups are equal. Rejection of the null hypothesis supports the alternative hypothesis that both POUs and IOUs engage in price discrimination. Pair-wise tests (46) were performed to determine which groups benefit from price discrimination. Also, Mann-Whitney U tests were used to test the null hypothesis that there is no difference in the extent to which price discrimination is applied by POUs and IOUs.

Theoretical Model: Estimation of Price-Marginal Cost Ratios

For each customer group, price-marginal cost ratios are estimated. The price variables used here are the average prices used in the previous section. The absence of sufficient rate data preclude the use of marginal prices. Long-run marginal costs are estimated using a technique similar to that used recently in an article by Primeaux and Nelson (92). In that article, they describe a procedure whereby long-run marginal costs are estimated for private electric power companies. Their procedure, which they attribute in theory to Boiteaux and Stasi (15), is to estimate short-run marginal variable costs first and then to add the marginal costs of meeting peak demand. This procedure can be traced to an even earlier article by Boiteaux (14).

In this section, short-run marginal costs will be estimated by (6.5) below.

$$SRMC_i = \delta\left(\frac{OMA}{Q}\right)_i \tag{6.5}$$

where $SRMC_i$ = short-run marginal costs of the ith utility in dollars per thousand gallons,

$\delta = \frac{\partial OMA}{\partial Q}\frac{Q}{OMA}$ = the elasticity of variable costs with respect to output, and

OMA and Q are defined as before.

In the chapter of firm efficiency, δ was estimated in equation (5.16) to equal .84. Data are not sufficient, however, to allow estimation of δ for the sample used in this section. Of the 126 firms comprising the sample used in the previous section on rate making, fewer than 25 percent of these firms had data on the input price ratio variable used in estimating the cost function in Chapter V. Because there would be too few degrees of freedom to reestimate the cost function, estimates of δ would be unreliable. But, because the sample used here and the one used previously in the chapter on firm efficiency have approximately the same number of observations, consist of the same size range firms in terms of population served, and contain roughly the same number of IOUs relative to POUs, the estimate for δ mentioned above will be taken as a parameter estimate for the purpose of estimating short-run marginal costs. The parameter estimate for δ will apply to both POUs and IOUs. The results of a Chow test reported in the chapter on firm efficiency indicated that the null hypothesis that the slope coefficients of the POU and IOU cost functions are equal could not be rejected. Thus, there is no statistical basis for using separate estimates of δ by ownership.

Primeaux and Nelson (92) allocate SRMC to the customer classes using a method employed earlier by Moore (78). They estimate the number of kilowatt-hours that must be produced or purchased in order to supply one additional kilowatt-hour to each customer group and then multiply this coefficient times the firm's SRMC. The same approach in theory could be applied to the water utility industry--that is, determining the number of gallons of water that must be produced or purchased to supply a given customer group with one additional gallon of water. Following a model employed by Primeaux and Nelson, an attempt was made to estimate the allocation coefficients mentioned above. The model is as follows:

$$UW_i = a + a_1Q_i^R + a_2Q_i^C + a_3Q_i^I + a_4M_i + U_i \qquad (6.6)$$

where UW_i = unaccounted-for-water (or water lost in the transmission and distribution system, free water, and water used in the treatment plant) for the ith utility in millions of gallons,

Q_i^n = millions of gallons of water supplied to the nth customer group by the ith utility; n = residential (R), commercial (C), industrial (I),

M_i = miles of transmission and distribution line for the ith utility, and

U_i = residual term for the ith utility.

Coefficient (a_1) can be interpreted as the additional water necessary to supply an additional million gallons to residential users. Primeaux and Nelson allocate SRMC by multiplying a coefficient such as (a_1) by $SRMC_i$. According to this procedure, the short-run marginal costs attributed to the residential user group would be given by:

$$SRMC_i^{Residential} = a_1 \cdot SRMC_i \qquad (6.7)$$

This approach was abandoned here because of the high degree of multicollinearity between the regressors and as a result the lack of confidence in both the parameter estimates and tests of significance. In the present analysis, the assumption will be made that the short-run marginal costs of supplying an additional 1,000 gallons of residential, commercial, or industrial water is the same as it is for the system as a whole.

It can be noted that any method of allocating short-run marginal costs must involve liberal assumptions given the data constraints. One would expect that the short-run marginal costs of supplying an additional 1,000 gallons of residential water would be higher relative to the same costs of supplying industrial water. Billing, customer service, meter maintenance, and variable distribution costs would all be expected to be greater for the residential relative to the industrial user group.

The available variable cost data is not disaggregated nor is it allocated to the various customer groups.

The next step in estimating long-run marginal costs is to estimate the marginal plant charges (MPC)--the additional cost of constructing enough plant capacity to produce an additional million gallons of water during the peak demand period. Primeaux and Nelson, following De Salvia (37), determine the (MPC) by analyzing the fixed costs of existing plant. They define fixed costs as a sum of depreciation, amortization, rent, taxes, net income, and interest payments. The latter two items are costs necessary to obtain new plant capacity whereas the first four cost items represent costs of using existing plant. If it is assumed that the firm constructs additional capacity in response to changes in peak demand and employs the new capital facilities in the same proportion to other inputs as previously used, then following Primeaux and Nelson, the MPC can be estimated as

$$MPC = (dFC/dQ_p) \cdot (dQ_p/dQ) \qquad (6.8)$$

where MPC = marginal plant charge in thousands of dollars,

$\frac{dFC}{dQ_p}$ = change in fixed costs (thousand of dollars) per million gallon change in peak day demand,

FC_i = the sum of depreciation, total taxes, in-lieu payments, debt service, and dividends for the ith utility in thousands of dollars, and

$\frac{dQ_p}{dQ}$ = change in peak day demand per million gallon per day change in total water demanded.

Rents were not available to include in the fixed cost definition. Debt service expenditures are included in place of amortization and interest payments. Dividends are included as a proxy of net income only for the IOU subsample regression. In-lieu payments are defacto taxes and included only in the POU subsample regression discussed below. Total output is defined as before, but peak-day demand output, Q_p, is defined as the maximum-day output of water delivered to the distribution system in 1970.

In order to estimate $(\frac{dFC}{dQ_p})$ and $(\frac{dQ_p}{dQ})$, the following equations were estimated.

$$FC_i = b + b_1 Q_{pi} + U_i \tag{6.9a}$$

and

$$Q_{pi} = c + c_1 Q_1 + U_i \tag{6.9b}$$

where FC_i, Q_{pi}, and Q_i are defined as above, and

U_i = residual term for the ith utility.

Taking the first derivatives of FC with respect to Q_p and Q_p with respect to Q give

$$b_1 = \frac{dFC}{dQ_p}$$

and (6.10)

$$c_1 = \frac{dQ_p}{dQ}$$

Because fixed costs are defined somewhat differently for the POU and IOU subsamples, b_1 and c_1 were estimated for POUs and IOUs separately. Thus, the marginal plant charge for the POU sample is defined as

$$MPC_{POU} = b_1^{POU} \cdot c_1^{POU} \tag{6.11}$$

and is defined for the IOU sample as

$$MPC_{IOU} = b_1^{IOU} \cdot c_1^{IOU} \tag{6.12}$$

The MPC is the addition to fixed costs in thousands of dollars to construct enough capacity to produce an additional million gallons of water during peak-day demand.

Once the MPC has been estimated, the next step is to allocate these costs to the various user groups. Economic theory suggests that these costs should be allocated to the user groups in proportion to their contribution to peak demand. However, because of the absence of this kind of data, the MPC will be allocated to the three user groups using the method employed by Primeaux and Nelson (92). The MPC is multiplied times the maximum-day demand, Q_p, to get the estimated <u>total</u> increase in fixed costs that would result in adding the capacity necessary to meet the <u>entire</u> peak-day demand. This would then be allocated to the user groups on the basis of the amount of water demanded by the jth user group as a percentage of total water demand, i.e., by PCT_j.

Let

$$PCT_{ji} = Q_{ji}/Q_i \qquad (6.13)$$

where PCT_{ji} = amount of water demanded by the jth user group as a percentage of total water produced or purchased by the ith utility,

Q_{ji} = amount of water demanded by the jth user group of the ith utility in millions of gallons,

Q_i = total water produced or purchased by the ith utility, and

j = residential, commercial, and industrial.

Therefore, the marginal plant charge for the jth user group of the ith utility and mth ownership type would be defined as

$$MPC_{mji} = (MPC_m \cdot Q_{pi} \cdot PCT_{ji}) \qquad (6.14)$$

where MPC_m = marginal plant charge in thousands of dollars for the mth ownership type; m = public ownership (P), private ownership (I), and

Q_{pi} and PCT_i are defined as above.

In order to convert MPC_{mji} to the same unit of measurement (dollars per thousand gallons) as is used for short-run marginal costs and average prices, it must be divided through by Q_i. The result is given in (6.15) below.

$$MPCQ_{mji} = (MPC_m \cdot Q_{pi} \cdot PCT_{ji})/Q_i \qquad (6.15)$$

In sum, $MPCQ_{mji}$ is defined as the total marginal plant charge in dollars per thousand gallons attributed to the jth user class of the ith utility and mth ownership type which is incurred in constructing capacity necessary to meet the entire peak-day demand.

