A DYNAMIC FINANCIAL MODEL OF A UTILITY

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Abstract

A model expressing the behavior of carriers as a function of time is essential to an understanding of their capability to respond to the needs of the computer industry. The model described is an attempt to interrelate the regulatory authority and the regulated company, and the company to its customer and owners.

1. INTRODUCTION

One of the most important issues arising out of the interdependence of the computer and communications industries is the question of the capability of the communications common carriers to respond to the needs of the computer industry. This question of capability arises in terms of the ability of the carriers to respond quickly enough and on a sufficiently large scale to meet the demand that appears to be developing for data communications. A dynamic model that can express the behavior of the carriers as a function of time is essential to an understanding of this question, and the model presented herein should be viewed as a first step in this direction. This model will allow us to interrelate meaningfully the diverse aspects of the interactions between the regulatory authority and the company that is regulated, between the company and its customers, and between the company and its owners.

The structure of the problem is shown in Figure 1. The arrows show the flow of cash or the flow of information. The individual interactions are as follows:

(A) The shareholders receive the dividends and evaluate the stock.

(B) The company receives monies for new shares at a market price.

(C) The public (investors, trusts, etc) receives the interest and repayments of bonds.

(D) The company receives monies for new bond issues.

(E) The regulatory agency receives the reports of the company's performance.

(F) The regulatory agency issues orders regarding the allowable rate of return and tariff rates.

(G) Telephone, data, and other users convey to the regulatory commission their satisfaction or dissatisfaction with the service offered

* This work was carried out while the author was on the staff of the Stanford Research Institute.

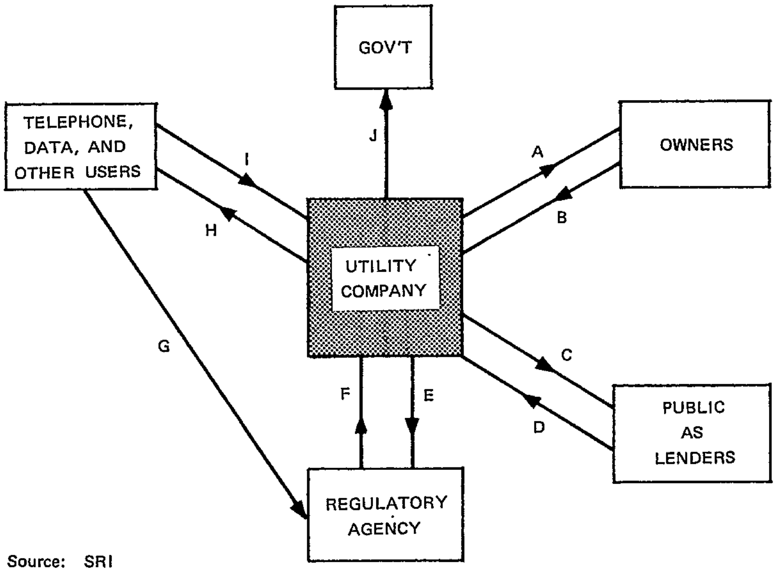

FIG. 1 THE UTILITY COMPANY AND ITS REGULATORY ENVIRONMENT

by the utility company.

(H) The utility company "offers" to the subscribers a plant of a certain size to match the demand for that plant.

(I) The subscribers pay for the service.

(J) The Internal Revenue Service collects taxes.

The model presented herein connects these aspects and includes a sufficient number of operational parameters to make these interactions explicit.

PROPERTIES OF THE MODEL

The dynamic model of the utility described in this paper exhibits some "lifelike" properties of real utilities:

- At "reasonable" rates of return (say, more than 5%) the utility grows, pays steadily increasing dividends, and the share price of the utility's stock increases.
- As the allowed rate of return increases, the utility can respond faster to a sudden change in demand.
- To keep the rate of return within a range of 7.5-8%, the regulatory commission has to decrease prices every two or three years.
- If the range of the allowed rate of return is made too narrow, the regulatory agency is forced to make constant adjustments. These adjustments succeed only in making the situation unstable.

There are some real life properties of the utility that the model ought to show but does not, mainly because the submodels used in it are not adequate, but also because some submodels are missing. These shortcomings include:

- The price-to-earnings ratio of the

utility in the model tends to level off at seven to ten. In the present market this ratio is about twice that. Obviously, the submodel that expresses the investor's valuation of the stock does not adequately reproduce the current market valuation.

