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NOMINAL CONTRACTING, ACCOUNTING METHODS, AND THE VALUATION OF RATE-REGULATED FIRMS

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1. INTRODUCTION

It is widely believed that the accounting methods (procedures) used by regulated utilities affect their operating cash flows since rate commissions rely on these methods to determine allowable rates (prices) which can be charged to utility customers. Hence, the accounting choices made by utilities (with commissions' permission) may affect their values in two ways: first by affecting the present value of utilities' operating cash flows, and second by the information conveyed to market participants by the resulting accounting numbers.[1]

It is conceivable then that alternative accounting methods could lead to different valuations of the same utilities. But the way in which they could is not so obvious. For example, rate commissions may operate in such a way that they effectively mitigate the influence of alternative accounting methods.

In this paper, I propose a model which shows how different accounting methods can affect the values of utilities. Essentially, the effects result from the fact that rate-regulation functions "as if" an implicit nominal contract exists between investors and utility customers, in which case the value of a rate-regulated firm will behave much like the value of a long-term bond; i.e., it will be inversely related to unanticipated changes in nominal interest rates. In this context, regulatory accounting methods will partially determine the sensitivity of the value of a utility firm to unanticipated changes in market-determined nominal interest rates.

The primary testable implications of this analysis are that alternative regulatory accounting methods observed in practice will have different effects on the sensitivity of firm-value to unanticipated changes in interest rates.

The intuition behind these implications is that the longer it takes a utility firm to recover its investment in plant assets from its customers, the greater the sensitivity of firm-value to interest rate changes. Specifically, the sensitivity of firm-value to interest rate changes will be:

(1) less for rate-regulated firms that use the normalization method of accounting for the tax benefits of accelerated depreciation and investment tax credits than for firms that use the flow-through method of accounting for these tax benefits and,

(2) less for rate-regulated firms that are permitted to include construction-work-in-progress in their rate-bases than for firms that must capitalize an allowance for funds used during construction.

Focusing on the nominal contracting position of the common shareholders, vis-à-vis the preferred stockholders and the bondholders, leads to testable implications for security price behavior. Because preferred stock and debt are securities backed by explicit nominal contracts between the firm and their holders, the ultimate effects of these regulatory accounting methods on the valuation of rate-regulated firms will be observable as cross-sectional differences in the sensitivity of common stock returns to unanticipated changes in nominal interest rates. Thus, after controlling for the effects of capital structure and other factors, these implications can be tested using data on long-term interest rates and common stock returns. The results of empirical tests support these implications in that they indicate significant differences in the sensitivity of common stock returns of electric utility firms to unanticipated changes in nominal interest rates, and these can be attributed to differences in regulatory accounting methods.

The rest of this paper is organized as follows. Section 2 shows how rate-regulation functions "as if" a nominal contract exists between investors and utility customers, and that a role of regulatory accounting methods is to specify the terms of this implicit contract. In Section 3, I develop a static multiperiod valuation model for the stream of expected future operating cash flows from existing assets under rate-regulation, in order to facilitate an analysis of the effects of regulatory accounting methods on the valuation of rate-regulated firms. A comparative statics analysis of this model is then used to develop specific predictions about how different regulatory accounting methods lead to differential degrees of sensitivity of electric utility common stock returns to unanticipated changes in nominal interest rates. In Section 4, I provide the results of empirical tests of these predictions based on cross-sectional and time-series data for electric utilities over the time period 1960-1979. Section 5 contains a brief summary and conclusions.

2. NOMINAL CONTRACTING UNDER RATE-REGULATION

Nominal contracts (e.g., receivables and debt) are contracts that call for nominal dollar payments of specific amounts on prespecified dates. In general, the present value of a nominal contract is inversely related to unanticipated changes in the nominal discount rate, and, the longer the discount period, the greater the effect of a change in the discount rate on the present value of nominal cash flows to be received at some future date.

Firms in industries subject to rate of return regulation, such as the electric utility industry, have an implicit nominal contract with their customers that is administered by the regulatory agency. The similarities between this implicit contract and other nominal contracts do not result from the phenomenon of "regulatory lag."[2] Rather, the essential nominal elements of this contract are attributable to the widely held principle that a regulated public utility is allowed to recover only the costs it incurs to provide service to the public, and to earn a "fair" rate of return on the (unrecovered) capital supplied by the common stockholders. In the process of implementing this principle, regulatory practices do not permit realized nominal rates of return on common equity to vary systematically with realized inflation rates or with unanticipated changes in nominal interest rates. As a result, rate-regulation essentially functions "as if" a nominal contract exists between investors and customers.

2.1 RATE-REGULATION AS A NOMINAL CONTRACT

In order for an implicit nominal contract to exist, the "contract" must specify (or imply) the amounts and timing of future nominal cash flows to a utility firm. Under rate-regulation, the expected stream of future cash flows from utility operations can be broken down into two components: a return of capital, consisting of utility plant costs recovered from customers as these costs are passed on as allowable operating expenses, and a return on capital, which is equivalent to utility operating income (revenues less allowable operating expenses except interest, after taxes). The rate-making process results in periodically redetermined rate schedules such that a utility firm is permitted to earn operating income equal to a specified percentage (the "allowed rate of return") of the capital invested in utility plant (the firm's "rate-base").[3]

Regarding the return of capital, the ruling principle behind determination of allowable operating expenses is a general prohibition against the double counting of costs. To avoid double counting, the (undiscounted) return of capital stream over the life of the enterprise is limited to the total nominal dollar acquisition cost of utility plant assets. The periodic pattern of this stream of cash flows becomes "fixed" in nominal terms based on regulatory accounting methods (e.g., depreciation methods), that specify when and how much of the total allowable operating expenses associated with investments in utility plant are periodically passed on to the customers. The total allowable costs are limited to the acquisition costs of utility assets by defining the utility's "rate base" in terms of "unrecovered" costs only. By definition, then, the "return on capital" stream becomes determined by the time series of future nominal "allowed rates of return" applied to the nominal dollar balances of "unrecovered" costs at future points in time.[4] To the extent that this expected "return on capital" stream is fixed in nominal terms, electric utility rate-regulation will effectively function as a nominal contract.

Under conventional rate-making procedures, the allowed rate of return on common equity could include an inflation premium to compensate shareholders for expected future decreases in the real value of their nominal claims to "unrecovered" costs that result from expected increases in the price level.[5] But, it is questionable whether regulatory commissions actually permit realized accounting rates of return on common equity to vary directly with nominal market interest rates.

To provide some evidence on this issue, I plotted the annual average yields on long-term U. S. government bonds (BYLD) from Ibbotson and Sinquefield [1979], and realized annual accounting rates of return on common equity (ROE) for my sample of 73 electric utility firms for the time period 1959-1978. The results appear in Figure 1, and they show that while long-term U. S. government bond yields more than doubled over this period (from 4.2% to 8.6%), realized accounting rates of return to common equity for electric utilities ranged only between 10.2% and 12.9%. A statistical test of the relationship between realized accounting rates of return on equity and the inflation premium in long-term U. S. government bond yields confirmed this general lack of association.[6]

The main implication of viewing the outcome of the regulatory process as an implicit nominal contract is that the common shareholders of public utility firms occupy a position analogous to the bondholders and the preferred shareholders, since the value of their ownership claims will be negatively related to unanticipated changes in nominal interest rates.[7] Of course, the claims of the common shareholders are not totally fixed in nominal terms since they bear the residual risks of the firm's operating activities. Nevertheless the implicit contract with the common shareholders under rate-regulation has a significant nominal component, so viewing rate-regulation in these terms provides a useful device for understanding how the values of rate-regulated firms may be systematically related to unanticipated changes in nominal interest rate rates.

2.2 THE ROLE OF REGULATORY ACCOUNTING POLICIES

Since rate-regulation functions as a nominal contract, the time pattern of the return of capital stream can be altered by regulatory commissions through changes in accounting methods for any accruals consisting of noncash charges or credits to income, under the commissions' general authority to prescribe accounting rules for the firms they regulate. While the major accrual item is depreciation on plant and equipment, it turns out that commissions generally compute depreciation on a straight line basis for rate-making purposes. A more significant source of variation in accounting methods for noncash charges to income across commissions is the rate-making treatment of deferred income taxes due to the use of accelerated depreciation methods and shorter useful lives for tax purposes. In practice, the two alternatives employed are: the "flow-through" accounting method and the "normalization" accounting method.

In the case of flow-through accounting, the only noncash charge against a utility's operating revenues is book depreciation expense, computed on a straight-line basis. Income tax expense for accounting and rate-making purposes equals actual income taxes currently payable. In effect, the current tax reductions from the use of accelerated depreciation for tax purposes "flow through" to current income, thereby benefiting the present customers by reducing the firm's current prices, ceteris paribus.

Under normalization accounting, noncash charges against operating revenues are made for both depreciation and for a provision for deferred income taxes, with the latter amount equal to the tax savings resulting from the use of accelerated depreciation and shorter depreciable lives for tax purposes. From the standpoint of rate-making, the end result under normalization accounting is equivalent to the regulatory commission allowing additional depreciation expense beyond straight line depreciation (equal to the provision for deferred income taxes) as an operating expense immediately recoverable from present customers.[8] Therefore, past investments in utility plant will be recovered more rapidly under normalization accounting than under flow-through. This illustrates how a regulatory commission's election of either flow-through or normalization accounting for "book/tax" timing differences affects the implicit nominal contract between customers and investors.

The terms of this implicit nominal contract can also be affected by choices of other accounting methods prescribed by regulatory commissions regarding noncash charges or noncash credits to income. Somewhat related to the above is the choice of normalization or flow-through accounting treatment for the investment tax credit (ITC), resulting in the same kind of difference in operating cash flows as with deferred income taxes.[9] This is a general statement which may be altered by the specific blend of accounting methods used for deferred income taxes and the ITC. For the years studied here, however, such additional complications could be ignored.

A third kind of accounting method choice by the regulatory commission has the effect of creating noncash credits to income called an allowance for funds used during construction (AFC), during periods of construction, counter-balanced by an increase in the firm's rate-base and its future "book" depreciation expense once assets are completed. In effect AFC produces "negative" depreciation charges on plant assets under construction, to be offset later by additional (positive) depreciation charges after these assets are placed in service. An alternative is to allow construction-work-in-progress (CWIP) to be included in a utility firm's rate-base even though the assets are still under construction. Hence, capitalization of AFC postpones cost recovery (like flow-through), whereas the practice of including CWIP in the rate-base accelerates it (like normalization).

To summarize, normalization accounting and CWIP in the rate-base lead to additional noncash charges to income, whereas flow-through and capitalization of AFC lead to lower total noncash charges. The issue now is whether these differences in accounting methods actually translate into differences in the valuation of utility firms. This issue is addressed in the next section.

3. REGULATORY ACCOUNTING POLICIES AND NOMINAL CONTRACTING

If rate-regulation functions as a nominal contract, then systematic changes in firm value will take place over time as unanticipated changes in nominal interest rates occur. In this section I first describe a static valuation model for rate-regulated firms, and then use a comparative-statics analysis of this model to generate propositions about the differential effects of unanticipated changes in nominal interest rates on the values of rate-regulated firms that use different regulatory accounting methods. Tests of the resulting propositions are described in Section 4.

3.1 THE VALUE OF THE FIRM UNDER RATE-REGULATION

The starting point is a multiperiod valuation model that expresses the static value of a utility firm as of a point in time as a function of three state variables:

(1) the current risk-adjusted nominal discount rate or cost of capital, r, appropriate for cash flows at all future points in time with continuous compounding, under a "flat" term structure,[10]

(2) the allowed rate of return, s, which is the market's assessment of the nominal rate of return that the regulatory commission is currently expected to allow the firm to earn on its rate-base in all future periods,[11]

and (3) a firm specific parameter, h(r), that is a function of regulatory accounting policies and will act as the "multiple" at which the excess of s over r is capitalized as part of the value of the firm, given the discount rate, r.

To simplify notation, time subscripts have been omitted from these state variables, and the lack of a time subscript will be understood to designate relative time zero, or "now."

Since the role of regulatory accounting methods is to specify when the original cost of utility plant assets is recovered from the rate-payers over time, a general function representing the time pattern of cost recovery completes the specification of the model. This cost recovery pattern will be represented by a continuous function, z(t), which integrates to unity. Formally, let:

$$\int_0^t z(x)\,dx \equiv \text{the fraction of the firm's current rate-base "recovered" within t periods via noncash charges to utility operating income,} \tag{1}$$

and define the complement of this integral as:

$$b(t) \equiv 1 - \int_0^t z(x)\,dx \,. \tag{2}$$

The quantity b(t) denotes the fraction of the firm's current rate-base that is yet to be recovered from the rate-payers after t periods, and z(t) is the absolute rate of change in $b(t)$. Ignoring net working capital,[12] and momentarily abstracting from construction-work-in-progress, $b(t)$ depicts the time path of one dollar of the firm's current rate-base, so $b(t)$ will be referred to as the "rate-base evolution function." By definition $b(0) = 1$, and $b(t)$ will eventually go to zero after some finite number of periods, n.

If the best current assessment of the nominal rate of return the regulatory commission will allow the firm to earn on its rate-base is the same for all future periods, then knowledge of the time path of the firm's rate-base is sufficient to describe the stream of expected future cash flows to the firm under rate-regulation. Given the rate base evolution function, $b(t)$, and the cost recovery function, $z(t)$, an expression for the stream of expected future operating cash flows from assets in place at $t = 0$, which will be denoted by $k(t)$, may be written as:

$$k(t) = s\ b(t) + z(t). \qquad (3)$$

The right hand side of (3) can be loosely interpreted as "instantaneous" cash flow from operations at t, consisting of a "return on capital," $s \cdot b(t)$, and a "return of capital," $z(t)$.

A particularly simple closed form valuation formula can be derived in the form of a market-to-book-value ratio by discounting the stream $k(t)$ at the firm's cost of capital. Assuming the net present value of "true" growth opportunities[13] is small, the market value of the firm per dollar of book value, which will be denoted as $v(r,s)$ to indicate that it is conditional on the allowed rate of return, s, and the discount rate, r, may be written as:

$$v(r,s) = \int_0^n [s\ b(t) + z(t)]\ e^{-rt}\ dt. \qquad (4)$$

To appreciate the intuition behind this valuation formula, visualize receiving an "instantaneous" cash flow of $z(t)$ at time t, after having received a continuous cash yield of s percent per period on it for t periods, such that $z(t)$ is the face value of a continuous coupon bond maturing at t. Then v(r,s) in equation (4) represents the value of an appropriately constructed portfolio of such bonds, each carrying the same coupon rate, s, but maturing on different dates.