There are at least two difficulties with this method of estimating and allocating marginal plant charges. For one, there is evidence that residential water customers relative to industrial water users contribute more to peak than to yearly demand. In a 1977 article on water rates by MacEwen (63), it is noted that

> . . . the ratio of maximum day demand to average day demand ranges from 1.9 to 4.8 for residential developments depending on the individual lot size and value of properties . . . By contrast large industries using public water supply have a much lower maximum day to average day ratio, (less than 1.5), and for those operating on a 24-hour per day basis the load factor is even more uniform (p. 521).

As a result, equation (6.15) tends to underestimate the marginal plant charge for residential customers and overestimates it for industrial customers. Second, plant capacity is generally never added just to meet current peak-day demand, but is added in sufficient quantities to meet forecasted future needs as well. The methods used here at least attempt to introduce cost-of-service into an analysis of price discrimination. There appear to have been no previous attempt to bring these cost considerations into an analysis of price discrimination for the water utility industry.

The final step in constructing price-marginal cost ratios is to sum short-run marginal costs and total marginal plant charges to get long-run marginal costs. Long-run marginal costs for the jth user class of the ith utility and the mth ownership type is defined as

$$LRMC_{mji} = SRMC_{i} + MPCQ_{mji} \quad (6.16)$$

Dividing this into AP_{ji}, the average price paid by the jth user class of the ith utility, gives

$$PMC_{mji} = \frac{AP_{ji}}{LRMC_{mji}} \quad (6.17)$$

where PMC_{mji} = price-to-marginal cost ratio applicable to the jth customer class of the ith utility and mth ownership type.

Ideally, both marginal costs and user prices should come from the last consumption block for each user class. Rates schedules with consumption blocks for each user group are unavailable in the 1970 AWWA operating data. In other words, marginal prices are not available for use in the numerator of the price-to-marginal cost ratios. The water rates which are reported in the AWWA survey are rates for specific <u>total</u> quantities, not <u>marginal</u> quantities. Because marginal prices are unavailable, average user prices are used.

Sample, Data, and Methodology

The sample used to test the price discrimination hypothesis is the same as that used previously in the rate level analysis. In order to test the hypothesis that public and private water firms price discriminate, a one-factor analysis of variance model (46) is used to test the null hypothesis that the price-marginal cost ratios are equal for the residential, commercial, and industrial user groups. The alternative hypothesis is that at least one of the price-marginal cost ratios are not equal. The analysis of variance test statistic is the F statistic. If the calculated F value exceeds the table F value at a stated level of significance, the null hypothesis can be rejected in favor of the alternative hypothesis that price discrimination exists. In order to determine which customer groups benefit from price discrimination, the S-method (46) or what is also known as multiple comparisons is used to investigate differences between pairs of user groups. The F test can tell us that at least one price-marginal cost ratio is not equal to the others but it does not tell us which one. The S-method is able to determine which of the particular differences are statistically significant.

In order to determine which ownership form price discriminates more, one would ideally have to have access to complete rate structures, the quantities of water purchased by customer groups at various points within that structure, as well as disaggregated cost and revenue data. Because this type of data is unavailable, greater price discrimination will be defined as a greater difference between the price-marginal cost ratios of the various user groups. Evidence of price discrimination exists if the price-marginal cost ratios are not equal between user groups. By inference, price discrimination is greater the less equal are these ratios. The null hypothesis to be tested is that the ratio of the POUs' price-marginal cost ratio for residential users to the price-marginal cost ratio of industrial users is equal to the same ratio for IOUs. The alternative hypothesis is that this ratio is greater for IOUs than for POUs. Because of the greater pressure for wealth maximization in private utilities relative to public utilities, private utilities are expected to price discriminate more completely than public utilities. Similar tests will also be presented for residential-commercial and commercial-industrial comparisons by ownership.

A Kolomogrov-Smirnoff test for normality is used to determine if the ratios described above are normally distributed for both ownership samples. The results of this test indicate that the null hypothesis of normality can be rejected. Thus, a nonparametric equivalent to the t-test, the Mann-Whitney U test, is used to test the null hypothesis that there is no difference between the extent to which POUs and IOUs price discriminate.

Empirical Results

Estimates of regression equation (6.9a and b) and the estimated marginal plant charges are presented in Tables XX and XXI. Next, descriptive statistics of variables used in the construction of the price-marginal cost ratios are presented in Table XXII. This is followed by the test of the hypotheses described above.

Chow tests of equations (6.9a and b) by ownership type allowed the rejection of the null hypothesis that the fixed costs and peak demand regressions were structurally the same for both ownership types. The Chow test F statistic was 32 and 6.6, respectively.

The results of the analysis of variance F tests indicate that price discrimination occurs among IOUs as well as POUs. The null

TABLE XX

ESTIMATION OF PARAMETERS USED IN ESTIMATING MARGINAL PLANT CHARGES (EQUATIONS 6.9a and b)

Ownership	Regressions 6.9a and b	Statistical Characteristics	
POUs			
	$FC_i = 87.213 + 24.546\, Q_{pi}$ $(1.038)^*$	$R^2 = .851$ $\bar{R}^2 = .849$ $F = 558.85$	$N = 95$ $dF = 93$ $MSE = 410690.227$
	$Q_{pi} = 2.469 + 1.756\, Q$ $(.056)^*$	$R^2 = .909$ $\bar{R}^2 = .908$ $F = 983.495$	$N = 95$ $dF = 93$ $MSE = 352.228$
IOUs			
	$FC_i = 553.204 + 45.357\, Q_{pi}$ $(5.069)^*$	$R^2 = .734$ $\bar{R}^2 = .725$ $F = 80.04$	$N = 31$ $dF = 29$ $MSE = 4382753.054$
	$Q_{pi} = 1.466 + 1.417\, Q_i$ $(.099)^*$	$R^2 = .875$ $\bar{R}^2 = .872$ $F = 205.94$	$N = 31$ $dF = 29$ $MSE = 725.788$

Note: Standard errors are in parentheses; (*) indicates significantly different from zero at a .01 level of significance.

TABLE XXI

ESTIMATION OF MARGINAL PLANT CHARGES BY OWNERSHIP TYPE

Ownership	Marginal Plant Charge
POUs	
	$MPC_{POU} = 1.756 \cdot 24.546 = 43.103$
IOUs	
	$MPC_{IOU} = 1.417 \cdot 45.357 = 64.271$

TABLE XXII

DESCRIPTIVE STATISTICS OF VARIABLES USED IN THE PRICE DISCRIMINATION HYPOTHESIS

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
SRMC					
POU	95	.150	.077	.041	.542
IOU	31	.184	.069	.098	.389
$MPCQ_R$					
POU	95	.065	.038	.000	.184
IOU	31	.098	.060	.012	.246
$MPCQ_C$					
POU	95	.028	.017	.001	.093
IOU	31	.042	.026	.001	.135
$MPCQ_I$					
POU	95	.043	.030	.000	.112
IOU	31	.047	.033	.002	.119
$LRMC_R$					
POU	95	.215	.091	.045	.659
IOU	31	.282	.093	.148	.557
$LRMC_C$					
POU	95	.177	.077	.042	.550
IOU	31	.227	.078	.115	.440
$LRMC_I$					
POU	95	.193	.077	.041	.552
IOU	31	.232	.071	.114	.427
AP_R					
POU	95	.550	.220	.139	1.529
IOU	31	.883	.278	.376	1.505
AP_C					
POU	95	.385	.161	.115	.938
IOU	31	.574	.159	.249	.902
AP_I					
POU	95	.236	.113	.039	.667
IOU	31	.315	.089	.164	.522

TABLE XXII (Continued)

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value
PMC_R					
POU	95	2.876	1.650	1.108	12.185
IOU	31	3.518	1.854	1.238	9.150
PMC_C					
POU	95	2.371	1.272	.597	10.812
IOU	31	2.700	1.044	1.532	6.517
PMC_I					
POU	95	1.397	1.228	.290	11.382
IOU	31	1.460	.605	.716	3.978

Note: (R) residential, (C) commercial, (I) industrial.

hypothesis that the price-marginal cost ratios are equal for all user classes can be rejected at the .01 level of significance for both ownership subsamples. The calculated F statistics and results of the multiple comparisons are presented below in Table XXIII.