- The model oversimplifies the problem in a number of respects, such as assuming that one regulatory agency is controlling one utility. Actually, in the case of telephone utilities, separate state Public Utility Commissions regulate the intrastate operations of the carriers and the Federal Communications Commission regulates interstate operations.
- The utility's labor costs ought to be sensitive to the utility's rate of return.
- Neither the utility nor the regulatory commission learn anything from their "experience." This is a consequence of not having the value model of either--these value models are at present unknown.
- The model is deterministic, in that at any time there is only one value for every variable and for every parameter. This is obviously a gross departure from uncertain reality, particularly with respect to the investor's reaction to the financial and business risk faced by the utility.

The model is nevertheless useful as: (1) a framework, or skeleton, that can be "fleshed out" by substituting more sophisticated submodels and (2) an experimental vehicle in which to include additional submodels such as a regulatory agency capable of learning from experience. Although useful only as an insight-producing tool, this model is considered to be a step toward a better quantitative understanding of some of the complex issues related to the regulatory process.

EXAMPLE OF MODEL OUTPUT

Figure 2 shows how, in spite of the three-year warning given by the forward forecasting technique,* the utility is caught off balance, and it takes about three years for it to catch up with demand.

2. THE STRUCTURE OF THE MODEL

The model combines the elements of the P&L (profit and loss) statement with the elements of the balance sheet (assets and liabilities). It describes the company once a year, for a period of many years. At the end of each financial year, the current dividend is declared, the investors react to the dividend, there is a shortage or an abundance of facilities, and the FCC reacts to the rate of return achieved by the company. The overall simulation run extends over 50 years of the company's life.

The state variables, which describe the environment and are not influenced by the decision variables, are:

- The rate of growth of demand of net plant.**

* See "the 'Model within a Model' Revision of Demand Forecasting" in Section 3.

** To simplify the structure of the model, the demand is expressed as <u>demand for net plant</u> and both revenues and expenses are time