Since knowledge of the function z(t) is sufficient to describe b(t) and vice versa, equation (4) can be simplified. Integration by parts on the definite integral involving z(t) yields:

$$\int_0^n z(t)\, e^{-rt}\, dt = 1 - r \int_0^n b(t)\, e^{-rt}\, dt. \tag{5}$$

To simplify notation, let h(r) denote the Laplace transform of b(t), such that:

$$\begin{aligned} h(r) &\equiv \int_0^\infty b(t)\, e^{-rt}\, dt \\ &= \int_0^n b(t)\, e^{-rt}\, dt, \end{aligned} \tag{6}$$

(where the last equality follows from the fact that $b(t) = 0$ for $t \geq n$). In words, h(r) represents the present value of a cash flow stream described by the function b(t). Then using (5) and (6), equation (4) can be rewritten as:

$$v(r,s) = s\, h(r) + [1 - r\, h(r)], \tag{7}$$

and equation (7) may be further simplified to:

$$v(r,s) = 1 + (s - r)\, h(r). \tag{8}$$

In equation (7), the term $s \cdot h(r)$ represents the present value of the "return on capital" portion of the stream of expected future operating cash flows under rate-regulation from assets existing at $t = 0$, and the term $[1 - r\, h(r)]$ represents the present value of the "return of capital" portion of this stream. Alternatively, in (8), the total value of this stream is equal to one plus the excess of the allowed rate of return, s, over the discount rate, r, capitalized at a "multiple" equal to h(r). This "multiple" is a function of the discount rate, r, but it is also a transformation of the rate-base evolution function b(t). Thus, the "multiple," h(r), is also determined by the firm's "cost recovery pattern" which, in turn, depends on regulatory accounting methods.

To illustrate the effect of alternative regulatory accounting methods on the parameter h(r), and ultimately on the market to book value ratio, v(r,s), consider two generalized cost recovery functions, $z^A(x)$ and $z^P(x)$, where the superscripts A and P indicate that the time pattern of cost recovery is "accelerated" under cost recovery pattern A (e.g., normalization) relative to recovery pattern P (e.g., flow-through), under which the recovery of costs is "postponed" relative to cost recovery pattern A. By definition, these accounting procedures require that:

$$\int_0^t z^A(x)\,dx \geq \int_0^t z^P(x)\,dx, \quad \text{for all } t > 0. \qquad (9)$$

Expression (9) simply says that the fraction of the firm's current rate-base that is recovered via noncash charges to utility operating income is greater under cost recovery pattern A than under cost recovery pattern P, at all future points in time. Alternatively, one could say that the cumulative time distribution of costs recovered from the rate-payers under cost recovery pattern A "dominates" the cumulative time distribution of costs recovered under cost recovery pattern P.

Furthermore, by substituting from equation (2), expression (9) implies that:

$$b^A(t) \leq b^P(t), \quad \text{for all } t \geq 0 . \qquad (10)$$

The inequality in (10) says that the rate-base evolution function determined by cost recovery pattern A lies on or below the rate-base evolution function determined by cost recovery pattern P. Figure 2 illustrates the relationship between $b^A(t)$ and $b^P(t)$ described by expression (10).

To see the effects of different time patterns of cost recovery on the value of the firm, consider two otherwise identical firms that employ different regulatory accounting methods, which will be identified by the superscripts A and P, corresponding to the resulting cost recovery patterns. The essential results follow directly from expression (10), from which the following proposition can be derived.

PROPOSITION 1: The "multiple," $h(r)$, at which the excess of the allowed rate of return, s, over the cost of capital, r, is capitalized, is greater for firm P than for firm A, i.e.,

$$h^P(r) > h^A(r).$$

PROOF: By definition:

$$h^P(r) - h^A(r) = \int_0^n [b^P(t) - b^A(t)]\, e^{-rt} dt > 0. \tag{11}$$

The difference between $h^P(r)$ and $h^A(r)$ will be positive because the rate-base evolution function for firm P always lies on or above that for firm A, which means that the bracketed quantity in (11) will always be nonnegative.

Intuitively, the "multiple" at which the excess of the allowed rate of return, s, over the cost of capital, r, is capitalized, is greater for firm P than for firm A because firm P is permitted to earn this excess return on a relatively larger rate-base than the rate-base of firm A, in all future periods. Thus, an immediate consequence of Proposition 1 and equation (8) is:

PROPOSITION 2: Holding the allowed rate of return and the cost of capital constant across firms, the market-to-book-value ratio for firm P will be greater than (less than) that of firm A, and both ratios will be greater than (less than) one, when the allowed rate of return is greater than (less than) the cost of capital. Furthermore, when the allowed rate of return is equal to the cost of capital, both market to book value ratios will equal one. Formally, these relationships are:

$$v^P(r,s) > v^A(r,s) > 1 \qquad \text{when } s > r,$$
$$v^P(r,s) = v^A(r,s) = 1 \qquad \text{when } s = r, \qquad (12)$$
$$\text{and: } v^P(r,s) < v^A(r,s) < 1 \qquad \text{when } s < r.$$

Essentially, Proposition 2 holds because a greater multiple is used for firm P than for firm A to capitalize the excess of the allowed rate of return, s, over the cost of capital, r. When this excess is positive, the result will be a relatively greater value for firm P than for firm A; however when this excess is negative, the result will be the reverse.

Figure 3 illustrates the relative positions of $v^P(r,s)$ and $v^A(r,s)$ described in Proposition 2, where the respective market values of firm P and firm A (relative to their book values) are plotted as functions of the cost of capital, r, for a given value of the allowed rate of return, s. In Figure 3, it is clear that when the allowed rate of return, s, equals the cost of capital, r, then (holding s fixed) a change in r of any magnitude will produce a greater change in the ratio of market value to book value for firm P than for firm A. Since both market to book value ratios initially equal one when s equals r, any movements from this initial position in Figure 3 along the horizontal axis corresponding to changes in the discount rate, r, will produce a greater absolute percentage change in the value of firm P than in the value of firm A. Hence, from this initial position, the sensitivity of firm value to any change in the discount rate r will always be greater for firm P than for firm A.

To generalize this observation to the entire range of values of r in Figure 3, it is sufficient to show that in all cases where the allowed rate of return, s, initially differs from the cost of capital, r, the absolute percentage rate of change in the function $v^P(r,s)$ exceeds that of the function $v^A(r,s)$. Formally, this requires:

$$\frac{\left|\frac{d}{dr}\,v^P(r,s)\right|}{v^P(r,s)} \geq \frac{\left|\frac{d}{dr}\,v^A(r,s)\right|}{v^A(r,s)}, \quad \text{for all values of r and s.} \tag{13}$$

Then, because the absolute percentage change in firm value for any discrete change in the discount rate is the product of such absolute percentage rates of change for infinitesimally small changes in the discount rate, expression (13) implies that the value of firm P will always be more sensitive to discrete changes in interest rates than the value of firm A.

The numerators of the fractions in expression (13) represent the absolute slopes of the value functions depicted in Figure 3. It can be shown that the absolute slope of the value function for firm P always exceeds that of firm A when the allowed rate of return, s, exceeds the cost of capital, r,--i.e., to the left of the point where s = r in Figure 3. Somewhere to the right of the point where s = r, the direction of the inequality between the slopes of these value functions will eventually reverse as the discount rate, r, becomes large relative to the allowed rate of return, s.[14] This means that when the allowed rate of return exceeds the cost of capital (s > r), both the numerator and the denominator of the expression on the left-hand side of the inequality in (13) will exceed their counterparts on the right-hand side. When the allowed rate of return is less than the cost of capital (s < r), the direction of the inequality between the denominators of these expressions is reversed, but the direction of the inequality between their numerators is generally indeterminate. Therefore, further analysis is needed to show when the inequality in (13) can be expected to hold in general. This analysis will require considering more primitive properties of the alternative cost recovery patterns for firms A and P than those underlying Propositions 1 and 2 and Figure 3, which required only that the rate-base evolution function for firm P lie on or above that of firm A.

3.2 ALTERNATIVE REGULATORY ACCOUNTING POLICIES AND THE DURATION OF THE STREAM OF EXPECTED FUTURE CASH FLOWS FROM OPERATIONS UNDER RATE-REGULATION

In this section I describe sufficient conditions for the value of firm P to be more sensitive to interest rate changes than the value of firm A, and then show how these conditions are related to alternative regulatory accounting methods. The first step in the analysis is to derive a general expression for the absolute percentage change in v(r,s) with respect to a change in r. Recall that v(r,s) is just an expression for the present value of the stream of expected future cash flows from operations under rate-regulation, k(t), which is "fixed" in nominal dollars. An expression for the absolute percentage change in the value of this stream with respect to a (one unit) change in the discount rate, r, which will be denoted as $\eta(r)$, can be written as follows:

$$\eta(r) \equiv \frac{\frac{-d}{dr}\, v(r,s)}{v(r,s)} = \frac{\int_0^n t\; k(t)\; e^{-rt}\; dt}{\int_0^n k(t)\; e^{-rt}\; dt} . \tag{14}$$

Equation (14) is simply an expression for the Macaulay (1938) measure of the "duration" of the cash flow stream k(t), which is a standard metric for describing the sensitivity of the values of bonds and other nominal contracts to unanticipated changes in interest rates. This measure is called duration because unlike an elasticity (which is a dimensionless number) duration is a measure that has dimension time (see Weil [1973]). For example, if the discount rate, r, is an annual rate, the duration, $\eta(r)$, of the cash flow stream k(t) is given in years by equation (14), and one would say that the longer the duration of this stream, the greater the sensitivity of firm value, v(r,s), to unanticipated changes in interest rates. Thus, comparing the duration of the stream of expected future cash flows from operations, k(t), for firm A with that of firm P is an integral intermediate step in the analysis because the ultimate objective is to focus on the partial effects of regulatory accounting methods on the sensitivity of firm value to interest rate changes.

In equation (14) above, the time until receipt of each "instantaneous" cash flow in the expected operating cash flow stream k(t) is weighted by its contribution to the present value of that stream. To compare the respective durations of different time patterns of cash flows, it is helpful to restrict attention to nonnegative cash flow streams. Then, the expression for duration given in (14) can be interpreted as the mean of a density function. That is, for any stream of nonnegative cash flows k(t), equation (14) says that the duration of that stream is the mean of a density function proportional to the quantity $k(t)\ e^{-rt}$ over the time interval $0 \leq t \leq n$. Formally, this density function will be denoted by f(t), and the corresponding (cumulative) distribution function will be denoted by F(t), defined as:

$$f(t) \equiv \frac{k(t)\ e^{-rt}}{\int_0^n k(t)\ e^{-rx}\ dt}, \text{ and } F(t) \equiv \frac{\int_0^t k(x)\ e^{-rx}\ dx}{\int_0^n k(x)\ e^{-rx}\ dx}. \qquad (15)$$

Both f(t) and F(t) are functions that describe the time distribution of components of the present value of the cash flow stream k(t). It is useful to interpret duration as the mean of such a distribution because comparing the respective durations of two different cash flow streams (and hence their relative sensitivity to interest rate changes) is mathematically equivalent to a comparison of means. However, for a utility firm, all of whose activities are subject to rate-regulation, the cumulative distribution function F(t) has a convenient economic interpretation as well because it represents the fraction of firm value derived from expected operating cash flows to be realized by time t. Hence, the function F(t) will be called the "value distribution function."

Using the concept of duration, it is now possible to state sufficient conditions for the value of firm P to be more sensitive to interest rate changes than the value of firm A where, as before, cost recovery is "accelerated" for firm A relative to that for firm P (or "postponed" for firm P relative to that for firm A). Holding the cost of capital and the allowed rate of return constant across firms, the value of firm A will be more sensitive to interest rate changes than the value of firm P if the inequality in expression (13) holds. Using the definition of duration, equation (14), this inequality can be rewritten as:

$$\eta^{A}(r) < \eta^{P}(r), \tag{16}$$

which requires that the duration of the stream of expected operating cash flows under rate-regulation for firm P exceed the duration of this stream for firm A.

Comparing the respective durations of these operating cash flow streams for firms A and P, which are distinguished only by the use of alternative regulatory accounting methods, requires that other factors be explicitly held constant across firms. To show how other factors must be held constant for expression (16) to hold, the analysis will proceed as a series of three propositions.

The most basic result is Proposition 3 below. This proposition presumes that all the firm's assets are nominal contracts and states that knowing the value distribution function $F^{A}(t)$ "dominates" the value distribution function $F^{P}(t)$ is sufficient to establish that (16) holds, so the sensitivity of firm value to interest rate changes will be greater for firm P than for firm A. That is, if the function representing the fraction of the value of firm A derived from cash flows to be realized by time t lies on or above the corresponding value distribution function for firm P, this is sufficient to establish the direction of the inequality between the respective durations of the underlying cash flow streams.

PROPOSITION 3: (Dominance Between Value Distribution Functions.) The duration of the stream of expected operating cash flows for firm A will be less than the duration of this stream for firm P if, at every point t in future time, a greater fraction of the value of firm A is derived from operating cash flows to be realized by time t than the corresponding fraction of firm value for firm P. Alternatively, this proposition may be written as:

$$\eta^A(r) < \eta^P(r), \text{ if}$$
$$F^A(t) \geq F^P(t) \qquad \text{for all } t. \tag{17}$$

PROOF: The duration of the cash flow stream $k^P(t)$ will exceed the duration of the cash flow stream $k^A(t)$ if the mean of a density function proportional to $k^P(t)\ e^{-rt}$ exceeds the mean of a density function proportional to $k^A(t)\ e^{-rt}$. A well-known sufficient condition for the required inequality in means is (17), or first-degree stochastic dominance of the corresponding cumulative distribution functions as outlined in Hadar and Russell [1969, p. 28-29].[15]

Intuitively, this proposition must be so because a greater fraction of the value of firm A is derived from cash flows received "up front" (that is, in the early periods) than that of firm P. In order to use this proposition to make a statement about the partial effects of regulatory accounting methods on the sensitivity of firm value to interest rate changes, it is necessary to show when a greater fraction of the value of firm A will be derived from cash flows to be realized by time t than that of firm P, and how this type of dominance is related to differences in the time pattern of cost recovery under rate-regulation produced by alternative regulatory accounting methods.

In principle, Proposition 3 permits the cost of capital, r, and the allowed rate of return, s, to differ across firms A and P, because the values of these parameters are subsumed in the expressions for the value distribution functions, $F^A(t)$ and $F^P(t)$. By successively holding the parameters r and s constant across firms, special cases of dominance between these value distribution functions can be shown to follow from the relationship between the expected operating cash flow streams, k(t), and then from the relationship between the cost recovery functions, z(t), for firms A and P respectively. These special cases are summarized in the two propositions described below, for which proofs are provided in Appendix 1.