TABLE XXIII

F STATISTICS AND CONFIDENCE INTERVALS USED IN THE PRICE DISCRIMINATION HYPOTHESIS AND PAIR-WISE COMPARISONS

Hypothesis			F Values and S-Method Confidence Intervals	
H_0: $PMC_R = PMC_C = PMC_I$				
			Table Value	
POU	N = 95	$F_{2,282} = 27.55$	$F_{2,282} = 4.61$	$\alpha = .01$
IOU	N = 31	$F_{2,90} = 20.41$	$F_{2,90} = 4.89$	$\alpha = .01$
H_0: $PMC_R = PMC_C$; $PMC_R = PMC_I$; $PMC_C = PMC_I$				
Confidence Intervals		$\alpha = .01$	$\alpha = .05$	
Treatment Effect Differences				
POUs	R - C:	(-.111, 1.121)	(.009, 1.001)	
	C - I:	(.358, 1.59)	(.478, 1.47)	
	R - I:	(.863, 2.095)	(.983, 1.975)	
IOUs	R - C:	(-.197, 1.833)	(.01, 2.048)	
	C - I:	(.225, 2.255)	(.432, 2.048)	
	R - I:	(1.043, 3.073)	(1.25, 2.866)	

Note: R = residential; C = commercial; I = industrial; and α = level of significance.

The confidence intervals presented above are estimated via the S-method which allows for all J(J-1)/2 pairwise comparisons from a set of J populations. In this case, J equals the three user classes. The advantage of the S-method is that it simultaneously compares differences among the means of the J populations. It is a ". . . statistically improper practice to run the test for the difference between two means on all possible pairs of populations" (46, p. 486) because of the difficulty of interpreting the results. If a given confidence interval presented in Table XXIII does not contain zero, it is significant at the stated level of significance. Note that at the .05 level of significance, for both ownership types, none of the confidence intervals contains zero. Thus, the three confidence intervals for both the POU and IOU samples hold simultaneously at a .95 level of confidence. The differences between the price-marginal costs ratios of all possible pair-wise comparisons are significant and thus the null hypothesis that there is no difference in price-marginal cost ratios for all possible pair-wise combinations can be rejected at a .05 level of significance. At the .01 level of significance, only the residential-commercial comparison is not significant. This result obtains for both ownership forms.

The evidence presented in Table XXIII is consistent with the argument that both POUs and IOUs price discriminate. This price discrimination is imposed on all three user classes with high-usage customers benefitting relative to low-usage customers (see Table XXII). These results will have to be considered as tentative, however, given the absence of both marginal prices and sufficient data to accurately estimate and distribute long-run marginal costs.

Mann-Whitney U tests were performed to determine if the null hypothesis that there is no difference in the extent to which POUs and IOUs price discriminate could be rejected in favor of the alternative hypothesis that IOUs price discriminate more than POUs. The null and alternative hypotheses can be stated as:

$$\begin{aligned}
&\text{a)} \quad H_0: \quad (PMC_R/PMC_I)^{POU} = (PMC_R/PMC_I)^{IOU} \\
&\qquad H_1: \quad (PMC_R/PMC_I)^{POU} < (PMC_R/PMC_I)^{IOU} \\
&\text{b)} \quad H_0: \quad (PMC_C/PMC_I)^{POU} = (PMC_C/PMC_I)^{IOU} \\
&\qquad H_1: \quad (PMC_C/PMC_I)^{POU} < (PMC_C/PMC_I)^{IOU} \\
&\text{c)} \quad H_0: \quad (PMC_R/PMC_C)^{POU} = (PMC_R/PMC_C)^{IOU} \\
&\qquad H_1: \quad (PMC_R/PMC_C)^{POU} < (PMC_R/PMC_C)^{IOU}
\end{aligned} \tag{6.18}$$

The results of the Mann-Whitney tests do not allow the rejection of any of the null hypotheses stated in (6.18). The one-tail probabilities for (6.18a, b, and c) are .38, .49, and .33, respectively. There appears to be no statistically significant difference between the extent to which POUs and IOUs price discriminate. This result is in contrast with Hansman's conclusion that private water utilities price discriminate more completely than public water utilities (45). Hansman's analysis consists of a matched-pairs test of 18 pairs of private and public water firms representing firms serving populations between 25,000 and 600,000. Hansman's test for the extent of price discrimination by ownership is similar to the one presented above with the exception that there is no consideration of cost-of-service differentials. Hansman computed two water price ratios: (water rates at 6,000 gallons/water rates at 50,000 gallons) and (water rates at 50,000 gallons/water rates at 300,000 gallons). Using a t-test for differences in means, Hansman found that the null hypotheses that the price ratios are the same for both POUs and IOUs could be rejected at a .02 level of significance in favor of the alternative hypothesis that IOUs have higher price ratios than POUs. Although her results are consistent with the predictions of property rights theory, her tests are inconclusive in the absence of cost-of-service considerations.

In order to investigate the importance of the bias created by omitting cost considerations, price ratios were computed absent of long-run marginal costs. The Mann-Whitney U test was used to test the null hypothesis that the ratios, (AP_R/AP_C), (AP_C/AP_I), and (AP_R/AP_I) do not differ by ownership. The null hypothesis with respect to the first ratio could not be rejected. However, the null hypotheses with respect to the latter two ratios can be rejected at the .10 level of significance in favor of the alternative hypothesis that these ratios are greater for IOUs relative to POUs. When price-marginal cost ratios are used in place of prices, the significant differences by ownership vanish. It can be inferred from these tests that Hansman's results may be biased by ignoring cost-of-service considerations.

In sum, it appears that both POUs and IOUs price discriminate, but it cannot be concluded that IOUs price discriminate to a greater extent than POUs. The price discrimination for both POUs and IOUs is relatively more beneficial to the user groups with greater per-capita consumption than those with lower levels of per-capita water consumption.

Conclusion

Certain theoretical implications can be drawn from a property rights analysis of water utility rate making. POUs relative to IOUs are expected to charge lower water prices for all customer classes, to price discriminate less, and to design the rate structure such that large users of water receive preferential treatment. It was found that POUs do charge lower prices for all customer classes than IOUs. This was the case even after controlling for both regulation and taxes. The cost-based average pricing model performed best for the residential regressions. The implication drawn earlier is that non-cost factors are more important in explaining commercial and industrial water prices and particularly for utilities operating in an environment of local regulation. While it was found that POUs price discriminate, the evidence presented here does not support the alternative hypothesis that POUs price discriminate less than IOUs. The next chapter is concerned with trying to isolate the effect of ownership in order to determine if regulatory-political factors are important determinants of water manager behavior.

CHAPTER VII

REGULATORY-POLITICAL INFLUENCE ON MANAGERIAL BEHAVIOR

Introduction

In the broadest sense, a property rights theory of managerial behavior must consider all important factors that shape the manager's set of costs and rewards. There is considerable evidence to support the hypothesis that ownership rights are an important determinant of the opportunity set faced by managers. However, it has been hypothesized here and elsewhere (66, 90), that regulatory and political influences are important as well, particularly for the utility industries. Strictly speaking, one must control for regulatory and political influences when trying to isolate the effect of ownership on economic behavior. Similarly, one must control for ownership in order to isolate regulatory and political effects.

In the chapter on water pricing with respect to rate levels, public ownership was found to exert a significant downward effect on rate levels even after controlling for regulatory effects. This chapter will attempt to determine if regulatory-political influences are important determinants of managerial behavior after controlling for ownership. First, the effect of local regulatory-political influences will be investigated with respect to the demand for water utility capital, labor, and variable costs. Second, the effect of local regulation with respect to the incentive to engage in economic regulation will be considered. Third, local regulatory-political influence will be analyzed with respect to its effect on user rates both inside and outside the municipal city limits.

Local Regulatory-Political Influence:
Capital, Labor, and Variable Costs

In order to isolate the effect of differences in ownership on labor and capital demand, it was mentioned in Chapter IV that ownership should be separated from local political influences to determine if ownership is an important noneconomic factor in the acquisition of labor and capital. It was hypothesized in Chapter IV that politicians have tastes for municipal capital and labor. If it is assumed that all politicians have similar tastes and preferences with respect to water utility capital and labor, then differences in the quantities of municipal labor and capital consumed by politicians would be due to differences in the constraints on the politicians' abilities to maximize utility.

One reason for the lack of research in the area of political influence and local government operation, particularly utility operation, might be due to the lack of good measures of political influence. There just do not seem to be any good measures of a local politician's ability to influence local water utility operations given the availability of both political and regulatory data. A binary variable for state versus local regulation cannot be used as a local political influence variable in either regression (5.9) or (5.10) because of the high degree of association between ownership and local regulation. Most POUs are locally regulated whereas IOUs are regulated by state regulatory commissions. The simple correlation coefficient between the binary variable for ownership and a binary variable for state versus local regulation is .88 for the sample used in the chapter on firm efficiency. Thus, multicollinearity would make it difficult to separate the ownership and local regulatory-political influence effects from one another.

Per-capita income has been suggested as a measure of the community's ability to finance municipal capital (66). The problem with using this variable as a measure of the constraint on the politician's ability to consume capital and labor is that changes in per-capita incomes would be expected to alter per-capita water demands. Because municipal utilities are required to meet demand, increases in supply in response to increases in demand may require increases in both capital and labor. In short, a local regulatory-political influence effect cannot be separated from a water demand effect in single equation capital and labor demand functions which include per-capita income as a regressor. It might be possible to construct a simultaneous-equation model to control for these interdependencies, but available census and water operating data preclude the construction of such a model.