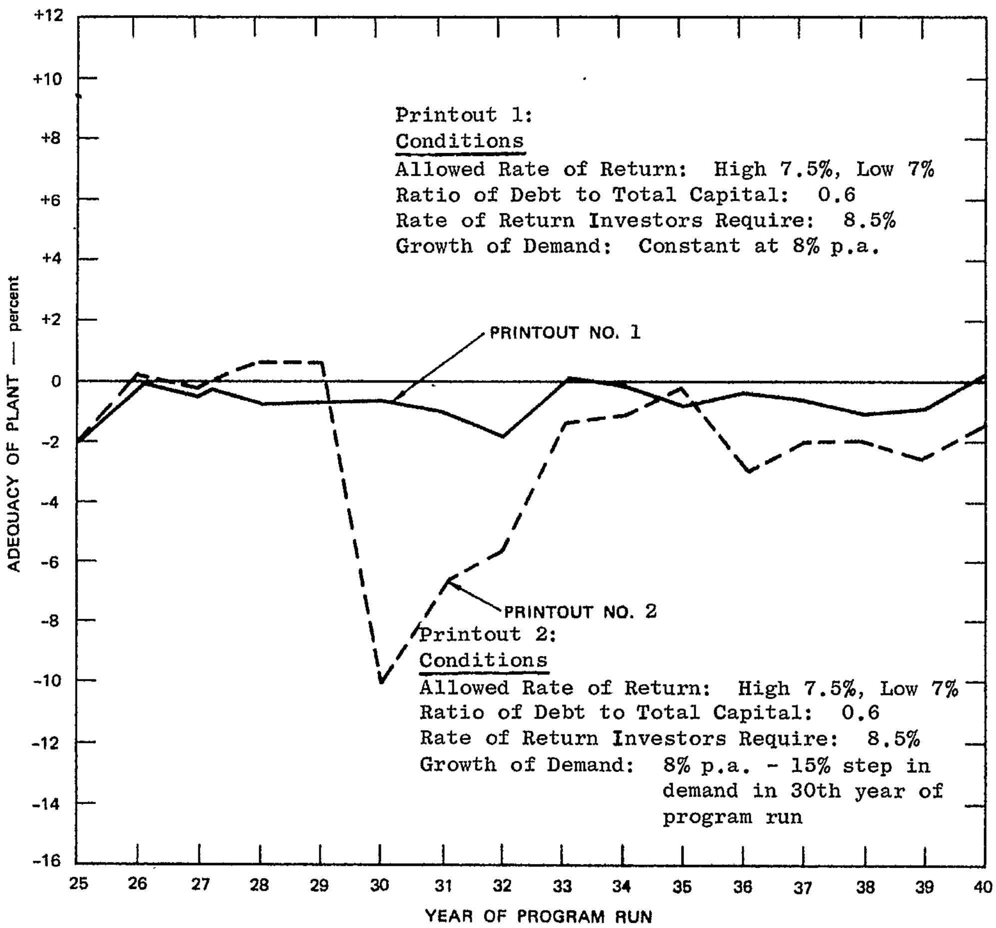

FIG. 2 THE EFFECT OF A SUDDEN STEP IN DEMAND ON ADEQUACY OF PLANT

- The rate of increase of revenues (per dollar unit of net plant).
- The (optional) sudden step in demand.

The decision variables are:

- High and low limits on rate of return allowed by the FCC.
- The debt-to-equity ratio to be followed by the company.

The outcomes or consequences provided by the model runs are the time streams of:

- Assets.
- Dividends.
- Rates of return on rate base (or assets)--i.e., the ratio of the after-tax-before-interest income-to-rate base.
- Net plant.
- Rates of growth of net plant.
- Tariffs as set by the regulatory a-

functions of net plant. A more realistc (but more complicated) way would be to describe the traffic demand and the improving ability of a modern plant to carry an increasing volume of traffic per dollar unit of net plant. The increased capability to carry traffic would then replace the assumed increase of the revenues per dollar unit of net plant.

gency (measured as a percentage change from an arbitrary initial setting).

- The ratio of the demand for net plant and the net plant in existence (measured in percent).
- The stock price (measured in arbitrary units, the same units as the dividends above).

The value model, which defines the obective to be satisfied, is not specified and is left to the discretion of the user of the program. Thus, the model is not optimizing, and the user will have to make several runs to arrive at what he considers to be a satisfactory outcome.

3. DESCRIPTION OF THE MODEL

Because the calculations of one year's operations comprise about 1,000 individual computations, the operation of the model is not described in detail. Instead, the basic structure of the model is shown in Figure 3, and the following description indicates where a certain group of calculations is made. The letter headings correspond to the letters in the functional blocks shown in the figure.

A. The initial payout ratio is assumed to be 0.6.

B. New capital requirements are determined--initially as 1.35 times the amount of depreciation funds. Funds are made available for new construction--they are the sum of depreciation, retained earnings, and new capital.

C. The new net plant is determined by referring to the construction funds that were made available in the preceding four years. New net plant is added to the "old" net

