OPERATIONAL EFFICIENCY IN TELECOMMUNICATIONS

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Introduction

The continuation of this project has taken a number of quite specific directions which are contained in the separate sections of this interim report. The four major work areas are: (a) pilot inter-firm comparison; (b) data methodology, documentation and collection; (c) regulation and policy; and (d) management uses.

In section one, the pilot inter-firm comparison is discussed. In this study, we are using publicly available data to compare firms' efficiency. With the cooperation of companies, we have clarified the differences in their current data. In the comparison, we have tried to isolate some of the differences between the companies by selecting alternative output and input definitions and measures. In addition, we have considered the usefulness of alternative methods of comparison.

The second section describes our efforts to implement the groundwork from last year's final report. This has been done in three stages. First, we have documented the current data methodology of the companies participating in our pilot project. This has permitted a much more intelligent interpretation of the pilot project results. The difficulties and possibilities of improving this existing data have been discussed extensively. Two stages of data development were considered. An "interim" data base was designed which we hoped could be used in this year's pilot project. It will not be possible to fully incorporate this new data into our pilot study. Some of the data cannot be produced and sent to us in time for full scale use. However the portion that has been produced has assisted us in understanding the companies' performances. Our final task in this area was to specify the appropriate methodology appropriate for the long run development of a data base suitable for internal and external efficiency measures.

Section three describes our efforts to evaluate the interaction of efficiency performance and measurement with regulation and policy making. We are in the process of (i) reviewing recent regulatory commentary on efficiency measurement, (ii) evaluating the impact of major regulatory decisions on efficinecy (iii) deriving analytic results for regulatory impact (iv) attempting to quantify the impact of regulation and (v) investigating "incentive" regulatoin including rate adjustment clauses.

The final section details our efforts in developing internal uses of efficiency measurement. Progress in this direction has partially been achieved through contact and discussion with the companies. In our written work we have extended the previous analysis in two directions. If efficiency analysis is integral to the decision-making within a firm it must be coordinated with existing budgetary, planning and control functions. Our work approaches this task through a more detailed analysis of disaggregated efficiency analysis within the firm and an extended analysis of the relationship between the aggregate level of efficiency, rate of return and profitability of the firm in planning.

I. INTER-FIRM COMPARISON

(a) An Interpretation of Alternative Methods of Comparing the Efficiency of Firms

Introduction

This brief report is intended to be a non-technical introduction to the comparison of firms' efficiency. In particular, the development of new methods which we will be using in our telecommunications study are discussed. There are two broad approaches to comparative efficiency. The accounting method attempts to derive from data on the prices and quantities of inputs and outputs a measure of relative efficiency. The simplicity of this method makes it very appealing and it will undoubtedly be widely used. Properly understood these methods can be very helpful and our discussion will concentrate on these methods.

The alternative approach requires much more information but holds out the potential of a far richer interpretation and understanding. If sufficient data is available, statistical procedures exist which will permit the estimation of the production technology of the firm. With these statistical results comparisons are possible which are more diverse than those available from the accounting procedure. The difficulties with this method are rooted in the veracity, sensitivity and reliability of the econometric results. Since these are not specifically problems associated with comparing efficiency levels and there is a very large literature associated with these problems, we can not discuss these problems here.

The Production Technology

Underlying any method of measuring productivity are some implicit or explicit assumptions about the production technology. This technology can be represented by either a production function or a cost function. The production function is a construct that represents in abstract fashion the simple ideas that (1) outputs can not be produced without inputs, (2) different input bundles permit you to produce different output bundles (3) the same output bundle may be produced by different input bundles (and vice versa) and (4) for any input bundle, there is an upper limit to how much of any output(s) can be produced.

Measures of productivity or efficiency are related to the production technology in several ways. First, all efficiency measures involve a comparison of the output level produced relative to the inputs used. Therefore these measures are concerned with the relationship between the volume of output that firms can produce with various input bundles. This is obviously related to the production technology. More formal relations can be developed by noting that any particular efficiency measure implies some assumptions about the production technology. We know for example that the use of a particular index number formula implies that the production technology must have a particular form. Often the particular form of the technology can be written down explicitly although this need not be true for our argument. Similarly efficiency formulas that use only an incomplete list of inputs or reduce output to value-added can be interpreted as implying specific restrictions on the technology in the latter case and implicit assumptions about the role of other inputs in the former case.

The production technology provides a framework to interpret all work on productivity. We will retain it throughout this discussion since without this structure very little can be said about the measurement of efficiency.

Comparing Firms

Suppose we knew the production function (or cost function) for each firm. Algebraically we can represent these functions by,

$$Q_i = f_i(K,L) \qquad\qquad i \text{ - indexes the firm}$$

where output Q is produced using inputs capital (K) and labour (L). Select any input bundle $X_0 \equiv (K_0, L_0)$ and calculate

$$Q_{i0} = f_i(K_0, L_0) \qquad ,$$

for all firms. A particular firm i will be more efficient than firm j if $Q_{i0} > Q_{j0}$. That is the more efficient firm i produces more output for a given input bundle than the other firm j. For any number of firms one can rank the firms using this procedure. If desirable, the proportional difference in the output levels between any two firms may be defined as the relative efficiency level. An index can be constructed by choosing any single firm as having an efficiency level of 100 and all other firms can be compared to this firm.

Notice carefully that we chose a particular input bundle X_0 for the comparison. Is the comparative ranking independent of this choice? In general the answer is no, although many methods implicitly assume the opposite. The methods we prefer permit the answer to depend on the input bundle chosen. While this complicates the comparison it is a desirable feature. Some firms may be more efficient than others for some input bundles and not for others. This is a sensible possibility that we do not wish to eliminate. To illustrate this situation, consider Figure 1. Output is produced with labour only in this two dimensional example. Firm Two is more efficient at input levels less than H while Firm One is more efficient at higher input levels. While the geometry becomes complex, the extension to more outputs and inputs can be done algebraically.

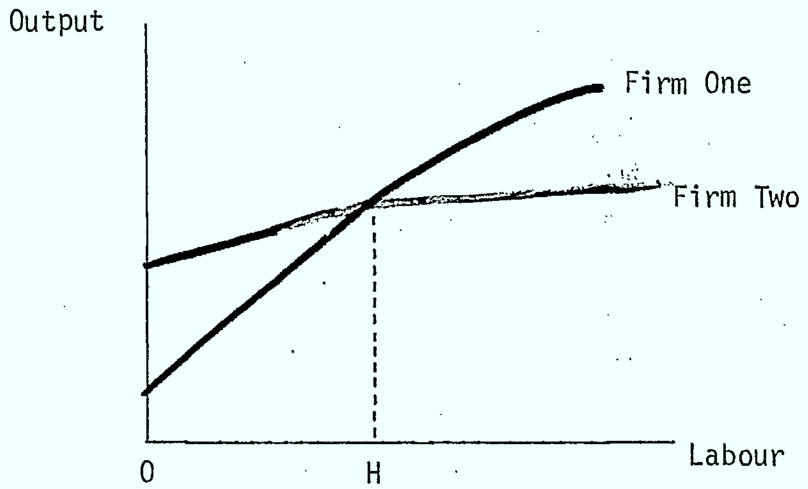

Figure 1

If we want to use cost functions, a similar procedure must be used. Assuming that we know the cost functions, $g_i(w_K, w_L, Q)$ for each firm, choose a particular set of input prices w_{K0}, w_{L0} and output level Q_0 and calculate

$$C_{i0} = g_i(w_{K0}, w_{L0}, Q_0)$$

for each firm. The firm with the lowest cost is most efficient. The remarks made about the input vector, X_0, pertain here to the input prices w_{j0} and output level, Q_0.

Provided we have enough information on the technology, our general methodology is very simple. At any specified input bundle, the firms output level produced from those inputs is compared. The efficiency ranking and levels may be different for different input bundles. We do not have all the required information and most of our efforts must be directed towards using the limited information available.

Two broad types of methods can be distinguished. First, there is the index number or accounting method on which we will concentrate here. Second there is the econometric method which we will only briefly discuss.

The econometric method requires a sufficient quantity of quality data to permit the estimation of the production and/or cost function. With these estimates, one can directly calculate the comparisons discussed above. There are a number of difficulties in obtaining the estimates of the technology. These will not be discussed at this stage of our work. When this method is used a discussion of any problems will be included.

The accounting method requires that we extract from limited information a measure of relative efficiency without knowing the complete production technology. With this method there is no requirement that we know the details of the production function. How are we going to attain a comparison without knowing the specific technology of the firms?

The accounting method, we prefer can now be outlined. The basic requirement is that we must be able to measure the relative efficiency of the firms using only data on the quantities and prices of the inputs used and outputs produced. This is a relatively weak data base but we wish to eliminate the necessity of complex statistical procedures or a reliance on other peoples estimates. The technology of any firm is to be approximated by a second-order approximation. As noted above, all methods must make some implicit or explicit assumption about the production technology. In this case, we will assume that a second order approximation to the true unknown technology is adequate. This does not presume a knowledge of the exact function, only the general type of second order function which can approximate any true unknown technology to the second order. In particular, an approximation in the logarithms of the outputs and inputs will be used in the case of production function. There are specific reasons for these decisions. The second-roder approximation is used because it will not be possible to use the limited data available with a higher order approximation. In fact we will use a quadratic function as the second-order approximation. This is also required by the limited data as we will explain more completely below. The choice of the logarithmic form is not necessary but it has one major advantage. We will be able to directly link our method to the most prevalent measure of productivity and to the pioneering method of measuring intra-firm efficiency. However for some purposes one may wish to give up these links.

The next few pages may be excessively technical for some readers. However it is suggested that the algebra be omitted and the text read in order to perceive in non-technical terms our procedures. Assume that the technology of the firm can be approximated by a quadratic form in the logarithms of the variables of the cost or production function. In this case, Diewert's quadratic Lemma proves that the difference in the logarithm of output between two firms can be expressed <u>exactly</u> as a weighted sum of the differences in the logarithms of the inputs and a term which we will interpret as the difference in the productivity level between firms.

Let the production function for all firms be written

$$Q = f(K, L, D) \qquad (1)$$

where D is a discrete variable indexing the firm. This representation restricts the differences in the approximation to each firm's technology. That is each firm's technology is approximated by a function which can be completely different for each firm. This is required for our method and a similar restriction is required for any accounting method.

The Quadratic Approximation Lemma States that

$$\log Q^i - \log Q^j = \tfrac{1}{2}[f_D^i + f_D^j][D^i - D^j]$$

$$+ \tfrac{1}{2}[f_K^i + f_K^j][\log K^i - \log K^j]$$

$$+ \tfrac{1}{2}[f_L^i + f_L^j][\log L^i - \log L^j] \qquad (2)$$

where f_z^i is the partial derivative of the production function with respect to the z-th argument evaluated at the i-th firms input vector.

The approximation to the production technology must be quadratic if equation (2) is to hold. The key property of (1) which requires the quadratic assumption is the presence of only first order derivatives. If non-quadratic approximations are used then the correct replacement for (2) will involve terms which include the second order derivatives of the production function. These second order derivatives are related to the curvature of the production function and consequently to the prices elasticities of factor demand. Unless one knows the price elasticities, which is very unlikely, it will not be possible to use accounting methods with expressions that include these second order derivatives. Since we cannot see any reasonable possibility of including more complex information requirements, the quadratic assumption is strongly recommended as a practical necessity.

The differences in the firms inputs and technology are weighted by the average of the first order derivatives. For the accounting method we must relate these derivatives to observable data. In the logarithmic case these are the shares of the inputs in total cost under the assumption that firms minimize costs in competitive markets. If one did not make the logarithmic assumption then one would find that these weights are not the average shares. In that case one might or might not be able to relate the weights to observable data. It will depend on the particular case. One must be careful not to choose some alternative to the logarithmic case which is impossible to apply with observations on only the prices and quantities of inputs and outputs.

In the logarithmic case, equation (2), the assumptions of constant returns to scale and competitive markets will permit us to rewrite the expression

$$\log Q^i - \log Q^j = \theta^{ij} + \tfrac{1}{2}[s_K^i + s_K^j][\log K^i - \log K^j] + \tfrac{1}{2}[s_L^i + s_L^j][\log L^i - \log L^j] \quad , \qquad (3)$$

where s_h^i is the cost share of input h in firm i and θ_{ij} is the raw measure of the efficiency differential between firms i and j. To provide an easier interpretation of the efficiency differential, we prefer to define

$$E_{ij} = \exp(\theta_{ij}) \quad .$$

The transformation to E_{ij} permits us to make the following interpretation. The efficiency differential, E_{ij}, is the output level in firm i relative to that in firm j after accounting for differences in the levels of inputs used by the two firms.

Recall that in the beginning we stated that we wished to consider the output levels produced by each firm with a given input bundle X_0. Our actual observations on input bundles are unlikely to be identical. To adjust for differences in the input levels across firms, some of the observed differences in the output levels are attributed to the observed differences in the input levels. It is not possible to compare the firms at identical input quantities unless we know the particular technology of the firm. Our method is an alternative which states that for certain classes of technologies we know <u>exactly</u> how differences in output levels must be allocated between efficiency differences and differences in the quantities of inputs.

Alternative Methods

Since the procedure we have been discussing has only recently been developed, I will consider the alternatives that have often been applied. It is possible to argue that there has only been one alternative measure although it has been applied in a number of variations. The major studies by Gilbert and Kravis (1954), Gilbert et. al. (1958) and Kravis et. al. (1975, 1978) have used variants of this methodology. In Canada, comparisons of the U.S. and Canada have also used this method, West (1971), and Walters (,).

It will be useful to define a revenue function, $R(p,X)$, where $p = (p_1,\ldots p_n)$ and $X = (X_1,\ldots X_m)$ are vectors of output prices and input quantities. The revenue function is defined as the maximum revenue that a producer can obtain at output prices, p , when using input quantities, X . For example, if we observe a firm which produces Q_i outputs which it sells at prices p_i then $R(p,X) = \sum_i p_i Q_i$. This assumes that firms attempt to maximize revenue in the markets in which they sell.

Consider an efficiency comparison between two firms. Each firm is observed to produce outputs Q_i^j which are sold at prices, p_i^j where $j = 1,2$ and indexes the firms. Suppose we want to compare efficiently (LP) measured as aggregate output (Q^j) per manhour (L^j) . How are we going to aggregate outputs for each firm? A common procedure is to aggregate outputs for each firm using both the output prices of the other firm and its own prices. Define Q_j^k ,

$$Q_j^k = \sum_i p_i^k Q_i^j \qquad ; \qquad j = 1,2; \qquad k = 1,2 \quad .$$

This will provide the basis for two productivity comparisons, Firm One's Prices: $LP_1^1 = Q_1^1/L^1$ vs $LP_2^1 = Q_2^1/L^2$

Firm Two's Prices: $LP_1^2 = Q_1^2/L^1$ vs $LP_2^2 = Q_2^2/L^2$

where the first pair use firm one's price weights and the second pair firm two's price weights. Is it possible to interpret these results to provide some understanding of what they mean?

Consider the output aggregates Q_1^1 and Q_2^2. These can be interpreted as $R_1(p^1,X^1)$ and $R_2(p^2,X^2)$, the revenue functions for firms one and two evaluated at their actual output prices and input quantities. The output aggregates Q_1^2 and Q_2^1 are not equal to any revenue function but do satisfy the following inequalities,

$$Q_1^2 \leq R_1(p^2,X^1)$$

$$Q_2^1 \leq R_2(p^1,X^2) \quad .$$

These inequalities must hold since in calculating Q_1^2 for example, firm two's prices are used to aggregate firm one's observed outputs. However if firm one actually had the opportunity to sell at firm two's prices, it would probably choose a different output vector than the actual observed output vector chosen at the actual prices for firm one. Given the definition of the revenue function, $R_1(p^2,X^1)$ must be the maximum revenue attainable at these output prices and input quantities. Consequently it must be at least as large as Q_1^2.

Rewrite the first comparison, LP_1^1 vs LP_2^1, as

$$R_1(p^1,X^1)/L^1 \quad \text{vs} \quad Q_2^1/L^2 \leq R_2(p^1,X^2)/L^2 \quad .$$

Using firm one's prices we have aggregated the output of both firms and divided by the respective labour input quantities. Firm two will do relatively poorly in this comparison since $Q_2^1 \leq R_2(p^1, X^2)$. I would argue that it is the unobserved $R_2(p^1, X^2)$ that should be used as aggregate output. Since it is not unobserved it is replaced with Q_2^1 which is probably smaller. The relative performance of the firm whose prices are not used will be underestimated by this method.

The other comparison, at firm two's prices has similar problems associated with the underestimate of firm one's efficiency when evaluated at firm two's prices.

A possible conclusion might be based on the following argument. Suppose firm one is more efficient when both its own prices and firm two's prices are used as weights. Can we conclude that firm one is more efficient? At firm two's prices, firm one's performance is underestimated. If it is more efficient as measured then it certainly must be more efficient when correctly measured at these prices. However the bias goes against firm two when firm one's prices are used. Consequently even if firm one is measured as more efficient it may not be so if correct methods were used. At best this method can establish which firm is more efficient only if the firm whose prices are not used is more efficient (as measured) than the firm whose prices are used. Notice that this will not permit any conclusion when comparing two firms using a third firm's set of prices.

This method generates two comparisons which do not correctly evaluate the efficiency of firms whose prices are not used. What is the difference between the two comparisons? In general, an empirical comparison may give different answers at every set of data for the firms. There is no sensible way of comparing the two relative efficiency measures. Each is as good as the other since they purport to compare the firms at different output prices. In neither case do we have the required data on the revenue functions and even if we did the relative efficiency levels may change as one selects different input and output vectors.

Our example was simplified by choosing a labour productivity measure. Suppose we shift to TFP with either one or many outputs. The procedure under discussion aggregates inputs in a manner comparable to the output aggregation and results in similar problems. Define input aggregates X_j^k

$$X_j^k = \sum_{h=1}^{m} w_k^k X_i^j$$

and TFP measures,

$$PR_j^k = Q_j^k / X_j^k$$

The input aggregates X_1^1 and X_2^2 can be interpreted as the value of the cost functions $C_1(w^1,(Q_i^1))$ and $C_2(w^2,(Q_i^2))$. The other input aggregates X_1^2 and X_2^1 must satisfy inequalities

$$X_1^2 \geq C_1(w^2,(Q_i^1))$$

$$X_2^1 \geq C_2(w^1,(Q_i^2)) .$$

That is, the aggregate input is too large when one firm's inputs are evaluated at the other firm's input prices.

Combining the problems of input and output aggregation two points can be observed. First if revenues equal costs, then the productivity index using own prices will always equal one, $PR_1^1 = PR_2^2 = 1$. To the extent that they do not, we are either measuring economies of scale, measurement error or some behavioral misspecification. The important point is that we are not measuring efficiency. Second, the value of PR_j^k for $j \neq k$ reflects the overestimate of X_j^k , $j \neq k$ and the underestimate of Q_j^k , $j \neq k$ which implies an underestimate of PR_j^k .

The same type of conclusions may be reached in this case. If the firm, whose output and input prices are not being used as weights, is more efficient than the firm whose prices are used then it is certainly more efficient if one could correct for bias. In all other cases no unambiguous conclusion can be reached and this includes all cases in which a third firm's prices are used.

The other most popular variant of this method of making comparison can be discussed as an example of using a third firm's prices. One can find examples in which outputs and inputs are priced at world prices when making comparisons. That is , no particular country's or country industry's prices are used. A third set of prices called world prices are used which will result in all the biases discussed above.

Both of the variants most commonly used suffer conceptual flaws even when used for a single year. Just as serious is their lack of any conceptual basis for linking intertemporal with interspatial measures of efficiency. While it is conceivable that measures could be developed they do not exist currently.

I have been fairly blunt in attacking the conceptual weakness of these methods and yet I intend to calculate such measures. What is a reasonable defense of these calculations. First, we want to see how the results compare with those of our preferred procedure. Second, the empirical magnitude of the errors may be small. This will occur when either (a) the quantities of outupts produced and inputs consumed are insensitive to differences in relative output and input prices or (b) relative input and output prices are very similar for the two firms. The first condition is never likely to occur although any approximation to it combined with relatively small differences in relative prices may make the biases quite small. For these two reasons, we will calculate the alternative measures.

I. INTER-FIRM COMPARISON

(b) Comparing the Efficiency of Firms in Canadian Telecommunications

Introduction

A study of the efficiency of individual firms is seldom possible due to data restrictions. This paper reports on a unique empirical investigation of the efficiency of four telephone companies in Canada. The data has been made available by the telephone companies. They originally developed the data for their own separate productivity studies. Without this considerable effort this paper would not be possible.

The data base for each company is not entirely comparable. The appendix to the paper clarifies the major differences. Part of our task is to evaluate the sensitivity of our comparisons to alternative measures of the variables. This is required to limit the errors of limited comparability of data and to study the advantages and disadvantages of definitions of economic variables. The latter problem is broader than the veracity of the measured variables. Telecommunications' firms offer a wide variety of services through their networks. There are alternative sensible definitions of economic variables which will alter the magnitude and perhaps ranking of the firms' efficiency. While not wishing to obscure the results, we believe that the complexity introduced by the alternatives provides a much better understanding of the detailed changes of efficiency within and across firms.

Given a set of data on the prices and quantities of inputs and outputs, the methods we use to compare efficiency have been discussed elsewhere by us (Denny, de Fontenay and Werner (1980a,b), Denny and Fuss (1980a,b) and by Christensen, Caves and Diewert (1980)). In this paper, we will apply these methods without extensive discussion due to space limitations.

An Introduction to the Companies

At a later stage of this paper, a formal analysis of the efficiency of Bell Canada (BELL), Alberta Government Telephones (AGT), British Columbia Telephones (BCT) and Teleglobe (TG) will be presented and discussed. In this section we want to provide a descriptive analysis of the four companies. Three of the companies, Bell, BCT and AGT, are the largest common carriers in Canada and provide a very wide range of telecommunications services within their geographic service area. Teleglobe provides overseas service almost exclusively and produces a more limited and specialized service mix. Bell and BCT are private companies whose rates and rates of return are federally regulated. AGT is a crown corporation, i.e., a public enterprise in the Province of Alberta. Teleglobe is a federal crown corporation.

In 1978, AGT, Bell and BCT provided about 75% of domestic telecommunications services in Canada. In Table I, the structure of revenue and costs for these companies in 1978 is presented. Bell is by far the largest company with revenues that are roughly five times larger than the other two firms.