Since the duration of any cash flow stream is generally a function of the discount rate, the first special case of dominance between value distribution functions can be derived by explicitly holding the cost of capital constant across firms. This is done in Proposition 4 below, which says that the dominance condition required in Proposition 3 will be satisfied if the expected operating cash flow streams for these two firms are related to one another in a particular way.

PROPOSITION 4: By holding the cost of capital constant across firms, a greater fraction of the value of firm A will be derived from expected operating cash flows to be realized by time t than the corresponding fraction of the value of firm P if the expected operating cash flows of firm A do not increase over time in proportion to those of firm P. Formally, this proposition is:

Holding the cost of capital, r, constant:

$$F^A(t) \geq F^P(t) \text{ for all } t, \text{ if}$$

$$\frac{k^A(t)}{k^P(t)} \text{ is a nonincreasing function of } t. \tag{18}$$

PROOF: See Appendix 1.

Intuitively, requiring the expected operating cash flows of firm A to be generally decreasing over time relative to those of firm P essentially means that firm A will have to receive proportionately more operating cash flows "up front" than firm P. Holding the cost of capital constant across firms ensures that this relationship between the expected operating cash flow streams of firms A and P will translate into the relationship between the value distribution functions required by Proposition 3. Again, in conjunction with Proposition 3, Proposition 4 can be used to say when the value of firm P will be more sensitive to interest rate changes than the value of firm A, in terms of the relationship between the expected operating cash flow streams under rate-regulation.

To show how alternative regulatory accounting methods affect the sensitivity of firm value to interest rate changes, it is necessary to link the properties of the expected operating cash flow streams, $k^A(t)$ and $k^P(t)$, to properties of the cost recovery functions, $z^A(t)$ and $z^P(t)$, that describe the "return of capital" components of these streams, for firms A and P, respectively. Since the stream of expected operating cash flows under rate-regulation consists of a "return on capital" component and a "return of capital" component, i.e., $k(t) = s\ b(t) + z(t)$, this can be done by holding the allowed rate of return, s, constant across firms A and P. Proposition 5 below shows that by holding the allowed rate of return constant, the relationship between the operating cash flow streams for firms A and P that is required in Proposition 4 will be obtained if the cost recovery functions for these two firms are related in precisely the same manner.

PROPOSITION 5: By holding the allowed rate of return constant across firms, the expected operating cash flows of firm A will not increase over time in proportion to the expected operating cash flows of firm P if the costs recovered under rate-regulation by firm A do not increase over time in proportion to the costs recovered under rate-regulation by firm P. Formally, this is:

Holding the allowed rate of return, s, constant:

$\frac{k^A(t)}{k^P(t)}$ will be a nonincreasing function of t, if

$\frac{z^A(t)}{z^P(t)}$ is a nonincreasing function of t. (19)

PROOF: See Appendix 1.

Combining the results of Propositions 3 through 5, if the cost of capital and the allowed rate of return are held constant across firms, the value of firm P will be more sensitive to interest rate changes than the value of firm A, provided the costs recovered under rate-regulation by firm A are generally decreasing over time in proportion to the costs recovered by firm P (i.e., on average, firm P takes longer to recover its investment in utility plant). However, condition (19) represents a stronger statement about the relationships between alternative cost recovery patterns than the condition underlying Propositions 1 and 2, which only required that the rate-base evolution function for firm P lie on or above that of firm A, because it can be shown that the former implies the latter, but not vice-versa (proof available on request). Thus, for Propositions 3 through 5 to lead to a rigorously derived conclusion about the partial effects of alternative regulatory accounting methods on the sensitivity of firm value to interest rate changes, condition (19) must be a plausible way to characterize the effects of these alternatives on the time pattern of cost recovery under rate-regulation.

In Appendix 2, I show that when the depreciable lives of assets acquired and the rate of growth in asset acquisitions are held constant across firms, condition (19) can be used to describe the partial effects of normalization versus flow-through accounting, as well as inclusion of CWIP in the rate-base versus capitalization of AFC, on the cost recovery pattern for a utility firm. Holding these factors constant, this condition follows as a natural consequence of pairwise comparisons of the differential effects of one of these sets of alternative accounting methods on the time pattern of cost recovery under rate-regulation, while the choice from the other set is held constant. For example, this condition will hold if firm A uses normalization accounting and firm P uses flow through, and both firms either capitalize AFC or include CWIP in the rate-base. Similarly, holding the choice between normalization and flow-through accounting constant, this condition will be satisfied if firm A includes CWIP in the rate-base while firm P capitalizes AFC. Therefore, one can say that, all other things equal, the duration of the stream of expected operating cash flows under rate-regulation will be greater for firm P than for firm A, when these firms are identified with alternative regulatory accounting methods as indicated above.[16]

3.3 TESTABLE IMPLICATIONS

The primary testable implications of this analysis pertain to the partial effects of alternative regulatory accounting methods on the sensitivity of firm value to unanticipated changes in nominal interest rates. To the extent rate-regulation functions "as if" a nominal contract exists between rate-payers and investors, the sensitivity of firm value to interest rate changes should be:

(1) less for rate-regulated firms that use normalization accounting for the tax benefits of accelerated depreciation and investment tax credits than for firms that use flow-through accounting for these tax benefits, and

(2) less for rate-regulated firms that include construction work in progress (CWIP) in the rate-base than those that capitalize an allowance for funds used during construction (AFC).

One additional step is needed before these implications can be tested using data on long-term interest rates and common stock returns for rate-regulated firms. Up to now, the effects of alternative accounting methods have been described in terms of the sensitivity of firm value to unanticipated interest rate changes, where the (total) value of the firm can be identified with the market value of all outstanding securities. However, the capital structures of rate-regulated firms typically comprise a mix of common stock, preferred stock, and long-term bonds, where the latter two classes of securities represent explicit nominal contracts between the firm and their holders. The presence of these nominal securities in the capital structures of rate-regulated firms could affect the implicit nominal contract between customers and the common shareholders, who are the residual owners of the firm.

While this may be shown in a more formal way (details available on request), ordinarily one would expect that a firm could reduce the sensitivity of the value of its common stock to unanticipated changes in interest rates by increasing financial leverage. However, under rate-regulation the situation is somewhat more complex, because only the "embedded," or contractual, costs of preferred stock and debt are passed on to utility customers. This means that when nominal interest rates increase, a rate-regulated utility might not gain from apparent opportunities to reinvest a portion of the cash "throw-off" from its operations at higher nominal interest rates until the claims of the creditors must be met. Essentially, this is because utility customers are entitled to the use of the capital supplied by the preferred stockholders and the bondholders at the historical "embedded" rates while these securities are outstanding. Thus, the rate-making treatment of the costs of preferred stock and debt can effectively prevent the residual equity holders from sharing in the wealth transferred away from creditors when unanticipated increases in nominal interest rates take place, because these wealth transfers are captured in the rate-making process, and passed on to customers in the form of lower rates. If so, the effects of unanticipated changes in interest rates on the value of common equity will be independent of the degree of financial leverage employed, and the effects of accounting methods cannot be offset by altering the degree of financial leverage. However, to be sure, differences in the use of financial leverage across firms will be controlled in the empirical tests.

4. EMPIRICAL TESTS FOR ACCOUNTING POLICY EFFECTS

This section reports the results of tests designed to pick up the partial effects of (1) normalization accounting versus flow-through accounting and (2) inclusion of CWIP in the rate-base versus capitalization of AFC on the sensitivity of the values of rate-regulated firms to unanticipated changes in nominal interest rates. In addition to controlling for leverage, the model leading to the identification of the effects of these accounting methods requires that the cost of capital, the allowed rate of return, the depreciable lives of assets acquired, and the rate of growth in asset acquisitions also be controlled in the tests.

As a first approximation, the cost of capital may be presumed to be the same for rate-regulated firms operating within a homogeneous industry environment, such as electric utilities. Hence, all of my tests are for electric utilities only.

The other factors are controlled for by diversifying away firm specific effects on common stock returns not systematically related to accounting methods, through the use of portfolios of firms. The technique employed to form portfolios, which isolates the effects of alternative regulatory accounting methods and controls for the effects of other factors, is an adaptation of the procedures used by Fama and MacBeth [1973]. This technique uses month-by-month cross-sectional multiple regressions of individual security returns on variables relevant to the valuation process to isolate the effects of one variable and to simultaneously control for the effects of the other variables on security returns. However, these cross-sectional regressions are simply an intermediate step in this technique, useful only because the time series of least squares values for the coefficients in such regressions can ultimately be interpreted as portfolio returns. Fama [1976, p. 320-37] describes this approach in detail, and refers to the resulting time series of coefficients as "least squares" portfolio returns.

4.1 PROPERTIES OF "LEAST SQUARES" PORTFOLIO RETURNS

In general, least squares portfolio returns are obtained from cross-sectional regression of the (month t) common stock returns for each firm i, r_i, on known values of P independent variables, x_{ip}, relevant to the valuation of firm i in month t, of the following form:

$$\tilde{r}_i = \tilde{\gamma}_0 + \sum_{p=1}^{P} \tilde{\gamma}_p x_{ip} + \tilde{e}_i, \tag{20}$$

where, to simplify notation, the subscript t, denoting the month for which stock returns are regressed on the independent variables, has been suppressed. The key properties of interest for the "least squares" values of the intercepts and the coefficients of the independent variables in these regressions are as follows (see Fama [1976, p. 328-29]). First, the "least squares" values of the coefficients, γ_p, $p = 0, 1, \ldots, P$, may be interpreted as portfolio returns for month t, because they can all be expressed as linear combinations of the common stock returns to individual firms.

In particular, the "least squares" value of the intercept, $\hat{\gamma}_0$, is the return for month t on a positive investment portfolio that has zero values for

x_p, for all $p \neq 0$. On the other hand, the "least squares" values of the coefficients of the independent variables, $\hat{\gamma}_p$ for $p \neq 0$, are the returns on zero investment (arbitrage) portfolios that have a value of unity for x_p, and have zero values for the other factors. This property is desirable because these arbitrage portfolios isolate the effects of one factor on security returns (e.g., choice of accounting method) while they "zero out" the effects of the remaining factors. However, in later analysis, it is most important to remember that these "least squares" portfolio returns are actual portfolio returns (i.e., the returns to trading strategies that could actually be implemented).

4.2 DATA AND EMPIRICAL MODELS

My sample of electric utility firms consists of all firms required to file annual reports with the SEC that were classified as electric utilities (SIC code 4911) or combination gas and electric utilities (SIC code 4931) that met the following selection criteria:

(1) The firm was a domestic (U.S.) utility,

(2) CRSP monthly returns data was available for the firm over the years 1960-1979, inclusive,

(3) Utility COMPUSTAT data was available for the firm over the years 1959-1978, inclusive.

(The time periods differed because of the need to form portfolios based on accounting data from each prior year.)

A total of 73 electric utility firms met these selection criteria. A significant fraction (38%) of the sample firms operated in multiple regulatory jurisdictions, meaning portions of those firms could have been subject to different regulatory accounting rules. Consequently, the use of flow-through or normalization accounting might not be a zero-one proposition for a particular firm. Indeed, "pure" cases of these two accounting methods should be regarded as the extremes on a continuum, with hybrid cases in between.

To distinguish normalizing firms from flow-through firms, I used the ratio of deferred income taxes to depreciation as a continuous measure for classifying utility firms on the basis of these accounting methods. Obviously, the value of this ratio for a pure flow-through firm would always be zero. Deferred taxes as reported by Utility COMPUSTAT includes all charges to offset federal and state income tax savings due to accelerated depreciation and amortization, guideline depreciation rates, and investment tax credits. Therefore, the operational definition of this ratio picked up both the effects of normalization versus flow-through accounting methods applied to depreciation book/tax timing differences, as well as analogous treatments applied to the investment tax credit.

Table 1 provides the details for the calculation of this ratio, along with similar ratio calculations for the six other variables used in the cross-sectional regressions to derive "least squares" portfolio returns. Except for AFC, the other variables are "control" variables. In contrast, the variable AFC (the ratio of AFC to depreciation) was used to form a time-series of portfolio returns in order to test the separate effects of capitalizing AFC versus including CWIP in the rate-base on the sensitivity of firm value to interest rate changes. Again, the use of these alternatives was not a zero-one proposition for a firm, since regulatory commissions often prescribed that CWIP may be included in the rate-base only for certain construction projects, and not for others.

Although the remaining variables in table 1 were intended to be "control" variables, a by-product of the "least squares" portfolio returns technique permitted measurement of the partial effects of these variables as well. The variable LEV was included to control for leverage, however it will allow for an indirect test of whether the regulators essentially pass on only the "embedded" costs of preferred stock and debt to utility customers. The inclusion of the control variables ROE, LIFE, and GROWTH follows directly from the development of the model, whereas the variable FUEL was included because the large oil price shocks of the mid-1970s could have led to greater than expected rates of inflation. Hence, the relative dependence of electric utility firms on high cost sources of fuel (such as oil and natural gas) might have affected the observed relationship between electric utility common stock returns and unanticipated changes in nominal interest rates during this time period.

Since I expected regulatory accounting methods to be consistently employed from period to period by a single firm, I tried to reduce measurement error in the accounting method variables by computing DFD and AFC for each firm as five year averages of the annual values of these ratios. Formally, "least squares" portfolio returns were computed for six arbitrage portfolios using the "least squares" values of the coefficients of the independent variables in the following cross-sectional regressions, across all 73 firms (subject to data availability), for each month of the 1960-1979 period:

$$\tilde{r}_{it} = \tilde{\gamma}_{0t} + \tilde{\gamma}_{1t}(DFD_{ij}) + \tilde{\gamma}_{2t}(AFC_{ij}) + \tilde{\gamma}_{3t}(LEV_{iy}) + \tilde{\gamma}_{4t}(ROE_{iy}) + \tilde{\gamma}_{5t}(LIFE_{iy}) + \tilde{\gamma}_{6t}(GROWTH_{iy}) + \tilde{\gamma}_{7t}(FUEL_{iy}) + \tilde{e}_{it}, \qquad (21)$$

where t is a month index, y is a year index for the year preceding the observation of security returns, and j is an index corresponding to y = 1,...,5, y = 6,...,10, y = 11,...,15, and y = 16,...,20, respectively, and the independent variables are defined in table 1.

Recall that to the extent rate-regulation functions as a nominal contract, the model predicts instantaneous changes in the market value of electric utility common stocks in response to unanticipated changes in nominal discount rates. However, the data available for testing these predictions consist of realized common stock returns measured over discrete time intervals, and not instantaneous common stock returns. The use of realized returns required a control for the effects of market-wide influences on common stock returns, which is incorporated in equation (22) below.