Still another measure of political influence is the variable used by Mann (66) in his study of municipal residential water rates--the percentage of the voting age population that voted in the 1968 presidential election. Actually, this variable is a measure of user influence rather than political influence. Mann hypothesized that the higher this percentage, the more politically active the community, and the more responsive would be politicians to the residential household's desire for lower water rates. This variable is inappropriate here because there is no reason to expect that households have tastes for municipal capital and labor at least to the extent that they are willing to engage in lobbying efforts to get them.

The variable used here as a measure of the politician's ability to affect local water utility operations, albeit a crude measure, is a binary variable for state versus local rate regulation of municipal water utilities. It is expected that in those states that have the power to regulate POUs, the local politician's ability to influence municipal utility decisions is diminished. However, the degree to which these states regulate POUs varies from minimal regulation of just outside rates to fairly complete regulation. The type of regulation for which state data is available that would seem to have the greatest impact on the local politician's ability to alter the size of the utility's capital stock and labor force would be internal rate regulation. Internal rate regulation affects rate levels and to a lesser extent price discrimination (66) which, in turn, affects the output of the firm and its demand for labor and capital.

Let

P_i = 1 if the state in which the POU operates regulates municipal inside rates and 0 if city councils or other forms of local regulation regulate municipal water rates (45);

$i = 1, 2, \ldots, n$ water firms.

If states regulate municipal water systems, local politicians are expected to have less of an ability to affect water utility operations. Thus, (P_i) is expected to vary inversely with the politican's ability to increase municipal capital and labor and therefore the local water firm's demand for labor and capital.

In order to test this hypothesis, the sample used in the chapter on firm efficiency was divided into two samples by ownership. The capital and labor demand functions were estimated for the POU sample using variable P_i. The equations to be estimated are:

$$\ln K_i = A - \frac{\alpha}{\alpha+\beta} \ln(r/w)_i + \frac{1}{\alpha+\beta} \ln Q_i + bP_i + U_i \tag{7.1}$$

and

$$\ln L_i = A - \frac{\beta}{\alpha+\beta} \ln(w/r)_i + \frac{1}{\alpha+\beta} \ln Q_i + cP_i + U_i \tag{7.2}$$

where b, c < 0.

The regression results for a sample of 87 POUs are shown below in Table XXIV.

TABLE XXIV

REGRESSION ESTIMATES OF THE CAPITAL AND LABOR DEMAND FUNCTIONS USING VARIABLE (P)

Regression	Variable	Coefficient	Standard Error	T Value	Significance Level
$\ln K_i$	$\ln(r/w)_i$	.273	.286	.95	.3429
	$\ln Q_i$	.894	.064	13.86	.0001
	P_i	-.085	.244	-.35	.7282
	(Constant)	3.734	2.250	1.65	.1008
R^2 = .730	F = 74.99	N = 87			
$\bar{R}^2$ = .720	MSE = .546	dF = 83			
$\ln L_i$	$\ln(w/r)_i$	-.388	.189	-2.06	.0428
	$\ln Q_i$	.849	.043	19.97	.0001
	P_i	.077	.161	.48	.6318
	(Constant)	-.350	1.484	-.24	.8140
R^2 = .851	F = 158.38	N = 87			
$\bar{R}^2$ = .846	MSE = .237	dF = 83			

The hypothesized inverse relationship betwee ln K_i and P_i occurs, but the coefficients on P_i in both the capital and labor demand regressions are not statistically significant. The results suggest that either political influence on the demand for water utility labor and capital is unimportant or that P_i is not measuring that political influence. It may be that local political influence manifests itself more in the design of the rate structure than in the employment by water agencies of labor and capital. The last section in this chapter will assess the importance of local political influence on both inside and outside water rates.

In Chapter IV, it was also suggested that politicians have a taste for expanding municipal services including water services. If politicians have a taste for expanding municipal water services and if P_i is measuring the politician's inability to do this, P_i is expected to be inversely related to water system costs. That is, local politicians in states that regulate municipal water rates will have less of an ability to influence rate and extension policies that affect both the water firm's size and costs. The cost function derived in Chapter V is estimated for the public sample only. The equation to be estimated is given in (7.3) below.

$$\ln C_i - \ln r_i = a + \frac{\alpha}{\alpha+\beta}(\ln w_i - \ln r_i) + \frac{1}{\alpha+\beta} \ln Q_i + dP_i + U_i \qquad (7.3)$$

where d < 0

and the regression estimates are shown in Table XXV.

The sign on P_i is inverse as hypothesized and is significantly less than zero at a .11 level. Thus, the evidence from Tables XXIV and XXV are only suggestive. The results do not strongly support the hypothesis that local regulatory-political influence is an important noneconomic determinant of water utility capital, labor, and variable costs. These results combined with the previous results from the chapter on firm efficiency do suggest, however, that ownership is an important noneconomic determinant of water utility capital, labor, and cost.

TABLE XXV

REGRESSION ESTIMATES OF THE COST EQUATION EMPLOYING (P)

Variable	Coefficient	Standard Error	T Value	Significance Level
$(\ln w_i - \ln r_i)$	.769	.138	5.60	.001
$\ln Q_i$	.821	.031	26.50	.0001
P_i	-.142	.117	-1.21	.2294*
(Constant)	-7.297	1.081	-6.75	.0001
R^2 = .896	F = 238.15	N = 87		
$\bar{R}^2$ = .892	MSE = .126	dF = 83		

*Significantly <u>less</u> than zero at a .11 level.

Local Regulation and the Incentive to Engage in Economic Regulation

In Chapter IV, it was hypothesized that local regulators, principally city councilmen, relative to state regulatory commissioners have less of an incentive to engage in economic regulation which is defined here as the extensive review and regulation necessary to impose cost-based pricing. Furthermore, it was hypothesized that non-cost influences such as local political influences would be expected to be more important for locally-regulated than state-regulated utilities.

To gain greater insight into utility rate-making, the average price regressions estimated previously were reestimated for the sample of locally-regulated water firms used in Chapter VI and compared to the state-regulated estimates presented in that chapter. The results of these regressions are consistent with the argument that economic regulation or (cost-based pricing) is less rigorously imposed at the local than at the state level of regulation. Comparing adjusted R^2s for the state versus local regulation subsamples, utility pricing for the state-regulated sample appears to be much more cost-based than it is for the locally-regulated sample (Table XXVI).

TABLE XXVI

ADJUSTED R^2 FOR RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL AVERAGE PRICE REGRESSIONS

Regression	State Regulation N = 55	Local Regulation N = 71
Residential	.705	.486
Commercial	.678	.311
Industrial	.598	.234

This conclusion together with the earlier statement from the chapter on utility pricing and rate levels that it was difficult to conclude that IOU pricing is more cost-related than POU pricing implies that both Hansman's (45) and Hennigan's (48) findings that private ownership relative to public ownership is associated with more cost-based pricing may be the result of regulatory effects not controlled for rather than the effect of ownership per se.

Local Regulatory-Political Influence and Water Rates

Outside Residential Water Rates

For the water industry, it has been hypothesized by Crain and Zardkoohi (according to De Alessi [33]) and Mann (66) that politically-active markets would receive lower water rates than politically-inactive markets. Peltzman (90) tested a similar hypothesis for the electric power industry. The 1970 AWWA survey provides data on both inside and outside residential water rates for the 500 cubic foot (or 3,750 gallon) consumption level. Those users outside city boundaries are defined as politically inactive whereas inside users constitute the politically active market. In discussing Crain and Zardkoohi's article, De Alessi (33) notes that Crain and Zardkoohi apparently controlled for no variables other than ownership. There was no attempt to assess the regulatory-political effect on inside versus outside rates. Crain and Zardkoohi found as hypothesized that inside rates are lower than outside rates.

In order to determine if local regulatory-political influences tend to bias rates upward for politically inactive markets and downward for politically-active markets, it is necessary to control for ownership and cost-of-service differentials. Because the AWWA operating data do not disaggregate sales to residential users according to whether they reside in- or outside municipal boundaries, no attempt will be made to control for cost-of-service differentials. However, it is possible using the sample used in the chapter on utility pricing to control for ownership. All POUs in that sample for which residential outside rates were reported constitute the sample used to test the null hypothesis that there is no difference between outside to inside water rate ratios for state- and locally-regulated public water utilities. If inside customers are preferred to outside customers by local politicians, and if local political influence is more important at local levels of regulation than at state levels of regulation, the ratio of outside to inside water rates for a given level of consumption is expected to be higher for locally-regulated relative to state-regulated POUs.[1]

The inside and outside water rates used to test the above hypothesis are inside and outside residential water rates for the 3,750 gallon consumption level. Missing data resulted in the loss of five of the state-regulated POUs and seven of the locally-regulated POUs. The resulting sample consists of 64 locally-regulated and 19 state-regulated POUs. The Mann-Whitney U test is used as the statistical test of the null hypothesis. The results are presented in Table XXVII.