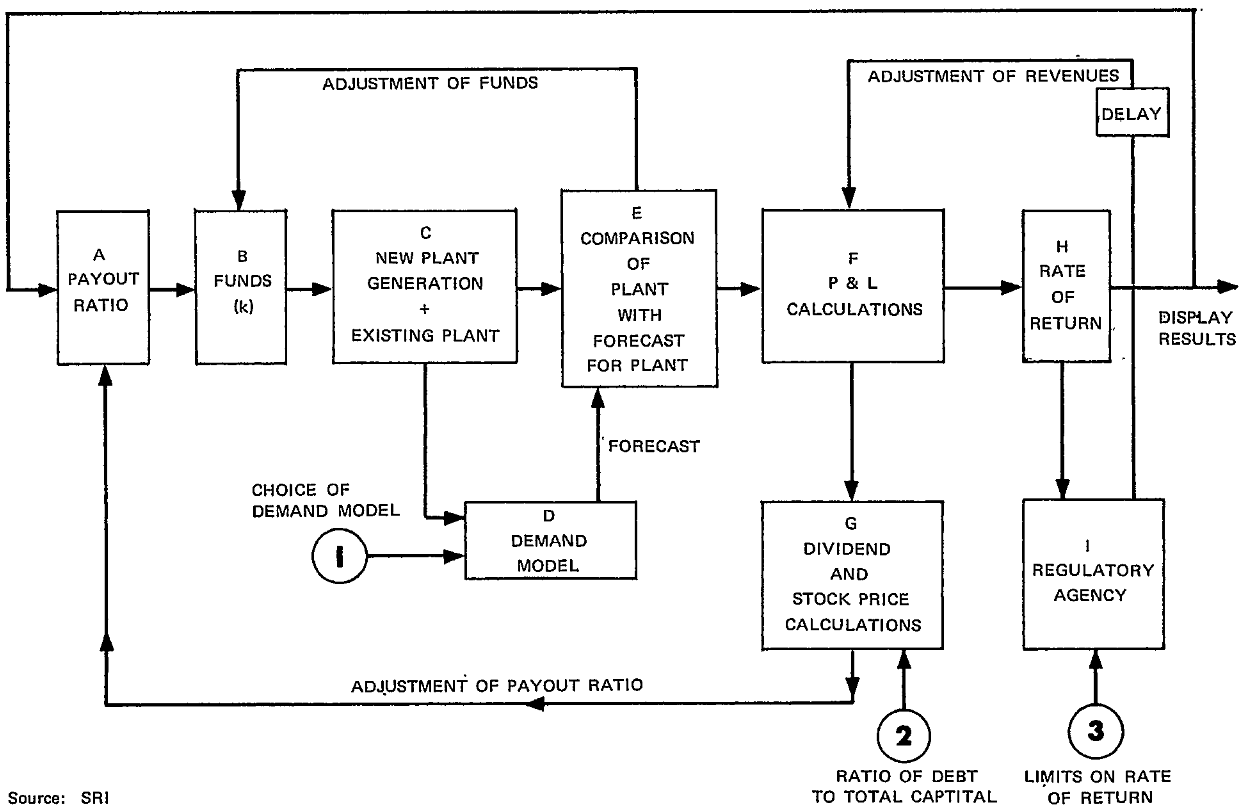

FIG. 3 BASIC STRUCTURE OF THE MODEL

plant. The operating capital requirement is then determined.

D. The demand model, selected by the user of the program (circle 1), is consulted to determine the net plant required. In the earlier G.E. FORTRAN version, the demand for the "current" year is compared with the plant available. In the later TYMSHARE version, the demand three years ahead is compared with the plant that can be made available three years "hence." The demand model is a separate subroutine.

E. The correction factor is determined from the ratio of plant available to the plant required, and this correction factor is used to adjust the funds required for new generation of equipment. The program reverts to step B, readjusts the funds required, and determines the size of new obligation. The new obligation can be any mix of new debt and new equity that is determined by the user of the program, who specifies the ratio of debt to total capital (circle 2). Then step C is traversed again but steps D and E are omitted to prevent the model from returning to B again.

F. At this stage, the net plant and the assets are already determined. The revenues and the expenses are now computed, using the value of α (ratio of revenues to net plant) that is available from the previous year's calculations. Profit after tax and before interest is computed, and interest charges are computed by calculating the payments for all debts outstanding and the interest on all debts unrepaid.

G. The retained earnings are calculated using the initial value of the payout ratio. With the new equity already determined in step E, the program calculates the number of shares that must be issued by referring to the last market price of the stock (the price of the stock is stored in memory). The total number of shares outstanding is the sum of old and new shares. Next the dividend per share is calculated. If the dividend (per share) is not greater than the previous year's dividend, the program reverts to step A, and the payout ratio is readjusted upward. Then steps B, C, F, and G are retraversed, but only once. If, in spite of an increase in the payout ratio, the "current" dividend is equal to, or smaller than, that of the previous year, the program prints a notice to that effect and continues on.

H. The rate of return is next computed (the ratio of profit after tax before interest to the rate base or assets).

I. The regulatory agency is "notified" of the rate of return. If the rate of return exceeds the upper allowed limit that has been set by the user (circle 3), to simulate the ruling of the regulatory agency, <u>next</u> year's revenues will be decreased by 5%* by means of readjusting the variable α. The degree of readjustment is printed under the heading "FCC". At this stage all the key information is available and is printed out.

SUBSCRIPTS AND NOTATION

The program is explained briefly, using

* The assumption of a 5% adjustment in tariffs is merely illustrative and perhaps too drastic.

symbols to identify the variables and using a subscript k to denote the value of the variable in the year k, where $1 \leq k \leq 50$.