The objective of the empirical tests is to determine whether "least squares" portfolio returns, denoted $\tilde{\gamma}_{pt}$ (where the time subscript is now explicitly appended), are associated with unexpected percentage changes in long-term U.S. government bond yields (u_t^*), the proxy for unanticipated changes in nominal interest rates, adjusting for market returns (r_{mt}). Results were obtained from the following time-series multiple regressions:

$$\tilde{\gamma}_{pt} = \beta_{0p} + \beta_{1p} r_{mt} + \beta_{2p} u_t^* + \tilde{e}_t, \tag{22}$$

where r_{mt} is the CRSP value weighted monthly market index.

Details behind the calculation of the series representing unanticipated changes in interest rates (u_t^*) are summarized in table 2. Box-Jenkins estimation techniques were used to derive the unexpected component, $\hat{u}_t$, of the long-term U.S. government bond yield series, U_t, described in Ibbotson and Sinquefield [1979]. The variable u_t^* is the unanticipated percentage change in interest rates (calculated as $\hat{u}_t/U_{t-1}$) because the duration of any cash flow stream is inversely related to the level of the (nominal) discount rate. Since nominal discount rates varied over the 1960-1979 period, I scaled the unexpected component of U.S. government bond yields by the level of the discount rate in order to reduce heteroskedasticity in the time-series regressions.

But, this required the coefficients of u_t^* in these regressions to be interpreted as "unitless" elasticities, rather than as estimates of duration (for which the units would be read as years).

4.3 RESULTS

In order to interpret the results of estimating equation (22) for the arbitrage portfolios that represent the effects of accounting policies, it will be helpful to examine the implicit system of portfolio weights underlying the "least squares" values of the coefficients $\tilde{\gamma}_p$, $p = 1,\ldots,P$. Fama [1976, p. 334] derives this implicit system of weights for the case of a cross-sectional regression equation of common stock returns in month t, $\tilde{r}_i$, $i = 1,\ldots,N$, on one independent variable, x_{ip}, of the form:

$$\tilde{r}_i = \tilde{\gamma}_0 + \tilde{\gamma}_p x_{ip} + \tilde{e}_i, \tag{23}$$

where the time subscript, t, is again suppressed. Using $\overline{x}_p$ and σ_p^2 to denote the sample mean and sample variance of x_{ip}, respectively, the portfolio weight for security i in portfolio p, w_{ip}, which implicitly determines the contribution of that security to the "least squares" arbitrage portfolio return $\tilde{\gamma}_p$, for month t, is:

$$w_{ip} = \frac{x_{ip} - \overline{x}_p}{N\,\sigma_p^2} \quad \text{for } p \neq 0. \tag{24}$$

Thus in the case of one independent variable, any firm i with a value of x_{ip} above (below) the mean will receive positive (negative) weight in arbitrage portfolio p. To illustrate, when the variable DFD (the ratio of deferred income taxes to depreciation) is used as the independent variable in this regression equation, normalizing (flow-through) firms receive positive (negative) weight in the arbitrage portfolio. According to my model, the duration of an arbitrage portfolio constructed by short-selling the securities of flow-through firms against the securities of normalizing firms held long should be a negative number. Hence the returns on such a portfolio should be positively related to unanticipated changes in nominal interest rates. Similarly, when the variable AFC (the ratio of AFC to depreciation) is used as the independent variable in this regression, firms which capitalize AFC will be sold short against firms which are allowed to include CWIP in the rate-base. Therefore, the resulting arbitrage portfolio will have a positive duration, so the returns on it should be negatively related to unanticipated interest rate changes.

To see what happens to the weights assigned to individual firms in these arbitrage portfolios as other variables are controlled, it is necessary to extend Fama's derivation of this implicit system of weights to at least the case of a cross-sectional regression with two independent variables. Consider a cross-sectional multiple regression equation for month t of the form:

$$\tilde{r}_i = \tilde{\gamma}_0 + \tilde{\gamma}_i x_{ip} + \tilde{\gamma}_k x_{ik} + \tilde{e}_i. \tag{25}$$

If ρ_{pk} is the sample correlation coefficient between $\tilde{x}_{ip}$ and $\tilde{x}_{ik}$, the portfolio weight for security i that determines its contribution to the "least squares" portfolio return for month t on arbitrage portfolio p, $\tilde{\gamma}_p$, will be:

$$w_{ip} = \frac{1}{N\,\sigma_p} \frac{\dfrac{(x_{ip} - \bar{x}_p)}{\sigma_p} - \rho_{pk} \dfrac{(x_{ik} - \bar{x}_k)}{\sigma_k}}{1 - \rho_{pk}^2}, \qquad \text{for } p \neq 0. \tag{26}$$

Therefore, with more than one independent variable, the weight in arbitrage portfolio p for any firm i is basically determined by starting with the weight given in the case of one independent variable, equation (24), then adjusting this weight for the number of standard deviations the value of x_k for the firm i is above or below the mean of x_k for all firms, where the sign and magnitude of this adjustment is determined by the correlation between x_p and x_k. For example, if x_p and x_k are positively correlated across all firms, equation (26) places relatively more weight than equation (24) on firms that have one value for x_p or x_k above the mean for all firms and the other below. This property is appealing because such firms provide the best sample evidence for isolating the separate effects of x_p and x_k on securities returns.

Table 3 provides summary statistics for the "least squares" portfolio returns, $\tilde{\gamma}_{pt}$, used as the independent variables in the time-series multiple regressions described by equation (22). The sample standard deviations for these portfolio returns vary depending on the scaling of the variables underlying these portfolios, but scale will have no impact on the test results for the "least squares" arbitrage portfolios, p = 1,2...,7.[17] However, departures from normality in the least squares portfolio returns series may affect statistical inferences in such tests, and the studentized range statistics indicate that departures from normality are most severe in the series $\tilde{\gamma}_{4t}$, which measures the partial effect of ROE. Since the distributions of monthly stock returns are slightly leptokurtic relative to normal distributions, the other series are more consistent with the distributions of returns on ordinary portfolios of common stocks. In particular, the studentized range statistics for the portfolios representing the partial effects of DFD and AFC are of roughly the same order of magnitude as the studentized range statistics for monthly returns on the 30 Dow-Jones Industrials reported by Fama [1976, p. 34].

The results of estimating equation (22), using each $\hat{\gamma}_p$ series as the dependent variable, are presented in table 4. The signs of the coefficients of u_t^* in the regressions for the portfolios representing the partial effects of DFD and AFC are as predicted, and significantly different from zero. These coefficients provide evidence that alternative regulatory accounting methods did affect the sensitivity of firms' value to unanticipated changes in nominal interest rates, in the direction predicted by the model.

More specifically, recall that normalization accounting reduces the sensitivity of firm value to interest rate changes, relative to the alternative of flow-through accounting. Since the values of electric utility firms are predicted to be inversely related to unanticipated changes in interest rates, the significantly positive coefficient of u_t^* in the time-series regression for the portfolio based on DFD indicates that as the ratio of deferred taxes to depreciation increases, electric utility common stocks become less sensitive to unanticipated changes in interest rates. In contrast, the significantly negative coefficient of u_t^* in the time series regression for the portfolio based on AFC indicates that increasing the amount of AFC capitalized (relative to utility depreciation expense) increases the sensitivity of electric utility common stock returns to changes in nominal interest rates.

Although tests of the effects of alternative accounting methods focus on the coefficients of u_t^* rather than those of r_{mt} in table 4, the coefficients of r_{mt} in the regressions for the portfolios based on DFD and AFC are of some interest also because they are large relative to their standard errors. These coefficients essentially measure the difference in market model betas associated with the use of alternative regulatory accounting methods. For example, the positive coefficient of r_{mt} for the portfolio based on DFD indicates that market model betas for normalizing firms are significantly greater, on average, than those of flow-through firms. Similarly, firms that capitalize AFC tend to have lower betas than firms that include CWIP in the rate-base, because the coefficient of r_{mt} for the portfolio based on AFC is negative.

Indirectly, the model can also be used to explain why such cross-sectional differences in market model betas related to alternative regulatory accounting methods are observed. Since prices for electric utility service are fixed in the short run and changed only at periodic regulatory proceedings, and Propositions 4 and 5 say that normalizing firms and firms that include CWIP in the rate-base derive a greater fraction of their values from cash flows to be received in the near future than their counterparts, observing that these firms are more sensitive to market-wide factors which determine the returns to common stocks in general might simply indicate that these firms are more sensitive to general economic conditions which influence short run variations in the quantity of electric utility demanded.

The remaining regressions reported in table 4 show the partial effects of the control variables. The estimated coefficient of u_t^* in the regression for the portfolio that represents the partial effect of LEV is negative and about one and one-half standard errors away from zero.[18] While this coefficient is not significant at conventional levels, its negative sign suggests that only the "embedded" costs of preferred stock and debt are being passed on to the rate-payers, and hence the effects of accounting methods cannot be offset by altering the degree of financial leverage.

Intuition, and the model, suggests that increasing the level of ROE will reduce the sensitivity of firm value to interest rate changes, since increasing the allowed rate of return decreases the duration of the expected stream of operating cash flows under rate-regulation (proof available on request). Consistent with this is the positive coefficient on u_t^* for the portfolio representing the partial effect of ROE. However, this coefficient is not close to being statistically significant. Based on the model, one would also expect that increasing the depreciable lives of assets increases the sensitivity of firms' values to interest rate changes, since this generally increases the time required for investors to recover their investment in utility plant. But, the coefficient on u_t^* for the portfolio representing the partial effect of LIFE in table 4 is negligible and insignificant. While the estimated coefficient of u_t^* on the portfolio representing the partial effect of FUEL is positive and relatively larger (in relation to its standard error), it too is not significant at conventional levels.

The only other significant, but somewhat anomolous, result in table 4 is the statistically significant positive coefficient of u_t^* on the portfolio representing the partial effect of GROWTH. The model suggests that since the rate-base of a faster growing firm would consist, on average, of more recently acquired assets with greater remaining depreciable lives than that of a firm growing more slowly, a negative coefficient of u_t^* should be observed for the portfolio representing the partial effect of GROWTH, thereby reflecting an increase in the sensitivity of firms' values to interest rate changes. However, GROWTH may be associated with the durations of firms' liabilities (i.e., the capital structures of faster growing firms might consist of relatively more recently issued debt with greater remaining terms to maturity). Since differences in leverage ratios have already been controlled, it is not clear whether "asset side" or "liability side" duration effects will dominate, hence the results on the partial effects of GROWTH should not be interpreted as evidence that the empirical model is misspecified.

Table 5 summarizes the annual correlation coefficients between the independent variables used in the cross-sectional regressions. These correlations suggest potential problems of interpreting the individual effects of the independent variables. For example, the annual correlations between LIFE and FUEL are consistently negative, and significant in 16 out of the 20 years, suggesting that relative fuel costs may be simply proxying for the useful lives of utility plant assets. This is intuitively plausible since low-cost power sources (hydro-power and coal) are used in conjunction with assets which have relatively long useful lives compared to the assets used with relatively higher cost fuels (oil and natural gas).[19] Of more importance to this study are the high, persistent correlations between AFC and the variables LEV, GROWTH, and FUEL. This suggests that the results for the partial effect of AFC should be also interpreted cautiously. Fortunately, the results for DFD are relatively unambiguous since the ratio of deferred taxes to depreciation is not highly correlated with any of the other variables.

As a final test of the model, I estimated differential slope coefficients for u_t^* during the years 1974 and 1975, which were years in which unusual events could have impacted on electric utility stocks. For one thing, the price of oil increased dramatically during this period. Another pervasive event was an increase in the investment tax credit rate for public utility property in January of 1975.[20] The results of this test are reported in table 6, which shows that the impact of u_t^* on the portfolio based on FUEL is significantly positive overall, but the differential slope coefficient for the 1974-1975 subperiod is negative, indicating that firms with relatively high fuel costs were more sensitive to unanticipated changes in nominal interest rates during 1974-1975. Moreover, the significantly positive coefficient of u_t^* for this portfolio in years other than 1974-1975 is consistent with the variable FUEL generally acting as a proxy for the depreciable lives of plant assets; that is, high fuel cost firms using shorter lived assets.

More importantly, table 6 shows that modifying the time-series regressions this way increases the significance of the coefficient of u_t^* in years other than 1974-1975 for the portfolio measuring the partial effect of DFD, but slightly diminishes the significance of the coefficient of u_t^* in these years for the AFC portfolio. Indeed, a significant negative differential slope coefficient for u_t^* shows up during the years 1974-1975 for the portfolio based on DFD in table 6. Thus, the results for the overall twenty year period reported in table 4 reflect a weighted average of two opposing effects -- a positive coefficient for all years except 1974-1975 and a negative coefficient for those years. In contrast, the differential slope coefficient on u_t^* during 1974-1975 for the portfolio based on AFC is negligable, so it had little effect on the overall significant negative coefficient for u_t^* observed earlier. Therefore, the results in table 6 indicate that the partial effects of DFD and AFC observed during the entire 1960-1979 time period are not being driven by peculiarities of the years 1974-1975. Other tests, not reported here, also indicate that the observable effects of alternative accounting methods are relatively robust to different empirical specifications.

5. SUMMARY AND CONCLUSIONS

Overall, the results reported here are consistent with rate-regulation functioning "as if" a nominal contract exists between utility customers and investors, where the role of regulatory accounting policies is to establish some terms of this implicit contract. Both the model and the empirical evidence indicate that alternative regulatory accounting methods systematically affect the sensitivity of the values of regulated electric utilities to unanticipated interest rate changes. As such, we may conclude that regulatory accounting policies have "real effects" on the valuation of rate-regulated firms.

Specifically, the model predicted that accounting methods that accelerate the recovery of utility plant costs relative to their alternatives generally reduce the sensitivity of firms' values to unanticipated changes in interest rates. Thus, the values of electric utility firms that use normalization accounting are less sensitive to interest rate changes than the values of firms that use flow-through accounting, and firms that follow the practice of including CWIP in the rate-base are less sensitive to interest rate changes than the values of firms that capitalize AFC. Evidence supporting these predictions was obtained for the decades of the 1960s and the 1970s by observing cross-sectional differences in the sensitivity of electric utility common stock returns to unanticipated changes in interest rates, conditional on the use of alternative regulatory accounting methods.

These effects of accounting methods persisted even when peculiarities of the 1974-1975 time period were recognized. Also, since evidence supporting these effects was found even after controlling for other firm-specific factors relevant to the valuation process, they do not appear to be an artifact of other salient differences between utility firms which employ different accounting methods. Finally, the model and the evidence pertaining to how the "embedded" costs of preferred stock and debt are treated in the rate-making process suggests that the effects of alternative regulatory accounting methods cannot be easily undone by simple modifications to firms' capital structures, such as changing the degree of financial leverage employed.