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[1]For state regulation, both inside and outside users constitute the politically-active market. Thus, state regulators would be expected to be indifferent between these two user groups with respect to rate levels. Differences in the treatment of these user groups are expected, however, to occur for locally-regulated water utilities. To the extent that outside to inside water rate ratios differ by the type of regulation, it can be inferred that regulatory-political effects do constitute important non-cost effects on water utility rate making.

TABLE XXVII

MANN-WHITNEY U TEST; RATIO OF OUTSIDE TO INSIDE MUNICIPAL WATER RATES BY TYPE OF REGULATION

Variable	Locally-Regulated POUs	State-Regulated POUs
Ratio of Outside to Inside Water Rates (3,750 gallons)	N = 64	N = 19
Mean Rank	43.68	36.34
Z Statistic	Z = -1.178	
One-tail Level of Significance	α = .119	

The null hypothesis that outside to inside residential water rates are not affected by regulation type can be rejected at a .119 one-tail level of significance in favor of the alternative hypothesis that local regulatory-political influences relative to state-regulation results in higher outside-to-inside municipal water rates. This result suggests that the type of regulation faced by utilities may be an important factor in the treatment of outside customers relative to inside customers.

Inside Water Rates

In Chapter IV it was hypothesized that both city councilmen and state regulatory commissioners have incentives to favor industrial relative to residential customers. It was also asserted that the preference for industrial customers would be greater for locally-regulated that state-regulated water utilities. It was hypothesized in Chapter IV that user group influence via regulatory forces would result in preferential water rates. In order to test this hypothesis, two rankings were used to measure the "importance" of the industrial user group relative to the residential user class. If preferential water rates result from user group influence being brought to bear on politicians and regulators, then as measures of the "importance" of the industrial user group increases, price-marginal costs ratios for that group are expected to decrease.

The two rankings used to measure the industrial user group's degree of importance or influence are:

1. Each firm is ranked according to the percentage of total water sold to industrial customers, and
2. Firms for which data are available are ranked according to the percentage of total value added contributed by the five 2-digit SIC industries that make the heaviest use of municipally-supplied water. The value added data is from the 1972 Census of Manufacturers (106) and pertains to the cities in which the water utility is located. The SIC industries are:

   33 - Primary Metals

   29 - Petroleum and Coal

   28 - Chemicals and Allied Products

   26 - Paper and Allied Products

   20 - Food and Kindred Products

Once the firms are ranked for each ownership type, the top half of the sample is compared to the bottom half in terms of the industrial price-marginal cost ratio. If the rankings are in ascending order, the top relative to the bottom half of both rankings is expected to be associated with lower industrial price-marginal cost ratios. The null hypothesis to be tested is that there is no difference between the industrial price-marginal cost ratios of the top and bottom halves of both rankings. In order to control for both ownership and regulatory influences, the rankings were separately done for IOUs, state-regulated POUs, and locally-regulated POUs.

Based upon the arguments in Chapter IV, the null hypothesis is expected to be rejected for all three classifications mentioned above. That is, state and local regulators are expected to respond to industrial user group influence. If this influence impinges more directly on local regulators than state regulators, the null hypothesis is expected to be rejected at a higher level of significance for locally-regulated water agencies than would be the case for the state-regulated IOUs and POUs.

Again, tests for normality indicate that the nonparametric Mann-Whitney U test is the appropriate test of the null hypothesis stated above. The null hypothesis can be rejected in favor of the alternative hypothesis that as the importance of the industrial user class increases, the industrial price-marginal cost ratio falls (see Table XXVIII). This is the case for all three classifications below. Note that the Z statistic is more than twice as large for the locally-regulated POU sample than it is for both the state-regulated IOU and POU samples. These results support the hypothesis that user group influence via the regulatory structure is more important for locally-regulated relative to state-regulated water utilities.

Using ranking 2, for only nine of the 31 IOUs and 26 of the POUs were there adequate value added data. Of the 26 POUs, five were state-regulated. It was decided to drop the five state-regulated POUs and test the null hypothesis using only two classifications: state-regulated IOUs and locally-regulated POUs. The same testing procedure that was followed above is followed with respect to ranking 2. When the top and bottom halves of the rankings were compared using the Mann-Whitney U test, the mean rank score for the top half of the POU sample was smaller than for the bottom half indicating that industrial price-marginal cost ratios are lower as the industrial user group influence increases. Just the opposite relationship occured for the IOU classification. However, in neither case were the results statistically significant (see Table XXIX).

TABLE XXVIII

MANN-WHITNEY U TEST; INDUSTRIAL PRICE-MARGINAL COST RATIOS BY RANKING 1

Utility Type	N	Z Statistic	Level of Significance
IOU (State Regulated)	31	-2.37	.0177
POU (State Regulated)	24	-2.77	.0056
POU (Local Regulation)	71	-5.64	.0000

TABLE XXIX

MANN-WHITNEY U TEST; INDUSTRIAL PRICE-MARGINAL COST RATIOS BY RANKING 2

Utility Type	N	Mean Rank Top Half	Mean Rank Bottom Half	Z Statistic	Level of Significance
		N = 5	N = 4		
IOU (State Regulation)	9	6.20	3.50	-1.4697	.1416
		N = 11	N = 10		
POU (Local Regulation)	21	10.73	11.30	-.2113	.8327

The results are therefore mixed with respect to political influence and user group preference. Ranking 1 provides support for the regulatory-political influence hypothesis advanced in Chapter IV. Ranking 2, however, casts some doubt upon whether ranking 1 is actually measuring user group influence via the regulatory structure. In order to ensure that ranking 1 was not capturing scale effects, the variable used in ranking 1 was correlated with the water utility scale variable, millions of gallons per day, used in the average price regressions. The simple correlation coefficient was -.134 hardly indicating that ranking 1 was capturing scale effects. In fact, the simple correlation suggests that utility size and the importance of the industrial user class are negatively related.

Conclusion

The results of this chapter suggest that political-regulatory influence may be an important factor shaping the opportunity sets faced by managers. Local regulators relative to state regulators tend to bias utility costs upward, tend to engage in less economic regulation, tend to prefer inside users relative to outside customers, and at least for ranking 1 tend to respond more to the user group influence of industrial customers.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Summary and Conclusions

As was stated in the introductory chapter, one objective of this dissertation was to derive a geometric model of a decision maker's maximization of utility that is general enough to incorporate the relaxation of all of the major ownership property rights. The model developed in Chapter II not only is able to allow for the relaxation of ownership rights, but can also be used to assess the effect that other important industry characteristics have on managerial behavior.

It was shown in Chapter II that a manager of a privately owned and unregulated corporation faced a different set of constraints on utility maximizing behavior than the manager-owner of the "classical" firm. The corporate manager maximizes utility in pecuniary-nonpecuniary income space whereas the "classical" owner-manager maximizes pecuniary income or profit. The reason for this distinction is that for the case of incorporation, a corporate manager's pecuniary income is no longer equal to profit as it was for the case of the classical manager.

The constraint on the classical owner-manager's behavior was a function of the market environment and technological characteristics of the firm. The constraint on the corporate manager's behavior includes in addition to the market and technological constraints, the minimal return required by the owner's of the firm. The minimal profit requirement depends in part upon the costs to owners of monitoring management. The greater these costs, the more discretion that managers will have to use the firm's resources to pursue utility-generating activities. It was also noted in Chapter II that because the manager's consumption of nonpecuniary income was expected to be less visible to owners than their consumption of pecuniary income, managers would consume relatively more nonpecuniary than pecuniary income as constraints are relaxed. In sum, the separation of ownership from management is expected to produce both an income and substitution effect on the manager's opportunity set. The corporate manager will consume more nonpecuniary and pecuniary income with his consumption of nonpecuniary income increasing relative to pecuniary income as constraints are relaxed.

The model was also used to compare the managerial behavior of private, private and regulated, and public firms. For instance, the model predicts that the manager of a regulated private firm will consume more pecuniary and nonpecuniary income than the manager of a comparable unregulated private firm, but less pecuniary and nonpecuniary income than the manager of a comparable public firm. Chapter IV extends the model by investigating differences in the constraints imposed on public and private water utility managers by some industry characteristics other than ownership. Chapter IV also gives some content to the manager's utility function. This makes possible a wider range of behavioral implications than is possible for the general model developed in Chapter II.

The brief overview of the water utility industry presented in Chapter III pictures the water industry as an industry that has grown largely in line with general population growth. It is not a very technologically progressive industry, nor can it be stated conclusively that there are economies of scale particularly when considering individual system components. The industry is dominated with public water firms with some 8 percent of the total number of public and private water firms serving 80 percent of the total population served. The water industry is one of the most capital intensive industries with fixed costs accounting for roughly one-third of total costs. Further, it appears that public water firms face a variety of forms of local regulation, but city council regulation is the dominant type. Private water firms are almost exclusively subject to state regulation.