REVENUES AND EXPENSES

Within the model, certain basic parameters or certain initial values of crucial variables have been assumed. The most important are:

- At the beginning of the program, revenues are 40% of net plant.*
- Expenses are initially 24% of net plant, and the initial value of this variable is multiplied by a factor that takes into account increases in expenses stemming from an annual influx of new plant--i.e., a heavy investment in new plant entails additional operating expenses.
- Taxes are 54% of net operating revenues.
- Assets are 30% higher than net plant and are assumed to be equal to the rate base.
- Depreciation is assumed to be linear at 5% per year.

If ROR = rate of return, PATBI = profit after taxes before interest, R = revenues, E = expenses, A = assets (rate base), NP^1 = new net plant, and NP = net plant, then the above five assumptions can be expressed as:

$$ROR = \frac{PATBI}{A} = \frac{0.46\ (R-E)}{A}$$

$$= \frac{0.46\left(\alpha\beta\ NP - \left(0.24 + \gamma\ \frac{NP^1}{NP}\right) NP\right)}{1.3\ NP}$$

$$= \frac{0.46}{1.3}\left(\alpha\beta - 0.24 - \gamma\ \frac{NP^1}{NP}\right) \qquad (1)$$

where α = revenue constant (initially 0.4) as adjusted by the FCC, $\beta = (1.01)^k$, γ = 0.05* and k is the "current" year of the program run.

NET PLANT AND DEPRECIATION

The following equations describe the net plant NP and depreciation flow D in any year k:

$$NP_k = 0.95\ NP_{k-1} \qquad (2)$$

$$D_k = 0.05\ NP_{k-1} \qquad (3)$$

and

CREATION OF A NEW PLANT

The new plant added each year results from funds generated in the current and prior years, as shown by:

$$NP_k = \sum_{i=k-4}^{i=k} f(i)F(i) \qquad (4)$$

where f(i) is the fraction of the funds F in the year i contributing to the new plant in year k and F(i) is the new capital expenditure undertaken by the company in year i.

* This is the starting assumption only. During the running of the model, this variable increases by 1% per year because of improvements in technology; and, in addition, it is adjusted from time to time by the FCC to keep the rate of return within speciticed limits.

** It is assumed that the initial operating expenses of new plant are approximately 5% higher than the operating expenses of the old plant to allow for installation, checkout, and so forth.

NEW CAPITAL FUNDS

The funds F required for satisfying the demand forecast consist of depreciation, retained earnings, and most of the new capital requirements (NC_1) except for an amount needed to provide operating capital.* Retained earnings (RE) are a fraction 1-p of the after-taxes, after-interest profit (PATAI), where p is the payout ratio. Thus:

$$F_k = D_{k-1} + RE_k + NC_{1k}$$
$$= D_k + (1-p)\ PATAI_k + NC_{1k} \qquad (5)$$

The payout fraction p is determined each year to make the dividend per share larger than the dividend in the previous year subject to a constraint:

$p \leq 0.8$ i.e., the maximum payout ratio is 0.8.

New debt is determined by a fraction r (ratio of debt to total capital, a decision variable, is specified at the beginning of the program.) The new capital requirements are increased by the necessity to generate sufficient operating capital:

$$NC_k = NC_{1k} + \overbrace{(1.30\ NP_k - A_{k-1})}^{\text{New Assets}} - \overbrace{(NP_k - NP_{k-1})}^{\text{New Net Plant}} \qquad (6)$$

where 1.30 NP_k are the assets required in the year k and (NP_k - NP_{k-1}) is the addition to net plant in the year k. The working capital is the difference between the required increase in assets and the increase in net plant.

Debt (which is assumed to consist of bond issues) is repayable in 30 equal installments. The unrepaid sum of all bonds outstanding in any year carries an annual interest charge of 4.5%.

New equity issue (EQ) consists of the number of shares (SH) sold at the previous year market price less a commission of 2%.

STOCK PRICE

The dividend per share (DPS) is computed as follows:

$$DPS_k = P_k \cdot PATAI_k / SH_k \qquad (7)$$

The stock price (SP'), unperturbed by external influences, in year 7 of the model run (by which time the growth of the company has settled somewhat) is determined by multiplying the earnings per share by the price-to-earnings ratio of 20.

$$SP'_7 = 20\ (PATAI_7 / SH_7) \qquad (8)$$

To describe the investors' evaluation of stock price changes, the M. J. Gordon** model is used:

$$\Delta\ SP' = \frac{DPS_{(k-1)}}{SP_{(k-1)}} + \Delta\ DPS - RORIR \qquad (9)$$

where Δ SP' and Δ DPS are the annual percentage changes in the value of stock price and dividend per share, and RORIR is the percentage annual rate of return that investors require. For example, if last year's dividend yield $\frac{DPS\ (k-1)}{SP\ (k-1)}$ was 2.5% and the current growth of dividend $\frac{DPS_{(k)}}{DPS_{k-1)}}$ is 6% and if RORIR is 8.5%, the stock price should remain constant:

* NC = NC_1 + C where C is the operating capital required.