Obviously, broader questions still remain. By focusing on the effects of alternative regulatory accounting methods that are observed in practice, this provides no evidence on why different regulatory commissions prescribe alternative accounting methods, or what are the total economic costs of regulatory tradeoffs between these alternatives. Hopefully, documenting the "real effects" of alternative accounting methods on the valuation of rate-regulated firms will be a useful step toward assessing such issues.

FOOTNOTES

[1]Financial accounting for rate-regulated firms generally conforms to regulatory accounting because, under the Addendum to APB Opinion No. 2 (December, 1962) and FASB Statement of Financial Accounting Standards No. 71 (December, 1982), rate-regulated firms are permitted to prepare financial statements for external reporting purposes on a basis consistent with the accounting methods prescribed by regulatory commissions. Of course, new "generally accepted" accounting standards may have an indirect impact on regulatory accounting rules (e.g., see Watts and Zimmerman [1978, p. 115]) by encouraging utility managers to lobby before their commissions. I only examine the wealth effect of changes in regulatory accounting methods.

[2]The term "regulatory lag" is generally used to refer to the tendency of rate-schedules to be changed infrequently, usually after lengthy administrative hearings.

[3]Automatic adjustment clauses may exist for some major cash operating expenses, such as fuel, but adjustment clauses enabling a utility to automatically pass on greater capital costs are virtually nonexistant. As a result, the realized accounting rate of return for most electric utilities lags behind increases in inflation rates, falling as new plant assets purchased at higher nominal prices replace older assets in the rate-base, and as debt with low "embedded" interest rates is refunded at higher current rates. Of course, commissions could make explicit "pro forma" adjustments to allowable operating expenses and the rate-base for these lags or they could argue that such lags have been considered in the determination of the overall allowed rate of return. But evidence on either of these courses of action is rare.

[4]Strictly speaking, these statements apply only to a firm that is allowed to include construction-work-in-progress in its rate-base. The alternative accounting treatment of capitalizing an allowance for funds used during construction as part of the cost of utility plant is discussed in section 2.2.

[5]Some jurisdictions are actually required by statute or case law to use a "fair value" rate base, which is adjusted, ex-post, for realized inflation in a price index of utility plant construction costs. But such "fair value" adjustments generally alter only that portion of the rate-base financed by common equity, and do not require similar inflation adjustments to be made to depreciation expense and other noncash charges to income. Since cost recovery will still be based on original cost in these jurisdictions, there is no need to distinguish between "fair value" and "original cost" rate-base determination in what follows. The only feasible mechanism to offset the effects of expected or unexpected inflation is to adjust the nominal "return on equity capital" portion of the firm's operating cash flows, but this is generally not done.

[6]A regression of ROE on BYLD in the first differences of the natural logarithms of both variables (to guard against heteroskedasticity) yielded the following results on both a contemporaneous and a lagged relationship (for 19 observations):

$$\Delta \ln ROE_t = \underset{(.009)}{.005} - \underset{(.109)}{.173}\, \Delta \ln BYLD_t + e_t, \qquad R^2 = .129,$$

and:

$$\Delta \ln ROE_t = \underset{(.009)}{.002} - \underset{(.104)}{.083}\, \Delta \ln BYLD_{t-1} + e_t, \qquad R^2 = .036,$$

(standard errors appear in parentheses). Neither slope coefficient was significant, suggesting that regulatory commissions apparently have not adjusted the common equity component of the "return on capital" stream to systematically compensate for unanticipated changes in nominal interest rates.

[7]Similar views have been expressed by Davidson and Weil [1975] who argued that public utility assets should be considered "monetary" for the purpose of preparing general price level adjusted financial statements, and by Keran [1976] who proposed that the returns to public utility common stocks should behave like the returns to fixed income securities.

[8]Only the Wisconsin state commission actually implements normalization accounting by specifying that additional depreciation expense is to be taken each period in the amount that would otherwise be accrued as the provision for deferred income taxes. Other commissions prescribing normalization accounting require deferred income taxes to be classified as income tax expense, and specify that the accumulated deferred income taxes (sometimes referred to as the "normalization reserve") are to be carried on the equity side of the firm's balance sheet. For rate-making purposes, however, the result of this method of accounting for deferred income taxes eventually leads to the same operating cash flows that would occur under the Wisconsin method.

[9]A main difference, however, is that the ITC is a direct credit against the tax, thereby providing a once and for all reduction in income taxes payable (related to the amount of qualifying investment in utility plant). A deferral of this ITC (normalization) spreads this tax reduction over the useful lives of the assets involved, while flow-through accounting for the ITC passes these credits on immediately to the rate payers.

[10]The assumption of a "flat" term structure is primarily to keep the analysis mathematically tractable.

[11]The static valuation model abstracts from any effects of "regulatory lag" by not allowing the market's current assessment of future allowed rates of return to vary across time. The variable s should be thought of as conditional on r since regulatory commissions can observe r before setting s.

[12]Strictly speaking, the book value of invested capital also includes a utility's investment in net working capital. For rate-making purposes, a formula adjustment to the rate-base is usually made for net working capital, however the effect of this adjustment is generally minor.

[13]"True" growth opportunities are defined by Fama and Miller [1972, p. 92] to be projects which have internal rates of return in excess of the cost of capital. I assume the net present value of such growth opportunities is in fact small.

[14]Substitution of (6) into (8) gives:

$$v(r,s) = 1 + (s-r) \int_0^n b(t)\, e^{-rt}\, dt,$$

and differentiating this expression with respect to r yields:

$$\frac{d}{dr}\, v(r,s) = -\int_0^n b(t)\, [1 + (s-r)t]\, e^{-rt}\, dt.$$

Therefore, the difference between the absolute slope of the value function for firm P and that of firm A is:

$$\left|\frac{d}{dr}\, v^P(r,s)\right| - \left|\frac{d}{dr}\, v^A(r,s)\right| = \int_0^n [b^P(t) - b^A(t)][1 + (s-r)t]\, e^{-rt}\, dt.$$

Given (10), this difference is always positive when $s \geq r$, but when $s < r$, this difference will be negative for sufficiently large values of r.

[15]Technically, first-degree stochastic dominance requires strict inequality between $F^A(t)$ and $F^P(t)$ for at least one value of t, however so long as the cash flow streams $k^A(t)$ and $k^P(t)$ are not identical, nor always proportional to one another, strict inequality in (17) will be assured for at least one value of t.

[16]I should note that these predictions do not require the assumption that the allowed rate of return is completely independent of the cost of capital. The same qualitative results for the partial effects of regulatory accounting methods can also be obtained from a more general model in which

there is a "regulatory reaction function" that specifies how the allowed rate of return varies as a function of the cost of capital. In this model, similar results can be obtained as long as there is less than unitary elasticity between the allowed rate of return and the cost of capital (meaning that rate-regulation functions, at least in part, as a nominal contract).

[17]Generally, the particular scale of the independent variables used in the cross-sectional regressions has no substantive impact on the test statistics in the time-series multiple regressions that use "least squares" arbitrage portfolio returns as the dependent variable. That is, the t-statistics of the coefficients β_{1p} and β_{2p} will be unaffected by any linear transformation of the underlying variable x_{ip}. This statement is not true for the positive investment portfolio returns that are obtained as the time-series of intercept values from these cross-sectional regressions, γ_0, because these intercepts will absorb any effects due to the rescaling of the independent variables.

[18]Although the theory indicates that market values should be used in the ratio LEV, I used book values because they are more readily available. Moreover, since the static valuation equation, (8), says that the market value of equity is also a function of regulatory accounting methods and other variables, the market value of common equity would have to be adjusted according to equation (8) once cross-sectional differences in other variables are controlled. Thus, using "unadjusted" values for the market value of common equity in the denominator of the leverage ratio would actually bias the resulting "least squares" portfolio returns obtained from equation (30), so that using the book value of common equity instead of its market value may be viewed as trading off efficiency in the estimation procedure to eliminate a known source of bias.

[19]The "guideline lives" (for tax purposes) of electric utility production plant assets are 28 years for steam production plant assets and 20 years

for both nuclear and combustion plant assets. Thus high fuel cost firms (i.e., those using more natural gas and oil than coal) are expected to have plant assets with relatively shorter depreciable lives than low fuel cost firms, especially when nuclear energy was not a significant source of power.

[20]One significant change that could have had differential effects was to allow firms that had been using flow-through accounting for the 4% ITC to adopt normalization accounting for the incremental portion of the new ITC. As an indirect test of the impact of this new legislation, I noted that the highest portfolio return observed in one month over the entire 20 year period was 26.0%, observed in January 1975, the month that the investment tax credit rules for utilities were liberalized.

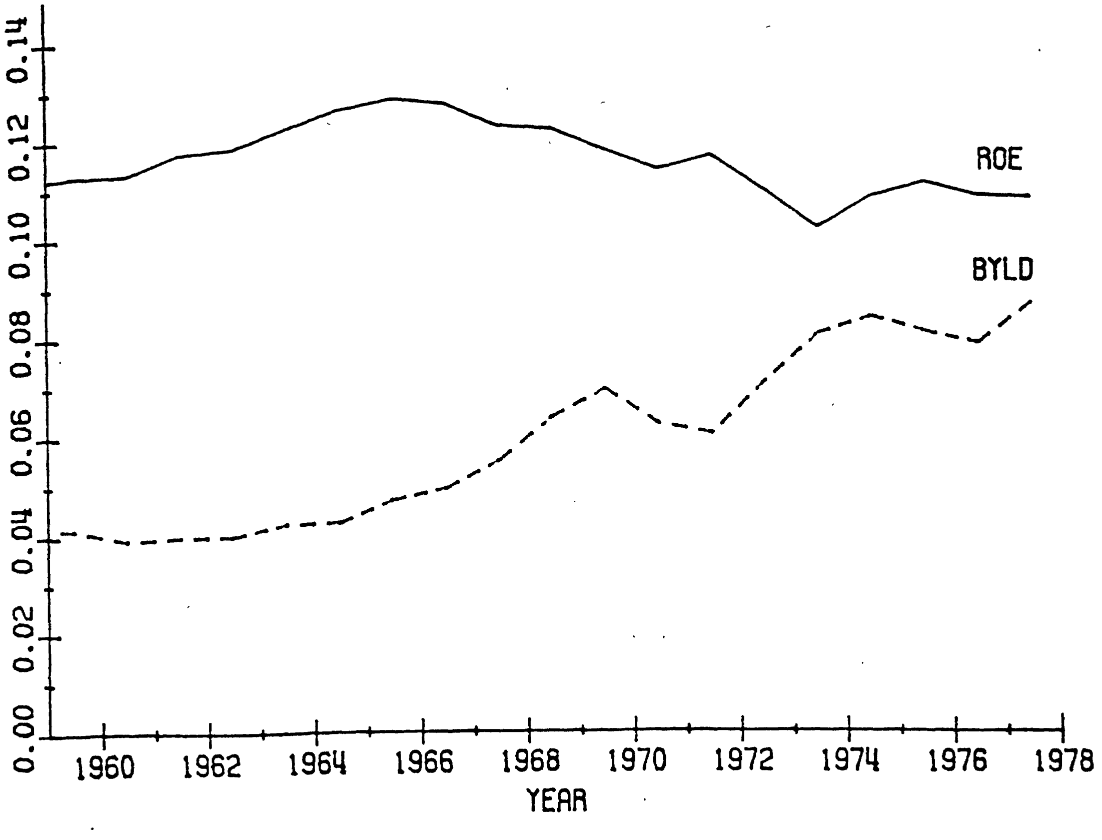

Figure 1.--Realized accounting rates of return on common equity for electric utilities (ROE) and annual average yields on long-term U.S. government bonds (BYLD): 1959-1978.

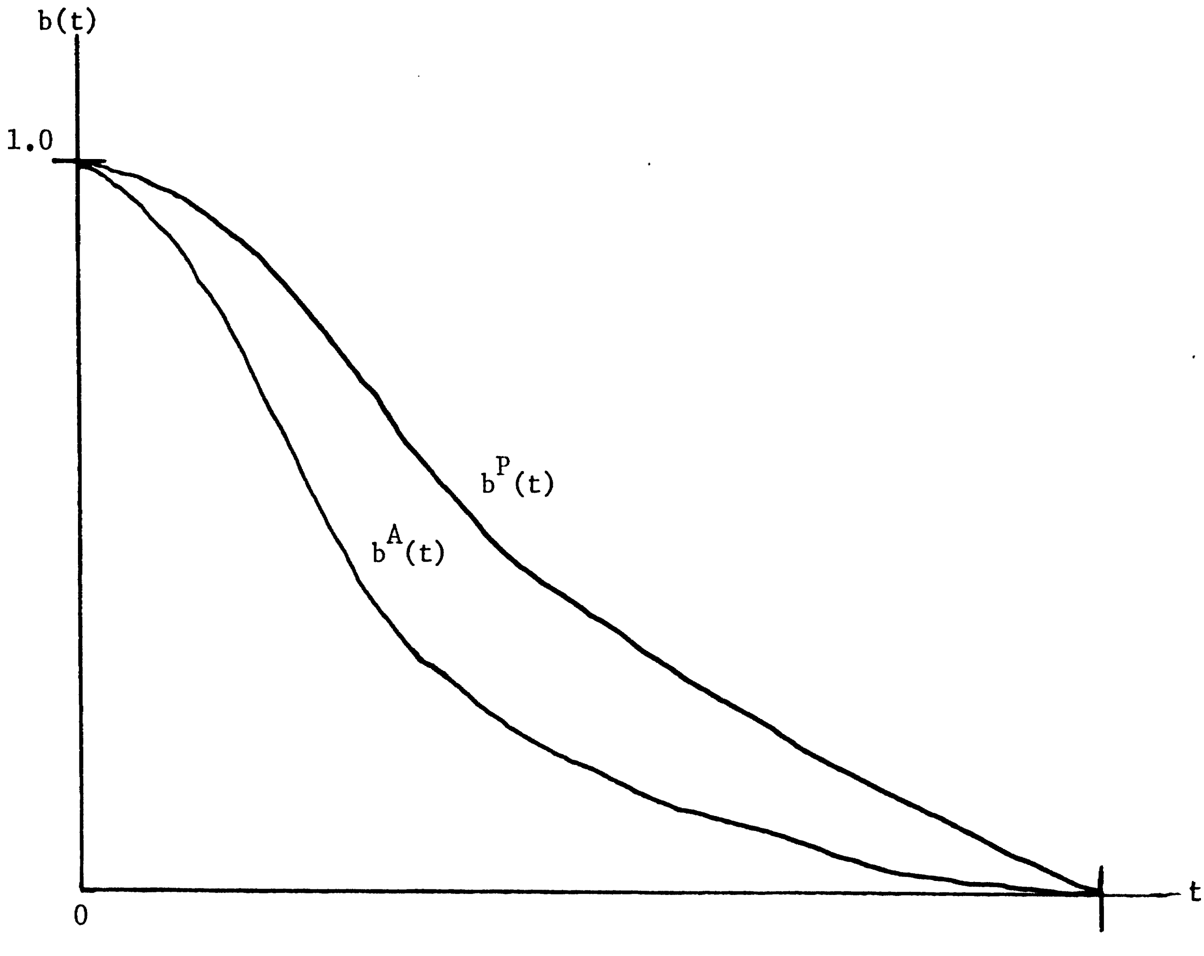

Figure 2.--Rate-base evolution functions, b(t), for firms using alternative regulatory accounting policies. (The concave segments of these functions would result from construction work in progress (CWIP) at time zero being phased in to a firm's cost recovery pattern.)