Public utilities in general tend to be self-supporting but many are tied financially to the local government. Some rely on subsidies for operation and others generate surpluses that are often used by the cities as a type of unlegislated tax revenue. Most utilities, private and public, employ a declining-block rate pricing policy although public and private water utilities differ with respect to the estimation of revenue requirements. Finally, it was noted that at least for 1969, water utilities apparently were producing water which did not conform to the 1962 drinking water standards.

In Chapter IV, the effect of industry characteristics other than ownership on managerial behavior was analyzed. Specifically, the important water industry characteristics that are expected to affect the manager's opportunity set are property taxes and in-lieu payments; capital financing; external sources of revenue such as property tax levies, government subsidies, and special assessments; and regulation. Property taxes and in-lieu payment to local governments constrain the manager's consumption of pecuniary and nonpecuniary income by absorbing a portion of the manager's discretionary profits. Property tax levies, local government subsidies, and special assessments have just the opposite effect. Because an investor-owned utility's tax burden exceeds the contribution that some public firms make to local government in the form of in-lieu payments and because public firms are often subsidized by local government, managers of public firms have fewer constraints placed on their want-satisficing activities relative to private managers. This reinforces a conclusion from Chapter II that a public manager relative to a private manager will have more discretionary resources with which to consume pecuniary and nonpecuniary income.

Capital financing for public relative to private water utilities results in lower per unit capital costs which allows more discretionary resources to be diverted by managers to utility-generating activities. Lower capital costs are also expected to encourage a more capital intensive operation. Regulation was hypothesized to affect managerial property rights by altering ownership rights and by directly placing operating constraints on management. Political motives via the regulatory structure were hypothesized to be an important determinant of the behavior of public managers, particularly for locally-regulated water firms.

Implications of the utility maximization model regarding managerial behavior with respect to firm efficiency, rate-making, and product quality were derived in Chapter IV. A number of these hypotheses can be inferred directly from the efficiency implications of the general model discussed in Chapter II. The hypotheses discussed in Chapter IV that are implications of the general model are that public water firms relative to private water firms will incur higher costs, combine inputs less efficiently, have lower average products of labor and capital, and will incur more input waste.

The price discrimination hypothesis can also be derived from the implications of the general model in Chapter II. The model in Chapter II implies that managers have an incentive to increase the discretionary resources over which they have command. One way for public managers to accomplish this is to price discriminate. In Chapter IV it was noted that a private water manager would be expected to price discriminate at least up to the point at which the owner's minimal return is assured. It was also noted that because of the private utility owner's emphasis on wealth maximization, private relative to public water managers would likely price discriminate more completely.

For the other hypotheses discussed in Chapter IV, however, it was necessary to add content to the manager's utility function. It was necessary to make assumptions about the sources of managerial utility and what kinds of activities give rise to managerial satisfaction. By assuming that specific managerial activities were related to specific sources of utility, additional implications of the model were derived. This was accomplished by first assuming that the utility functions of private and public managers were identical and then altering managerial property rights in order to make directional statements about the managers' consumption of various sources of managerial utility. In particular, it was hypothesized that public water managers relative to private water managers would employ more labor and capital, charge lower user prices for all customer classes, give preferential treatment to high-usage relative to low-usage customers and to residents relative to nonresidents, and would produce a higher quality product.

The evidence reported in Chapter V is consistent with the alternative hypotheses that public relative to private water firms are less efficient, but produce a higher quality product. It was found that public ownership exerts a positive effect on both the demand for labor and capital. The reduced-form input demand function performed best for the labor demand regression. Economic considerations appear to play more of a role in the water firm's demand for labor than its demand for capital. An implication is that noneconomic factors such as ownership may be more important in explaining the water system's demand for capital than its demand for labor. It was also found that public water firms employ input combinations less efficiently, incur higher variable costs, have lower average products of labor and capital, and produce a higher quality product.

The only hypothesis from Chapter IV that produced results inconsistent with the predictions of the property rights model was the input waste hypothesis. The results of that test were not significant, however.

The results from Chapter V leave the water policy maker in an uneasy position. If a region has both water quality and water shortfall problems, it is not clear whether public or private ownership is to be preferred. Public ownership is apparently associated with higher water quality, but the more efficient private water supplier would be expected to be able to produce more water for a given commitment of resources. In those regions that experience periodic water shortages but have a reasonably high level of raw water quality, private ownership may be preferred to public ownership as a possible alternative to water conservation practices.

In Chapter VI, results of tests of the rate level hypothesis revealed that public relative to private water firms charge lower water rates for all user groups. This result obtains even after controlling for differences in tax liabilities and regulation. Further, the cost-based pricing model performed better for the residential customer group than it did for either the commercial or industrial user groups. The pricing model performed even better for a subsample of just state-regulated water utilities. Cost factors, therefore, seem to be more important determinants of residential relative to commercial and industrial rates and for state-regulated utility rates in general. The implication drawn in Chapter VI was that noncost factors such as local political influence may be more important in explaining commercial and industrial water rates, particularly for locally-regulated utilities than in explaining the water rates of residential users. It was not concluded in Chapter VI, however, that private water firms' rate-making practices are more cost-based than public water firms' rate making.

The evidence from the last half of Chapter VI is consistent with the alternative hypothesis that public water firms price discriminate. It was found that industrial customers benefit from the lowest price-marginal cost ratios and that price discrimination is practiced between all possible pairs of user groups. The null hypothesis that there is no difference in the extent to which public and private water firms price discriminate could not be rejected.

The results from Chapter VI also provide implications regarding water conservation policies. Lower water prices for all user groups mean that the quantity of water demanded will be greater and there will be the need for earlier investment in capacity than if water rates were higher. Thus, the finding that public relative to private ownership results in lower water prices suggests that the conversion of public water assets to private ownership or some sort of combined franchise system of operation would likely result in more economic pricing with prices performing the rationing function rather than legislative fiat.

In Chapter VII attempts were made to isolate local regulatory-political influences from ownership in order to determine if regulatory-political constraints on the manager's opportunity set were important influences on managerial behavior. Using a regulatory binary variable as a proxy of local regulatory-political influence, the evidence presented in Chapter VII appears to be consistent with much of the discussion of the expected regulatory-political effects on managerial behavior presented in Chapter IV. Specifically, it appears that local regulators (city councilmen) relative to state regulators tend to bias utility costs upward, engage in less economic regulation, and give preferential treatment to the politically-active users relative to the politically-inactive users.

Suggestions for Future Research

The model discussed in Chapter II and expanded and applied in Chapter IV generated a number of implications regarding the behavior of private and public water utility managers. The empirical results presented in Chapters V, VI, and VII attest to the power and potential of property rights analysis. There is need, however, for further theoretical and empirical efforts in property rights theory.

Economists are still uneasy about allowing themselves the liberty of discussing what constitutes the components of the decision maker's utility function. More research is needed by economists and other social scientists on the factors that decision makers consider as important sources of satisfaction. The dividends of such research will come in the form of an expanded set of behavioral implications.

A wider range of application of the property rights theory is needed. The utility maximization model can be used to derive behavioral implications for any type of decision maker as long as the decision maker's property rights can be distinguished. Conceivably, political models, models of comparative economic systems, models of childhood behavior and so on could be built in the property rights context. Further, economists need to work closer with other disciplines such as psychology, sociology, political science, and management when formulating property rights models.

Work remains to be done in providing more conclusive tests of the efficiency, price, and quality hypotheses. The availability of disaggregated cost data would allow the estimation of cost functions for each water system component. It would also make it easier to accurately estimate long-run marginal costs which are needed for the price discrimination hypothesis. There is also a need for more accurately assigning marginal costs to the various user groups. Access to complete rate schedules together with detailed cost and production data are needed if simultaneous-equation models are to be used to minimize simultaneity problems that exist in the regulated environment. If national chemical contaminant, water operator grade level, surveillance, and other important data become available on a firm level, there is need for a test of the water quality hypothesis for the nation as a whole to ensure that the results presented in Chapter V are not unique to Oklahoma. Other aspects of product quality should be investigated as well such as customer service and water pressue at the tap.

Finally, there appear to have been virtually no attempts to determine the importance of ownership relative to other factors that affect the manager's opportunity set. More work needs to be done to determine what industry characteristics are consistently more important determinants of managerial behavior. There is still much need to investigate the importance of local regulatory-political forces on the public manager's behavior and to distinguish that effect from the ownership effect on managerial behavior.

A SELECTED BIBLIOGRAPHY

(1) Adams, Oscar H. "The Safe Drinking Water Act and the Water Utility Owner." Journal of the American Water Works Association, Vol. 69, No. 5 (1977), pp. 229-233.

(2) Alchian, Armen A. "Some Economics of Property Rights." Il Politico, Vol. 30, No. 4 (1965), pp. 816-829.

(3) Alchian, Armen A. and Harold Demsetz. "Production, Information Costs, and Economic Organization." American Economic Review, Vol. 62, No. 2 (1972), pp. 777-795.