The operating revenue of the three firms is derived from local, long distance and other services. The revenue proportion of these services is quite different. Bell receives over one-half of its revenue from local services while AGT receives less than one third. BCT generates about 43% of its revenue from local services. The observed differentials are partially the result of AGT's long distance revenue received for transit traffic that neither originates nor terminates in AGT's territory. This is a more important source for AGT than the other companies. AGT also provides long distance services for Edmonton Tel. The latter firm provides local services

Table I

Revenues and Costs in 1978
(percentage distribution in brackets)

		AGT	BELL	BCT
1.	Operating Revenue	444	2497	551
2.	Local	138 (31)	1263 (51)	242 (43)
3.	Long Distance	292 (66)	1153 (46)	319 (57)
4.	Other	17 (4)	94 (4)	-2.3 (0)
5.	Operating Cost	339	1785	393
6.	Maintenance	87 (26)	420 (23)	109 (28)
7.	Depreciation	125 (37)	474 (27)	113 (29)
8.	Traffic	24 (7)	127 (7)	40 (10)
9.	Marketing	29 (9)	141 (8)	46 (12)
10.	Other	64 (19)	481 (27)	58 (15)
11.	Non-Income Taxes	9 (3)	141 (8)	28 (7)

for one of the largest urban areas in Alberta. If one combined AGT with Edmonton Tel., the revenue shares would be very similar to those of BCT. Consequently, it may be suggested that AGT's high long distance revenue share is due to both transit traffic and the existence of a large local service company within AGT's territory.

The 1978 operating costs for the companies have also been broken down in Table I. For all companies maintenance and depreciation are over 50% of total operating costs. Bell appears to have a lower share of costs devoted to maintenance than the other companies. AGT has an enormously high depreciation cost share which will be discussed further below. Bell has tended to have a larger share of other costs than BCT and AGT.

The static situation portrayed in Table I may disguise rapid shifts in the importance of the revenue and cost components due to growth through time. To characterize shifts through time, Table II shows the 1978 values of revenue and cost component indexes with base year 1972. Revenue growth has been much faster for AGT than for Bell and BCT.

Total costs have grown with revenue for AGT but have exceeded revenue growth in Bell and BCT. For all companies traffic costs have grown more slowly than total costs. For AGT, the growth in depreciation and maintenance costs has been higher and in non-income taxes, lower than total costs. Bell's other costs grew much more while depreciation and marketing grew less than the firm's average. Marketing and non-income tax costs grew faster than average and maintenance costs grew slower in BCT. While there is some diversity in the revenue and cost growth and shares it is not sensible to conclude anything about efficiency from these data. They will provide some questions which we will attempt to explore in more depth later in the paper.

Table II

1978 Indexes of Revenue and Costs, 1972 = 100

	AGT	BELL	BCT
Local Revenue	319	201	227
Long Distance Revenue	315	248	278
Total Revenue	314	222	242
Total Cost	314	233	246
Maintenance	329	217	222
Depreciation	342	208	260
Traffic	217	192	201
Marketing	311	203	315
Other Costs	309	310	236
Non-Income Taxes	248	261	321

A further simple comparison of these companies can be based on the number of telephones per employee. Very roughly this measures the magnitude of the network served by each employee. The companies differ enormously in the value of this measure as one can see in Table III. Of the three major companies, Bell has the largest number of telephones per employee followed by BCT and AGT. There are some sharp fluctuations in the annual series and perhaps a very slight trend upwards.

What do these differences signify? First, the AGT numbers are extremely low and this appears to be a function of the low average density of the AGT area served. Edmonton Telephones is included in Table III to provide a contrast. Their urban network has a very high number of telephones per employee. If we combine Edmonton Tel. with AGT the results are very similar to those for BCT. If this interpretation is correct the high numbers for Bell may only signify a more densely packed network. We will try to explore this in more detail below.

This example should highlight the difficulty of using very simple measures to compare the companies. The number of telephones is an important component of output and we will consider it more fully below but it ignores too many other components to be satisfactory alone. Moreover, the type of network each company serves is going to make a difference to our comparison and it is one which we will have a difficult time treating adequately with out existing data.

Table III

Telephones per Employee

	BCT	AGT	BELL	EDMON. TEL.
1972	109	85	166	240
1973	98	87	165	250
1974	99	84	162	230
1975	112	82	176	222
1976	112	86	173	220
1977	121	90	171	220
1978	121	95	168	245

Productivity as Measured by the Companies

All four companies have produced productivity measures and for reference purposes we have included some of their estimates here. In Table IV, some company estimates are shown. B.C.Tel., Bell Canada and Teleglobe have calculated estimates of total factor productivity growth rates. Teleglobe has had exceptionally fast increases in productivity. Bell has had an average rate of growth of TFP of 3.1% compared to the lower B.C.Tel. average of 2.6% from 1972-79. Given the differences in the methods used the Bell-B.C.Tel. results cannot be easily compared but Teleglobe's productivity has clearly grown more swiftly.

AGT and Bell produce estimates of value-added productivity. AGT's productivity has grown at 7.2% a year which is substantially higher than Bell's average of 4.0%. Without any serious investigation of methodology, the ranking using these measures would be Teleglobe, AGT and Bell and B.C.Tel tied. There is no doubt that these are very high rates of productivity growth relative to other industries. Our task is to evaluate why these results were achieved and to provide a more detailed underpinning for these results.

Measured productivity growth is often correlated with output growth. This is expected since accurate measures of utilitization of quasi-fixed inputs is seldom possible. In periods of slow output growth, productivity growth is low since our input measurements incorrectly overestimate utilization which falls as firms maintain input levels over fluctuations in demand growth. This may be a more serious problem in telecommunications due to the high weight of relatively fixed capital and the labour required to maintain it.

Table IV

Company Measures of Productivity Growth

	TFP			Value-Added Productivity	
	B.C.Tel	BELL	TELEGLOBE	BELL	AGT
1967	—	5.7	—	6.6	—
1968	—	3.9	—	4.5	6.9
1969	—	2.9	—	7.4	6.8
1970	—	3.5	—	4.2	5.5
1971	—	-1.0	—	-1.0	4.7
1972	0.3	3.8	12.7	4.5	11.5
1973	2.8	4.8	16.7	5.7	9.0
1974	5.7	4.7	8.9	5.6	14.2
1975	5.9	6.9	10.7	8.2	9.9
1976	4.7	1.0	14.3	1.2	0.7
1977	-3.6	0.7	11.3	0.8	7.2
1978	2.5	2.0	—	2.5	2.7
1979	2.4	1.3	—	1.5	—

In Table V, the companies' output growth rates are shown. First one can see that Teleglobe and AGT have had very high rates of output growth underlying their high rates of productivity growth. Bell's output grew at 10.2% compared to B.C.Tel's output growth of 8.8% from 1972-79. These are less than 60% of AGT's output growth rate. For all companies relatively high average rates of output growth have accompanied relatively high rates of growth of productivity. It is not yet clear why this relationship exists.

If fluctuations in productivity and output growth are considered for individual companies, there is no consistent pattern. It is easy to find exceptions to any but weak relationships that tie ups and downs in the two measures together.

Table V

Company Measures of Output Growth Rates

	BCT	BELL	AGT	TELEGLOBE
1967	—	9.1	—	—
1968	—	9.1	10.5	—
1969	—	10.4	13.7	—
1970	—	9.5	12.1	—
1971	—	5.6	10.6	—
1972	9.0	8.1	15.7	14.8
1973	11.0	10.7	13.9	24.3
1974	14.3	11.0	20.1	24.3
1975	10.3	11.0	19.0	27.9
1976	9.2	7.6	12.2	17.5
1977	6.3	6.9	13.6	18.6
1978	9.8	8.7	19.2	—
1979	11.7	6.3	—	—

Labour Productivity and Labour Efficiency Levels

To begin our comparison, we have measured labour productivity and compared the companies on their levels of labour productivity. Output is the aggregate of the output disaggregation provided by the firms and discussed in the appendix. For reasons of comparability, labour is measured as unweighted man-hours of labour worked in each company.

In Table VI, indexes of labour productivity for AGT, B.C.Tel. and Bell are shown. Labour productivity in AGT and B.C.Tel. have grown at approximately 8% a year since 1972 compared to about 4.5% in Bell. Prior to 1972, labour productivity was growing at an annual rate above 10% at AGT and 7.7% in Bell Canada.

Output growth was higher at Bell than B.C.Tel. after 1972. Labour input must have grown substantially faster at Bell than at B.C.Tel. in order to convert the output growth advantage into a lower labour productivity growth performance. AGT had the fastest rate of growth of output after 1972 but this was not translated into a higher labour productivity growth relative to B.C.Tel. Given the rates of growth of output, B.C.Tel. has managed a superior performance relative to Bell and AGT in achieving labour productivity growth.

Table VI

Labour Productivity
(1972 = 100.0)

	AGT	BCT	BELL
1967	61.7	—	69.2
1968	70.7	—	76.4
1969	76.7	—	82.7
1970	81.4	—	87.3
1971	88.2	—	92.8
1972	100.0	100.0	100.0
1973	107.2	104.2	105.3
1974	121.8	111.9	110.3
1975	143.8	131.4	122.1
1976	149.3	150.8	125.1
1977	164.1	159.9	129.0
1978	159.3	157.1	130.1
1979	—	149.2	133.1

Total Factor Productivity: An Initial Comparison

To begin our comparison, we will measure total factor productivity for AGT, Bell and BC.Tel. using a common methodology and data which is partially standardized. Define the rate of growth of productivity,

$$\dot{TFP} = \dot{Q} - \dot{F}$$

where the aggregate output growth rate $\dot{Q}$ is defined by,

$$\dot{Q} = \sum_j r_j \dot{q}_j$$

and the aggregate input growth rate, $\dot{F}$ is defined by,

$$\dot{F} = \sum_j s_i \dot{x}_i \quad .$$

The disaggregate output $(\dot{q}_j)$ and input $(\dot{x}_i)$ growth rates are weighted by the revenue (r_j) and cost (s_i) shares respectively. This standardizes the methodology for the three companies.

The data are partially standardized by the choice of input variables. At this stage, we will not standardize the output measurement. This process will require a separate section below. For each company, labour input is measured as man-hours worked without any adjustment for skill levels. Capital is measured as the gross capital stock which is aggregated from detailed disaggregates. Material inputs are not completely comparable but this is not believed to be a problem. Finally, the assumption is made that the value of capital services can be measured as a residual component in total realized costs. Each of these measurement choices will be discussed below. Given the limitations of the public data, we cannot directly move to an improved data set. Our strategy has to be more indirect.

For the three companies, the rates of growth of total factor productivity are shown in Table VII and a productivity index (1972 = 100) appears in Table VIII. The rough standardization does not alter our earlier comments based on the companies published results. AGT has had a faster rate of growth of TFP than Bell and B.C.Tel. during any time period when comparable data is available. From 1972-78, AGT's productivity grew at an average annual rate of 6.6% compared to a rate of 3.9% for Bell and 3.5% for B.C.Tel.

Recall that AGT and B.T.Tel. had almost identical rates of growth of labour productivity. The TFP results indicate that B.C.Tel. achieved the labour productivity results through faster rates of growth of the capital-labour and the materials-labour ratio relative to AGT. The latter company was more successful at achieving high rates of labour productivity growth via high rates of TFP growth.

Bell had a substantially lower rate of growth of labour productivity than B.C.Tel. but TFP grew at least as quickly. Relative to Bell as well as AGT, B.C.Tel. must have had a faster rate of growth of capital and materials to labour intensities in order to achieve the results portrayed above.

Table VI

Annual Rates of Growth of TFP

	BCT	AGT	BT
1967	—	—	6.4
1968	—	5.3	4.9
1969	—	5.5	3.5
1970	—	4.6	4.3
1971	—	4.2	1.2
1972	—	9.3	4.2
1973	2.9	7.7	5.2
1974	5.9	11.9	4.9
1975	6.2	8.3	7.5
1976	4.5	3.3	1.8
1977	-2.2	6.6	3.0
1978	3.1	2.0	3.0
1979	2.4	—	1.6

Table VIII

TFP Indexes
(1972 = 100)

	BCT	AGT	BT
1967	—	74.9	84.4
1968	—	78.9	88.6
1969	—	83.4	91.8
1970	—	87.3	95.8
1971	—	91.1	95.8
1972	100.0	100.0	100.0
1973	102.9	108.0	105.3
1974	109.2	121.7	110.7
1975	116.2	132.3	119.3
1976	121.6	132.8	121.4
1977	118.9	141.8	122.9
1978	122.6	144.8	126.6
1979	125.6	—	128.7

Using the data underlying our calculations of labour and total factor productivity, an initial comparison of the firms' relative levels of efficiency was made. Relative efficiency will be measured in the following ways. Define the relative total factor productivity level, of firm be relative to firm h, E_{kh}

$$\log E_{kh} = \log (Q_k/Q_h) - \tfrac{1}{2} \sum_i (s_{ik} + s_{ih}) \log (X_{ik}/X_{ih}) \quad ,$$

where s_{ik} is the cost share of factor i in firm k and X_{ik} is the equivalent quantity.

From the cost function, one may define a relative cost efficiency level, CE_{kh}

$$\log CE_{kh} = \log(C_k/C_h) - \tfrac{1}{2} \sum_i (x_{ik} + x_{ih}) \log (w_{ik}/w_{ih}) - \log (Q_k/Q_h) \quad ,$$

where C_k is the total cost and w_{ik} the price of input i in firm k.

Tables IX and X present the results, E_{kh} and CE_{kh}, of measuring both of these relative efficiency measures for the three companies. Consider the results of comparing Bell and AGT in Table IX. The results for 1967 state that Bell's relative TFP level was 140.4 compared to AGT's 100. Alternatively one may state that the quantity of output produced by Bell was approximately 40% greater than that produced by AGT after accounting for differences in input quantities. For the companies to be equally efficient, the E value for Bell would have to be 100.

The results are roughly equivalent when measured from the cost side. Bell's cost efficiency in 1967 was 71.3 relative to AGT's 100. Bell's costs were only 71.3% of AGT's after accounting for differences in input prices and output levels.

Table IX

Relative Efficiency of Bell Compared to AGT

	Productivity		Cost Efficiency
	BELL	AGT	BELL
1967	140.4	100	71.3
1968	140.4	100	71.3
1969	136.8	100	73.1
1970	136.2	100	73.4
1971	130.2	100	76.8
1972	124.0	100	80.6
1973	120.4	100	83.0
1974	111.5	100	89.7
1975	110.5	100	90.5
1976	111.3	100	89.8
1977	104.9	100	95.2
1978	105.2	100	95.0

Table X

Relative Efficiency of AGT and Bell Compared to BCT

	Productivity			Cost Efficiency	
	AGT	BELL	BCT	AGT	BELL
1972	107.7	134.6	100	92.8	74.3
1973	113.4	137.5	100	88.2	72.8
1974	120.2	134.8	100	83.2	74.2
1975	122.8	137.8	100	81.4	72.6
1976	118.4	132.9	100	84.4	75.2
1977	130.5	136.5	100	76.6	73.2
1978	130.3	136.9	100	76.7	73.1

Through time AGT has eliminated most of the relative efficiency gap. In 1978 there is almost no difference in the relative efficiency level. In our explorations below we will try and indicate what led to this sharp improvement in AGT's relative efficiency.

In Table X, AGT and Bell are compared to B.C.Tel. for the years 1972-78. At the beginning of the period, Bell had much higher relative efficiency level which they have roughly maintained over the time period. AGT has made sharp gains in relative efficiency relative to BCT. A minor AGT advantage in 1972 was converted into a major efficiency advantage for AGT by 1978.

Our initial set of results suggest that AGT's very rapid growth in total factor productivity has resulted in a major shift in their efficiency relative to the other two companies. Bell has maintained its high level of efficiency relative to B.C.Tel. The latter company has had the weakest performance during this period.

A First Interpretation

The magnitude of the differences in our initial comparative results surprised us. Much of the remainder of the paper will be an exploration of the factors that result in these differences. To begin, it is useful to consider the input-output ratios for the three companies. These are presented in Table XI for labour, capital and materials.

The labour-output ratio has fallen steadily for all companies. Bell has had the lowest labour coefficient but both AGT and B.C.Tel. have gained relative to Bell. By the end of the period the use of labour did not contribute strongly to the major relative efficiency differences.

The variations in the capital-output ratio provide a sharply different interpretation. In Table XI, Bell has had a much lower capital coefficient than either AGT or B.C.Tel. However AGT has managed to reduce the size of its capital coefficient to within 20% of Bell's capital coefficient. B.C.Tel. has had and continues to have a very large capital coefficient. this difference must significantly contribute to the relative efficiency differences that persist for B.C.Tel.

The materials input coefficient is of less quantitative importance. AGT has had the smallest coefficient almost every year. The size of Bell's coefficient is moderately high which tends to offset the advantages they have had in labour and capital.

This brief look to the time-path of input-output ratios clearly suggests that the capital stock be more closely investigated. This will be done below.

First we will consider the underlying implications from the cost side. From equation ( ), the differences in measured cost efficiency must

Table XI

Input-Output Ratios

	Labour			Capital			Materials		
	AGT	BCT	BELL	AGT	BCT	BELL	AGT	BCT	BELL
1967	.112	-	.074	6.29	-	4.27	.148	-	.155
1968	.098	-	.066	6.27	-	4.23	.146	-	.150
1969	.090	-	.060	6.01	-	4.10	.140	-	.162
1970	.085	-	.057	5.79	-	4.04	.134	-	.150
1971	.078	-	.053	5.69	-	4.08	.129	-	.169
1972	.069	.060	.049	5.33	6.58	4.03	.115	.130	.160
1973	.064	.057	.046	4.94	6.46	3.85	.103	.126	.154
1974	.056	.053	.044	4.39	6.25	3.69	.094	.111	.146
1975	.048	.045	.040	4.15	6.31	3.56	.096	.103	.131
1976	.046	.040	.039	4.13	6.34	3.54	.106	.105	.131
1977	.042	.037	.038	4.01	6.34	3.54	.091	.133	.137
1978	.042	.038	.037	3.74	6.29	3.38	.097	.115	.138
1979	-	.040	.036	-	5.93	3.40	-	.106	.130

arise from differentials in input prices and output levels relative to total cost differentials. The observed total cost differentials are largely offset by output level differentials. The input price differentials for labour and materials are quite small. Most of the differential efficiency arises from quite large capital service price differentials. This may be the cost side manifestation of what we observed on the production side through the input-output coefficients. However, there are some independent issues that need clarification.

As stated earlier, the capital service price is the implicit price defined by the residual value of capital services divided by the gross capital stock. If we choose a non-implicit, ex ante measure of a capital service price the relative efficiency measures will be substantially altered. In particular if we equalize the capital service price across firms we will practically equalize the relative efficiency. A later version of this paper will include results based on the development of ex ante capital service prices.

The large differences in first relative efficiency measures must be considered an initial reference point from which we will explore further to discover the underlying differences in the efficiency of the firms.

Incomplete Work

The current draft is at best a minimal introduction to the final paper. The work which is in progress but incomplete is outlined here.

First, the definition of output in telecommunications and the aggregation of outputs using existing prices will be extensively explored in order to provide more comparability across firms and an understanding of what types of activities have resulted in measured productivity increases.

Second, the measurement alternatives on the input side are under investigation. The importance of capital measurement has already been stressed. There are similar although not as crucial issues for labour and capital.

Third, some information on the network characteristics of the firms exists and this will be used to evaluate the impact of treating the network as a more conventional production process.

Fourth, the comparison can be made more illuminating by using a simple NIPA type analysis to indicate the financial consequences of differential efficiency.

Table A.1

Cost Shares: AGT
(percentage of operating costs)

	Labour	Capital	Materials
1967	39.7	47.8	12.5
1968	33.3	54.4	12.3
1969	33.4	54.3	12.3
1970	34.5	53.0	12.4
1971	36.7	50.9	12.3
1972	34.4	54.1	11.5
1973	34.1	54.7	11.1
1974	33.9	54.5	11.6
1975	36.6	50.6	12.8
1976	33.8	52.7	13.5
1977	33.8	54.3	11.8
1978	31.6	55.2	13.2

Table A.2

Cost Shares, Bell Canada
(percentage of operating costs)

	Labour	Capital	Materials
1967	27.3	58.6	14.1
1968	26.8	58.9	14.1
1969	26.7	57.4	15.8
1970	27.1	58.1	14.7
1971	26.4	56.8	16.7
1972	26.9	57.0	16.0
1973	26.8	57.4	15.7
1974	28.1	55.7	16.2
1975	29.2	55.5	15.2
1976	30.1	54.2	15.6
1977	31.0	52.0	17.0
1978	29.9	53.0	17.0
1979	31.4	52.1	16.4

Table A.3

Cost Shares: B.C.Tel.
(percentage of operating costs)

	Labour	Capital	Materials
1972	37.1	49.8	13.0
1973	36.2	50.7	13.1
1974	37.9	49.3	12.8
1975	35.6	52.4	11.9
1976	36.3	51.6	12.1
1977	32.9	51.9	15.3
1978	32.4	54.2	13.3
1979	34.2	52.5	13.3

II. DATA: METHODS, DOCUMENTATION AND COLLECTION

DATA

I) INTRODUCTION:

The ultimate reliability of empirical results, in any study, after model specification, will depend largely on data quality and consistency. The exact definitions of both these characteristics will depend on the nature of any particular study. In general, however, the former may be viewed as pertaining to the fidelity of the data's information content. For example, a fuel efficiency indicator for fleet of vehicules that simply sums the gallon consumption values of different petroleum grades would not be considered as high quality data. To upgrade the quality of this type of "input" data would require an intermediate data "massaging" step whereby all the fuel is standardized in terms of, say, BTU's. Another example of this infidelity of data to information content, can be found within a modern telephone/telecommunications company which would never imagine that counting telephone sets, disregarding whether they were main stations or extensions, in some sense accurately measures local service output. Along with consistency, which is defined below, it is within this context of data "quality" that existing and forthcoming telephone/telecommunications company data will be evaluated.

The consistency issue becomes relevant only when we introduce the notion of comparison, either chronologically or at a point in time. When the exercise involves only one entity, over time, then consistency is a unidimensional concept. Having resolved quality, consistency simply implies data that is more or less identically defined and measured in each successive period. When comparing two or more entities, the consistency issue assumes more complex proportions.

Not only must there be chronological correspondence within each entity over time, but, as well, there must exist acceptably strong similarities in data across entities at any point in time. These similarity exigencies, when the entities under consideration are, for example, two identical plants, on either side of the same road, would normally not present any further obstacles than those already removed for chronological consistency. However, when contrasting firms each of which,while ostensibly in the same business, have unique output distributions, geographical quirks, accounting procedures, regulatory restrictions and so on, then consistency becomes more difficult to ensure because the line between it and the quality issue becomes somewhat blurred. One alternative would of course require one single, entirely standardized, set of data, whereby each firm sacrifies some of its (to a certain extent) subjective quality considerations for the sake of consistency. This type of "second best" solution is, however, not entirely satisfactory. While it purports to provide a middle ground, it would, in practice, be very difficult for every firm to accept all empirical results without at least a tinge of suspicion that the data compromises may have been more comprimising for some. While there may not be any choice, given short term time constraints, a more serious approach would be to consider comparisons which use more than one data definition. A case in point concerns the treatment of income generated from activities outside of the operational definition of a telephone company, such as interest and investment income. While it may be argued that this type of income generating activity is non-operational, does not directly enter the production process and therefore cannot be defined as part of the production function, this view also ignores the impact of internally generated funds on the cost of invested capital. Furthermore, in the case of a firm where this type of revenue is relatively important, its elimination would definitely understate the enterpeneurial efficiency of its management. Ideally, in this case, data would be defined both with and without this other income. Fig. 1 provides a graphic view of this consistency question.