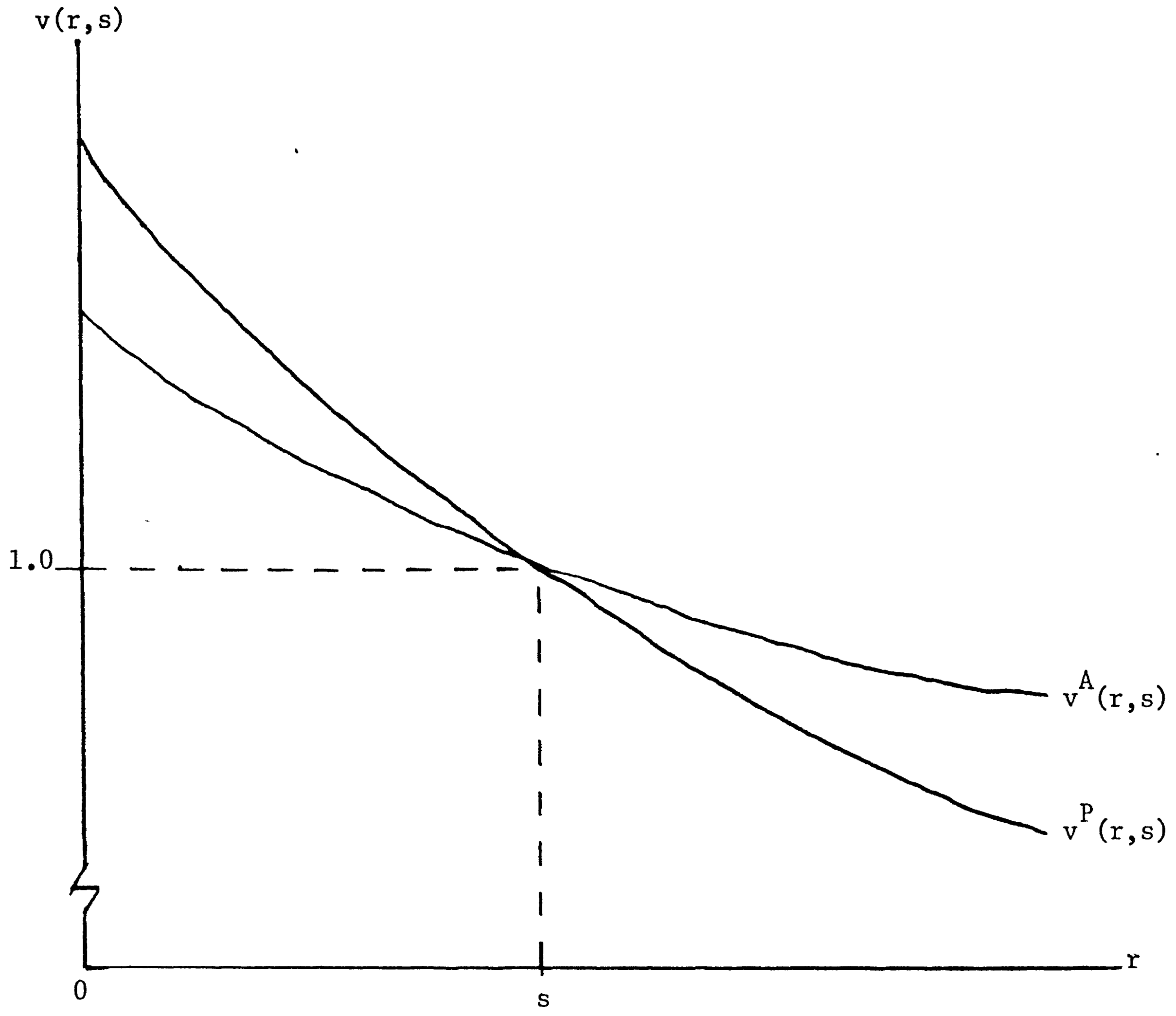

Figure 3.--Market-to-book-value ratios, v(r,s), for firms using alternative regulatory accounting policies, as a function of the cost of capital, r, holding the allowed rate of return, s, constant.

TABLE 1

OPERATIONAL DEFINITIONS OF THE INDEPENDENT VARIABLES IN THE CROSS SECTIONAL REGRESSIONS USED TO DERIVE "LEAST SQUARES" PORTFOLIO RETURNS

Variable	Represents	Operational Definition[a]
DFD_j	Normalization versus flow-through accounting treatment.	$\frac{\text{Income Taxes Deferred: (\#18)}}{\text{Utility Depreciation Expense (\#16)}^{b}}$
AFC_j	Capitalization of AFC versus inclusion of CWIP in rate-base.	$\frac{\text{Allowance for Funds Used During Construction (\#24)}}{\text{Utility Depreciation Expense (\#16)}^{b}}$
LEV_y	Financial leverage (nominal securities in capital structure).	$\frac{\text{Preferred Stock (\#4) + Long-Term Debt (\#6)}}{\text{Common Equity as Reported (\#3)}}$
ROE_y	Level of allowed rate of return on common equity.	$100\left(\frac{\text{Net Income after Minority Interest (\#26)}}{\text{Common Equity as Reported (\#3)}}\right)$
$LIFE_y$	Book depreciable lives for utility plant in service.	$\frac{\text{Gross Utility Plant (\#1) - Construction Work in Progress}^{c,d}}{\text{Utility Depreciation Expense (\#16)}^{b}}$
$GROWTH_y$	Rate of growth in gross utility plant.	100 (Three-year compound rate of growth in Gross Utility Plant (#1) Less Cumulative AFC)[e]
$FUEL_y$	Relative fuel costs (dependence on high cost sources of fuel).	$\frac{\text{Total Fuel Expense (\#77)}^{f}}{\text{Utility Depreciation Expense (\#16)}^{b}}$

[a]Utility COMPUSTAT data item numbers are given in parentheses.

[b]Utility depreciation expense, a "flow" measure, was used as the denominator of these ratios rather than a "stock" measure of gross plant because depreciation expense acts as an instrumental variable for the average amount of plant in service during the year. The variables DFD and AFC for a particular firm are five-year averages of the annual ratio values shown under the operational definition heading, computed for four successive five-year subperiods, $j = 1,\ldots 4$, corresponding $y = 1,\ldots,5$, $y = 6,\ldots,10$, $y = 11,\ldots,15$, and $y = 16,\ldots,20$, respectively.

[c]The quantity "gross utility plant less construction work in progress" is an average of beginning of year and end of year values. Due to the use of average values, values of this ratio could not be calculated for 1959, so the 1960 ratio values were used in both 1959 and 1960.

[d]Construction work in progress (CWIP) was taken from the COMPUSTAT Expanded Industrial file (item #73) for the years 1973-1978 (the only years which contain nonmissing values). For the remaining years, end of year values for CWIP were estimated by dividing the following year's allowance for funds used during construction (AFC) by an assumed cost of funds rate. The rates used were 7.5% for 1970-1973 AFC, 7% for 1969 AFC, 6.5% for 1968 AFC, and 6% for 1960-1967 AFC.

[e]Since computation of this ratio requires lagged values for Gross Plant, the 1961 values of this ratio for each firm were used in the years 1959-1961.

[f]Total fuel expense was not available on Utility COMPUSTAT for the years 1959 and 1960, so the 1961 values of this ratio for each firm were used in the years 1959-1961.

TABLE 2

ESTIMATION RESULTS FOR VARIABLE u_t^* WHICH REPRESENTS UNANTICIPATED CHANGES IN NOMINAL INTEREST RATES

Series[a]	Estimated Autocorrelations (standard errors in parentheses)												Box Pierce Q Statistic[b]		
	$\hat\rho_1$	$\hat\rho_2$	$\hat\rho_3$	$\hat\rho_4$	$\hat\rho_5$	$\hat\rho_6$	$\hat\rho_7$	$\hat\rho_8$	$\hat\rho_9$	$\hat\rho_{10}$	$\hat\rho_{11}$	$\hat\rho_{12}$	Q	T	d.f.
U_t	.95 (.06)	.94 (.10)	.93 (.13)	.90 (.16)	.90 (.18)	.89 (.19)	.86 (.21)	.86 (.22)	.86 (.24)	.83 (.25)	.83 (.26)	.82 (.27)	2351.7	252	12
u_t	-.54 (.06)	-.08 (.08)	.37 (.08)	-.32 (.09)	.06 (.09)	.24 (.09)	-.32 (.09)	.03 (.10)	.31 (.10)	-.33 (.10)	.05 (.11)	.28 (.11)	248.9	252	12
$\hat u_t$	.02 (.06)	-.00 (.06)	-.01 (.06)	.00 (.06)	.08 (.06)	.02 (.06)	-.20 (.06)	-.01 (.07)	.01 (.07)	.08 (.07)	-.03 (.07)	-.01 (.07)	13.2	240	6

[a]Series consist of monthly observations of the following variables:

U_t = yield to maturity on long-term U.S. government bond portfolio from Ibbotson and Sinquefield [1979] for 1/1959-12/1979 (252 months), annualized by multiplying by 12. The addition of observations for 1959 facilitates estimation of residuals for the multiplicative seasonal ARIMA model over 1960-1979.

$u_t = U_t - U_{t-1}$.

$\hat u_t$ = residuals from the following Box-Jenkins multiplicative seasonal ARIMA$(2,1,0)(0,0,4)_3$ model for 1/1960-12/1979 (240 months):

$$u_t = -.810\ u_{t-1} - .477\ u_{t-2} + \hat u_t - .026\ \hat u_{t-3} - .040\ \hat u_{t-6} + .201\ \hat u_{t-9} + .256\ \hat u_{t-12}.$$

[b]The Box Pierce Q statistics are for estimated autocorrelations at the first 12 lags, where T denotes the number of observations. These statistics are distributed approximately Chi-square (χ^2) with the indicated number of degrees of freedom (d.f.). Selected fractiles of the Chi-square distribution are:

fractile	$\chi^2(p)$	
(p)	6 d.f.	12 d.f.
.95	12.6	21.0
.975	14.4	23.3
.99	16.8	28.3

TABLE 3

SUMMARY STATISTICS FOR "LEAST SQUARES" PORTFOLIO RETURNS

Portfolio (p)	"Least Squares" Portfolio Returns[a]	Portfolio Represents Partial Effect of	Summary Statistics: Mean	Standard Deviation	Studentized Range[b]
0	$\hat{\gamma}_{0t}$	----	.00964	.08548	7.93
1	$\hat{\gamma}_{1t}$	DFD	.00206	.03966	6.25
2	$\hat{\gamma}_{2t}$	AFC	-.00416	.08396	6.55
3	$\hat{\gamma}_{3t}$	LEV	-.00006	.01761	7.33
4	$\hat{\gamma}_{4t}$	ROE	-.00015	.00428	11.08
5	$\hat{\gamma}_{5t}$	LIFE	.00001	.00095	6.60
6	$\hat{\gamma}_{6t}$	GROWTH	.00022	.00298	7.99
7	$\hat{\gamma}_{7t}$	FUEL	-.00020	.00957	6.29

[a]"Least squares" portfolio returns consist of 240 monthly observations for each portfolio during the period 1960-1979, computed as the "least squares" values of the coefficients from the following cross-sectional multiple regressions of the return to the common stock of firm i in month t, r_{it}, on known values of seven independent variables:

$$\tilde{r}_{it} = \tilde{\gamma}_{0t} + \tilde{\gamma}_{1t}(DFD_{ij}) + \tilde{\gamma}_{2t}(AFC_{ij}) + \tilde{\gamma}_{3t}(LEV_{iy}) + \tilde{\gamma}_{4t}(ROE_{iy})$$
$$+ \tilde{\gamma}_{5t}(LIFE_{iy}) + \tilde{\gamma}_{6t}(GROWTH_{iy}) + \tilde{\gamma}_{7t}(FUEL_{iy}) + \tilde{e}_{it},$$

where y is a year index for the year preceding the observation of security returns, and j = 1,2,3,4 is an index corresponding to y = 1,...,5, y = 6,...,10, y = 11,...,15, and y = 16,...,20, respectively. See table 1 for operational definitions of the independent variables used in these regressions.

[b]Selected fractiles of the sampling distribution for the studentized range (SR) in samples of 200 from a normal population are:

lower percentage points: fractile	SR	upper percentage points: fractile	SR
.10	4.90	.90	6.15
.05	4.78	.95	6.38
.025	4.67	.975	6.59
.01	4.56	.99	6.85
.005	4.50	.995	7.03

TABLE 4

MULTIPLE REGRESSIONS OF MONTHLY "LEAST SQUARES" PORTFOLIO RETURNS ON THE CRSP VALUE-WEIGHTED MONTHLY MARKET INDEX (r_{mt}) AND UNEXPECTED PERCENTAGE CHANGES IN NOMINAL INTEREST RATES (u^*_t) OVER THE TIME PERIOD 1960-1979:

$$\tilde{\hat{\gamma}}_{pt} = \beta_{0p} = \beta_{1p} r_{mt} + \beta_{2p} u^*_t + \tilde{e}_{pt}.$$

Dependent Variable ("Least Squares" Portfolio Returns)[a]	Portfolio Represents Partial Effect of:	Intercept (t-statistic)	Time-series Regression Results: Coefficient (t-statistic) for Independent Variables: r_{mt}	u^*_t	R^2 (F)
$\hat{\gamma}_{0t}$	---	.0064 (1.23)	.6917 (5.61)	-.1935 (-2.19)	.152 (21.22)[b]
$\hat{\gamma}_{1t}$	DFD	.0001 (0.04)	.1726 (2.85)	.1129 (2.61)	.050 (6.28)[b]
$\hat{\gamma}_{2t}$	AFC	-.0012 (-0.22)	-.2129 (-1.64)	-.2101 (-2.27)	.027 (3.33)[b]
$\hat{\gamma}_{3t}$	LEV	.0005 (0.40)	-.0284 (-1.03)	-.0308 (-1.58)	.013 (1.52)
$\hat{\gamma}_{4t}$	ROE	-.0002 (-0.60)	-.0015 (-0.23)	.0046 (0.95)	.005 (0.54)
$\hat{\gamma}_{5t}$	LIFE	.0000 (0.36)	-.0027 (-1.79)	.0003 (0.27)	.015 (1.79)
$\hat{\gamma}_{6t}$	GROWTH	-.0003 (-1.75)	.0010 (2.23)	.0067 (2.03)	.031 (3.83)[b]
$\hat{\gamma}_{7t}$	FUEL	-.0004 (-0.68)	.0200 (1.34)	.0146 (1.37)	.012 (1.55)

[a]See Table 3.