(4) Alchian, Armen A. and Reuben A. Kessel. "Competition, Monopoly, and the Pursuit of Money." Aspects of Labor Economics. (National Bureau of Economic Research, Special Conference Series, Vol. 14) Princeton: Princeton University Press, 1962, pp. 157-175.

(5) American Water Works Association. "The Water Utility in the United States." Journal of the American Water Works Association, Vol. 58, No. 7 (1966), pp. 767-785.

(6) __________. Water Utility Salaries and Wages, 1968, Committee Report. New York, NY, 1968.

(7) __________. "Taxation and Revenue Allocation for Municipally Owned Water Utilities." Journal of the American Water Works Association, Vol. 66, No. 11 (1974), pp. 623-627.

(8) __________. Operating Data for Water Utilities, 1970 and 1965. New York, NY, 1974.

(9) __________. "A Survey of Quality Control Practices in Water Bacteriology Laboratories." Journal of the American Water Works Association, Vol 72, No. 1 (1980), pp. 10-20.

(10) Averch, Harvey and Leland L. Johnson. "Behavior of the Firm Under Regulatory Constraint." American Economic Review, Vol. 52, No. 5 (1962), pp. 1052-1069.

(11) Beatty, Kathleen and John C. Pierce. "Representation and Public Involvement in Water Resource Politics: A Comparison of Six Participant Types." Water Resources Bulletin, Vol. 12, No. 5 (1976), pp. 1005-1017.

(12) Becker, Gary S. The Economics of Discrimination. Chicago: University of Chicago Press, 1957.

(13) Bernard, C.I. The Functions of the Executive. Cambridge: Harvard University Press, 1962.

(14) Boiteux, Marcel. "Peak-Load Pricing." Journal of Business, Vol. 33, No. 2 (1960), pp. 157-179.

(15) Boiteux, Marcel and P. Stasi. "The Determination of Costs of Expansion of an Interconnected System of Production and Distribution of Electricity." Marginal Cost Pricing in Theory and Practice. Ed. J.R. Nelson. Englewood Cliffs: Prentice-Hall, Inc., 1964.

(16) Call Jr., Harrison. "The Interrelationships Between Water Consumption and Rates." Journal of the American Water Works Association, Vol. 69, No. 1 (1977), pp. 52-55.

(17) Cheung, Steve N.S. "Private Property Rights and Share-Cropping." Journal of Political Economy, Vol. 76, No. 2 (1968), pp. 1107-1122.

(18) __________. "The Structure of a Contract and the Non-Exclusive Resource." Journal of Law and Economics, Vol. 13, No. 1 (1970), pp. 49-69.

(19) Clarkson, Kenneth W. "Some Implications of Property Rights in Hospital Management." Journal of Law and Economics, Vol. 15, No. 2 (1972), pp. 363-384.

(20) Coase, Ronald H. "The Problem of Social Cost." Journal of Law and Economics, Vol. 3 (1960), pp. 1-44.

(21) Colberg, Marshall R. "Utility Profits: A Substitute for Property Taxes." National Tax Journal, Vol. 8, No. 4 (1955), pp. 382-387.

(22) Conover, W.J. Practical Nonparametric Statistics. 2nd edition. New York: John Wiley and Sons, 1980.

(23) Crain, Mark W. and Asghar Zardkoohi. "A Test of the Property Rights Theory of the Firm: Water Utilities in the United States." Journal of Law and Economics, Vol. 21, No. 2 (1978), pp. 395-408.

(24) __________. "Public Sector Expansion: Stagnant Technology or Attenuated Property Rights?" Southern Economic Journal, Vol. 46, No. 4 (1980), pp. 1069-1082.

(25) Curran, Terence P. "Water Resources Management in the Public Interest." Water Resources Bulletin, Vol. 7, No. 1 (1971), pp. 33-39.

(26) Danielson, Leon E. "An Analysis of Residential Demand for Water Using Micro Time-Series Data." Water Resources Research, Vol. 15, No. 4 (1979), pp. 763-769.

(27) Davies, David G. "The Efficiency of Public Versus Private Firms, The Case of Australia's Two Airlines." Journal of Law and Economics, Vol. 14, No. 1 (1971), pp. 149-165.

(28) De Alessi, Louis, "Implications of Property Rights for Government Investment Choices." American Economic Review, Vol. 59, No. 1 (1969), pp. 13-24.

(29) __________. "Private Property and Dispersion of Ownership in Large Corporations." Journal of Finance, Vol. 28, No. 2 (1973), pp. 839-851.

(30) __________. "Managerial Tenure Under Private and Government Ownership in the Electric Power Industry." Journal of Political Economy, Vol. 82, No. 1 (1974), pp. 645-653.

(31) __________. "An Economic Analysis of Government Ownership and Regulation: Theory and Evidence from the Electric Power Industry." Public Choice, Vol. 19 (1974), pp. 1-42.

(32) __________. "Ownership and Peak-Load Pricing in the Electric Power Industry." Quarterly Review of Business and Economics, Vol. 17, No. 4 (1977), pp. 7-26.

(33) __________. "The Economics of Property Rights: A Review of the Evidence." (Unpub. manuscript, Florida State University, 1978.)

(34) Demsetz, Harold. "Some Aspects of Property Rights." Journal of Law and Economics, Vol. 9 (1966), pp. 61-70.

(35) __________. "Toward a Theory of Property Rights." American Economic Review, Vol. 57, No. 1 (1967), pp. 347-359.

(36) __________. "The Growth of Bureaucracy." (Unpub. paper presented at the Public Choice Society Meetings, New Orleans, March, 1977.)

(37) De Salvia, D.N. "An Application of Peak-Load Pricing." Journal of Business, Vol. 42, No. 4 (1969), pp. 458-476.

(38) Eckert, Ross D. "On the Incentives of Regulators: The Case of Taxicabs." Public Choice, Vol. 14 (1973), pp. 83-99.

(39) Frech III, H.E. "The Property Rights Theory of the Firm: Empirical Results from a Natural Experiment." Journal of Political Economy, Vol. 84, No. 1 (1976), pp. 143-152.

(40) Goolsby, William C. Optimal Pricing and Investment in City Water: Model for Urban Finance. (Unpub. Ph.D. dissertation, University of Wisconsin, 1974.)

(41) Gordon, R.A. Business Leadership in the Large Corporation. Berkeley: University of California Press, 1961.

(42) Gysi, Marshall and Daniel P. Loucks, "Some Long-Run Effects of Water-Pricing Policies." Water Resources Research, Vol. 7, No. 6 (1971), pp. 1371-1382.

(43) Hanke, Steve H. "Pricing Urban Water." Public Prices for Public Products. Ed. Selma Mushkin. Washington, DC: The Urban Institute, 1972.

(44) Hanke, Steve H. and John J. Boland. "Water Requirements or Water Demands?" Journal of the American Water Works Association, Vol. 63, No. 11 (1971), pp. 677-681.

(45) Hansman, Jean M. Urban Water Service Pricing: Public vs. Private Firms. (Unpub. Ph.D. dissertation, George Washington University, 1976.)

(46) Harnett, Donald L. Introduction to Statistical Methods. 2nd edition. Reading: Addison-Wesley Publishing Co., 1975.

(47) Hazen, Richard. "Taxation as a Source of Water Utility Income." Journal of the American Water Works Association, Vol. 60, No. 10 (1968), pp. 1095-1103.

(48) Hennigan, John F. Economic Differences Between Public and Private Ownership: The Water Utility Case. (Unpub. Ph.D. dissertation, University of West Virginia, 1976.)

(49) Hiller, Robert L. "Potential Liabilities Faced by Utilities in Supplying Drinking Water." Journal of the American Water Works Association, Vol. 69, No. 6 (1977), pp. 290-292.

(50) Hilton, George W. "The Basic Behavior of Regulatory Commissions." American Economic Review, Vol. 62, No. 1 (1972), pp. 47-54.

(51) Hines, Lawrence G. "The Long-Run Cost Function of Water Production for Selected Wisconsin Communities." Land Economics, Vol. 45 (1969), pp. 133-140.

(52) Hinomoto, Hirohide. "Unit and Total Cost Functions for Water Treatment Based on Koenig's Data." Water Resources Research, Vol. 7, No. 5 (1971), pp. 1064-1069.

(53) Hirshleifer, J., J.C. DeHaven, and J.W. Milliman. Water Supply: Economics, Technology, and Policy. Chicago: University of Chicago Press, 1960.

(54) Intriligator, Michael D. Econometric Models, Techniques, and Applications. Englewood Cliffs: Prentice-Hall, Inc., 1978.

(55) Jackson, Raymond. "Regulation and Electric Utility Rate Levels." Land Economics, Vol. 45 (1969), pp. 372-376.

(56) Jeffrey, Edgar A., and J.E. Singley. "Benefits and Costs of Water Quality Improvements." Journal of the American Water Works Association, Vol. 70, No. 12 (1978), pp. 675-679.