** Testimony before the FCC on Docket No. 16258, Exhibit No. 17. This model is used merely as an example of a stock valuation model. Other submodels may be substituted for this one within the framework of the present overall model.

$SP = 2.5\% + 6\% - 8.5\% = 0$

External market fluctuations are simulated by multiplying the stock price as valued by the investor by a random number as follows:

$SP_k = SP'_k\ (1+X)$

with X_k being a normally distributed random variable with a standard deviation of 0.1 and a mean of 0.

THE DEMAND MODEL

To forecast the net plant required, three demand models are available. They are defined by the following assumptions:

Model 1: To simulate a simple extrapolation of an exponential growth, for each year in the program, the rate of growth of the preceding four years is calculated. The net plant then is extrapolated for five years ahead by using this growth rate.

Model 2: The demand for net plant grows at a constant rate.

Model 3: The demand for net plant consists of two segments, one growing at 8% per year and the other at 70%.*

ELASTICITY OF DEMAND

In the demand Model 3, a simple elasticity mechanism, which is shown in Figure 4, is assumed for the fast growing demand segment as follows:

- A reduction of tariffs to zero (i.e., $\alpha = 0$) causes trebling of demand for net plant in the fast growing segment.
- A doubling of tariff (from the preceding tariff) caused a two-thirds (67% or from 1 to 1/3) decrease of demand of net plant in the fast growing segment.

THE "MODEL WITHIN A MODEL" REVISION OF DEMAND FORECASTING

While exploring the response of the hypothetical utility to a sudden growth in demand, such as one simulated by the Demand Model 3, it was noticed that the supply of net plant "lags" with respect to the demand. The ratio of the net plant supplied to the net plant required was as low as 0.5 when the annual rate of growth of demand rose to 70%.

This lag was traced to the lack of forward forecasting; the algorithm adopted compares the net plant "currently" in existence** with the net plant forecast for the "current" year that was made five years ago. If a difference between the supply and demand exists, a corresponding correction is made in the funds allocated for future plant expansion. Obviously, this is not the way that decisions about new plant requirements are made. Actually, the demand forecast is evaluated for consistency with selected trends and indicators. Moreover, investment decisions are influenced by the financial well-being of the company, by the state of the money market, and by many other factors.

However, if the demand forecast were to be believed implicitly, then the determination of the actual funds needed would require that a projection be made of the future plant generated by those funds. It

* This enormous rate of growth was selected as a higher boundary of the possible rate of growth of data communications. The higher growing segment starts at a very low percentage of the total demand but soon overtakes the other, slower growing segment.

** Currently means "at that point of time" during the model run. For instance, if the model calculates the 21st year in the "life" of the utility, "currently" means in the 21st year.