Data, within the context of measuring relative efficiency (for individual, as well as across firms), as it exists publicly, as it has been requested for the interim data basis and as it will be desired for the longer term, will be evaluated as per the dual criteria of quality and consistency. This can most easily be done by commenting on and detailing the method of data preparation for those firms with established productivity studies. The descriptions will encompass, as well, procedures pertaining to aggregation and index number methodologies.

(see Fig. 1 on the following page).

Fig. 1

MULTIDIMENSIONAL DATA CONSISTENCY

	FIRM A				FIRM B		
Period	Data Defined For A		Data Defined For B		Data Defined For A		Data Defined For B
		CONSISTENCY		CONSISTENCY		CONSISTENCY	
1	A_1		AB_1		BA_1		B_1
2	A_2		AB_2		BA_2		B_2
3	A_3		AB_3		BA_3		B_3
4	A_4		AB_4		BA_4		B_4

CONSISTENCY (vertical, across periods 1–4 for A_1–A_4)

Each datum or data series will be either an "input" or an output. Both of these general labels have a number of subheadings which in turn are composed of what we may consider as basic elemental data. It is our intention to begin with this basic information and trace its evolution towards the general input/output aggregate. While index numbers provide the medium for aggregation there will not be any major discussion of their relative theoretical merits. As for data, the operational subheadings for the major categories will be:

OUTPUT	INPUT
- Local Services	- Capital
- Toll Services	- Labour
. intra-company	- Materials
. trans-Canada (originating, terminating)	
. adjacent members (East, West)	
. transit	
. Canada/U.S.	
. overseas	
- Other Toll	

It should be noted that not all telecommunications companies produce the same array of outputs. The above list closely covers the service offering of those companies loosely defined as domestic telecommunications carriers such as Bell Canada (Bell), British Columbia Telephone Company (BCT), Alberta Government Telephones (AGT), etc. Companies such Teleglobe Canada (TC) and Telesat produce a fairly different set of telecommunications service outputs. These will be listed and described when the TC productivity study is discussed.

II) AGGREGATION:

All the carriers with productivity (TFP) studies follow procedures which have many general similarities. They all begin with a relatively disaggregate set of price and/or quantity data and develop aggregate indexes for each of the major categories listed in the introduction. These are ultimately aggregated into total input/output quantity or price indexes which form the basic variables of the TFP equation. Thus if

Q_{ijt} = the quantity of the ith element of the jth major category of output in year t.

X_{klt} = the quantity of the kth element of the lth major category of input in year t.

q_{ijt} = the price of the ith element of the jth major category of output in year t.

x_{klt} = the price of the kth element of the lth major category of input in year t.

then the first stage consists of either $\sum_i G_{ijt}\dot{Q}_{ijt} = \dot{Q}_{jt}$ and $\sum_k x_{klt}\dot{X}_{klt} = \dot{X}_{lt}$ for all j and l in every period t or $\sum_i G_{ijt}q_{ijt} = \dot{q}_{jt}$ and $\sum_k x_{klt}X_{klt} = \dot{X}_{lt}$ for all j and l in every period t. This gives a set of major input and output aggregate indexes of either quantity or price. These are subsequently aggregated into total output and input quantity or price indexes through either $\sum_j G_{jt}\dot{Q}_{jt} = \dot{Q}_t$ and $\sum_l x_{lt}\dot{X}_{lt} = \dot{X}_t$ or $\sum_j G_{jt}\dot{q}_{jt} = \dot{q}_t$ $\sum_l x_{lt}\dot{X}_{lt} = \dot{X}_t$ for every period t.

(It should be noted that in some cases, where weights are not updated, then $G_{ijt} = G_{ijo}$ and $X_{klt} = X_{klo}$). These aggregate indexes are then combined to calculate either $\dot{TFP}_t = \dot{Q}_t - \dot{X}_t$

or, if $q_t Q_t = x_t X_t$, which implies that returns are identically (in every period) equal to costs,

$$\dot{TFP}_t = \dot{x}_t - \dot{q}_t$$

where the dot over a variable means the proportional rate of change of that variable. It should be noted that while all the existing studies do in fact assume $q_t Q_t = x_t X_t$, none uses the second TFP expression in its calculations. Each calculates quantities either directly or indirectly through the expressions $\dot{q}_{jt} + \dot{Q}_{jt} = \dot{R}_{jt}$ and $\dot{x}_{1t} + \dot{X}_{1t} = \dot{C}_{1t}$ where $R_{jt} = \sum_i q_{ijt} Q_{ijt}$ and $C_{1t} = \sum_k x_{k1t} X_{k1t}$.

It is the evolution of elements from Q_{ijt}, X_{k1t}, q_{ijt}, x_{k1t} through to Q_t, X_t, q_t, x_t and their respective definitions that will be scrutinized below. The different data categories will be covered by the four distinct data sets, Bell, BCT, AGT and TC. After each category, differences (or inconsistencies) between these data sets will be enumerated.

III) DATA:

A) Output:

1.) Local Services

Most services that are billed on an access (and, in some instances, on a duration) basis with no consideration to distance as a variable, are considered as part of the local service offering. It should be noted that distance is a variable in determining rate differences between Local Service groupings but has no significance within particular ones. That is, once the distance parameter is chosen then communications within that L.S. grouping no longer give it any consideration.

There are several major categories of L.S. which include primary, extension, auxiliary, installation and special facilities. Their extent is summarized in Table 1A taken from the Bell(CRTC) 27 Dec. 79-701.

For purposes of computing a Local Service quantity or price index (i.e. $\dot{Q}_{jt}$ or $\dot{q}_{jt}$) we would ideally like to account for every single item and its changes, particularly since non-primary services have assumed very significant proportions in the general earnings of the domestic telephone company. In reality, however, while it is not known whether any company actually accounts for all of its Local Service components, individual practice differs between them. Beyond certain clear inconsistencies in approach (such as one company which simply counts number of extensions as opposed to another which purportedly accounts for differences in extension models as well) there is also the problem, when comparing two firms, of nomenclature. This difficulty is present both in terms of the same name applied to different products and, its inverse, whereby the same product goes under different names. To the extent that such information is available, the carriers each develop a local service index as follows:

Bell:

This company purportedly includes, with individual revenue weights, the prices of most of the items (from Table 1A) to construct an aggregate Local Service price index. For most of the historical period, however, it seems that the elements of this aggregate index are in fact unavailable (for the most part) because there was never any pressing need to save them. Furthermore, they do not necessarily reflect actual price changes because both these and the weights were based on some future test period calculated for regulatory rate hearings to demonstrate revenue impacts. While more recent calculations take price elasticity effects into consideration, previous such efforts did not, thus suggesting that the weights were also probably incorrect. The most positive aspect of the L.S. index is the alleged extent of coverage.

TABLE 1A

LIST OF SERVICE CATEGORIES

CONTRACT PRIMARY

- RESIDENCE PRIMARY
  - Individual Line
  - Two-Party Line
  - Four-Party Line
  - More-than-Four-Party Line
  - PBX Trunks
- BUSINESS PRIMARY
  - Individual Line - Flat Rate (Including Add'l Individual Lines)
  - Individual Line - Message Rate
  - Two-Party Line
  - Four-Party Line
  - More-than-Four-Party Line
  - PBX Trunks
- MISCELLANEOUS PRIMARY
  - Hotel PBX Trunks - G.T. Item 620.1(b)
  - Hospital PBX Trunks - G.T. Item 660.1(b)(1)
  - Exchange Radio Telephone Service
  - Semi-Public Telephone Service Daily Guarantee
  - Centrex
  - Exchange-Wide Dial PBX

NON-CONTRACT PRIMARY

- Public Telephone Service
- Message Charges - Mobile
  - - Individual Line - Message Rate Service
  - - Other
- Service System Service

TABLE 1A (continued)

CONTRACT EXTENSION

- Residence Extensions
- Business Extensions
- Hotel Guest-Room Extensions
- Hospital Patient-Room Extensions

CONTRACT AUXILIARY

- Manual PBX Systems
- Dial PBX Systems
- Hotel PBX Systems
- Automatic Call-Distributor Systems
- Push-Button and Key Telephone Systems:
  - 6 Button Telephones
  - Logic 10 Telephones
  - Call Directors
  - Line Feature (illuminated)
  - Other
- Telephone Answering Boards
- Residence Push-Button Dialing (TouchPhone)
- Business Push-Button Dialing (TouchPhone)
- Contempra Telephones
- Equivalent Service
- Special Billing Codes
- Intercom Circuits
- Intercommunicating Telephones
- Mobile Telephone Service
- Other Auxiliary for which rate changes are requested
- Other Auxiliary for which no rate changes are requested

TABLE 1A (continued)

INTER-EXCHANGE, DATA AND LOCAL CIRCUITS

Message Toll Service
- Ontario-Quebec-Schedule 1
- Message Time Allowance Plan (Econopak)
- Other Message Toll (Message Toll Schedules 2 and 3, Zenith listings)

WATS

Inter-Exchange Voice-Grade Circuits or Channels (G.T. Item 3750.1(d))
- Voice Circuits or Channels
- Data and Signal Channels

Telpak

Other Private Line Voice Facilities

TWX Message Charges (intra-Bell Canada)

Teletype - Grade Circuits or Channels: Ontario-Quebec Schedule (G.T. Item 3750.2(a))

Channels for Program Transmission
- Local (Including Wired Music)
- Inter-Exchange

Television Channels
- Local
- Inter-Exchange

Data and Teletype Equipment

Other Data Facilities

Local Circuits and Channels (G.T. Item 950.3)
- Voice-Grade
- Teletype-Grade

Information - System Access Lines (ISAL's)

Extra Exchange Mileage/Distance

Commuted Extra Exchange Mileage/Distance (Locality Rates)

TABLE 1A (continued)

SERVICE CHARGES

OTHER

Directory Assistance Charge (DAC)

Special Facilities Tariff

- Items for which rate changes are requested
- Items provided under the Bell Loop Agreement
- Items for which no rate changes are requested

Individual Exchange Tariff Items (excluding Locality Rates and Exchange-Wide Dial PBX Service)

Arrangements for Cable Television Lessees

- Partial Cable - Distribution Systems
- Use of Support Structures

Tariff for Interconnection with the Equipment and Facilities of CNCP (Type 1 and Type 2 Connections)

BCT:

The disaggregation does not seem as extensive as with Bell, nor does BCT, for the most part, calculate quantities indirectly. Instead, as can be seen in Table 1B, most of the items are counted quantities such as "number of telephones, mid-year average" for Monthly Contract Business Extensions. There are 10 L.S. components (number 1-8, 10, 27).

AGT:

While the extent of disaggregation for this firm is unknown, its methodology, at whatever level of detail, is stated, in evidence submitted by Hu Harries (in April 1978) for the CP interconnect case, to be identical to that used by Bell.

AGT has quantity information on a monthly basis regarding telephones in service and covering the following categories:

Residence & Business	- Main Stations - Equivalent Main Stations - Extensions
PBX	- Equivalent Main Stations - Extensions
Key	- Equivalent Main Stations - Extensions
Multi Party	- Main Stations - Extensions

AGT: (continued)

Existing price indexes, at AGT were calculated on the basis of a future test year as in the case of Bell (with all its noted shortcomings) and comprised a somewhat different set of categories than those listed above. They include:

Residence & Business	- Individual Lines - Extensions - Multi Party
Switchboards	- Trunks - Stations - Manual - Dial - Centrex - Auxiliary Equipment
Key Equipment	- Trunks - Stations - Auxiliary Equipment
Miscellaneous Equipment	- Premium Services - Emergency Reporting - Private Line Local - etc.

The revenue weights were previous month actuals and a twelve-month arithmetic average was used to derive the annual index.

Table 1B

DESCRIPTION OF OUTPUT

Category		Quantity	Value
1. Monthly Contract - Business Main (1)	DESCRIPTION:	No. of telephones, mid-year average Include "individual", "measured", "party" and "radio"	Billed revenue with no adjustment. Derived from "Analysis of Local Revenue"
	SOURCE:	Telephone Data	Financial Planning and Forecasting records
2. Monthly Contract - Business Extension (1)	DESCRIPTION:	No. of telephones, mid-year average	
	SOURCE:	Telephone Data	(as above)
3. Monthly Contract - Residence Main (1)	DESCRIPTION:	No. of telephones, mid-year average Include "individual", "measured", "party" and "radio"	
	SOURCE:	Telephone Data	(as above)

Table 1B (Continued)

Category		Quantity	Value
4. Monthly Contract - Residence Extension(1)	DESCRIPTION:	No. of telephones, mid-year average	
	SOURCE:	Telephone Data	(as above)
5. Monthly Contract - PBX & Centrex(1)	DESCRIPTION:	No. of PBX & Centrex, mid-year average Include PBX, Centrex - CO, CU	
	SOURCE:	Telephone Data	(as above)
6. Service Connection	DESCRIPTION:	Total Inward Movements Include both business and residence	Service connection, moves and changes charge
	SOURCE:	Forecasting Department records	MOR
7. Local PL	DESCRIPTION:	No. of PL telephones, mid-year average	Local PL Service Revenue less PL Radio (8 below) Local PL Service is broken down into (1) Local PL telephones & (2) PL Radio
	SOURCE:	Telephone Data	Financial Planning and Forecasting records

Table 1B (Continued)

Category		Quantity	Value
8. PL Radio	DESCRIPTION:	No. of PL radios, mid-year average	Billed revenue
	SOURCE:	Telephone Data	Accounts 5393 and 5394 Financial Planning and Forecasting records
9. Rent of Equipment	DESCRIPTION:	Revenue deflated by GNE Implicit Deflator	Rent revenues
	SOURCE:		MOR(2)
10. Other Operating Revenue	DESCRIPTION:	Revenue deflated by GNE Implicit Deflator	Other operating revenue See Accounting Manual for detailed description
	SOURCE:		MOR
11. WATS	DESCRIPTION:	No. of WAT lines, mid-year average	WATS revenue See Accounting Manual for detailed description
	SOURCE:	Telephone Data	MOR

Table 1B (Continued)

Category		Quantity	Value
12. Toll PL	DESCRIPTION:	Revenue deflated by GNE Implicit Deflator	Toll PL Service revenue See Accounting Manual for detailed description
	SOURCE:		MOR
13. Message Charge	DESCRIPTION:	Business Measured Service, mid-year average	Message charge - gross See Accounting Manual for detailed description
	SOURCE:	Telephone Data	MOR
14. Semi-Public Coin and 15. Public Coin	DESCRIPTION:	Revenue / $.10	Semi-Public Coin Revenue
	SOURCE:		MOR

Table 1B (Continued)

Category		Quantity	Value
16 to 25[4] Message Tolls - TC OPR - TC DDD - US OPR - US DDD - Alta OPR - Alta DDD - Intra OPR - Intra DDD - OVS Mtl - OVS Van	DESCRIPTION:	For each settlement, toll messages allocated on the basis of TSF, DDD and OPR breakdown	Toll revenue for each settlement allocated on the basis of TSF, DDD and OPR breakdown.
	SOURCE:	Toll Sample File (TSF) and Financial Planning and Forecasting records.	As left.
26. TWX	DESCRIPTION:	Originating Message	Billed Revenue
	SOURCE:	Financial Planning and Forecasting records	Financial Planning and Forecasting records
27. Directory Assistance	DESCRIPTION:	Revenue/.25	Billed revenue
	SOURCE:	Estimated from MOR	MOR
28. Miscellaneous (Residual)	DESCRIPTION:	Revenue deflated by GNP Implicit Deflator	Adjusted revenue less sum of all above
	SOURCE:		Calculated as residual

Teleglobe:

Teleglobe is an international carrier and it does not have a Local Service component to its output.

Local Services Summary:

Apart from the fact, but that is already crucial, that Bell and AGT measure quantities indirectly, through the medium of a price index, while BCT directly counts quantities there are a number of important differences that could render the data inconsistent. The most important of these involves the different levels of disaggregation with Bell allegedly greater than BCT (and unknown for AGT). This, of course, implies that no account is taken of possibly important mix charges. For example, in the BCT "Monthly Contract Residence Extension", from Table 1B, the number of telephones, without regard for type, are simply counted. This lack of distinction could readily distort the weighted results, particularly if there are any shifting preferences between these various equipment types with different unit prices.

2.) Toll Services:

All services that are billed on a usage basis with consideration given to distance (and, in some instances, access as well) are considered as part of the toll service category. It is a mixed bag of different types of toll services which include: Intra, Trans-Canada, Adjacent Member, Canada/U.S., Overseas and Other Toll. While Intra, which are toll messages that originate and terminate within the territories of the carriers, presents no real data problem, the other categories are not as straightforward. For each of Trans-Canada, Adjacent Members, Canada/U.S. and Overseas, any toll call can be either an originating or terminating message. In that part of the charges collected from consumers in the originating territory are paid (on the basis of some complex revenue sharing agreement) to the terminating territory administration, with some amount also going to those administrations whose territory is trans-itting, originating, terminating and transit traffic should really be treated as separate goods. Therein lies the difficulty.

There is no explicit collection of this type of data. At present, information is readily available on originating messages and revenues and settled revenues. However, the information from which to extract the terminating and transit traffic data would seem to exist. At the very minimum, for billing and settlement purposes, records are kept that show the originating and terminating territories (by area codes) from which it would seem possible to derive values for transit and terminating territory message durations. The present practice, by the domestic carriers, of calculating price indexes weighted by originating calls in order to deflate settled revenues does not seem entirely appropriate. Teleglobe Canada, on the other hand, as will be explained below, correctly treats originating and terminating telecommunications separately. The treatment accorded the various toll categories by specific carriers are as follows:

Bell, AGT:

Both of these carriers in developing their TFP measures seem to treat toll more or less identically. The big difference would really enter only at the level of disaggregation chosen for either and the fact that AGT does not seem to include distance as a consideration.

Intra:

This is the only one of the toll indexes developed by the carriers themselves. Price indexes are calculated through weighting by originating messages classified by type (i.e. operator handled, DDD, etc.), time of day, conversation minutes and, only for Bell, by distance as well. These indexes are then used to deflate settled intra company revenues which may or may not differ from originated for both carriers. In the case of AGT they do differ. The reasons are not entirely clear but seem to involve settlements between AGT and private companies, within the province of Alberta, such as Edmonton Telephones. As mentioned above, the difference between settled and originated revenues does introduce inconsistencies with respect to weighting by originating messages.

Trans-Canada:

Price indexes are calculated by TCTS presumably in the same way that the individual carriers derive their intra indexes. Price movement is weighted by originating messages by type, duration, time of day and distance. The number of categories is not known.

Canada/U.S. and Overseas:

Although these are settlements concluded through TCTS, in conjunction with TC and AT&T it is available separately from the Trans-Canada indexes. However, while Bell explicitly lists this as a separate category in its Toll breakdown, it is not clear whether AGT also considers Canada/U.S. and Overseas apart from the general TCTS index.

BCT:

For all the above categories, the major differences are that:

a) Quantities are counted and quantity indexes are thus directly calculated.

b) The basic quantity is the "message" without any consideration for duration. Its has only two explicit characteristics, being either DDD or operator handled.

c) It covers all settlements including Canada/U.S. and Overseas.

Teleglobe Canada:

Toll is really the only output category that provides an important point of similarity between TC and the domestic carriers. It should, of course, be kept in mind that the TC "toll" category includes outputs other than voice service. However, Telephone does account for almost 65% of total revenue in 1979 with overseas Telex and Telegraph making up only 15% and 1% respectively.

While TC sends and receives telecommunications to and from well over 200 different locations around the globe, nine of these account for over 70% of its toll revenue. Thus TC, begins with distance data (known as streams) for nine specific locations and a tenth category grouping the remaining "other" streams. In addition, each stream is either inward or outward traffic classified by type of communication, whether operator handled (station to station or person to person) or ISD (which is the international equivalent of DDD) and also by time of day. These categories can be summarized as follows:

Telephone	10 streams
	by 2 directions (inward or outward)
	by 3 types of calls (operator handled: person to person
	operator handled: station to station
	ISD)
	by 2 times of day (full rate or reduced rate)
total:	120 telephone categories
Telex	12 streams
	by 2 directions
total:	24 telex categories
Telegraph	2 directions
total:	2 telegraph categories
TOTAL:	146 Toll categories

Toll Services Summary:

With respect to the domestic carriers while Bell and AGT data differ more with respect to levels of disaggregation the gulf between them and BCT seems quite large. Not accounting for duration would introduce no important inconsistency for the BCT data vis-à-vis its Bell and AGT equivalents if average message duration (given distance and type of call) remained unchanged over time. This, however, is quite a remote possibility. Thus, assuming some relatively stable level of network utilization, an increased average message duration would depress output growth and vice versa in the case of decreased average message duration for BCT.

Apart from consistency, the major problem with present toll service data is the lack of explicit information on terminating and transit traffic. If the latter makes up significant portions of a carriers output it can introduce some serious distortions in the final TFP measure. Transit switching facilities are almost all fully automatic (i.e. hardpatch) and the cost structure is probably quite different from either regular toll or local services. Thus, a price index based on originating messages applied to total toll revenues which are composed of significant transit traffic income, will probably not reflect true quantity movements.

3.) Other Toll

Once again, as in Toll Services, this is a mixed bag of services which presents even more consistency problems. While Trans-Canada and Intra have more or less standard definitions across companies, other toll includes some special, unique services which are different across companies. These include such items as private measured lines, WATS, TWX, etc.

B) INPUT

As per our definitions, for the study of TFP, each of the multitude of inputs entering the production process falls under one of three major headings: either Capital, Materials or Labour. We will cover the price and/or quantity and value representations for each of these items. While labour has a fairly straightforward interpretation the others are more ambiguous. For purposes of TFP Capital is viewed either as a stock or a flow. The stock of capital is the value (in constant terms) of all plant and other relevant assets in service (or about to enter service, as in the case of plant under construction). The flow of capital services from the capital stock is a concept born out of the fact that capital is durable and put in place to provide service for longer than one "accounting period". The role of each and the connection between them will be fully covered below. Materials, on the other hand, falls under a pure flow concept. It is sometimes referred to as "Intermediate Inputs" whose current value is the "other expense component of total operating expense on the income statement.

1) Labour

While in general terms the four carriers have similar labour input derivations, using productive, expensed only, manhours aggregated with relative labour expense weights, there are some important differences. These include, the labour classes chosen, the use of service age data, and the allocation principles for benefits.