(57) Kafoglis, Milton Z. "Output of the Restrained Firm." American Economic Review, Vol. 59, No. 2 (1969), pp. 583-586.

(58) Keig, N.G., C.W. Fristoe, and F.O. Goddard. "Structure of Publicly-Owned Water Utilities." Journal of the American Water Works Association, Vol. 62, No. 4 (1970), pp. 215-219.

(59) Keller, Charles W. "Pricing of Water." Journal of the American Water Works Association, Vol. 69, No. 1 (1977), pp. 10-12.

(60) Kmenta, Jan. Elements of Econometrics. New York: The MacMillan Co., 1971.

(61) Linaweaver, Jr., F.P. and C. Scott Clark. "Costs of Water Transmission." Journal of the American Water Works Association, Vol. 56, No. 12 (1964), pp. 1549-1560.

(62) Luthin, John C. "Rate Making Practices of State Regulatory Commissions." Journal of the American Water Works Association, Vol. 68, No. 9 (1976), pp. 490-491.

(63) MacEwen, Peter K. "Municipal and Industrial Water Rates." Journal of the American Water Works Association, Vol. 69, No. 10 (1977), pp. 519-521.

(64) Machlup, Fritz. "Theories of the Firm: Marginalist, Behavioral, Managerial." American Economic Review, Vol. 57, No. 1 (1967), pp. 1-33.

(65) Maddala, G.S. Econometrics. New York: McGraw-Hill Book Co., 1977.

(66) Mann, Patrick. "The Political Influence of Residential Consumers on Water Rates." Water Resources Bulletin, Vol. 9 No. 5 (1973), pp. 976-984.

(67) __________. "User Power and Electricity Rates." Journal of Law and Economics, Vol. 17, No. 2 (1974), pp. 433-443.

(68) __________. "Water Rates-An Evaluation of Options." Journal of the American Water Works Association, Vol. 69, No. 2 (1977), pp. 84-88.

(69) Mann, Patrick C. and John L. Mikesell. "Ownership and Water System Operation." Water Resources Bulletin, Vol. 12, No. 5 (1976), pp. 995-1004.

(70) Mayer, Thomas. "The Distribution of Ability and Earnings." Review of Economics and Statistics, Vol. 42, No. 2 (1960), pp. 189-195.

(71) McLeod, Robert J. "Place of Federal Grants and Loans in Utility Financing." Journal of the American Water Works Association, Vol. 60, No. 10 (1968), pp. 1104-1108.

(72) McKean, Roland N. "Products Liability: Implication of Some Changing Property Rights." Quarterly Journal of Economics, Vol. 84, No. 4 (1970), pp. 611-626.

(73) Mercer, Lloyd J. and W. Douglas Morgan. "Political Participation and Water Rates, A Closer Look." Water Resources Bulletin, Vol. 10, No. 6 (1974), pp. 1302-1307.

(74) Meyer, Robert A. "Publicly Owned Versus Privately Owned Utilities: A Policy Choice." Review of Economics and Statistics, Vol. 57, No. 4 (1975), pp. 391-399.

(75) Mikesell, John L. "Regulation and Electric Utility Rates Structure." Mississippi Valley Journal of Economics and Business, Vol. 7, No. 1 (1971), pp. 82-89.

(76) Moon, Charles R. "Legal Aspects." Journal of the American Water Works Association, Vol. 60, No. 3 (1968), pp. 258-262.

(77) Moore, Charles G. "Has Electricity Regulation Resulted in Higher Prices? An Econometric Evaluation Using a Calibrated Regulatory Input Variables." Economic Inquiry, Vol. 13, No. 2 (1975), pp. 207-220.

(78) Moore, Thomas G. "The Effectiveness of Regulation of Electric Utility Prices." Southern Economic Journal, Vol. 36, No. 4 (1970), pp. 365-375.

(79) Morgan, Douglas W. "Investor Owned Vs. Publicly Owned Water Agencies: An Evaluation of the Property Rights Theory of the Firm." Water Resources Bulletin, Vol. 13, No. 4 (1977), pp. 775-781.

(80) Newhouse, Joseph P. "Toward a Theory of Nonprofit Institutions: An Economic Model of a Hospital." American Economic Review, Vol. 65, No. 1 (1970), pp. 64-74.

(81) Nichols, Alfred. "Stock Versus Mutual Savings and Loan Associations: Some Evidence of Differences in Behavior." American Economic Review, Vol. 57, No. 1 (1967), pp. 337-379.

(82) Niskanen, William A. "The Peculiar Economics of Bureaucracy." American Economic Review, Vol. 58, No. 1 (1968), pp. 293-305.

(83) Noll, Roger G. "The Behavior of Regulatory Agencies." Review of Social Economy, Vol. 29, No. 1 (1971) pp. 15-19.

(84) National Oceanic and Atmospheric Administration. Climatological Data. Ashville, NC: National Climatic Center, 1978-1979.

(85) Oklahoma State Department of Health, Environmental Health Services. Public Water Supply Report, 1979. Oklahoma City: Oklahoma State Department of Health Print Shop, (1980).

(86) __________. Model State Information System, Public Water System Inventory Subsystem: Comprehensive Report--Selection Extract File. Oklahoma City: Computer Printout, July, 1980.

(87) Orlob, Gerald T. and Marvin R. Lindorf. "Costs of Water Treatment in California." Journal of the American Water Works Association, Vol. 50, No. 1 (1958), pp. 45-55.

(88) Pashigan, Peter B. "Consequences and Causes of Public Ownership of Urban Public Transit Facilities." Journal of Political Economy, Vol. 84, No. 2 (1976), pp. 1239-1259.

(89) Patterson, W.L. "Comparison of Elements Affecting Rates in Water and Other Utilities." Journal of the American Water Works Association, Vol. 57, No. 5 (1965), pp. 554-560.

(90) Peltzman, Sam. "Pricing in Public and Private Enterprises: Electric Utilities in the United States." Journal of Law and Economics, Vol. 14, No. 1 (1971), pp. 109-147.

(91) Posner, Richard A. Economic Analysis of Law. Boston: Little, Brown, and Co., 1972.

(92) Primeaux, Jr. Walter J. and Randy A. Nelson. "An Examination of Price Discrimination and Internal Subsidization by Electric Utilities." Southern Economic Journal, Vol. 47, No. 1 (1980), pp. 84-99.

(93) Rima, Ingrid Hahne. Development of Economic Analysis. 3rd ed. Homewood, IL: Richard D. Irwin, Inc., 1978.

(94) Roberts, D.R. "A General Theory of Executive Compensation Based on Statistically Tested Propositions." Quarterly Journal of Economics, Vol. 70, No. 2 (1956), pp. 270-294.

(95) S. 433, Public Law 93-523. Safe Water Drinking Water Act. 93rd Congress. Washington, D.C., December 16, 1974.

(96) Sampson, Roy J. "Public Ownership Constraints on Utility Management." Journal of the American Water Work Association, Vol. 61, No. 10 (1969), pp. 495-498.

(97) Sampson, Roy J. and Martin T. Farris. Public Utilities: Regulation, Management, and Ownership. Boston: Houghton Mifflin Co., (1973).

(98) Simon, Herbert A. "The Compensation of Executives." Sociometry. Vol. 20 (1957), pp. 32-35.

(99) __________. Administrative Behavior. 2nd edition, New York: Macmillan (1957).

(100) Smith, Courtland L. "Contrasts in Community Action and Opinion." Water Resources Bulletin, Vol. 10, No. 5 (1974), pp. 877-883.

(101) Sonnen, Michael B. "Benefit Estimation for Quality Improvements." Journal of the American Water Works Association, Vol. 68, No. 11 (1976), pp. 600-603.

(102) Stacha, John H. "Several Water Treatment Alternatives." Southwest and Texas Water Works Journal, Vol. 61, No. 3 (1979), pp. 22-27.

(103) Stigler, George J. "The Theory of Economic Regulation." Bell Journal of Economics, Vol. 2, No. 1 (1971), pp. 3-18.

(104) Stigler, George J. and Claire Friedland. "What Can Regulators Regulate? The Case of Electricity." Journal of Law and Economics, Vol. 5 (1962), pp. 1-13.

(105) Tullock, Gordon. Politics of Bureaucracy. Washington, DC: Public Affairs Press, 1965.

(106) U.S. Department of Commerce, Bureau of the Census. Census of Manufacturers, 1972. Vol. 3, No. 1 and 2, "Area Statistics." Washington, DC: U.S. Government Printing Office, 1976.

(107) U.S. Department of Health, Education, and Welfare, Bureau of Water Hygiene. Community Water Supply Study-Analysis of National Survey Findings. Washington, DC: U.S. Government Printing Office, 1970.

(108) U.S. Environmental Protection Agency, Office of Water Supply. Survey of Operating and Financial Characteristics of Community Water Systems. Washington: U.S. Government Printing Office, 1977.

(109) Williamson, Oliver E. "Managerial Discretion and Business Behavior." American Economic Review, Vol. 53, No. 2 (1963), pp. 1032-1057.

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