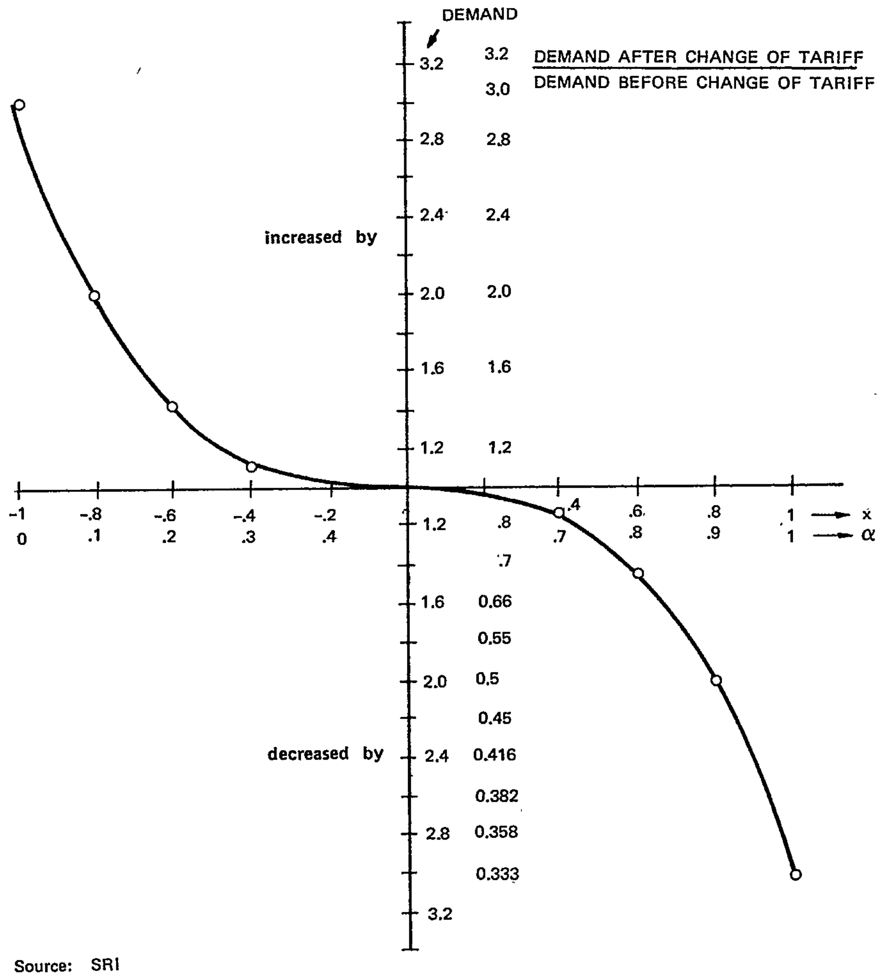

FIG. 4 PRICE ELASTICITY OF DEMAND FOR DATA

may be assumed that the hypothetical utility would have a forecasting model of its own operations--perhaps similar to the one described here--and with the help of such a model it could project its net plant growth several years ahead. Therefore, it was decided to use the complete model to make predictions within the model and thus to establish the future adequacy of new plant. If the future plant proves to be inadequate, the decision determining the allocation of capital funds is changed to meet the projected demand. As a result of this more sophisticated forecasting, a later version of the model "builds" the new plant to match the specified demand within 1% or so.

DEVELOPMENT OF THE MODEL

The model described herein was written between other assignments, by the author in FORTRAN IV and in G. E. FORTRAN over a period of 10 weeks on time-shared computers from a home console. The easy availability of the terminal was a key to the model's completion. The task was undertaken as a part of Stanford Research Institute's study of the interdependence of computers and communications for the Federal Communications Commission.

REFERENCES

(1) Averch, H., and L. Johnson, "Behavior of the Firm under Regulatory Constraint," American Economic Review, Vol. 52, December 1962, pp. 1052-69.

(2) Troxel, E., "Demand Elasticity and Control of Public Utility Earnings," American Economic Review, Vol. 38, June 1948, pp. 372-82.

(3) Gordon, M. J., The Investment, Financing, and Valuation of the Corporation, Irwin, Homewood, Illinois, 1962.

(4) Modigliani, F., and M. Miller, "The Cost of Capital, Corporate Finance, and the Theory of Investment," in Ezra Solomon (ed.), The Management of Corporate Capital, Free Press, Glencoe, Illinois, 1958.

(5) Miller, M., and F. Modigliani, "Dividend Policy, Growth, and the Valuation of Shares," Journal of Business, October, 1961.

(6) Lerner, E., and W. Carleton, "The Capital Structure Problem of a Regulated Public Utility," Public Utilities Fortnightly, July 8, 1965.

(7) Forrester, W., Industrial Dynamics, John Wiley, New York, 1961.

(8) Dean, V., "Quantitative Methods in New Product Planning," a paper presented at The Institute of Management Sciences and the Operations Research Society of America, October 7-9, 1964.

(9) Lipinski, A. J., D. W. Ross, and D. M. Salmon, "Development and Application of a Simple Product Development and Marketing Strategy Model," Second Conference on Applications of Simulation, New York, December 2-4, 1968.

(10) Goldberg, S., Introduction to Difference Equations, John Wiley, New York, 1958.

(11) Statistics of Communication Common Carriers, Federal Communications Commission, 1965.