[b]F-statistic significant at .05 level.

TABLE 5

SUMMARY STATISTICS FOR ANNUAL CORRELATIONS COEFFICIENTS BETWEEN THE INDEPENDENT VARIABLES IN THE CROSS-SECTIONAL REGRESSIONS USED TO DERIVE "LEAST SQUARES" PORTFOLIO RETURNS FOR THE PERIOD 1959-1978.[a]

Variable	Mean of Annual Correlation Coefficients					
	DFD	AFC	LEV	ROE	LIFE	GROWTH
DFD	1.0000					
AFC	.0067	1.0000				
LEV	-.1079	.2777	1.0000			
ROE	.1686	-.0560	-.0350	1.0000		
LIFE	-.1404	.1595	-.0002	-.3132	1.0000	
GROWTH	.1376	.3500	.1788	.0701	-.1554	1.0000
FUEL	-.0367	.1243	.0097	.0642	-.3052	.2497

Variable	Number of Positive Annual Correlation Coefficients (Number of Positive and Significant at .05 Level)					
	DFD	AFC	LEV	ROE	LIFE	GROWTH
AFC	10 (0)					
LEV	2 (0)	20 (13)				
ROE	18 (5)	10 (0)	9 (1)			
LIFE	3 (0)	14 (5)	10 (0)	1 (0)		
GROWTH	20 (3)	19 (12)	19 (8)	17 (0)	3 (0)	
FUEL	10 (0)	13 (9)	10 (0)	13 (1)	0 (0)	20 (6)

Variable	Number of Negative Annual Correlation Coefficients (Number of Negative and Significant at .05 Level)					
	DFD	AFC	LEV	ROE	LIFE	GROWTH
AFC	10 (0)					
LEV	18 (0)	0 (0)				
ROE	2 (0)	10 (5)	11 (3)			
LIFE	17 (1)	6 (0)	10 (0)	19 (14)		
GROWTH	0 (0)	1 (0)	1 (0)	3 (0)	17 (6)	
FUEL	10 (0)	7 (5)	10 (1)	7 (0)	20 (16)	0 (0)

[a]See Table 1 for operational definitions of variables. Annual sample size ranges from 69 to 73 firms depending on data availability.

TABLE 6

MULTIPLE REGRESSIONS OF MONTHLY "LEAST SQUARES" PORTFOLIO RETURNS ON THE CRSP VALUE-WEIGHTED MONTHLY MARKET INDEX (r_{mt}) AND UNEXPECTED PERCENTAGE CHANGES IN NOMINAL INTEREST RATES (u_t^*), 1960-1979, WITH DIFFERENTIAL SLOPE COEFFICIENT FOR u_t^* DURING 1974-1975:

$$\tilde{\hat{\gamma}}_{pt} = \beta_{0p} + \beta_{1p} r_{mt} + \beta_{2p} u_t^* + \beta_{3p} u_t^* I_{74-75} + \tilde{e}_{pt},$$

where I_{74-75} is an indicator variable set to one in 1974-1975, zero otherwise.

Dependent Variable ("Least Squares" Portfolio Returns)[a]	Portfolio Represents Partial Effect of:	Intercept (t-statistic)	Time-series Regression Results: Coefficient (t-statistic) for Independent Variables: r_{mt}	u_t^*	$u_t^* I_{74-75}$	R^2 (F)
$\hat{\gamma}_{0t}$	---	.0065 (1.24)	.6798 (5.45)	-.1741 (-1.89)	-.2102 (-0.73)	.154 (14.30)[b]
$\hat{\gamma}_{1t}$	DFD	.0002 (0.09)	.1563 (2.57)	.1393 (3.10)	-.2864 (-2.03)	.067 (5.62)[b]
$\hat{\gamma}_{2t}$	AFC	-.0012 (-0.22)	-.2180 (-1.66)	-.2017 (-2.08)	-.0906 (-0.30)	.028 (2.24)[c]
$\hat{\gamma}_{3t}$	LEV	.0005 (0.44)	-.0337 (-1.22)	-.0222 (-1.09)	-.0938 (-1.47)	.022 (1.74)
$\hat{\gamma}_{4t}$	ROE	-.0002 (-0.68)	.0007 (0.11)	.0009 (0.18)	.0397 (2.57)	.032 (2.56)[c]
$\hat{\gamma}_{5t}$	LIFE	.0000 (0.38)	-.0028 (-1.88)	.0005 (0.49)	-.0028 (-0.81)	.017 (1.41)
$\hat{\gamma}_{6t}$	GROWTH	-.0003 (-1.78)	.0108 (2.34)	.0056 (1.65)	.0110 (1.03)	.036 (2.90)[b]
$\hat{\gamma}_{7t}$	FUEL	-.0004 (-0.61)	.0128 (0.87)	.0263 (2.43)	-.1266 (-3.73)	.068 (5.73)[b]

[a]See Table 3.

[b]F-statistic significant at .05 level.

[c]F-statistic significant at .10 level.

APPENDIX 1

In this appendix, I establish Propositions 4 and 5, which describe sufficient conditions for the value distribution function for firm P to dominate the value distribution function for firm A. The first step is to derive a sufficient condition for this type of dominance to hold in terms of properties of the underlying cash flow streams, $k^A(t)$ and $k^P(t)$. Since the duration of any cash flow stream is generally a function of the discount rate, r, this can be done if both streams are discounted at the same rate, as follows.

PROPOSITION 4: Holding the discount rate, r, constant:

$$F^A(t) \geq F^P(t) \text{ for all } t, \text{ if}$$

$$\frac{k^A(t)}{k^P(t)} \text{ is a nonincreasing function of } t. \tag{A1.1}$$

PROOF: To prove this proposition, it must be shown that dominance between the value distribution functions follows from (A1.1) when the discount rate is held constant across firms. By definition, dominance between the value distribution functions $F^A(t)$ and $F^P(t)$ can be written as:

$$\frac{\int_0^t k^A(x)\, e^{-rx}\, dx}{\int_0^n k^A(x)\, e^{-rx}\, dx} \geq \frac{\int_0^t k^P(x)\, e^{-rx}\, dx}{\int_0^n k^P(x)\, e^{-rx}\, dx}, \qquad \text{for all } t \geq 0. \tag{A1.2}$$

Since attention has been restricted to nonnegative cash flow streams, all of the integrals in (A1.2) are positive numbers, so (A1.2) implies that:

$$\frac{\int_0^t k^A(x)\, e^{-rx}\, dx}{\int_0^t k^A(x)\, e^{-rx}\, dx} \geq \frac{\int_0^n k^P(x)\, e^{-rx}\, dx}{\int_0^n k^P(x)\, e^{-rx}\, dx}, \qquad \text{for all } t \geq 0. \tag{A1.3}$$

For the inequality in (A1.3) to hold, it is sufficient that the ratio $[\int_0^t k^A(x)\, e^{-rx} dx \;/\; \int_0^t k^P(x)\, e^{-rx}\, dx]$ be a nonincreasing function of t. This requires that the derivative of this ratio with respect to t have a nonpositive sign for all $t > 0$. Differentiating this ratio with respect to t, and ignoring the positive term in the denominator, gives:

$$\operatorname{sgn}\left\{\frac{d}{dt}\left[\frac{\int_0^t k^A(x)\, e^{-rx}\, dx}{\int_0^t k^P(x)\, e^{-rx}\, dx}\right]\right\} = \operatorname{sgn}\left\{k^A(t)\, e^{-rt} \int_0^t k^P(x)\, e^{-rx}\, dx - k^P(t)\, e^{-rt} \int_0^t k^P(x)\, e^{-rx}\, dx\right\}. \quad \text{(A1.4)}$$

If the ratio of $k^A(t)$ to $k^P(t)$ is assumed to be a nonincreasing function of t, then (in principle) $k^A(t)$ can go to zero before $k^P(t)$ does, but once the function $k^A(t)$ reaches zero it must stay there. Therefore, without loss of generality, let t* be the point at which $k^A(t)$ reaches zero. Then, the sign of (A1.4) will be nonpositive for $t \geq t^*$, and the ratio of $k^A(t)$ to $k^P(t)$ will be zero for these values of t. Thus, it remains only to show that condition (A1.4) holds when $t < t^*$, where the ratio of $k^A(t)$ to $k^P(t)$ is always greater than zero, and assumed to be a nonincreasing function of t.

For values of $t < t^*$, both $k^A(t)$ and $k^P(t)$ are positive numbers. Hence, dividing the right hand side of expression (A1.4) through by $k^A(t)\, e^{-rt}$ and by $k^P(t)\, e^{-rt}$, will not change its sign. Doing so, then rearranging, yields:

$$\operatorname{sgn}\left\{\frac{d}{dt}\left[\frac{\int_0^t k^A(x)\, e^{-rx}\, dx}{\int_0^t k^P(x)\, e^{-rx}\, dx}\right]\right\} = \operatorname{sgn}\left\{\int_0^t \left[\frac{k^P(x)}{k^P(t)} - \frac{k^A(x)}{k^A(t)}\right] e^{-r(x-t)} dt\right\}. \quad \text{(A1.5)}$$

If the sign of (A1.5) is to be nonpositive, it is sufficient that the quantity in the interior brackets on the right-hand side of (A1.5) be nonpositive. This quantity will be nonpositive if:

$$\frac{k^A(t)}{k^P(t)} - \frac{k^A(x)}{k^P(x)} \leq 0, \quad \text{for } 0 < x < t. \quad \text{(A1.6)}$$

Condition (A1.6) will hold for all $t < t^*$ if the ratio of $k^A(t)$ to $k^P(t)$ is a nonincreasing function of t. Q.E.D.

The next step is to show that the relationship between the expected streams of future cash flows under rate-regulation for firms A and P that is required in Proposition 4 will be obtained if the same relationship holds between the "return of capital" components of these streams, that is, if the ratio of the cost recovery function $z^A(t)$ to $z^P(t)$ is also a nonincreasing function of t. This can be done by holding the allowed rate of return, s, constant across firms, as follows.

PROPOSITION 5: Holding the allowed rate of return, s, constant:

$\frac{k^A(t)}{k^P(t)}$ will be a nonincreasing function of t, if

$\frac{z^A(t)}{z^P(t)}$ is a nonincreasing function of t. (A1.7)

PROOF: The proof consists of showing that the derivative of the ratio of $k^A(t)$ to $k^P(t)$ will be nonpositive if (A1.7) holds, or:

$$\frac{d}{dt}\frac{k^A(t)}{k^P(t)} = \frac{d}{dt}\frac{[s\ b^A(t) + z^A(t)]}{[s\ b^P(t) + z^P(t)]} \leq 0. \tag{A1.8}$$

Ignoring the positive term in the denominator of the resulting expression, the derivative of this ratio with respect to t (time) is given by:

$$\begin{aligned} \text{sgn}\ \left\{\frac{d}{dt}\frac{k^A(t)}{k^P(t)}\right\} = \text{sgn}\ \{&[s\ b^P(t) + z^P(t)]\ [-s\ z^A(t) + z_t^A(t)] \\ &-[s\ b^A(t) + z^A(t)]\ [-s\ z^P(t) + z_t^P(t)]\}, \end{aligned} \tag{A1.9}$$

where the subscript t is used to denote partial derivatives with respect to time, and (A1.9) makes use of the fact that z(t) is the absolute rate of change in b(t), i.e., $b_t(t) = -z(t)$. Multiplying through and rearranging on the right-hand side of (A1.9) yields:

$$\begin{aligned} \text{sgn}\ \left\{\frac{d}{dt}\frac{k^A(t)}{k^P(t)}\right\} = \text{sgn}\ \Big\{&s\ b^A(t)\ z^P(t)\ [s + \frac{-z_t^P(t)}{z^P(t)}] - s\ b^P(t)\ z^A(t)\ [s + \frac{-z_t^A(t)}{z^A(t)}] \\ &+ z^P(t)\ z_t^A(t) - z^A(t)\ z_t^P(t)\Big\}. \end{aligned} \tag{A1.10}$$

It remains to be shown that the sign of the bracketed expression on the right-hand side of (A1.10) is nonpositive if the ratio of $z^A(t)$ to $z^P(t)$ is a nonincreasing function of t. This ratio will be a nonincreasing function of t if its derivative is nonpositive for all values of t, or:

$$\frac{d}{dt} \frac{z^A(t)}{z^P(t)} \leq 0 \text{ for all } t, \tag{A1.11}$$

which implies that:

$$z^P(t)\; z_t^A(t) - z^A(t)\; z_t^P(t) \leq 0, \qquad \text{for all } t. \tag{A1.12}$$

Thus, if the ratio of $z^A(t)$ $z^P(t)$ is to be a nonincreasing function of t:

$$z^P(t)\; z_t^A(t) \leq z^A(t)\; z_t^P(t), \qquad \text{for all } t, \tag{A1.13}$$

is required. For nonzero values of $z^A(t)$ and $z^P(t)$, (A1.13) implies that:

$$\frac{-z_t^A(t)}{z^A(t)} \geq \frac{-z_t^P(t)}{z^P(t)}, \qquad \text{for all } t. \tag{A1.14}$$

Also, assuming that the ratio of $z^A(t)$ to $z^P(t)$ is a nonincreasing function of t implies that, before the function $z^P(t)$ goes to zero:

$$\frac{z^A(t)}{z^P(t)} \geq \frac{z^A(x)}{z^P(x)}, \qquad \text{for } t \leq x < n, \tag{A1.15}$$

thus it must be true that:

$$z^A(t)\; z^P(x) \geq z^P(t)\; z^A(x), \qquad \text{for } t \leq x < n. \tag{A1.16}$$

Integrating the expressions on both sides of (A1.16) over all $x \geq t$ yields:

$$z^A(t) \int_t^n z^P(x)\, dx \geq z^P(t) \int_t^n z^A(x)\, dx, \tag{A1.17}$$

which implies that:

$$z^A(t)\; b^P(t) \geq z^P(t)\; b^A(t). \tag{A1.18}$$

Therefore, using the results in (A1.13), (A1.14), and (A1.18), the bracketed expression on the right-hand side of (A1.10) will be nonpositive because all of the products preceded by a minus sign exceed their counterparts. Q.E.D.