Table 2B

LABOUR CLASSIFICATION

1. Plant Management
2. Traffic Management
3. Commercial Management
4. Engineering Management
5. Marketing Management
6. Executive Management
7. Accounting Management
8. MIS Management
9. Legal Management
10. Personnel Management
11. Public Affairs Management
12. ST&B Management
13. Plant Clerical
14. Traffic Clerical
15. Commercial Clerical
16. Engineering Clerical
17. Marketing Clerical
18. Executive Clerical
19. Accounting Clerical
20. MIS Clerical
21. Legal Clerical
22. Personnel Clerical
23. Public Affairs Clerical
24. ST&B Clerical
25. Operators
26. Plant Occupational
27. Traffic Occupational
28. Engineering Occupational
29. Marketing Occupational
30. ST&B Occupational
31. Engineering Engineers
32. Marketing Engineers
33. Salesmen
34. Commercial Service Reps
35. Marketing Service Reps
36. Traffic Technicians
37. Engineering Technicians
38. Marketing Technicians
39. Draftsmen

* BC Tel. Total Factor Productivity Study

BCT:

Ostensibly there are nine (9) occupational groupings divided into twelve (12) departments. These are listed in Table 2B. We know that expensed payroll dollars are taken directly from the General Ledger for 1971-1976 by the 39 occupational and departmental groupings and then adjusted by a scaler to conform to Form S5005[1]. Subsequently, for 1977 onwards, this information comes directly from MIS (Management Information Services), and is still adjusted by a scaler to conform with Form S5005.

Productive hours for 1971-1976 are calculated for the company as a whole. These are defined as "(i) hours worked plus rest period and (ii) exposure hour less training hour and conference hour." The meaning of "exposure hour" is not quite clear. This total is then allocated, by head count proportion, to the 39 categories. Because operators work shorter shifts, their head count is scaled down by approximately 7% to 7.5% (sic)[2]. From 1977 onward (with the exception of Traffic Operators) this information is available from MIS. "Traffic hours .... are calculated as the sum of Total on Duty Hours and On Board Hours less the sum of Traffic Management and Clerical Hours. Traffic Hours are calculated using summary data from Traffic Department's Daily Efficiency Report."[3]

Capitalization of dollars and hours is assumed to occur only in Plant and Engineering Departments. Total payroll charged to construction is allocated to these departments based on their relative gross payrolls. Total hours are adjusted down to reflect only the expensed portion by applying the proportion of expenses to capitalized payroll for each of these occupational groups.

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1. Internal BCT accounting form
2. BC. Tel. Total Factor Productivity Study, June, 1980
3. IBID

Expensed benefits and payroll tax are allocated on the basis of relative expensed payroll for each of the 39 categories. Finally, the expensed hours and dollars are reaggregated by department (to give 12 categories). It is, however, not clear if this is a weighted aggregation. Ultimately, the 12 departments are aggregated into a labour input index for TFP.

BELL:

While it is not clear whether BCT weights its labour by occupation, by department or just by department, Bell definitely has occupational group as one of its weight determinants. In addition, the occupational classes are further disaggregated by service age, for a total of 28 labour input categories. These and their respective descriptions are listed in Table 2A. As for data, it has been indicated that while annual data (as described below) was collected for the labour index computations it was never stored and would be difficult to recalculate.

To calculate productive, rather than paid, hours, the number of available annual working hours per group are adjusted for losses due to vacation, statutory holidays, sickness, compassionate leave and lunches (with training, as opposed to the BCT methodology, left in). Finally, overtime hours are added. Total manhours worked per group are then calculated by simply multiplying employees per group and productive hours.

Table 2A

Bell Labour Input Classification

Occupation Groups and Years of Service	Description
1) Telephone Operator -1 1-2 3-5 6+	Self explanatory
2) Plant Craft -1 1-2 3-5 6-8 9+	Self explanatory
3) Clerical -1 1-2 3-5 6+	Self explanatory
4) Other Non-Management -1 1-2 3-5 6+	Includes all support staff not accounted for in the other categories, as well as all secretaries for assistant vice-presidents down.
5) Foremen and Supervisors -5 5-9 10-14 15+	All plant foremen, first and second levels of management and all secretaries not included in category (4) above

Occupation Groups and Years of Service (Cont'd.)	Description
6) Executive and Staff	All management from the third level and above (where an assistant vice-president is at the fifth level).
-5	
5-9	
10-14	
15-19	
20+	
7) Part Time	Self explanatory
8) Occasional	Self explanatory

Source: Bell Canada

The adjustment for capitalized hours is somewhat more elaborate. It entails the derivation of a percentage of total labour cost which is charged to construction for "general office", "engineering", "traffic", "commercial" and "marketing" employees. This percentage (whose calculation is not made clear) is then applied to the wage payments for each group to obtain an estimate of wage payments charged construction by group. For "Plant and Services", wage payments charged construction are calculated by substracting the total amount derived for the other groups from total wage payments charged construction. For "General Office" and "Engineering" the percentage calculated above is applied to the total employees in these categories to give the number engaged in construction activities. For "Traffic", "Commercial" and "Marketing", the wage payments charged to construction are divided by the average (annual) engineering salary, and the wage payments charged to construction for "Plant and Services" are divided by that category's average (annual) salary to give the number of employees in construction activities for each of the groups. Finally, the percentage of employees not engaged in construction, for each, group, is applied to that group's total manhours worked in order to derive the quantity of expensed manhours. Presumably, these expensed manhours proportions are applied to the 28 labour categories as per the number of employees from each group with the respective category. For example, if "Foremen and Supervisors 15+" had 3000 engineering hours and, say, 4000 marketing hours and these groups had 75% and 50% expensed hours, respectively, then "Foremen and Supervisors 15+" would have a total of 4250 expensed manhours.

The value of labour services is equal to the sum of all employee related expenses. These include all wage and all fringe benefits. The fringe benefits costs are not normally included within the published wage figures and must be calculated. However, since a computation of actual, individual fringe benefits per employee would constitute a major undertaking convenient allocation principles are used. Consideration is given to that group of employees such as temporary and part-time, which do not participate in the entire benefit package of the firm. The relevant benefits are identified and quantified. They include such items as Canada and Quebec Pension Plans, Cafeteria Deficits, Medical Plan, Workmen's Compensation and Unemployment Insurance. Since all employees (part and full time as well) participate in these, the ratio of part-time and temporary salaries to total salaries can be used to allocate their portion. Then, this amount is substracted from total benefits, the remainder of which is allocated to all the other categories based on the proportions of their salaries to total salaries (for the relevant groups, of course).

Until at least 1978, the 28 labour categories were aggregated into a labour input index with 1967 weights where each weight equalled the proportion of average group salary to total average salary. Essentially, a base weighted Laspeyres quantity index of manhours worked.

The Labour classifications are:

1. Telephone Operator
2. Plant Craft
3. Clerical
4. Other Non-Management (support staff not in other categories and all secretaries for AVP and down)
5. Foremen and Supervisors (plant foremen, 1st and 2nd levels of management and all secretaries not in 4.)
6. Executive and Staff
7. Part-Time
8. Occasional

AGT:

At present only total unadjusted expensed manhours and employee expenses seem to be used. A breakdown by occupational group and seniority is feasible post 1975, but prior years data is non-existant except in aggregate. The occupational groupings are:

1. Management and Executive (assistant V.P. and up)
2. Management (lowest to director)
3. Other Management (special skills)
4. Non-Supervisory (engineers, associates, technicians)
5. Craft
6. Traffic (operators)
7. Clerical
8. Casual

Categories 1, 5, 6, 7, 8 seem to have direct equivalents with the Bell breakdown, while categories 2, 3 and 4 seem to be grouped into the two Bell classes, "other non-management" and "foremen and supervisors". With respect to benefits, while the information seems to be available, it is not clear whether or not allocation would be difficult.

Teleglobe Canada:

Manhours worked are derived by adjusting manhours paid for loss due to sickness, vacation, legal holidays and other identifiable non-productive hours. Benefits are allocated on the basis of the relative payroll proportions per group. While adjusting manhours for capitalization is recognized as important, Teleglobe Canada does not yet have the means for identifying the relevant amounts.

The category breakdown, somewhat different from the other three carriers is:

1. Management (includes supervisors as well)
2. Technical & Professional (engineers, accountants, analysts, etc.)
3. S.C.T.T. (maintenance and repair technicians)
4. Support Staff (secretaries who are exempt from union, local 1653. Attached mainly to management)
5. Local 1653 (all clerical workers and secretaries not in 4.)
6. Hawaii (all personnel whose place of work is in Hawaii. They are not counted in the above categories).

2) Materials (M)

Materials include all those items which contribute neither to Labour nor Capital costs. It is comprised of stationary, fuel and utilities, travel, rentals, and so on. All the carriers ultimately calculate the value of Materials as a residual. This is possible due to the constraint that in all periods returns are identically equal to costs, or, alternatively, the total value of output is always exhausted in meeting, exactly, the required payments to factors.

BCT:

As with the others Materials includes all costs other than those attributable to Labour and Capital. Its calculation closely mirrors that for Bell, whereby its current value equals total operating expense less depreciation, employee benefits and expensed payroll. It is then deflated by the GNE implicit price deflator.

BELL:

The procedure is essentially identical to that for BCT. Materials (Other Expense) current value is calculated as per the example of Tables 3A and 4A where the first shows the income statement and the second demonstrates the manipulation of the various items to derive Materials. Constant value is derived, as with BCT, by deflating the current value of Materials with the GNE implicit price deflator.

(78 12)

TABLE 3A

BELL CANADA

TELECOMMUNICATIONS OPERATIONS

INCOME STATEMENT

1	Local Service				
2	Toll Service				
3	Miscellaneous				
4	Less Uncollectibles				
5	Total Operating Revenues				
6	Maintenance				
7	Depreciation				
8	Traffic				
9	Commercial				
10	Marketing				
11	Executive				
12	Comptrollers				
13	Finance				
14	Law				
15	Public Relations				
16	Personnel				
17	Engineering				
18	Other General Office Salaries and Expenses				
19	Operating Rents				
20	Provision for Service Pensions				
21	Employee Benefits				
[illegible]	Other Operating Expenses				
[illegible]	Taxes – Other than Income				
24	Corporate Systems Organization				
25	Real Estate				
26	Administrative Services				
27	Less: Employee Benefits Charged Construction				
28	General Expenses Charged Construction				
29	Other Taxes Charged Construction				
30	Total Operating Expenses				
31	Net Operating Revenues				
32	Dividend Income				
33	Interest Earned				
34	Interest Charged Construction				
35	Less: Miscellaneous Income Charges – Net				
36	Total Other Income – Net				
37	Income Before Underlisted Items				
38	Interest on Long Term Debt				
39	Other Interest				
40	Amortization of Long Term Debt Expenses				
41	Total Interest Charges				
42	Income After Interest Charges				
43	Amort. of unrealized gain (loss) on F.X. – L.T.D.				
44	Income Before Income Taxes				
45	Taxes – Income				
4[illegible]	Income Telecommunications Operations				

TABLE 4A

Employee Expense, Depreciation Expense, Other Expense, Other Taxes

1978 Bell Canada Example

Total Operating Expense
  income statement line 30

Depreciation Expense
  income statement line 7

Other Taxes
  before charges to construction line 23
  less charges to construction line 29
    expensed other taxes

Employee Expense
  Total wage payments (from other records)
  less capitalized & other portion (other records)
    expensed wage payments ①

  Pension expense before charges to construction line 20
  Benefits before charges to construction line 21

  less capitalized benefits & pensions line 27

  less wages included in pensions & benefits
  (already counted in expensed wage payments) ②

  vacation liability accrual ③

  Employee expense ① + ② + ③

Other Expense
  TOE - Depreciation - Other Taxes - Employee Expense

AGT:

Its procedure is identical to that of Bell.

Teleglobe Canada:

Teleglobe Canada, as well, derives Materials as a residual except that it does not apply the same procedure as the other whereby Materials is extracted from total operating expenses. Teleglobe Canada begins with Revenues = Costs and given Revenues, Labour costs and Capital costs then M = Revenues - Labour costs - Capital costs. Once again the volume of Materials, as with the other carriers is derived through deflation of current value Materials by the GNE implicit price deflator.

3) Capital (K)

Conceptually K can be treated as either a stock or a flow. The capital input variable in a TFP study refers to the flow concept. Before describing the particular methodologies that different carriers use to calculate their capital data it will be informative to briefly review the two concepts of capital.

i) Capital Stock:

Accounting records of the K stock are not directly usable for a TFP study. These list the value of K in original cost terms whereby the total value of any particular category is really a blend of plant values from different years. In order that these different "vintages" be amenable to aggregation requires that they all be repriced to a common value. This requires a price index for capital equipment. While records may exist detailing the surviving value of plant additions by year of emplacement at original cost for part of the capital stock (with the remainder requiring estimation), price indexes are not normally stored. Thus, in order to ultimately have available a capital stock series in constant value terms requires the extracting from existing records and estimation through survivor curve techniques of vintage information and, secondly, the development of an appropriate price index for the repricing of the vintage values.

i) Capital Stock: (cont'd.)

In so far as the vintage distributions are concerned, for that part of the data found in existing records, to the extent that most firms follow fairly similar capital accounting procedures, there should be very little difference between the companies with respect to data collection. Appendix I gives a relatively detailed description of this aspect, including a short discussion of curve fitting techniques.

The required Telephone Plant Price Index (TPPI) is the more difficult of the two capital stock requirements. First of all it should be made clear that we are dealing with a reproduction cost index, whereby it is designed to measure the effect of price changes through time on the cost of reproduction of annual gross additions to telephone plant. This is to be distinguished from a replacement cost type of index which endeavours, explicitly, to include the effects of technology. The reproduction cost index, it should be noted also includes the effects of technology, but only coincidentally so, when it updates weighting distributions.

For index number calculation plant is broken down into m categories. Generally each K_i $(i = 1,\ldots\ldots m)$ has five identifiable components:

1. Material
2. Engineering) Normally employed by the equipment supplier
3. Labour)
4. Engineering) In-house capitalized labour
5. Labour)

These components normally have associated with them prices (or rather price indexes) and naturally values which become the weights for indexing K_i. Thus, if the five components were each denoted by q_{ir} for quantity with price (or price index) P_{irj}, then the index for K_i would be:

$$\sum_r \left(\frac{P_{irj}Q_{irj}}{\Sigma P_{irj}Q_{irj}} \right) (\dot{P}_{irj}) = TPI_{ij} = \text{A price index for } K_i \text{ in year j.}$$

where the proportional change in the price of each component ($\dot{P}_{ir}$) is weighted by its share of the total value of K_i. If there are m categories of plant and T years of data then their should be m x T components in the index number series. Then, the original value of the ith category of plant placed in service in year j and still surviving in year S (S = k,......T; $k \geqslant 0$) is denoted as $TPI_{ij}K_{ijs} = S_{s-1,s}\ TPI_{ij}K_{ij,s-1}$ where $S_{s-1,s}$ is the rate of deterioration of K_{ij} from (s-1) to (s). In order to now combine all the $TPI_{ij}K_{ijs}$ into on aggregate K_{is} requires revaluing with the TPI.

$$TPI_{ijs}K_{ijs} = (TPI_{ij}K_{ijs}) \frac{TPI_{ijs}}{TPI_{ij}} \quad \text{for } j = 0,........,S$$

And, finally, since we are interested in ultimately monitoring the movement of $TPI_{ijs}K_{ijs}$ over all s, s = k,........T we much choose one S, say r where $k \leq r \leq T$ and calculate the series:

$$K_{irs} = TPI_{ijr} \sum_j K_{ijs} \, TPI_{ijs} = \frac{TPI_{ijr}}{TPI_{ijs}} \quad TPI_{ijs} \sum K_{ijs} \, TPI_{ijs} \quad \text{for } s = k,\ldots\ldots\ldots T$$

We now have m constant value capital aggregates for each of the (T-k) years. There are various ways of grouping these into overall capital stock series. These include:

1) $$\sum_i K_{irs} = \dot{K}_{rs} \quad \text{for } s = k,\ldots\ldots\ldots\ldots,T$$

which is the simple unweighted (and least desirable) version.

2) $$\sum_i \left(\frac{\sum_j TPI_{ijs} \, K_{ijs}}{\sum_{ij}\sum TPI_{ijs} K_{ijs}} \right) K_{irs} = K^2_{irs}$$

which is the weighted aggregate of the M constant capital values in every year S with the weights being the roportion in, current value of each of the M categories to total aggregate current value of the M categories in each year S.

3) This version is also a weighted aggregate except that the weights in this case are the cost of capital (which is a flow concept) for each K_{irs} as a proportion to the aggregate cost of capital. Thus, if we denote proportional rate of change with a dot over the variable, i.e. $\dot{X}$ and let P_{is} be the cost of capital in year S pertaining to capital category i, then,

$$\sum_{i} \frac{P_{is}K_{irs}}{\sum_{i} P_{is}K_{irs}} (\dot{K}_{irs}) = \dot{K}^{3}_{irs}$$

The cost of capital is defined as the sum of depreciation expense, debt cost (i.e. long term interest costs), equity costs and income, property and other capital related taxes. (It is more precisely defined below).

w = the proportion of interest payments applicable for tax deductions

x = the proportion of capital losses chargeable against income

$\dot{q}/q$ = the rate of capital gains/losses

h = the rate of interest or required return to equity (or both)

Naturally, computation of c independantly would mean that the sum of labour, material and capital expenses would equal total revenues only by coincidence. This is inconvenient not in the sense that TFP analysis would be made any more difficult but rather that the choice of r in the above formulation would have to be called into question. For, ultimately, it is the choice of r that renders the inequality between total revenues and costs.

The method of the residual eliminates the problem of explicitly calculating c. Instead, it assumes that the residual portion of total revenues, after payment to labour and materials suppliers, is always identically equal to the cost of capital. In the long run this is probably true. If it were consistently below some true c then the firm would certainly go out of business and if above, then other firms would enter the industry until approximate equality between returns and c were established. (And in the case of regulated industries the authorities would react to a return consistently above c). In the short run, on the other hand, the equality between returns and costs is a doubtful proposition.

We will examine individual company practice, separately, within the contexts of the stock and the flow:

ii) Capital Services Flow (or cost of capital):

The nature of capital equipment with an anticipated life span greater than one period is such that it provides a stream of services over the period of its useful life and is purchased and put in place with this view in mind. Naturally, payments to the owners of the capital are also timed to coincide (roughly) with its flow of services. When considering capital input to the production process it is this flow of services and not the total stock that is relevant. Although in all of the company methodologies which are discussed below the cost is always assumed equal equal to the return (or service flow) of capital, this is, of course, not necessarily always the case. There are essentially two methods of computing the cost of capital; either independantly or as a residual (which is the method chosen by the four companies presented below). The mechanics of the independant method are usually associated with Jorgenson and we will therefore present his formula for the cost of capital (found in: Jorgenson, D.W., "Capital Theory and Investment Behaviour", AER, p. 248, 249, May 1963):

$$c = q \left[\frac{1 - uv}{1 - u} s + \frac{1 - uw}{1 - u} h - \frac{1 - ux}{1 - u} \frac{\dot{q}}{q} \right]$$

where:

q = the price of capital goods (i.e. the TPI)

u = the rate of direct taxation

v = the proportion of depreciation applicable for tax deductions

s = the rate of depreciation

The Stock:

The equipment for Bell, B.C. Tel. and AGT are essentially similar and given the fact that Bell and B.C. Tel., at least, both have TPI's then their breakdown must also be fairly detailed. For BCT, as can be seen in Table 3 B, there are at least 41 different categories of plant. These are all revalued at reproduction cost in 1973 prices. (In addition, the figures are all mid-year averages). Bell, although it has constructed a very detailed TPI (which requires detailed capital stock information), reveals only six aggregate categories of plant, as seen in Table For AGT, while no vintage distribution of depreciation exists, it does have a very detailed set of gross additions by vintage. Finally, TC also has a very detailed list of gross additions by surviving amounts in original cost dollars. It should be noted, however, that there is a limited similarity between its plant (with large proportions of undersea cable and satellite systems) and that of the domestic carriers, AGT, Bell and BCT.

To reprice the stock, Bell and BCT both seem to have very well developed TPI's. AGT does, as well, but only since 1976, to the extent that it is participating in the Joint Statistics Canada/CTCA TPPI study. TC, on the other hand, even though it also participates in the above study, must itself develop most of its own indexes because of the differences in its plant from the other carriers.

TABLE 3B

BRITISH COLUMBIA TELEPHONE COMPANY

Category

1 Pole Lines
2 Aerial Cable
3 Underground Cable
4 Buried Cable
5 Submarine Cable
6 Aerial Wire
7 Underground Conduit
8 Buildings
9 Microwave Tower
10 Access Road
11 Aerial Tramways
12 Wharves & Landings
13 Telephone Apparatus
14 Small PBX Equip.
15 Telephone Booth
16 Teletypewriter
17 Radiotelephone
18 Large PBX & Test Equip.
19 Video
20 Lg.Priv.Branch Sw.
21 Step X Step C611&618
22 Step X Step C612
23 Step X Step C619
24 Step X Step C613
25 Crossbar
26 Electronics
27 Switchboards
28 Circuit
29 Radio C871
30 Radio C872
31 Radio C873
32 Radio C875
33 Radio C878
34 Radio C879
35 Furn.& Off.Equip.
36 Telephone Connections
37 Teletypewriter Conn.
38 Radiotelephone Conn.
39 Motor Vehicles
40 Aircraft
41 Other
42 Traffic Labour
43 Commercial Labour
44 Gen.Office Labour
45 Traffic Other
46 Commercial Other
47 Gen.Office Other
48 Other Expense

TABLE 5A

PRICE INDEXES OF CATEGORIES OF PLANT

YEAR	LAND & BUILDINGS	CENTRAL OFFICE EQUIP.	STATION EQUIP.	OUTSIDE PLANT	GENERAL EQUIP.	PLANT UNDER CONSTRUCTION	AGGREGATE
1975							
1976							
1977							
1978							
*1979							
*1980							
*1981							

CATEGORY WEIGHTS FOR GROSS STOCK OF PHYSICAL CAPITAL

YEAR	LAND & BUILDINGS	CENTRAL OFFICE EQUIP.	STATION EQUIP.	OUTSIDE PLANT	GENERAL EQUIP.	PLANT UNDER CONSTRUCTION

Aggregation methods do differ among the carriers. We do not believe that any use the simple unweighted aggregation procedure described above but rather use methods (2) and (3). Bell, it appears, uses method (2) at a certain level of disaggregation, but applies "investment weights" at the very detailed stage (which would be at say, the level of aggregating different types of pole prices into one pole category) in developing the TPI_{irs}. These "investment weights" are merely the proportion of total investment in a particular K_{iu} within the i th category of plant.

AGT has details on gross and net stocks of capital for 70 different categories. It has TPI from 1976 on, that is specific to AGT and is linked to the Bell TPI in prior years. The method of aggregation, we can only guess, is similar to that of Bell.

BCT and TC follow identical methods of aggregation which, unlike the other carriers, is actually an integral part of the TFP calculation process. The details are outlined in the following section, "The Flow". Essentially, BCT and TC use method (3), as described above.

The Flow:

All the carriers use the method of the residual, abbeit, differently applied. That is, remaining revenues after payment to all other factors are considered equal to the current value of capital costs. The other important assumption (although not restricted to accompany only the residual method) is that the growth in the stock of capital is proportional to the growth in capital services (or input).

Bell and AGT choose a base year (whether it is fixed or an individual year from each of a set of chained two year periods) and then calculate

$$C_t = \frac{R_t - w_t L_t - m_t M_t}{K_{rs}^2} \quad \text{for } t=r=s$$

so that capital input in year t equals $R_t - W_t L_t - m_t M_t$ and capital input in year t + v = $C_t K_{r,t+v}$ (where $K_{r,t+v}$ is the value of the capital stock in constant dollars of year t. R_t = total revenues in year t; $w_t L_t$ and $m_t M_t$ are the values of labour and materials expenses in year t and K_{rs}^2 is according to the definition given in the description of aggregation method (2) above). In words, the proportion of the revenue residual (after payment to all other factors) to the value of the capital stock in that year yields an approximation to the cost of capital, C_t, which is then applied to the subsequent years constant value of capital stock, $K_{r,t+v}$, thus calculating a constant value of capital input in every year. It should be noted that Bell and AGT may now be chaining this calculation.

TC and BCT also use the method of the residual but apply it somewhat differently. They explicitly sum the values of depreciation expenses, debt expenses, income and capital related (such as property) taxes and net income applicable to dividend payments and it is this total that equals the cost of capital. It is the inclusion of net income that makes this a residual method because net income is in fact the residual on an income statement. This total is then allocated to the i plant categories K_{irs} (as defined above), which are then aggregated into a capital growth figure through Tornqvist's discrete approximation to the continuous Divisia index:

$$\prod_i (\dot{K}_{irs})^{\frac{1}{2}\left(\frac{P_{is}K_{irs}}{\sum_i P_{is}K_{irs}} - \frac{P_{i,s-1}K_{ir,s-1}}{\sum_i P_{i,s-1}K_{ir,s-1}}\right)} = \left(C_s\ \dot{K}_{rs}\right)$$

APPENDIX I

A) Determining Original Value Surviving Plant:

Let $K_{i,t,T}$ be the original value of the i^{th} category of plant, put in place in period t, which is still surviving in period T, $t \leq T$. If we choose, as a starting point $t = s$ where $s > 1$ then we would have a data matrix, as below, where, say, $K_{i,1,\ T-2}$ signifies the original value of the i^{th} plant category, put in place in period 1 that is still surviving in period T - 2.

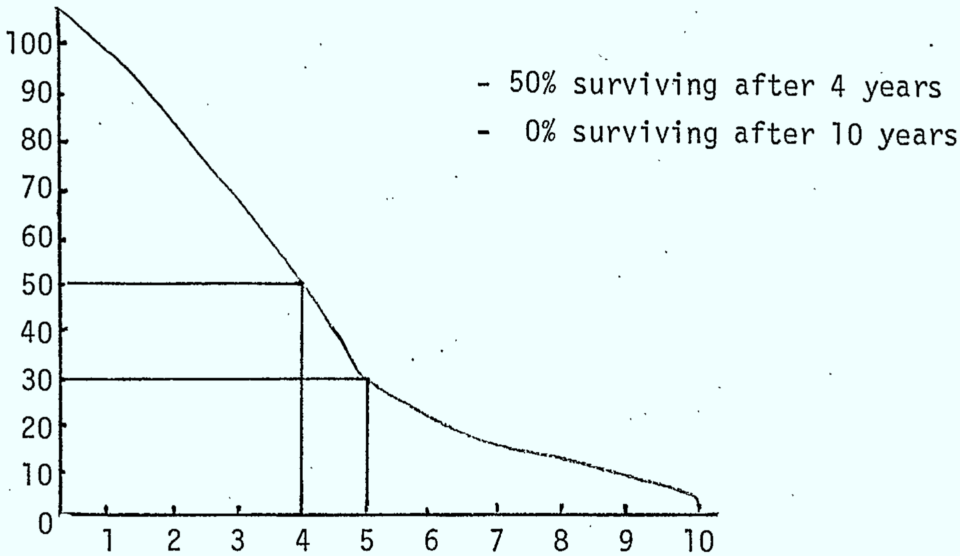
	S	S - 1	S - 2	....	T - 2	T - 1	T
1.	$K_{i,1,S}$	$K_{i,1,\ S+1}$			$K_{i,1,\ T-2}$		$K_{i,1,T}$
2.	$K_{i,2,S}$	"			"	"	"
3.	"	"	"		"	"	"
	"	"	"		"	"	"
S	$K_{i,S,S}$	$K_{i,S,\ S+1}$			"	"	"
S-1		$K_{i,\ S+1,\ S+1}$ ------	------	------			
"					$K_{i,T-2,\ T-2}$	$K_{i,T-2,T-1}$	$K_{i,T-2,T}$
"						$K_{i,T-1,T-1}$	$K_{i,T-1,T}$
"							
T							$K_{i,T,T}$

It should be noted that for any pair of row elements in the matrix, the following relation always holds:

$$K_{i,t,T} \geq K_{i,t,S} \; ; \quad t \leq S \leq T$$

That is, row elements signify plant that is subject only to degeneration. There are no additions, except for the first element of any row, which is the initial addition for that period.

If all the elements of the matrix are <u>not</u> available, i.e. there is not enough plant retirement information, then mortality curves must be fitted, in order to plug the gap. The methodology (as explained in the attachment), basically fits a curve to existing data, at various intervals and thus allows the gaps to filled. Such a curve may resemble:



B) Averaging:

Once the elements of the matrix are known we proceed with an averaging procedure that affects only the diagonal elements of the matrix. It is done in order to smooth out a capital investment schedule which incorrectly attribute production to large capital projects completed in a particular period even though it may not have entered service until the very end of the period. The averaging also includes all plant under construction (PUC). The basic averaging function is:

$$\text{Average } K_{i,t,T} = 0.5\left[\left(\frac{P_{i,t,T}}{P_{i,t-1,T-1}}\right) K_{i,t-1,T-1} + K_{i,t,T}\right] \quad ; \quad \begin{matrix} t = S......T \\ T = S......T \end{matrix}$$

which basically revalues one element of the diagonal, in order that it be suitable for addition to the next consecutive element down the diagonal.

C) Revaluing of Surviving Plant from Original to Current Values:

Once the elements of the matrix are all known (and the diagonal is averaged), then they must all be repriced into common values. This is done by column. Thus, column S would be entirely revalued in terms of period S values, column S+1 in terms of period S+1 values and so on. The elements can now be added, within columns to produce T-S aggregate surviving plant values, one for each period. Thus, if we let $K^{C}_{i,t,T}$ denote the current surviving value of $K_{i,t,T}$, then:

$$K^{C}_{i,t,T} = \frac{P_{i,t,T}}{P_{i,t,T}} K_{i,t,T} \qquad t = 1,\ldots\ldots\ldots T$$

and the current value of aggregate surviving plant category i, in period T is:

$$K^{C}_{i,T} = \sum_{t=1}^{T} \frac{P_{i,t,T}}{P_{i,t,T}} K_{i,t,T}$$

D) Current to Constant Value Plant:

Given K^{c}_{iT} and $P_{i,t,T}$; $t = 1, \ldots\ldots, T$ we can revalue the K^{c}_{iT} into constant value. Choose t = o as the base year, then:

$$K^{k}_{iT} = \frac{P_{i,o,T}}{P_{i,T,T}} K^{c}_{iT}$$

III. REGULATION AND POLICY

REGULATORY AND POLICY USES OF PRODUCTIVITY

I) INTRODUCTION

The productivity performance of a firm will reflect directly on its ability to absorb input price increases. Naturally, those input price increases that cannot be covered by productivity growth must be offset through output price rises. Thus, we can understand the more than passing interest that a regulatory body might have in a regulated firm's productivity record. To note that a connection does exist is, however, not enough, it must be understood, measured and interpreted before it can be put to intelligent use. Understanding is not a problem. It is widely accepted that unit costs will change by the difference between the changes in productivity and costs. For example, a 5% rise in productivity, accompanied by a 10% price increase, will translate into a 5% growth in unit costs. The next logical step, one might imagine, would be for the regulator, presented with this unit cost calculation, to award a petitioning utility a 5% increase in rates (given no demand effects). This, however, does not necessarily follow. The rate award would have to be contingent upon the regulator's acceptance of, on the one hand, the appropriateness of the given productivity measurement techniques and, on the other hand, the merits of both the measurement and interpretation of costs. By interpretation, we refer to the perception of costs as either controllable or uncontrollable. An additional consideration, in determining the size of the rate award would, of course, be the incentive criteria.

Thus given that the regulatory use of productivity is in some sense an effort to link rate awards to productivity movement, it cannot be properly examined without an equally close scrutiny of the measurement and interpretation problems. The following discussion will focus mainly on past efforts to introduce an automatic rate adjustment (ARA) formula as a supplement to the normal regulatory process of full dress hearings. The view will be in terms of the measurement and interpretation issues. It will also draw upon recent research in the area of productivity comparisons which offers the possibility of overcoming one of the major deficiency of an ARA formula, choosing an acceptable productivity level standard.

Given that as a policy goal the operational objective is quite simply to promote increased efficiency in the telecommunications industry this question really does not require a great deal of elaboration. It will suffice to state that specific policies designed to increase productivity should, in some sense, be measurable. In addition, the degree of expected improvement should also be quantifiable. This latter problem is easily solved within the context of interfirm productivity comparisons while the former issue can be resolved through single company measurement.

The following discussion will then focus on regulatory uses beginning with a short historical survey which will include the criteria usually set forth by the regulators for an ARA. While the survey is by no means complete it does cover some of the more important ARA cases.

II) AUTOMATIC RATE ADJUSTMENT

Historically, there are four salient events in this area, for North America:*

- January 1972, NARUC, in an economic paper (NARUC, Economic paper no. 1, by Subcommittee of Staff Experts on Economics) proposed an "Automatic Adjustment Clause" (AAC). See Appendix 1.

- December 1972, The New Jersey Board of Public Utility Commissioners proposed a "Comprehensive Adjustment Clause" (CAC).

- In March 1974, Illinois Bell proposed a "Cost and Efficiency Adjustment Clause" (CEAC).

- In August 1974, the Canadian Transport Commission proposed a Rate Adjustment Formula (RAF).

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* Some of the above material is taken from J. Lemay, "COTC and Rate Adjustment Formula Procedure", November 14, 1974. An internal report prepared for the COTC (now Teleglobe Canada).

The common threads in all the above proposals included a desire to reduce (or eliminate) regulatory lag, a need ease the regulatory cost and administrative burdens and a recognition that without some built in incentives the formulae would become cost plus subsidies for inefficiency.
Apart from the NARUC statement which was meant only as a stimulant for the utilities to develop working formulae, the other proposals all had built in productivity incentives.

a) The New Jersey Bell Formula included productivity only implicitly. It entered the adjustment in several ways:

1) The allowed rate of return was allowed to fluctuate between a minimum of 8.15% and 8.30%, thus offering an incentive for productivity gains to capture the 0.15%.
Naturally, the assumption being that maximum productivity gains would be pursued even if they pushed the rate of return beyond 8.30% which would require downward adjustments in tarrifs.

2) Salaries and Wages would be, first of all subject to a ceiling (of 5.5% as a result of federal price controls) in order to ensure that the CAC does not unduly influence wage negotiations, and secondly, would be adjusted downwards by the value of the labour productivity increase. Thus there does not seem to be any incentive to introduce labour saving devices.

3) Depreciation expenses, larger than 12.2% of total revenues (as determined from a historical average) would not be allowed. Anything under 12.2% would result in a definite and total cost pass through. This of course encourages slower depreciation and consequently the holding back of new technology. A definite disincentive.

4) Other expenses were tied to the CPI, whereby the company would be allowed to recover price increases in this category equal to 50% of the CPI growth. Naturally this creates an incentive to keep down the increased burden of covering other expenses through productivity offsets but only to the extent that the rate of return is not pushed beyond the maximum allowed value of 8.30%. This is therefore not always a complete incentive.

5) Taxes included, as part of the adjustment criteria, those relating to real estate, revenue and social security. The cost pass through for changes in these rates or, as with sccial security taxes, for changes in the maximum salary amounts to which social security tax rates are applied, was to be full. Absolutely no adjustment was to be reflected for higher income tax dollars or rates because such would have interfered with the intention of federal or state legislation. That is, automatic adjustment in the income tax category would have run counter to fiscal policy as well as called into play questions of legality.

While, as can be seen from the above description, the New Jersey formula attempted to go beyond the existing electric utility fuel adjustment clauses by introducing some productivity incentive, allert implicitly, there were some problems. Among these three stand out. First of all limiting the allowed rate of return range also limited to the productivity incentive range. Secondly, the magnitudes and corresponding indices, such as the CPI, to which the company's own cost increases were tied may have had little correlation with its own experience. Finally, there was no consideration given to the question of controllable vs uncontrollable costs.

b) <u>The Illinois Bell</u> proposal put forward essentially the same arguments as NARUC and New Jersey Bell concerning the need of it CEAC in order to eliminate regulatory lag and reduce the cost and administrative burdens of full dress rate hearings; "With continuing inflation at the 4% a year level, and possibly substantially more, it is almost certain that Illinois Bell will find it necessary to petition the Illinois Commerce Commission for higher service rates on at least a biennial, and possibly a more frequent, basis during the decade or so ahead.

Substantial savings of time and money, of course, could accrue to both the company and the commission, and customers could receive better service if some kind of automatic revenue adjustment clause was included in the company's tariff, thereby minimizing regulatory lag and reducing the frequency of necessary formal rate case."*

Illinois Bell in its argument also recognizes the necessity of building a formula which includes incentives to efficiency. To this end they go on to say,"...... To the extent that a management efficiency incentive or reward could be incorporated, consumers could potentially benefit to an even greater extent and formal rate cases might be even further deferred....... such ARAC's have sometimes been criticized because that contain no incentive for efficient performance,....."**

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* "Illinois Bell, Cost and Efficiency Adjustment Clause", internal document, October 1, 1973.

** Ibid.

The efficiency incentive, referred to above is the "universally accepted concept of Total Factor Productivity". This TFP is essentially of the type used, to until recently by, among others, Bell Canada. The general CEAC formula can be stated as:

$$\text{Revenue Adjustment} = \left(\frac{a\%}{100\%}\right)(\text{unit cost change}) + \left(\frac{b\%}{100\%}\right)(\text{productivity saving}) - (\text{rate of return ceiling})$$

If b was equal to zero then it would become the standard electric and gas utility cost plus fuel adjustment clause. If a were equal to zero then high inflation, compared to productivity would unduly punish the company and, in the opposite case the consumer would never derive the benefit of lower rates. The final formula, as per Appendix 1, put a value of: a = 50 and b = 150.

Despite some minor drawbacks such as the arbitrariness of b = 150 and a = 50, as well as the fact (as can be seen by studying the formula) that the partial intrastate business reacts with a total factor productivity measure covering all company operations, it was a promising formula. The state regulators, however, chose to reject the use of the Illinois Bell proposed CEAC. An important reason relates back to the basic question of determining the extent of controllable vs uncontrollable costs. The ICC went on to say "operating expenses are incurred as a result of the exercise of managerial decision and responsability and, as such, are subject to the control in whole

or substantial part by respondent." They went much further than previous such discussions in affirming that the basic difference between a gas and electric utility and the telephone utility is that the uncontrollable cost is the exception rather than the rule. Thus they conclude that "approval of the cost and efficiency revenue adjustment clause (CEAC) proposed by Bell in the tariff filing of March 29, 1974,... is not currently in the public interest or just and reasonable at the present time and the schedules contained in said tariff filing should be permanently cancelled and annulled."*
See Appendix 2 for details.

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* Illinois Commerce Commission, Order #58916.

c) The Canadian Transport Commission proposal dates from Order No. T-474 of August 15, 1974 originally summarized in the "Telecommunication's Committee Decision on Bell Canada's Ammended Application B" for a general rate increase, in 1974. It involved all the same reasons as the previous proposals by NARUC, New Jersey Bell and Illinois Bell, blaming regulatory lag and burdensome rate hearings:*

"....to make regulation more responsive to the present circumstances and in order to ensure that the carriers are able to provide adequate service without resorting to frequent lengthy public hearings,..... in addition to reducing the regulatory lag."

The CTC proposal, as well, expressed concerns similar to those exposed in previous proposals, emphasizing the need to isolate only those cost not directly controllable by management and to ensure that the automatic adjustment would not act as a disincentive to inefficiency,**

"The formula selected should compensate the carriers for the uncontrollable changes in cost. Any changes in costs under the control of the carriers will not be considered.

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* Rate Adjustment Formula Procedure for Telecommunications Carriers under the Jurisdiction of the Canadian Transport Commission", Decision of August 15, 1974.

** Ibid.

Given the broad guidelines of including only uncontrollable costs as well as incentives for efficiency, the CTC formula proposed the same four broad breakdown of cost categories as the New Jersey case discussed above. These included "Wages and Salaries" (all but those amounts already capitalized), "Taxes", (excluding income taxes), "Depreciation" and "Other Expenses". For "Wages and Salaries" the CTC recommended using a combination of company specific and economy wide indexes in order to minimize its influence of the labour-management wage bargaining process. Taxes were to be passed on in their entirety. Depreciation was to be view in terms of changing rates, on the one hand, and changing capital goods prices on the other. While the changing rates are fairly straightforward, capital prices are not. The Commission recommended using the Bell Canada Telephone Plant Price Index (TPI) for that company and similar indexes developed specifically for the other companies. Finally, other expenses were to be tied to the general economy wide "price of gross national expenditures" (PGNE) deflator. In all the above, it should be noted, the adjustments are applicable on to the price effect with cost increases due to growth already removed.

The productivity adjustment, as in previous cases, remained a problem.*

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* Ibid.

"Clearly, productivity gains can be used by the carriers to offset some of the uncontrollable costs it incurs. The problem on an adequate productivity adjustment is very difficult."

One of the main difficulties (at that time) was the rarity of company produced productivity (on a global basis) indexes. The CTC, therefore, recommended the use of a partial labour productivity measure, at once recognizing its drawbacks,*

"The major drawback in using a partial-factor labour productivity correction, especially in a capital intensive industry, is that all improvements are then assigned to labour, and serious distortions may occur."

The full extent of the CTC proposal and concerns can be found in Appendix 3.

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* Ibid.

From the above discussion it is, first of all, clear that any ARA must have some built in incentive mechanism and, secondly, that this mechanism be, in some sense, related to most of the company's activities. The best overall measure would seem to be the "Universally accepted of Total Factor Productivity."* This notion of a total measure is given further support by the CTC proposal, which, although it ultimately recommends a labour partial productivity measure, would have, in the event of wide availability, otherwise opted for a TFP measure.** While there are several different approaches to the measurement issue, the TFP measurement scheme, outlined and used throughout the other sections of this report, can easily fit into any automatic cost adjustment formula as the incentive parameter.
It is interesting, at this juncture to briefly look at the recent decision of December 18, 1979, by the New York Public Service Commission, which declared that TFP analysis "should not be made mandatory in rate cases," and must be understood for its limitations. While administrative law judge Frank S. Robinson puts forward an eloquently worded defense of the decision, a reading of his article in the Public Utilities Fornightly*** will show that some of the more salient concerns of the commission can be easily allayed. These include the length and expense of a TFP study, incomparability of consecutive years, impossibility of forecasting TFP and the burden of heavy capital investment, due to long term productivity considerations.

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* c.f. Illinois Bell proposal.
** c.f. CTC proposal.
*** Frank S. Robinson, "Total Factor Productivity Studies as a Rate Case Tool", Public Utilities Fortnightly, March 13, 1980.

The first concern might be legitimate if regulation was the only possible use of a TFP study. However, given the panaroma of management models, NIPA, UNIPA, PAP, etc., all based, to varying degrees on TFP, the cost is more than justified. The other concerns can more appropriately be combined and recycled as the single concern of knowing to what level of TFP the firm should be liable. While this is not an easy question its solution lies somewhere in the fruitful and relatively advanced studies of interfirm productivity comparisons by Denny, Jorgenson and Nishimizu and the ongoing CTCA/DOC study, among others. The relative efficiency standing or, rather loss of standing of a particular firm can informatively be viewed within the context of similar firms in the same industry. That is, a dramatic change in a company's historical performance could be more accurately viewed with a comparative context.

The New York decision then, did voice the correct concerns but, unfortunately was unable to bring available solutions into perspective. Further, the solution proposed by Mr. Robinson, in light of the accessibility of TFP, are primitive. He would rather use pure guesswork and the belief that the arbitrariness "would not be artibrary in the unlawful sense; rather, it would represent a responsible exercise of a commission's obligations to fix just and reasonable rates."
He goes on to say: "This need (for productivity gain rates) is properly met by approximate, judgemental productivity adjustments, since to do better is impossible."

It should be noted that Mr. Robinson's thinking may have been to some degree influenced by the Consolidated Edison TFP study*, upon which the commission reached its decision. The study, in all fairness, was based on Kendrick's original methodology as outlined in his 1967 pamphlet "Measuring Company Productivity" and his "Productivity Trends in the U.S.", Number 1961. This methodology pales as terms of accuracy and utility with respect to work being done today. Naturally, some erroneous conclusions may have been drawn.

One of the more important regulatory applications of research into total factor productivity measurement is, therefore, within the context of an automatic rate adjustment formula. The essential characteristics of such a framework for expeditious regulation would not differ substantially from the Illinois formula discussed earlier. It would of course require a mutually acceptable set of definitions vis-â-vis uncontrollable cost, an agreed upon indexing procedure and finally a defensible measure, which must always be company specific, of Total Factor Productivity. The TFP measure would, further, have to be defined in terms of some "optimal" level. This latter requirement can be fulfilled either by extensive engineering investigation or through carefully designed interfirm productivity comparisons. In terms of cost and time, the comparative study would appear to be the more expeditious of the two approaches.

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* Consolidated Edison of New York Inc., Electric Dept. "Functional Analysis of Inputs and Outputs for the years 1967 to 1976 on the Historical Cost Basis and as repriced at the 1960 price level.

EIGHTY-FOURTH ANNUAL CONVENTION

NARUC
ECONOMIC PAPER NO. 1

By

SUBCOMMITTEE OF STAFF EXPERTS ON ECONOMICS*

This paper represents the opinions of the NARUC Subcommittee of Staff Experts on Economics. It has not been submitted to, or approved by, the Committee on Accounts.