APPENDIX 2

The purpose of this appendix is to show that, holding the depreciable lives of assets acquired and the rate of growth in asset acquisitions constant across firms, the ratio of the cost recovery function for firm A to that of firm P will be a nonincreasing function of t in each of the following cases:

Case 1: Firm A uses normalization accounting while firm P uses flow-through; both firms include CWIP in the rate-base.

Case 2: Same as Case 1, except both firms capitalize AFC.

Case 3: Firm A includes CWIP in the rate-base while firm P capitalizes AFC; both firms use normalization accounting.

Case 4: Same as Case 3, except both firms use flow-through accounting.

To show that this is true requires a description of basic economic characteristics of firms A and P. I assume that gross investment in utility plant has been growing at an exponential rate of g, and that all "vintages" of utility plant assets acquired are being depreciated over the same useful life, n, with zero salvage value. This means that "instantaneous" gross investment at time $-x$ (i.e., x time units ago) was:

$$I(-x) = I(0)\, e^{-gx}, \tag{A2.1}$$

where I(0) is the current level of instantaneous gross investment, in dollars. Furthermore, at any time $t > 0$, only vintages acquired subsequent to time $-(n-t) = t-n$ will still be subject to depreciation.

Also, for simplicity, I assume that the same marginal tax rate, τ, applies at all (past and future) points in time, and that AFC is capitalized only for book purposes, and not for tax purposes. (Only capitalization of the debt interest component of AFC for tax purposes is in question here and, until recently, utilities could elect not to do so.) Also, I assume that "book" depreciation is always computed on a straight line basis. Therefore, since the standard tax depreciation function applicable to a single vintage of plant, denoted $z_0^T(x)$, is a decreasing function of time, whereas the corresponding standard book depreciation function, denoted $z_0^B(x)$, is constant over time, it is obvious that the ratio of $z_0^T(x)$ to $z_0^B(x)$ is a nonincreasing function of time.

To set up common elements of the proofs, let the functions $z_0^A(x)$ and $z_0^P(x)$ represent the "standard" cost recovery patterns applicable to a single vintage of utility plant acquired by firms A and P respectively, which will depend on regulatory accounting policies. Then, for each of these firms, the composite cost recovery function, z(t), describing how the unrecovered dollar cost of assets existing at time zero, B(0), will be recovered in the future, is given by:

$$z(t) = \int_t^n I(t-x)\, z_0(x)\, dx \,/\, B(0), \tag{A2.2}$$

where the unrecovered dollar cost of assets existing at time zero is:

$$B(0) = \int_0^n \int_t^n I(t-x)\, z_0(x)\, dx\, dt. \tag{A2.3}$$

Thus, using (A2.1), the ratio of $z^A(t)$ to $z^P(t)$ can be written as:

$$\frac{z^A(t)}{z^P(t)} = \frac{I(0) \int_t^n z_0^A(x)\, e^{-g(x-t)}\, dx \,/\, B^A(0)}{I(0) \int_t^n z_0^P(x)\, e^{-g(x-t)}\, dx \,/\, B^P(0)}, \tag{A2.4}$$

The task is to show that this ratio is a nonincreasing function of t in each of the four cases outlined above. In all four cases, since $B^A(0)$ and $B^P(0)$ are constants, the sign of the derivative of this ratio with respect to t is given by:

$$\mathrm{sgn}\{\frac{d}{dt} \frac{z^A(t)}{z^P(t)}\} = \mathrm{sgn}\{\frac{d}{dt} \frac{\int_t^n z_0^A(t)\, e^{-g(x-t)}\, dx}{\int_t^n z_0^P(t)\, e^{-g(x-t)}\, dx}\}$$

$$= \mathrm{sgn}\{[\int_t^n z_0^P(x)\, e^{-g(x-t)}\, dx][\int_t^n z_0^A(x)\, g\, e^{-g(x-t)}\, dx - z_0^A(t)]$$

$$- [\int_t^n z_0^A(x)\, e^{-g(x-t)}\, dx][\int_t^n z_0^P(x)\, g\, e^{-g(x-t)}\, dx - z_0^P(t)]\}$$

$$= \mathrm{sgn}\{z_0^P(t) \int_t^n z_0^A(x)\, e^{-g(x-t)}\, dx - z_0^A(t) \int_t^n z_0^P(x)\, e^{-g(x-t)}\, dx\}. \qquad (A2.5)$$

Now, if both $z_0^A(t)$ and $z_0^P(t)$ are positive numbers for all $t > 0$, dividing the bracketed expression in (A2.5) by either of these numbers will not change its sign. However, the standard cost recovery function for a single vintage of plant assets, $z_0(x)$, will always be positive for a firm that includes CWIP in the rate-base; but this function must take on negative values during the construction period for a firm that capitalizes AFC. Therefore, let x^* denote the number of time units it takes to construct a single vintage of plant assets. Then (A2.5) implies that:

$$\mathrm{sgn}\{\frac{d}{dt}\frac{z^A(t)}{z^P(t)}\} = \mathrm{sgn}\{\int_t^n [\frac{z_0^A(x)}{z_0^A(t)} - \frac{z_0^P(x)}{z_0^P(t)}]\, e^{-g(x-t)}\, dx\}, \quad \text{for } t > x^*. \qquad (A2.6)$$

Thus, for values of $t > x^*$, the sign of (A2.6) will be the same as the sign of the expression within the square brackets on the right-hand side, and the sign of this expression will be nonpositive if:

$$\frac{z_0^A(x)}{z_0^P(x)} - \frac{z_0^A(t)}{z_0^P(t)} \leq 0, \qquad \text{for } x > t > x^*. \qquad (A2.7)$$

Expression (A2.7) will hold if the ratio of the standard cost recovery functions, $z_0^A(x)$ to $z_0^P(x)$, is a nonincreasing function of x for $x > x^*$. Thus, to prove that the ratio of the composite cost recovery functions, $z^A(t)$ to $z^P(t)$, is a nonincreasing function of t requires showing that:

(i) the sign of the bracketed expression in (A2.5) is nonpositive for values of $t \leq x^*$,

and: (ii) the ratio of $z_0^A(x)$ to $z_0^P(x)$ is a nonincreasing function of x for values of $x > x^*$.

Individual proofs for cases 1 to 4 follow.

<u>CASE 1</u>: Firm A uses normalization accounting while firm P uses flow-through; both firms include CWIP in the rate-base.

Since both firms include CWIP in the rate-base, both $z_0^A(x)$ and $z_0^P(x)$ are zero during the construction period, hence the sign of (A2.5) is nonpositive for $t \leq x^*$, and this proves (i).

To prove (ii), note that under normalization accounting, a gross charge (credit) of the fraction $\tau[z_0^T(x-x^*) - z_0^B(x-x^*)]$ of the cost of each vintage of assets acquired will be made to the provision for deferred income taxes x time units after acquisition (i.e., x-x* time units after these assets are placed in service). Thus, the standard cost recovery function for firm A is a weighted average of the standard tax depreciation function and the standard "book" depreciation function, with weights τ and $(1 - \tau)$, respectively, because:

$$\begin{aligned} z_0^A(x) &= z_0^B(x-x^*) + \tau[z_0^T(x-x^*) - z_0^B(x-x^*)] \\ &= \tau\, z_0^T(x-x^*) + (1 - \tau)\, z_0^B(x-x^*). \end{aligned} \tag{A2.8}$$

Since the standard cost recovery function for firm P is determined by book depreciation alone, or $z_0^P(x) = z_0^B(x-x^*)$, the ratio of $z_0^A(x)$ to $z_0^P(x)$ is:

$$\frac{z_0^A(x)}{z_0^P(x)} = \tau \frac{z_0^T(x-x^*)}{z_0^B(x-x^*)} + (1 - \tau). \tag{A2.9}$$

This ratio is obviously a nonincreasing function of x for $x > x^*$ because the sign of its derivative is the same as that of the ratio of $z_0^T(x)$ to $z_0^B(x)$, which always is a nonincreasing function of x, proving (ii).

<u>CASE 2</u>: Firm A uses normalization accounting while firm P uses flow-through; both firms capitalize AFC.

When both firms capitalize AFC, $z_0^A(x) = z_0^P(x)$ and both are negative numbers during the construction period (i.e., $x \leq x^*$), because capitalized AFC is essentially equivalent to negative depreciation. Therefore the sign of (A2.5) will be negative if:

$$\int_t^n z_0^A(x)\, e^{-g(x-t)}\, dx > \int_t^n z_0^P(x)\, e^{-g(x-t)}\, dx, \qquad \text{for } t \leq x^*. \tag{A2.10}$$

By substituting g for r in Proposition 1, the inequality in (A2.10) will hold for $t = x^*$. Also, all terms in the integrands on both sides of this inequality are equal for $t < x^*$, so the portions of these integrals between t and x^* cancel, hence this inequality will hold for all $t \leq x^*$. Therefore, the sign of (A2.5) is nonpositive for $t \leq x^*$, proving (i).

For values of $t > t^*$, the situation is much the same as in Case 1, except that the standard cost recovery pattern for both firms now must integrate to something greater than unity between x^* and n, in order to recoup the "negative" depreciation charges made for capitalized AFC. However, after the construction period, the standard cost recovery function for firm A will still be a weighted average of the standard book depreciation function, $z_0^B(x)$, and the standard tax depreciation function, $z_0^T(x)$, as in Case 1. Thus, letting w denote the cumulative amount of AFC capitalized during the construction period as a fraction of the initial construction expenditure on a vintage of construction, the standard cost recovery function for firm A, $z_0^A(x)$, will be:

$$z_0^A(x) = \tau\, z_0^T(x-x^*) + (1 - \tau + w)\, z_0^B(x-x^*). \tag{A2.11}$$

Compared to (A2.8) in Case 1, (A2.11) shows that the standard cost recovery function for firm A under normalization accounting simply places relatively more weight on the standard book depreciation function and less on the standard tax depreciation function when AFC is capitalized than when CWIP is included in the rate-base (because AFC is capitalized for book purposes only). In contrast, when AFC is capitalized for the flow-through firm, firm P, its standard cost recovery function, $z_0^P(x)$, is now only proportional to the standard book depreciation function, $z_0^B(x)$, i.e., $z_0^P(x) = w\, z_0^B(x-x^*)$, instead of being strictly identical to this function as in Case 1. Therefore, the ratio of these standard cost recovery functions is:

$$\frac{z_0^A(x)}{z_0^P(x)} = \frac{\tau}{w}\,\frac{z_0^T(x-x^*)}{z_0^B(x-x^*)} + \frac{(1 - \tau + w)}{w}. \tag{A2.12}$$

This ratio is a nonincreasing function of x for $x > x^*$, as in Case 1, which proves (ii).

CASE 3: Firm A includes CWIP in the rate-base while firm P capitalizes AFC; both firms use normalization accounting.

The proof for this case follows primarily from results derived in the proofs of Cases 1 and 2. Since firm P capitalizes AFC while firm A does not, during the construction period $z_0^A(x) = 0$ and $z_0^P(x) < 0$. Thus, the sign of the inequality in (A2.5) is negative for $x \leq x^*$, and this proves (i).

To show that (ii) holds, (A2.11) and (A2.8) can be used to write the ratio of the standard cost recovery function for firm A to that of firm P as follows:

$$\frac{z_0^A(x)}{z_0^P(x)} = \frac{\tau\ z_0^T(x-x^*) + (1-\tau)\ z_0^B(x-x^*)}{\tau\ z_0^T(x-x^*) + (1-\tau+w)\ z_0^B(x-x^*)}. \tag{A2.13}$$

After some algebra, the sign of the derivative of this ratio with respect to x is:

$$\mathrm{sgn}\{\frac{d}{dx}\frac{z_0^A(t)}{z_0^P(t)}\} = \mathrm{sgn}\{\tau\ w\ [z_0^B(x-x^*)\ z_{0x}^T(x-x^*) - z_0^T(x-x^*)\ z_{0x}^B(x-x^*)]\}, \tag{A2.14}$$

where the subscript x is used to denote partial differentiation with respect to x. Using the same logic as that used to derive expression (A1.13) of Appendix 1, the expression within the square brackets on the right-hand side of (A2.14) will always be nonpositive if the ratio of $z_0^T(x)$ to $z_0^B(x)$ is a nonincreasing function of t, proving that (ii) holds.

CASE 4: Firm A includes CWIP in the rate-base while firm P capitalizes AFC; both firms use flow-through accounting.

Case 4 is the easiest to prove because when both firms use flow-through accounting, after the end of the construction period, the standard cost recovery function for firm A is always proportional to that of firm P. Thus the ratio of these functions, $z_0^A(x)$ to $z_0^P(x)$, is a constant, w, proving (ii). Since the effect of one firm's capitalizing AFC, while the other does not, on the standard cost recovery functions of these firms for values of $t \leq x^*$ is the same as in Case 3, (i) holds as well. Q.E.D.

REFERENCES

Davidson, Sidney and Roman L. Weil. "Inflation Accounting: Public Utilities," Financial Analysts Journal (May-June 1975): 30-34, 62.

Fama, Eugene F. Foundations of Finance: Portfolio Decisions and Securities Prices. New York: Basic Books, 1976.

________ and James D. MacBeth. "Risk, Return and Equilibrium: Empirical Tests," Journal of Political Economy 71 (May-June 1973): 607-36.

________ and Merton H. Miller. The Theory of Finance. New York: Holt, Rinehart, and Winston, 1972.

Hadar, Josef and William R. Russell. "Rules for Ordering Uncertain Prospects," The American Economic Review 59 (March 1969): 25-34.

Ibbotson, Roger G. and Rex A. Sinquefield. Stocks, Bonds, Bills, and Inflation: Historical Returns (1926-1978). Charlottesville, Virginia: Financial Analysts Research Foundation, 1979.

Keran, Michael W. "Inflation, Regulation and Utility Stock Prices," The Bell Journal of Economics 7 (Spring 1976): 268-80.

Macaulay, Frederick R. Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields, and Stock Prices in the United States since 1865. New York: Columbia University Press, for the National Bureau of Economic Research, 1938.

Watts, Ross L. and Jerold L. Zimmerman. "Towards a Positive Theory of the Determination of Accounting Standards," The Accounting Review 53 (January 1978): 112-34.

Weil, Roman L. "Macaulay's Duration: An Appreciation," The Journal of Business 46 (October 1973): 589-92.