AUTOMATIC ADJUSTMENT CLAUSES

An automatic adjustment clause (AAC) is a provision in a utility company's tariff by which a change in a selected cost item will automatically change rates charged consumers. The most common form of adjustment clause is based on fuel costs in the case of electric utilities and purchased gas cost in the case of gas utilities. Automatic clauses have also been utilized for wages, taxes, and other such easily identifiable cost items. This paper is not concerned with automatic rate increases that may occur for other reasons—such as an increase in telephone calling scope.

AAC Advantages

1. During a period of inflation automatic clauses protect a company's rate of return from the impact of a rapidly changing cost item by reducing the time lag between changes in cost, and the collection of compensating rates.
2. During a period of declining costs, AAC may help to prevent an unreasonable enhancement of the company's rate of return.
3. They ease the administrative burden on the regulatory body and reduce the cost of regulation assessable to the utility by eliminating the prospect of repetitive tariff petition filings over a short time period. These adjustments also replace the need for full scale hearings by an automatic procedure that allows tariff changes to compensate for known changes in specific cost items.

AAC Disadvantages

1. Automatic adjustment clauses give undue weight to a single cost item while ignoring other cost items thus possibly distorting the relationship of rates to costs. That is, they conflict with the goal of holding rates to a just

*Original draft by Alvin Kaufman, New York Public Service Commission.

and reasonable level unless the change in the item selected for automatic adjustment parallels the change in the total cost of service.

2. These clauses pass on to the consumer increased costs without allowing for compensating economies that may accrue from other cost elements such as economies of scale or improved technology. For example, in the case of fuel adjustment clauses fuel costs may rise, but may be more than balanced by operating economies accruing from greater labor productivity. Despite this balancing of cost the consumer would be required to pay higher rates. Thus, AAC may generate excess earnings for those companies continuing to benefit from enhanced labor and plant productivity.

3. Because costs that can be automatically adjusted are passed on to the consumer quickly and easily, they tend to dampen the company incentive to bargain for a better fuel price or better wage settlement, etc. As a consequence, they may tend to cause additional price escalation for the adjustable item.

4. A profusion of automatic adjustment clauses will rob the utility of its incentive to operate efficiently and may in fact become a subsidy for inefficiency. In an instance where a company is permitted to adjust for fuel costs, as well as wages, taxes, and possibly other items, then the utility in effect is operating under a kind of "cost plus contract", and has no need to be efficient since the costs of inefficiency can be passed on to the consumer quickly and without regulatory interference.

Fuel Adjustment Clauses

As an example of automatic clauses we can consider those used for fuel cost adjustments. Such clauses tend to put great emphasis on changes in fuel cost while minimizing the importance in changes in administrative, interest, and maintenance costs, as well as changes in capital or rate of return. Many automatic adjustment fuel clauses do not take account of changes in the heat content per ton of fuel with consequent changes in cost per Btu, nor do these clauses take account of changes in technical efficiency or economies of scale which might tend to offset fuel increases. Quite often these clauses will also ignore mitigating cost circumstances that may result from use of more than one method of electric power generation with consequently different fuel costs. As a consequence, even though a given fuel price may rise, total fuel costs for the company may increase very little if at all. In addition, automatic fuel cost adjustments may, during a period of rising costs, bias the selection of alternate production methods such as nuclear plants.

There is presently a great diversity of automatic fuel adjustment clauses with some states allowing rate adjustments for specific customer classes only, such as industrial consumers, and others applying the change uniformly. All clauses, however, should take account not only of fuel price, but also fuel heat content, the trend of company heat rate, the proportion of purchased, hydro, nuclear, and fossil fuel-generated energy. It may also be well to permit the recovery of only a limited portion (say, 90%) of increased cost. Such a limitation has the advantage of preserving the utility's incentive to bargain for cost reductions.

A recent FPC survey as of January 1, 1970 showed that 35 percent of the larger privately owned utilities had fuel adjustment clauses in their residential schedules, 58 percent had such clauses in their commercial schedules, and 72 percent in their industrial schedules.

Possible Legal Problems

In a recent case by an electric power company before a state commission requesting approval to utilize a fuel clause adjustment as a means of coping with rising fuel costs the question arose as to the legality of a state regulatory agency having the authority to approve a fuel clause adjustment. Many states have permitted a fuel clause adjustment and under some state regulatory statutes the authority may be specifically granted the regulatory agency to delegate its rate making authority *via* the automatic adjustment clause vehicle. However, in lieu of specific statutory authority the legality of an automatic adjustment clause of any kind becomes an important factor for the regulatory agency to consider when confronted with request for the approval of these type clauses.

In the case of a recent power company's request to a state commission for authority to invoke an automatic fuel clause adjustment the argument against the agency having the legal authority to grant the request by the power company ran thusly:

> The effective result of the proposed filing, if granted by the commission, would be to delegate solely to the power company and its suppliers of fuel who enter into private contracts with the power company, the power and authority to determine the level of charges to be made by the power company for electric service sold and distributed to, the using and consuming public, and various state agencies which purchase said electric service from the power company.
>
> In support of the foregoing, the Attorney General argued that the power to fix and regulate the reasonable rates and charges to be made for such service is vested solely in the commission. It was further contended that this rate-making power is a delegable power and duty which has been delegated solely to the commission by the state General Assembly, in the exercise of the states' police powers and no further delegation of the rate-making power of the state is authorized; and that the using and consuming public would be deprived of the money it pays for electricity by a state franchised monopoly without due process of law.

Aside from the economic disadvantages enumerated previously, all regulatory agencies should also carefully consider the legality of automatic adjustment clauses when deciding whether or not to permit their implementation.

Recommendation

It is recommended, therefore, that adjustment clauses, when believed advantageous to a commission, should be weighted to reflect the relative importance of the particular item in the company cost structure, and should include provisions compensating for economies that may accrue from improved managerial efficiency, technology, innovation, or economies of scale. In addition, it may be advisable for an adjustment clause to include other safeguards, such as a requirement for periodic cost-of-service submissions for commission review, in order to minimize the risk of the company's having excess earnings for an extended period.

Automatic clauses should also be operable in two directions. That is, AAC should be permitted to track increases during periods of rising costs, and decreases during periods of declining costs rather than be used solely during inflationary periods.

Automatic adjustment clauses should be established only after careful consideration of all relevant factors from the standpoint of the commission's regulatory responsibilities.

STATE OF ILLINOIS

ILLINOIS COMMERCE COMMISSION

Illinois Bell Telephone Company	:	
	:	
Proposed monthly changes in telephone rates applicable to all exchanges of the Company due to Cost and Efficiency Adjustment Factor.	:	58916

ORDER

By the Commission:

On March 29, 1974, Illinois Bell Telephone Company ("Bell", "Respondent" or "Company") filed a tariff consisting of Schedules Ill. C.C. No. 1, Section 1, 1st Revised Sheet 29 and Original Sheet 30 of the General Local Exchange Tariff; Ill. C.C. No. 3, 4th Revised Sheet 1 and 1st Revised Sheet 13 of the Domestic Public Land Mobile Telephone Service Tariff; and Ill. C.C. No. 1, Original Sheet 8.50 of the Signaling Service Tariff by which Bell proposed a new cost and efficiency revenue adjustment clause (hereinafter sometimes referred to as "CEAC"), applicable to all exchanges of the Company.

Under the proposed tariff filing, billings to customers for telephone service would be increased or decreased by applying a cost and efficiency revenue adjustment factor which factor thereby constitutes a filing in the nature of a general rate increase.

Notice of the proposed tariff filing was posted in a conspicuous place in each of the business offices of Respondent and published in secular newspapers of general circulation throughout the Company's service area, as evidenced by the record in this case, all in accordance with the requirements of Section 36 of the Illinois Public Utilities Act and the provisions of General Order 157 of this Commission.

An examination of the filed tariff schedules resulted in a determination by this Commission to enter upon hearings concerning the propriety and reasonableness of the cost and efficiency revenue adjustment clause, inter alia, contained therein and that, pending hearing and decision thereon, the filed tariff should not become effective. On April 3, 1974, the Commission entered an Order suspending the proposed tariff to and including August 27, 1974, and thereafter on August 21, 1974, entered a Resuspension Order extending the period of suspension of the tariff filing to and including February 27, 1975, pursuant to the provisions of Section 36 of the Public Utilities Act of Illinois.

Pursuant to notice as required by law and the General Orders of this Commission, the initial hearing in this cause was held before a duly authorized Examiner of the Commission, at its offices in Springfield, Illinois, on May 16, 1974. An appearance was entered by counsel on behalf of Respondent. Various other persons, representatives of corporations and other entities were present, many represented by counsel; those appearing were allowed to participate in the initial hearing by the Examiner subject to an Order of the Commisson allowing individual intervention. Staff members of the Commission's Telephone Engineering Section, and Accounts and Finance Section fully participated in all hearings held in this cause.

Subsequent to the tariff filing of the Company, petitions to intervene were filed on behalf of: General Telephone Company of Illinois, General Services Administration (GSA), Continental Telephone Company of Illinois and Bernard Carey, States Attorney of Cook County, Illinois (States Attorney). All of the foregoing entities were subsequently allowed to intervene by Order of the Commission. On June 12, 1974, a staff attorney representing the corporation counsel entered the appearance of the City of Chicago and participated fully on behalf of said City in these proceedings as a party intervenor. Other municipalities were represented at various hearings.

On July 30, 1974, a representative of Chicago Chapter of the Center of United Labor Action, filed a petition to intervene which was subsequently denied by order of the Commission on September 4, 1974. A later Request for a Special Public Hearing, filed September 3, 1974, on behalf of such organization, was granted by the Commission on September 18, 1974; said special hearing was held by the Examiner on October 11, 1974, during which hearing members of the public appeared and testified on behalf of themselves and certain organizations in the manner provided by Section III(c) of the Rules of Practice of this Commission.

Subsequent to the initial hearing held in this cause, various hearings were held and on October 11, 1974, the case was marked "Heard and Taken" by the Examiner. Notice of the initial hearing and all subsequent hearings scheduled and held were mailed by the Secretary of the Commission to the parties and other persons and entities as shown by the docket sheet, maintained by the Secretary of the Commission, for purposes of this cause, all in accordance with the Rules of Practice of this Commission.

The initial brief of Respondent was filed on October 15, 1974. Answer briefs were filed on behalf of various intervenors on or before November 19, 1974, and the reply brief of Bell was filed November 20, 1974. Oral argument, requested by various parties, was heard by the Commission en banc on November 20, 1974, and at the conclusion thereof, the oral argument was marked "Heard and Taken under Advisement".

Suggested corrections to the transcript of record were filed on behalf of various parties without objection by any party to this cause. The Commission having examined the suggested corrections, is of the opinion that the record should be changed in accordance therewith and that the same be made a part of the official record of this case.

The official record before this Commission consists of approximately 2,778 pages of transcript exclusive of oral argument and voluminous exhibits relating to the proposed tariff filing. All parties were afforded the opportunity to examine witnesses appearing at the hearings held and to offer evidence with respect to all proper issues in this proceeding.

During the course of these proceedings various parties to this cause filed interrogatories and requested additional information from other parties. The Commission is of the opinion that the responses thereto as directed, allowed or modified by ruling of the Examiner, constitute a just and reasonable dispostion of the interrogatories and informational requests of the moving parties, when viewed in light of the statutory time limits provided by Section 36 of the Public Utilities Act of Illinois. All remaining motions, objections and other matters not specifically disposed of by the Examiner should be taken with the case and disposed of in a manner consistent with the ultimate conclusions contained in this Order.

Bell is one of 24 operating companies included in the American Telephone and Telegraph Company's Bell System. All of Respondent's outstanding capital is owned by AT&T. The Bell System includes, inter alia, Bell Telephone Laboratories, Inc. and Western Electric Company. Research, development and design work are performed by the former, and the latter manufactures, purchases, repairs and distributes apparatus, equipment and supplies, and installs central office equipment for the Bell System. The long-lines department of AT&T constructs, operates and maintains long distance interstate lines. The parent company also provides many other contractual services for the operating Bell Telephone Companies and undertakes to provide all financing requirements of the Bell System.

Respondent serves about 3,000,000 customers throughout a substantial part of Illinois and Northern Indiana. It provides telephone service constituting both intrastate and interstate communication services in addition to a variety of ancillary services relating to the transmission of telephone messages between points within and without this state. The proceedings in this case relate to Respondent's Illinois intrastate operations.

The purpose of Bell's tariff filing of March 29, 1974, is to provide a method or formula for calculating a cost and efficiency revenue adjustment factor (CEAF) which if allowed to become effective may result in a monthly increase or decrease in charges for telephone service based not only on changes in operating expenses but also on changes in operating efficiencies. Bell contended that CEAC would in the future provide an opportunity for the Company to earn a rate of return within the range allowed by this Commission as a result of its most recent investigation and determination concerning just and reasonable rates allowed to become effective by virtue of an Order of this Commission.

GSA Exhibit 2, admitted into evidence, (a study made by Bell entitled "Illinois Bell Productivity Study Concepts and Methodology"), and the record in this case contain a lengthy and detailed discussion of theory and methodology utilized in the preparation of the CEAC formula.

During the course of these proceedings, Respondent submitted Company Exhibit 9, admitted into evidence, containing Schedule Ill. C.C. No. 5 Part I - Section 5, Original Pages 18 and 19. Said pages were purported to be part of Respondent's proposal to modernize its tariff; containing in language and in substance, the cost and efficiency revenue adjustment clause (CEAC) proposed by Bell in the tariff filing of March 29, 1974. The Company suggested that upon approval of the tariff filing of March 29, 1974, the Schedules contained in said filing should be made to conform to the language contained in Company Exhibit 9.

Public interest requires that the regulated utilities be allowed by the Commission, to establish a just and reasonable tariff, containing rates and charges which are as low as possible for the consuming public and yet sufficient to provide an opportunity for a public utility to earn a fair and reasonable return on the "value" of the utility's property dedicated to public use. The standards by which a just and reasonable tariff may be judged are many and varied. History discloses the theories and methods used by regulatory agencies in arriving at proper tariffs.

Increased supervision of the regulated utility during periods of severe economic stress is necessary if this Commission is to fulfill its obligations under the law to the public and to the regulated utilities.

The Commission is of the opinion that the CEAC formula contained in the tariff filing of March 29, 1974 would result in a change in rates for telephone service provided the customers of Bell. Under Section 36 of the Public Utilities Act the legislature delegated to this Commission the power and authority to enter upon a hearing concerning the propriety and reasonableness of changes in rates or other charges, classifications, contracts, practices, rules or regulations, which are contained in a filed tariff. Periods of suspension are authorized during which time the Commission may establish rates or other charges, etc. which it shall find just and reasonable. The Commission was at the same time delegated the power and authority to allow changes in such rates or other charges, etc. to become effective by merely not exercising its power and authority to enter upon a hearing concerning the changes.

A reading of the statute, however, clearly indicates that the legislature intended that the public be given the opportunity to be heard prior to the imposition of a significant rate increase or other significant action by the public utility.

Consistent with this legislative intent, this Commission has uniformly entered upon full and complete public hearings to determine the just and reasonable nature of proposed changes in rates or charges which would constitute a general increase in rates of a substantial nature. The Commission is of the opinion that such practice is in the interest of the public.

The proposal of Bell (CEAC) is novel in scope and untried in Illinois utility regulations but has been carefully considered by this Commission. The Supreme Court of New Jersey recently published an opinion of the Court, decided February 10, 1975, which modified and approved a tariff containing a "Comprehensive Adjustment Clause" (CAC) authorized as a result of two orders of the New Jersey Board of Public Utility Commissioners (PUC) entered December 13 and December 23, 1973, under PUC Docket No. 732-134. CAC would enable the New Jersey Bell Telephone Company to recapture by flowing through to its customers certain portions of any increase in certain operating expenses as an annual adjustment. CAC is not as all-inclusive as CEAC proposed by Respondent in this case. Four categories of operating expenses were included in CAC: (1) salaries and wages including fringe benefits; (2) depreciation charges; (3) other expenses; and, (4) taxes. The adjustment was to be based upon audited operating results for a twelve month period ending September 30 in each year commencing with September 30, 1973. Under the operation of the Comprehensive Adjustment Clause, PUC would have the opportunity to examine actual audited operating results of New Jersey Bell for a twelve month period in a retrospective and comparative manner. The operation of CAC would appear to enable the New Jersey Board of Public Utility Commissioners to make a partial determination of the just and reasonable nature of four categories of operating expenses prior to recapture by flow through to customers.

As suggested by the parties to this cause, adjustment clauses have been utilized by regulatory Commissions, including this Commission, for many years. The cost of fuels and natural gas, certain taxes, and recently the cost of certain environmental expenditures incurred by some utilities have been the basis for automatic rate adjustment clauses in this state.

The Commission is of the opinion that the Supreme Court of Illinois has settled the issue relating to the power and authority of the Illinois Commerce Commission under Section 36 of the Public Utilities Act of Illinois, to authorize a public utility to place on file and allow to become effective, a tariff, containing an automatic rate adjustment clause.

In the City of Chicago vs. the Illinois Commerce Commission, et al. 13 Ill. 2d 607. (1958) at page 611, the court stated:

> "The city of Chicago contends that the authorization of the automatic adjustment clause contravenes section 36 and permits changes in rates without the filing of rate schedules and constitutes an abuse of the exercise of the Commission's discretion. We cannot agree. As commonly used, "rate" is defined as a "price or amount stated or fixed on anything with relation to a standard; a fixed ratio; a settled proportion." (Webster's New Twentieth Century Dictionary, 2d ed., p. 1496.) Under the statute, "'Rate' includes every individual or joint rate, fare, tolls, charges, rental or other compensation of any public utility or any schedule or tariff thereof, and any rules, regulation, charge, practice, or contract relating thereto." (Ill. Rev. Stat. 1957. chap. 111 2/3, par. 10.16) Under the common, as well as the statutory definition, it is clear that the statutory authority to approve rate schedules embraces more than the authority to approve rates fixed in terms of dollars and cents."

At page 614, et sequel, after discussing a decision of the Supreme Court of Appeals of Virginia in a matter entitled, City of Norfolk v. Virginia Electric & Power Co.90 SE 2d, 140, the Supreme Court of Illinois concluded that:

> "We find the foregoing decision in point, and while not binding upon us, its logic is sound and compelling. We conclude that the Public Utilities Act of Illinois vested in the Commission the power to authorize an automatic adjustment clause to be filed in a rate schedule in the proper case." (emphasis added)

Certain intervenors suggest that the CEAC formula is unreasonable and unlawful in that the public is deprived of an opportunity to participate in a hearing concerning the propriety and reasonableness of increased rates as a result of the operation of CEAC and that the burden of proving the just and reasonable nature of rates allowed to become effective is shifted from the Company to the public.

Section 36 of the Public Utilities Act confers upon this Commission the power to determine the just and reasonable nature of telephone rates allowed to become effective in the various areas provided telephone service by Bell. Rates produce operating revenues which, after deduction of operating expenses, should result in operating income determined by this Commission to be a fair and reasonable return on Bell's investment in plant dedicated to public use in Illinois. All such terms are specifically defined by law, court interpretation or general order of this Commission. Of necessity therefore, this Commission has the power to determine the just and reasonable nature of all operating expenses, which are included as a deduction from operating revenues in arriving at operating income of the Company. Bell has substantial control over the amount, nature and timing of the expenses incurred in fulfilling its obligations as a public utility. This Commission has power and the obligation to inquire into and determine the just and reasonable nature of such expenses. The question of whether or not to make a given expenditure on a day-to-day or month-to-month basis is a managerial decision, to be made by the Company within the confines of sound business judgment, applicable law and judicial interpretation thereof and the standards established by this Commission. The Commission does have the power and obligation to inquire into the just and reasonable nature of all operating expenses of Bell in order to properly determine the rates for telephone service allowed to become effective.

In Antioch Milling Co. vs. Public Service Co. 4 Ill. 2d 200, the Court stated at page 210:

> "The Commission is not just an umpire. It has been given active functions of policy making and supervision. It may initiate hearings on its own motion, and it has a wide discretion in shaping proceedings brought by others. The act provides that rates shall be reasonable; but it entrusts the enforcement of that obligation in the first instance to the Commission."

The Commission is of the opinion that the power to establish policy and supervise utility operations does not justify intervention in each and every managerial decision at the time same are required to be made.

At the present time, the reasonableness of operating expenses can best be determined by the Commission in retrospect and after a reasonable opportunity to examine individual items of expense on an accumulated basis in comparison with other periods of time. The Commission is of the opinion that at the present time and under present economic conditions the determination of the just and reasonable nature of operating expenses incurred by Bell is best accomplished by hearings concerning the propriety and reasonableness of proposed rates or other charges under the provisions of Section 36 of the Public Utilities Act of Illinois and not by an automatic revenue adjustment clause such as proposed herein.

While it may be true that the Company does not have sole control over the increases in costs during a period of inflation or severe economic stress, nor the ability to overcome the effect of such inflation or stress solely through productivity or managerial decision, it cannot be concluded that the Company has no control whatsoever. The Company does have substantial control over its operating expenses. The Commission is of the opinion that Bell's management has the obligation to make decisions which most effectively reduce or keep at a minimum, the cost of providing efficient, reliable, safe and adequate utility service to the public. It is the obligation of this Commission to pass judgment upon the just and reasonable nature of operating expenses incurred by the Company and the obligation of the Company to exercise proper judgment when incurring such expenses. It is the control of this Commission and that of Respondent over such expenditures which distinguishes the CEAC formula from the automatic rate adjustment clause approved by the Supreme Court of Illinois in the case of the City of Chicato vs. The Illinois Commerce Commission (id).

Traditional rate making procedure would require Bell to justify the reasonableness of operating expenses to be incurred during a test year period. Under such procedure, this Commission has an opportunity to determine the just and reasonable nature of actual utility operations prior to establishing rates for the future which will allow Bell to offset proper operating expenses and allow an opportunity to earn a fair and reasonable return on the "value" of its used and useful properties dedicated to public use.

In order to respond to the immediate needs of the public and utility alike, this Commission has adopted the practice of allowing interim rate relief, when justified, pending public hearing and decision on the full request of a utility for rate relief. In Central Illinois Public Service Company, Docket No. 57300, this Commission entered an order on March 13, 1973, which in effect has eliminated the expense and time formerly required by major utilities to prepare and present reproduction cost evidence in a general rate case proceeding. These efforts on the part of this Commission, as well as other innovations, will tend to eliminate to some extent the so called "regulatory lag" and permit reasonable time for the fulfillment of regulatory obligations. This Commission is able to exercise its duties in a manner consistent with the requirements of the utility and its rate payers.

The evidence in this proceeding demonstrates that under the present method of rate making, Bell's charges are approximately the same as they would have been had the CEAC formula been in operation during the past several years. Therefore the Commission concludes that the traditional method of entering upon public hearing to inquire into and examine the factual bases for requested rate relief as provided in Section 36 of the Public Utilities Act is in the public interest and in compliance with legislative intent. The operation of the proposed CEAC formula would allow a very substantial portion of any increase in operating expense experienced by Bell to be recaptured by flow through to its customers without providing this Commission with an opportunity to fulfill its regulatory obligations by examination of such expenses in a retrospective and comparative manner and determine the reasonableness thereof. The implementation of the CEAC formula would be tantamount to an abdication of regulatory responsibilities. The Commission is of the opinion that the automatic rate adjustment clause, CEAC, proposed by Bell in the tariff filing of March 29, 1974, consisting of Schedules Ill. C.C. No. 1, Section 1, 1st Revised Sheet 29 and Original Sheet 30 of the General Local Exchange Tariff; Ill. C.C. No. 3, 4th Revised Sheet 1 and 1st Revised Sheet 13 of the Domestic Public Land Mobile Telephone Service Tariff; and Ill. C.C. No. 1, Original Sheet 8.50 of the Signaling Service Tariff and including the proposed modernization and suggested language contained in Company Exhibit 9, should be permanently cancelled and annulled.

The Commission, having considered the entire record herein and now being fully advised in the premises, is of the opinion and finds that:

(1) Illinois Bell Telephone Company is an Illinois corporation engaged in the business of supplying telephone and communication service to the public throughout various parts of Illinois, and, as such, is a public utility within the meaning of an Act entitled, "An Act concerning public utilities," as amended and now in force in the State of Illinois;

(2) on March 29, 1974, Respondent filed with this Commission a certain tariff providing for a new cost and efficiency revenue adjustment clause which would constitute a change in rates and other charges applicable to telephone service furnished to its customers in Illinois, to become effective April 29, 1974;

(3) on April 3, 1974, the Commission issued a Suspension Order suspending the filed tariff to and including August 27, 1974, pending hearing thereon, and thereafter by Resuspension Order, entered on August 21, 1974, resuspended the said tariff filing until, to and including February 27, 1975;

(4) notices of the initial hearing held in this cause were mailed by the Secretary of the Commission to Respondent, the mayor or attorney and the clerk of all communities as shown by the docket sheets maintained by the Secretary of the Commission for purposes of this case, in addition to other persons

and entities shown thereby, all in accordance with the rules and regulations of this Commission;

(5) Respondent has complied with the requirements of General Order 157 and the law, rules and regulations applicable to the Commission relating to notice and publication of a legal notice in newspapers of general circulation in the area serviced by Respondent and affected by these proceedings;

(6) the Commission has jurisdiction of Respondent and of the subject matter of this proceeding;

(7) statements of fact and conclusions reached in the prefatory part of this order by the Commission are supported by the evidence and record and are hereby adopted as findings of fact;

(8) operating expenses are incurred as a result of the exercise of managerial decision and responsibility and, as such, are subject to the control in whole or substantial part by Respondent;

(9) the determination of the just and reasonable nature of all operating expenses of Bell by this Commission, on a day-to-day or month-to-month basis, would be required under the provisions of the CEAC formula proposed by Respondent in the tariff filing of March 29, 1974;

(10) public interest does not currently require that this Commission determine the just and reasonable nature of all operating expenses, incurred by Respondent, on a day-to-day or month-to-month basis as proposed by Respondent;

(11) operating expenses incurred by Respondent are subject to the inquiry, approval, supervision and policymaking control of this Commission under the provisions of the Public Utilities Act of Illinois;

(12) approval of the cost and efficiency revenue adjustment clause (CEAC) proposed by Bell in the tariff filing of March 29, 1974, consisting of Schedules Ill. C.C. No. 1, Section 1, 1st Revised Sheet 29 and Original Sheet 30 of the General Local Exchange Tariff; Ill. C.C. No. 3, 4th Revised Sheet 1 and 1st Revised Sheet 13 of the Domestic Public Land Mobile Telephone Service Tariff; and Ill. C.C. No. 1, Original Sheet 8.50 of the Signaling Service Tariff and including the proposed modernization and suggested language contained in Company Exhibit 9, is not currently in the public interest or just and reasonable at the present time and the schedules contained in said tariff filing should be permanently cancelled and annulled;

(13) any objections and motions made during the course of these proceedings that remain undisposed of should be disposed of in a manner consistent with the ultimate conclusions contained herein.

IT IS THEREFORE ORDERED by the Illinois Commerce Commission that the tariff filing made on behalf of Illinois Bell Telephone Company on March 29, 1974, consisting of Schedules Ill. C.C. No. 1, Section 1, 1st Revised Sheet 29 and Original Sheet 30 of the General Local Exchange Tariff; Ill. C.C. No. 3, 4th Revised Sheet 1 and 1st Revised Sheet 13 of the Domestic Public Land Mobile Telephone Service Tariff; and Ill. C.C. No. 1, Original Sheet 8.50 of the Signaling Service Tariff, together with and including the proposed modernization and suggested language contained in Company Exhibit 9, be and the same are hereby, permanently cancelled and annulled.

IT IS FURTHER ORDERED that any and all objections and motions made during the course of these proceedings that remain undisposed of, be, and the same are hereby, disposed of consistent with the ultimate conclusions contained herein.

By Order of the Commission this 26th day of February, 1975.

Chairman

RHB/nms

APPENDIX 2

Illinois Bell
Cost and Efficiency Adjustment Clause

The Rationale for a Telephone Utility Cost and Efficiency Adjustment Tariff Clause

Public utilities, such as the electric and telephone industries, have long been characterized by efficient performance and high productivity achievements. As a result, the quality and reliability of utility services have steadily improved and the prices to consumers for such services in real terms have declined substantially over the past several decades. Since 1940, for example, inflation has raised the consumer price index more than 215%, while Illinois Bell's rates, on average, have increased only some 50%.

However, in recent years the rapid pace of inflation has outrun the still commendable achievements in public utility efficiency and productivity. As a result, every state regulatory commission in the country has been deluged with urgent public utility petitions for rate relief and with the associated, almost endless and frequently redundant public hearings. Such almost continuous rate cases involve substantial costs to both the commission and to the company which, in turn, must eventually be paid for by the consumer. In addition, to the extent the utilities' earnings have not been adequate enough to attract new investor funds, the quality of service to consumers may well be impaired.

If this experience of the last few years could be characterized as unusual and unlikely to occur in the future, the issue might end there. But this optimistic possibility is remote indeed. On the contrary, there is clearly no end in sight for the present 4%+ pattern of inflation now solidly built-in to the economy by the federal government and its "full employment" manipulation of prices in the economy.

The Problem

The heart of the problem is simply that under the current pattern of continuous government built-in inflation in the nation's economy, utilities find it almost impossible, in spite of rigid cost control measures and well above average productivity achievements, to even earn at the "floor" level authorized by the regulatory authority. As a result, there is no end in sight for the utilities' need for continuing, year after year, rate relief.

A proper range for a utility's rate of return is a matter of reasoned judgment and reasonable men can and will differ on precise figures. So, it is not surprising that most utilities will argue convincingly and honestly that today's returns allowed by most regulatory commissions are far too low. And they may well be right. But this is really not the problem here. The crucial problem is that the pace of inflation and utility earnings attrition have been so fast that public utilities have found it almost impossible to even earn the minimal rate of return authorized by the regulatory agencies.

It is also important to note that, while inflation is at the root of this issue, the utilities problem of rising (unit) costs would not be solved even if inflation were somehow completely eliminated. This is because their inherent capital intensiveness and their relatively long-lived capital facilities guarantee that as facilities purchased in the past wear out in the future, they will have to be replaced with today's higher cost facilities; and service growth, too, will also have to be provided with today's higher cost facilities. As a consequence, depreciation, ad valorum taxes and interest costs per unit of output will continue to rise for many years as a result of past inflation. Thus, the utility's earnings level will continue to erode as a result of this "attrition" effect, even in the absence of future inflation (a highly unlikely possibility).

However, this problem of inflation, past or present, and its severe impact on public utilities, making it almost impossible for them to earn the rate of return allowed by the regulatory authorities, has not gone unnoticed by the state regulatory commissions. In a variety of ways these commissions are either experimenting with ways to somewhat automatically allow utility revenue adjustments to be made as needed, within the constraints set down in the preceding formal rate order, or are attempting to speed-up the processing of rate increase applications, or both.

Solution Attempts

The Pennsylvania commission has been especially active in this area. In 1970, and without a public hearing, the commission authorized the public utilities in its jurisdiction to pass-on to their customers, through an appropriate surcharge, the impact of certain new and future state taxes. (The order was supported by the press and upheld in the courts.) In 1971, after study by the commission staff, again without public hearings, the commission authorized the gas and electric utilities under its jurisdiction to promptly add automatic fuel adjustment and automatic purchased gas adjustment clauses to their filed tariffs. During this period, the commission also suggested to the utilities in its jurisdiction that they prepare their future rate cases in two parts, the first part to be limited to a rate increase application consistent with the rate of return and other findings in the commission's prior order. This part, in effect, merely updates the commission's prior order and, as such, can be ruled on without the need for extensive hearings, if any.[1] The second part of the case is devoted to new issues or the possibility of changes in the findings of the prior order and, as such, will appropriately be set for full public hearings. In noting these actions, Chairman Bloom points out that:

> "(The Pennsylvania) commission is neither pro-utility nor anti-utility. It is pro-public in that it recognizes the paramount interest of the people in having ample utility services; and it intends to protect that paramount interest by whatever measures the circumstances require."[2]

In a somewhat related step the Massachusetts commission recently ordered a public utility rate increase without hearings, following a court remand of an earlier case decision. In its order, the commission noted that:

> "...The issues which were so vigorously contested in the prior case have now been settled by the court, and these are the same issues which are presented in the Company's present proposal. Thus, additional public hearings could not materially affect the result. They would merely impose a financial burden on the public...(and) the users."

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[1]For an example of an interim rate increase without public hearings, see Pennsylvania Public Utilities Commission Docket #29, re: Philadelphia Electric Co., order dated October 3, 1972.

improving telephone service. To the extent that this (rate increase) will enable the Company to get on with the business of raising the necessary capital, it is consistent with this emphasis. Clearly, improvement of the service will continue to demand substantial expenditures for construction of added capacity and modernization, for which, in turn, capital must be available."[3]

Some commissions have granted utilities earnings attrition allowances above the normal rate case increase allowance in an effort to ensure that the utility will actually be able to earn the allowed rate of return in the year ahead. Most recently the Oregon commission granted such an allowance to the Pacific Northwest Bell Company with the provision that if the company's rate of return exceeded that specified in the order (8.93%), the amount above such return would be placed in a reserve, subject to the future order of the commission.[4]

Interim rate increases are a device used by the New York and other commissions to help speed-up the regulatory process and reduce regulatory lag. As Chairman Swidler has noted:

> "It is important that prompt steps be taken to counteract (utility earnings) erosion. We have, therefore, been realistic in granting interim increases, subject to refund, to companies with a poor earnings picture. In 1972 we prescribed higher permanent rates in 19 cases....In 11 of these cases, interim increases...had already been granted. Another seven interim increases were approved in 1972, for which the permanent rate applications are still pending.... Our willingness to grant substantial interim increases when conditions warrant... is evidence of our concern for the financial health of the utilities....For companies whose earnings may not be critically low, but which are not reaching the level anticipated in our rate decisions... we have an abreviated procedure which enables us to reach a decision in about three months (on rate increases up to 2½%)....Automatic adjustment clauses are designed for somewhat the same purpose as (this) minor increase procedure."[5]

To further speed up the normal regulatory process, others have suggested the greater use of issue stipulations to eliminate the redundant debate, year after year, of either non-pertinent issues or opinion issues that have not changed. A complete reargument of the same issues year after year can't help but involve an inefficient use of everyone's time, money and other resources. And service to consumers undoubtedly suffers as the utilities must wait months, if not years, for the revenue relief they so badly need. Such use of stipulations is merely a prehearing agreement between the utility, key intervenors, and the commission that each party's testimony will speak to only certain key points. From this it can be quickly agreed that other points either involve no controversy or reflect positions or views no different from those expressed in an earlier case. As an illustration, the Public Service Commission of Indiana in its 1972 rate case decision awarding intrastate toll increases for all 69 telephone companies in the state, accepted a rate of return stipulation between the Public Counselor and the utilities consistent with the rate of return found in a prior case. The stipulation listed different positions on rate of return, but the lengthy testimony of witnesses, subsequent cross-examination and rebuttal was not required.[6]

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3 Massachusetts Department of Public Utilities, Docket No. 17150, Re: New England Telephone Co.; order dated Jan. 31, 1972.

4 Oregon Public Utility Commissioner, Docket UF-2955, Re: Pacific Northwest Bell, order dated July 14, 1973.

5 "Regulation of Utility Rates by the New York State Public Service Commission," a talk by Joseph C. Swidler, Chairman, NY PSC, at NY Society of Security Analysts, Jan. 31, 1973.

6 Public Service Commission of Indiana : Cause No. 32816, Re: Indiana Bell Telephone Co., et. al., order dated Aug. 4, 1972 - based on rate of return decision in Cause No. 32552, dated July 2, 1972.

Disadvantage No. 1 --. Present ARACs take too narrow a view of expenses. By looking only at changes in the price of fuel or purchased gas, the formula may be ignoring offsetting economies of management efficiency or changing technology elsewhere in the business. Thus, in the best interest of the consumer, the report appears to tacitly endorse an ARAC formula that more nearly includes all cost categories.

Disadvantage No. 2 -- Present ARACs have no incentive element to stimulate management efficiency and productivity. As such, the utility "has no need to be efficient since the costs of inefficiency can be passed on to the consumer quickly and without regulatory interference." Here the tacit conclusion is that a sound ARAC must utilize a formula that on the one hand rewards management efficiency and productivity increases and, on the other hand, penalizes the utility for inefficiency or a fall-off in productivity increases.

Disadvantage No. 3 -- Present ARACs may be illegal. Sincere though it may be, this observation is almost completely without merit. In spite of predictable court challenges at the time of their inception, the author is unaware of any ARAC case that has not received the endorsement of the courts. Further, to the extent that future ARACs are designed to avoid the first two disadvantages above, the possibility of illegality seems remote indeed.

A rather important point not mentioned in the NARUC study, but undoubtedly understood, is the basic premise that a sound ARAC for any utility must operate within the rate of return and other possible constraints set down in the utility's last formal rate case. This is really the heart of the ARAC concept. It is, in effect, merely a periodic updating of the last rate case. There are, basically, no new points at issue. The utility, in an ARAC adjustment, is accepting the regulatory commission's decision on rate of return, rate base and all other matters, as set down in the last rate case where intervenors have had almost unlimited opportunity to present their views and their expert witnesses and have had equal opportunity to cross examine on the record all other participants in the case. Similarly, commission and court appeal channels were available to everyone and in some cases were used. So, there would appear to be nothing left to discuss.

The only conceivable point left to discuss is whether or not the regulatory commission has the authority to authorize an ARAC. And to the author's knowledge, this authority has never been successfully challenged in the courts. The ICC in Docket 43173 (Peoples Gas ARAC, 3/16/56), noted at length that a recent Virginia Supreme Court "decision, construing provisions of the Virginia Code similar to the pertinent and controling provisions of the Illinois Public Utilities Act, agrees with this Commission's construction of its statutory powers under the Illinois Act. We have consistently taken the position that our powers under the Public Utilities Act clearly include the authorization of such adjustment clauses."

And further, "This Commission's powers are sufficiently broad to allow the approval of an automatic Purchased Gas Adjustment Clause without the necessity of prescribing any additional requirements for subsequent formal filings to reflect each change in rates which may occur pursuant to the terms of the adjustment clause. This broad power has in fact been exercised by this Commission in the promulgation of our General Order 157 which prescribes rules and regulations pertaining to notice and publication of changes in rates or charges for service furnished by gas and other utilities."

Where possible changes from the last rate case order become appropriate, of course, a formal rate case inquiry can be set. However, the frequently lengthy processing of this formal rate case should not affect the orderly operation of the ARAC until the formal decision is received and finalized. Then, of course, the provisions of the new order set the future constraints for the ARAC.

An Illinois Bell Productivity Oriented ARAC

With continuing inflation at the 4% a year level, and possibly substantially more, it is almost certain that Illinois Bell will find it necessary to petition the Illinois Commerce Commission for higher service rates on at least a biennial, and possibly a more frequent, basis during the decade or so ahead.

Substantial savings of time and money, of course, could accrue to both the company and the commission, and customers could receive better service if some kind of automatic revenue adjustment clause was included in the company's tariff, thereby minimizing regulatory lag and reducing the frequency of necessary formal rate cases. To the extent that a management efficiency incentive or reward could be incorporated, consumers could potentially benefit to an even greater extent and formal rate cases might be even further deferred.

An equitable ARAC, of course, must first remove all cost increases associated with growth. The remaining cost increases are, in effect, inflation caused increases in unit costs. (For example, if costs increase 10% and output increases 7%, the 3% difference represents the increase in cost per unit of output.) This is the typical concept behind the electric fuel adjustment and purchased gas adjustment clauses widely used in Illinois. However, as noted, such ARACs have sometimes been criticized because they contain no incentive for efficient performance as apparent in the negatively sloped ARAC formula plot in Attachment 3.

Unlike a formal rate case, where management efficiency can be explored at length, a sound ARAC should ensure consumers and the regulatory commission, without a public hearing, that the utility is operating efficiently at all times and is therefore deserving of the periodic automatic revenue adjustment called for by an ARAC in the utility's tariff.

A telephone ARAC could overcome nearly all the objections to electric and gas ARACs, if it introduced the incentive concept of a reward for efficiency and productivity improvements (and a penalty for productivity declines). (To distinguish a productivit oriented ARAC from the conventional non-productivity oriented ARAC, as characterized by the fuel adjustment and purchased gas adjustment clauses dating back to the turn o the century, a more distinctive or descriptive terminology would be helpful. Such an ARAC might more appropriately be called a "cost-efficiency adjustment clause.") Such formula would take the general form:

Rev. Adj. in \$ = a x (chg. in unit costs) + b x (productivity savings)

In this formula, which all ARACs or CEACs ultimately narrow down to, the change in un costs is equal to the aggregate difference between total costs and those total costs associated with changes in output. (The logical measure of output in the telephone i dustry is dollars of revenue, after removing the revenue effect of all rate changes a pass-on taxes. This adjustment to "constant" dollars of revenue, in effect, yields a composite output measure in physical terms.)

Productivity here refers to the universally accepted concept of total factor productivity. As such, it includes the aggregate effect of capital, labor and other factor productivity changes. In simplest terms, it is a comparison of the utility's rates of output to input for two consecutive time periods. In the formula, this relationship is applied to the total level of costs to reflect the dollar savings that consumers realized from productivity improvements.

Terms a and b can have just about any value from 1% to 100% except zero. (An important condition of the formula, however, is that it yield enough of a revenue adjustment to meet the utility's needs or a basic purpose of the CEAC, to reduce the frequency of formal rate cases, will not be achieved.) If b is zero, productivity is eliminated and what remains is the gas and electric type ARAC, with its shortcomings. If a is zero, unit cost changes are removed from the formula and the customer may be denied the rate reduction that might be possible due to declining unit costs. Equally important, during periods of severe inflation, the productivity element of the CEAC formula is not large enough to offset the spiraling cost increases and the resulting sharp drop in rate of return. In short, if the a term is zero, the formula will tend to yield a grossly inadequate revenue adjustment at the very (inflationary) time it is designed (and should be expected) to yield an adequate revenue adjustment. Thus, the formula would largely fail in its basic objective.

These observations suggest that a sound CEAC formula should include both terms. And because of the concept's emphasis on stimulating management efficiency and higher productivity, the b factor weighting should be as high as possible. This objective, along with the fact that the productivity term (during periods of high inflation) is the smaller of the two, suggests that the b term be 100%, or something close to that value. The a term then should be designed to make the formula yield the CEAC results desired. Such a formula, below, was used to plot the CEAC curves on Attachment 3.

Rev. Adj. = 50% x (chg. in unit costs) + 100% x (productivity savings)

Note that this formula, unlike the gas and electric ARACs, incorporates the two key NARUC suggestions to reflect management efficiency or productivity and all unit cost changes.

The two CEAC plots on Attachment 3 (at either the top or bottom of the page) illustrate the basic difference between a productivity oriented CEAC and the typical gas and electric (non-productivity oriented) ARAC: At low productivity or efficiency levels, authorized revenue adjustments under a productivity oriented CEAC are reduced as a penalty measure; at high levels of productivity they are increased as a reward or incentive to efficiency. On the other hand, while there is nothing here to suggest that gas and electric utilities are inefficient, it is true that less efficient performance under a non-productivity oriented ARAC yields a significantly greater revenue adjustment than a more efficient performance. Thus the incentive or penalty effect, if any, is the reverse of the case for a productivity oriented CEAC.

The downward bend in the CEAC curve is caused by the rate of return ceiling constraint, to be discussed later.

The plots at the top of the page illustrate the average results that Illinois Bell might have experienced had a CEAC been in effect for the 1971-72 period. As the reader can see, the average monthly revenue adjustment would have been about $.2 million. This would be accomplished by the application of an average monthly adjustment factor of about 1.0029 to the customers' intrastate bill. (Tariff rates are not changed under a CEAC concept.) For this inflation ridden 24-month period, the aggregate revenue adjustment would have totaled about $59 million, or an increase in the customers' bill of some 7%. (These results, of course, relate only to current expense reimbursement within the rate of return and other constraints set down by the ICC in its prior formal order and, as such, cannot be directly compared to the company's current rate applications.)

The actual calculation worksheet format for these results is shown in Attachment 4.

The plots at the bottom of Attachment 3 are an attempt to show what the pattern of results would have been with a CEAC if the 1971-72 period had been deflationary, rather than inflationary. The slope of the CEAC plot is about the same as before. However, average monthly revenue reductions are called for. And to the extent the deflation effect were greater, the corresponding revenue reductions would be larger.

In Attachmen 3, reflecting today's level of total factor productivity increase, the revenue adjustment to the company, by coincidence, is the same under either formula. However, with increasing productivity, the incentive CEAC begins to pay off; and conversely, at lower levels of productivity the penalty feature sets in. (It is important to recognize the above formula as nothing more than a rational arithmetic device to recover inflation caused unit cost increases for a prior period of operation, as would be the approach in a formal rate case. During such prior period, both employees and customers have received the full benefit of these prior productivity improvements. The formula use of productivity is merely a way for the Commission to say, in effect, "We will permit you to automatically recover your inflation caused expenses to the extent you can prove you have been operating efficiently.")

Costs or cost increases as used in this study, and as noted in Attachment 4, refer to intrastate operating expenses (including wages, depreciation expense, materials, rents and supplies), taxes (less FIT) and interest expense.

Not surprisingly, a key point in a productivity oriented CEAC is rate of return. Unlike the gas and electric ARAC formulas, which simply recover unit cost increases and, at best, tend to hold rate of return at or just below a prior level, the incentive feature of a productivity oriented CEAC may permit efficient firms to modestly raise their rates of return. However, such associated automatic revenue adjustments would, obviously, not be permitted to raise a company's pro-forma return above the ceiling level set by the regulatory commission in its last order covering the company's return. (The actual calculation worksheet format for this ceiling rate of return test is shown in Attachment 5.) This automatic commission surveillance, which holds CEAC revenue adjustments to no more th than a "reasonable" amount, adds a third dimension to the CEAC formula, which now in effect becomes:

$$\text{Rev. Adj.} = a\% \times \begin{pmatrix}\text{unit}\\ \text{cost}\\ \text{chg.}\end{pmatrix} + b\% \begin{pmatrix}\text{product-}\\ \text{ivity}\\ \text{saving}\end{pmatrix} - \begin{pmatrix}\text{Rate of}\\ \text{Return}\\ \text{Ceiling}\\ \text{adj.}\end{pmatrix}$$

It is this rate of return ceiling constraint that causes the "kink" in the CEAC plot in Attachment 3. The pattern of that portion of the CEAC plot to the right of the "kink" will vary with circumstances. But the pattern in Attachment 3 is representative. Also note the two-way operation of the CEAC as suggested in the plot at the bottom of Attachment 3. When rate of return is high, rate decreases to customers can occur if rate of return exceeds the ceiling set by the regulatory commission or if costs decline by virtue of reduced inflation.

Where the utility's rate of return is below the "floor" level rate of return set by the commission, the rather unusual possibility of a revenue decrease being called for by a CEAC is remotely possible, but should not be permitted. Note here that there is no CEAC provision for raising the utility's return back to the reasonable range. This downside constraint merely prevents revenue reductions from being made when the utility is already in financial difficulty. In such a situation, a formal rate case is undoubtedly called for.

Under reasonably normal inflationary or non-inflationary circumstances, a properly developed productivity oriented CEAC would clearly tend to reduce the frequency of the typical lengthy and costly formal rate case. But, it would not eliminate the need for them. At least every five years or so a formal rate case would undoubtedly be required to rule on new circumstances that may have developed and to restructure tariff rates, as necessary, to bring the CEAC factor (on the customer's bill) back to 1.0.

The productivity oriented CEAC formula suggested here has an almost infinite number of possible variations and applications. In addition, the flexibility of this CEAC concept permits it to "fit", on either a temporary or a permanent basis, into almost any kind of economic stabilization program that can be devised.

Therefore, in view of the outlook for continued inflation, the company's increasing needs for huge amounts of capital to meet consumer demand in the decade or so ahead, and the increasingly competitive market for investors' capital, the possible prompt addition of a sound cost-efficiency adjustment clause to the company's intrastate tariff should be considered.

10-1-73

APPENDIX 2

ILLINOIS BELL TELEPHONE COMPANY
GENERAL LOCAL EXCHANGE TARIFF
TELEPHONE SERVICE

GENERAL REGULATIONS

34. COST AND EFFICIENCY ADJUSTMENT FACTOR (Cont'd) (N)

C. Calculating the Cost and Efficiency Adjustment Factor

The method for calculating the Cost and Efficiency Adjustment Factor (CEAF) to be applied each month is shown below.

$$CEAF = \frac{C + E\text{, but not more than } RRC}{R}$$

Where: C = half of the dollar value of change in unit costs = .5 (S - T) U

S = rate of change in total Illinois intrastate operating expenses (including interest and taxes, excluding federal income tax)

T = rate of change in output (total Illinois intrastate revenue, expressed in constant dollars, in accordance with conventional productivity measurement usage)

U = total intrastate operating expenses (including interest and taxes, excluding federal income tax)

$$E = \text{dollar value of the efficiency factor} = 1.5 \frac{V \times W}{1.0 - W}$$

V = total payments to labor, capital and other factor inputs

W = rate of change in total factor productivity

RRC = the rate of return constraint, i.e. the revenue change necessary to meet a rate of return ceiling of 9.0%, computed by the methods used in the Commission's order of December 21, 1973 in Cases 57903-6 and 58033

R = total billed intrastate revenue (excluding those tariffs and items to which the CEAF does not apply as specified in Paragraph 34.B., preceding)

Notes: Variables S and T are the quotients of the current 12 month moving total divided by the 12 month moving total for the preceding month

Variables U, V, RRC and R are 12 month moving totals

Variable W is a 5 year moving average

Dollar amounts used in this formula are the Illinois intrastate figures computed to the nearest thousand

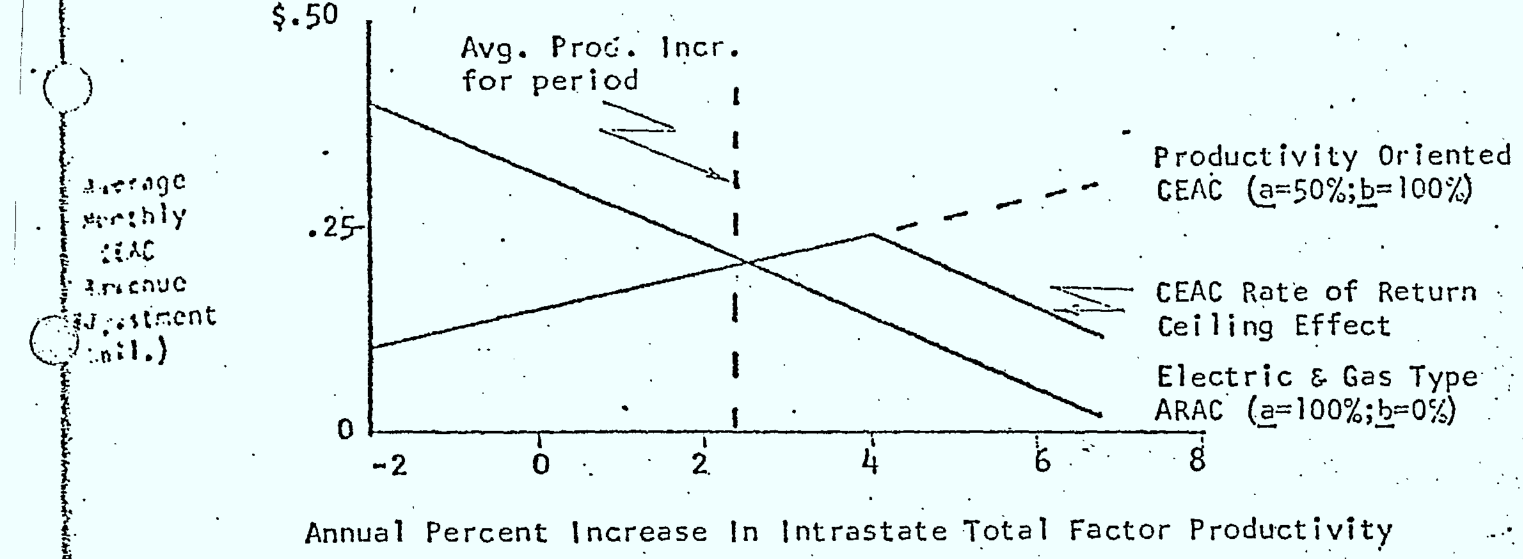
Each CEAF is computed to five decimal places (N)

Issued

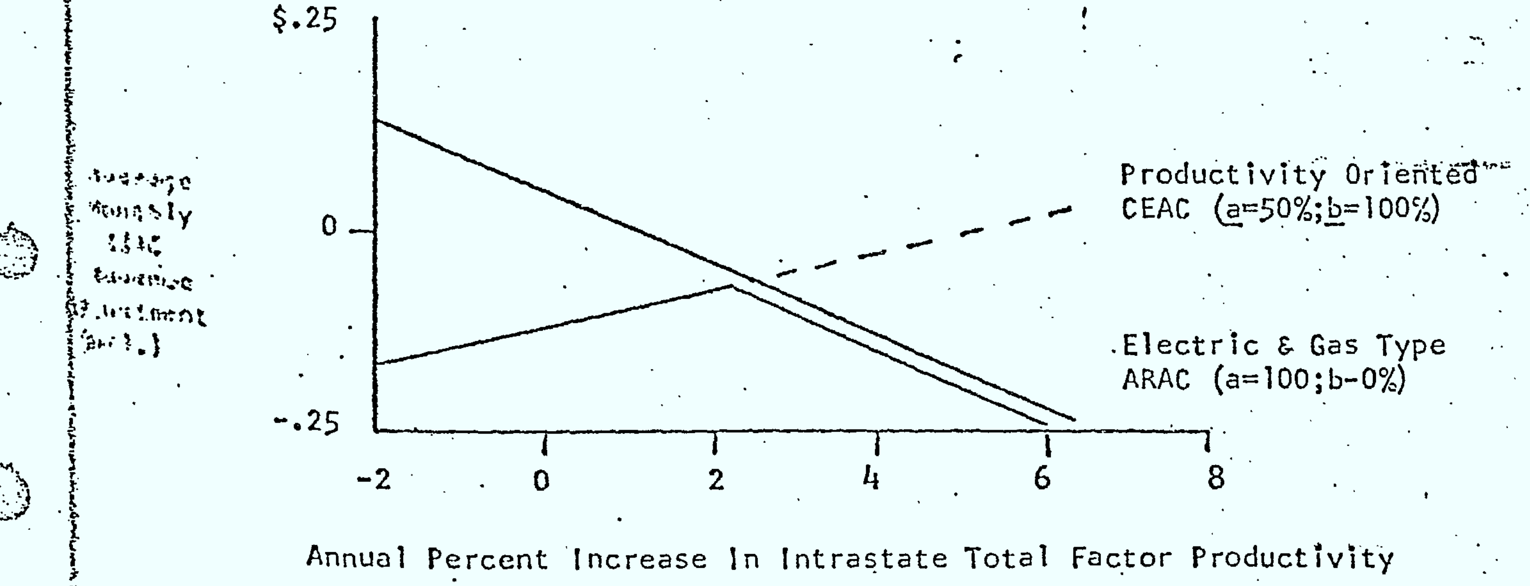
By H. A. Latimer, Vice President and Treasurer
225 West Randolph Street, Chicago, Illinois 60606

Estimated Monthly Illinois Bell Revenue Changes with a CEAC
For Simulated Changes In Illinois Intrastate Productivity

1971-1972



A Simulated Deflationary Period
With Ceiling Rate of Return



Efficiency and Telecommunications Policy

In this section, we wish to consider the broad types of policies that will be the source of substantial political controversy during the next decade. It is not possible to focus narrowly on the role of efficiency without discussing some aspects of the broader issues. However, this discussion should not be construed as a complete analysis of these issues since there are many considerations not analyzed adequately.

Historically, there has been substantial but incomplete separation of various communications media. Postal systems had a monopoly in delivering something called mail but there existed competition of a variety of types from slower telecommunications services such as telegrams as well as from delivery systems which handled packages in competition with the postal service. Broadcasting was controlled but faced competition both internally between radio and television and externally from the print media and other entertainment sources; plays, movies, etc. Telecommunications provided predominantly voice service although it has been clear for many decades that a wide variety of non-voice services were technically feasible but ruled out by costs. Certainly voice communication competed with the postal service. The advances in solid state physics and electrical engineering have provided the possibility of further competition across these communications industries.

It is helpful to remember what is telecommunications' primary activity. Information represented in various visual, auditory or physical form is encoded at the sending end, transmitted over some media and reconstructed into a desired form at a receiving end. What is important is the variety of original representations of information that can be encoded, the speed at which it can be transmitted and the variety of final forms that can be reconstructed. Crucially important is the quality of the latter relative to the original. Overriding all of the technical dreams are the costs involved. Given the costs and consequently the prices what demand exists for an enormous variety of products at these cost determined prices.

The technical revolution in telecommunications involved, predominantly, the possibilities of reducing enormously the costs of providing these typs of services. Although this description is adequate it is worthwhile noting that this includes a wide variety of services that were not available previously due to cost constraints implicit in existing technical knowledge. That is, new technical capabilities are translated into reduced service costs.

Before plunging into the complexities of policy, how is productivity related to these broad issues? At one level, the relationship is direct and compelling. Productivity, the TFP variety, is simply a measure of efficiency and efficiency is a very general social goal whose importance needs no defence. The difficult task is to weigh the achievement of efficient production against other desired goals. This must be followed by the design of a policy to promote efficiency and to measure the efficiency of the industry in order to monitor the achievement of that goal.

Broadcasting - A Special Case?

Attention has been focussed on the content of broadcasting particularly in regard to the production and distribution of Canadian material. Moreover some policies have been concerned with the possibilities of receiving foreign, predominantly American, broadcast signals. Broadcasting will be imperfectly defined as one way communication for mass reception. To the extent that content policies for broadcasting continue then this is a separate policy whose intent is not to affect efficiency directly. However this type of policy may alter efficiency. We will not discuss policies that deal with content excep to the extent that these policies alter efficiency. Broadcasting is a special case because the thrust of policy has been so strongly directed towards content control. The emerging technology may present difficulties for this type of policy because the range of available information at low cost is going to be increased dramatically. Attempting to promote or insist on Canadian content in this type of technical environment will be very difficult in the mass markets. On the other hand, specialized Canadian programs for limited audiences may be more readily available. The major danger for efficiency is that content control policies will strongly reduce efficiency through a refusal to permit the use of technology that appears to limit content control. Some of the satellite and the pay-T.V. policies appear to at least have the possibilities of these negative consequences.

Whither the Electronic Highway?

The thrust of the new technologies is to permit the provision of large capacity at relatively low cost for a very wide variety of telecommunications services. Any sharp separation between postal, broadcast (radio and television), data and voice services in any number of directions, e.g., two-way television, will be steadily reduced. The efficient provision of communications services will require the restructuring of industries. Attempts to maintain current boundaries will certainly result in welfare losses through inefficient production structures. It is easy to see some of the problems using a number of specific policy choices.

a) Electronic Mail

Canada Post has developed a limited form of electronic mail. At the moment this sytem uses the transmission facilities of CNCP Telecommunications. Individuals and companies with access to computer networks can and do duplicate (roughly) electronic mail systems all the time. There is no sensible method for defining 'mail' in such a way that Canada Post can eliminate close substitutes. If there is to be a monopoly in the post office, it should reside only in the non-electric collection and distribution of 'mail'. Even this may become increasingly inefficient. The alternatives of receiving 'mail' through video displays with storage facilities and of sending using simple terminals will become attractive. For hard copy material, the technology of printing does not suggest that delivery and collection will be eliminated. However, the pricing of hard copy mail needs to be re-evaluated. There are serious problems with a continuance of the current type of price structure. Once a local delivery and collection system is organized the marginal cost of an extra piece of mail is very low. Current prices are well above that marginal cost. If electronic mail is priced closer to marginal cost which is quite likely, then the relative prices of electronic versus non-electronic mail will be wrong and the difficulties of operating a non-electronic mail system will be increased.

IV. MANAGEMENT USES

(a) TFP in a Post-Mortem and Planning Framework

I. Introduction

The question in most firms is not whether there is any preoccupation with productivity but rather the level at and the degree to which it is applied. There has, over the past 60 years, been considerable effort in the direction of first measuring, then improving, and ultimately, monitoring productivity. The sequence is probably repeated to different levels of sophistication in most departments or areas of activity. It is certainly highly pervasive within the actual operating areas, such as the plant floor, work sites and so on. Briefly an inquiry about productivity, in almost any firm, would not be met by a blank stare. However, inquiring as to the significance of these micro-applications of partial productivity measures to overall corporate performance would almost certainly not elicit an informed response. Further, inquiring about the role of all the micro-measures in the corporate planning exercise would elicit even less of a response. Given the partial nature of all the diverse productivity and quasi-productivity measures in use at the detailed activity levels of the firm, it would be almost impossible to make any meaningful connection with some global type of measure. This is not to imply that these micro-measures are in some sense unimportant when, on the contrary, they are probably an excellent cost control tool for section, division or department managers. The only point of contention lies rather with the inability to string them together for ultimate use in corporate/budgetary planning. To draw together the diverse inputs and outputs of any large firm requires a somewhat more global measure of productivity. The theme of this paper centres on the analytical and planning models that are integrated into the planning process on the basis of a Total Factor Productivity (TFP) measure.

A series of related productivity models for management will be introduced. We will start with the by-now standard NIPA (Net Income Productivity Analysis) model which is a purely descriptive and passive management tool, and then present the UNIPA (Unconstrained NIPA) model which enables the firm to compare its rate of return to the capital market. Third we will show how the UNIPA model can be used for a post-mortem analysis, through which the firm can evaluate its success in meeting its planned budget. Finally we will introduce the PAP (Productivity Analysis for Planning) model which the firm can use as a top-down guideline and control in its corporate budgeting and planning.

The first, NIPA, is a model developed to analyse the impact of productivity both historically and within the context of a fully developed financial plan. It is oriented, in particular, towards explaining the growth in Net Income, which, for the management of the firm, is the most important single statistic which they monitor. For them, it is the complex which most clearly mirrors performance. It is for this reason that the productivity model has been designed around Net Income growth as its reference point. From a purely economic perspective there is nothing unnatural about this approach. While the accountant views Net Income as a residual return to invested capital, the economist sees it as both a cost of and a return to invested capital. Considering net income, as the value of some quantity of capital that is supplied to the enterprise at a fixed price per unit, along with the trade-off between quantity and productivity (as dictated by price movements) the model will be seen as just another more elaborate view of the basic profit statement. In that it is merely a decomposition and subsequent rearrangement of the basic price and quantity income statement components, many different presentations of the same data are possible. Clearly, each of the various presentations will emphasize different aspects. We will examine them below. We will begin by a summary and brief commentary of the version developed independently at AT&T and Teleglobe Canada.[1] Following that overview of the NIPA, we will introduce, as a tool to compare the firm's earnings performance to what it can expect on the capital market, the UNIPA model. Fundamentally, we will remove the identity between revenue and cost which in the NIPA analysis is used to define residually the cost of capital, and we will allow for profits or losses.

In particular, our version resembles a combination of the analytical models at Electricité de France (Reimeringer (1980)) which do not constrain the return to capital to always equal its cost, and NIPA, which does not admit the possibility that planned and actual costs and revenues may not always be equal. Finally, we shall show how the UNIPA models can be used as a post-mortem and quasi-planning model. It can analyse historical performance and, as well, review future plans with a view to identifying the implicit productivity gains (or losses) and their impact on Net Income growth. In their present form NIPA and UNIPA models do not, in contrast to the PAP model also presented below, actually generate the plan.

The PAP is a pure planning model designed to develop a complete budgetary/corporate plan, at a fairly aggregate level, where the components of the various financial/accounting summaries all embody certain key management and corporate targets. More succinctly we may view this as something of a pure or guideline theoretical budget generated for top management so that they can more intelligently guide the longer more tedious development of a full-blown, bottom-up corporate budgetary plan. With the results of the planning model the process becomes far less arbitrary. The planners are in a position to prescribe unique upper limits for all the key financial statement items including labour and other expenses and the size of the capital budget. They are armed with the knowledge that any overshooting of these benchmark expense and expenditure figures will ensure that some or all of the preset targets will not be attained. While there are a whole array of possible targets, our model is built around what we believe to be the most important of these: the required return to invested capital (r), the forecast demand for the firm's production and, the desired growth in productivity.

II. NIPA

a) Introduction

Productivity gains or losses play an essential role in the degree to which a firm will succeed. It is productivity that allows the firm to weather the ravages of input price inflation without resorting to excessive output price increases which could damage market share in a competitive environment or not be permissible by the regulator and thus harm capital market operations. Although these are facts acknowledged by any entrepreneur, there are not many who, if they even measure it, effectively tie productivity information into the overall management of the firm. It is unfortunate because, once the measurement problem (which is probably the major stumbling block) is resolved, productivity results can be integrated directly into a quasi-financial accounting framework for use by decision-makers. This is apparent when we look at the basic accounting identity.

$$\text{Revenues} \equiv \text{Costs}$$

where costs account for all payments including those required capital payments such as interest, taxes and return to equity holders. By looking directly at the price and quantity components, the accounting identity becomes

$$(\text{Price of Outputs}) \times (\text{Quantity of Outputs}) = (\text{Price of Inputs}) \times (\text{Quantity of Inputs})$$

and with the definition:

$$\text{Total Factor Productivity} = \frac{\text{Quantity of Outputs}}{\text{Quantity of Inputs}}$$

it follows that:

$$(\text{Price of Outputs}) = (\text{Price of Inputs}) \div \text{Total Factor Productivity}$$

In other words, the basic rule, embedded in the accounting identity says that the price of output should be such as to cover that part of the price of inputs which is not offset by gains in Total Factor Productivity (TFP). Although this is somewhat of an oversimplification, it nevertheless demonstrates the essential role of TFP, as an offset (either partial or complete) to input price inflation. While most firms will try to price at what they believe the market will bear, and thus maximize the residual, net income, the basic pricing rule embedded in the accounting identity does provide an excellent guideline for any market situation, including the regulated sector.

Accepting the premise of the pricing rule is not very difficult. The major source of inhibition lies rather with the practical aspects of implementation. These include (i) the index number problem; (ii) the data definition problem and (iii) the difficulty of relating the individual price and quantity elements of Revenues and Costs directly to a management decision designed to affect the bottom line of the firm's income statement. While issues (i) and (ii) are of paramount importance, they are given extensive treatment elsewhere in Denny, de Fontenay and Werner (1980) and de Fontenay (1980) and will be assumed away leaving us to deal only with the last difficulty. Given that economic theory already provides a very extensive coverage of this aspect, with pricing and production rules for any number of market/optimization-objectives combinations, it may seem redundant to write yet another on the subject. However, while economic theory may tell the entrepreneur what level of output should be produced and at which price it should be sold, given his production function, cost relationships and market organization, it does not provide any link with the realities of his income statement, balance sheet or funds flow statistics. In this paper we propose to do just that. Section I will examine current applied work at AT&T and Teleglobe Canada. Specifically it will look at the Net Income Productivity Analysis (NIPA) model, a version of which is also presently in use at Electricité de France. In addition a more powerful version of NIPA will be presented in the second part of Section 1. As an extension of these purely post-mortem quasi-planning type of management TFP models, Section II introduces a pure planning model with explicit consideration given to targeted productivity and financial variables. It is partially based on work by Werner (1979) for Teleglobe Canada.

b) The Model

The final question, after deriving the basic NIPA relationship, concerns the best approximation to its set of continuous variables. As part of the development of this management tool it will be useful to examine two approaches: (1) beginning with TFP growth as the difference between the logarithmic differentials of output and input it will be seen that the final discrete approximation is arbitrary and (2) by developing the NIPA statement through the application of Diewert's Quadratic Lemma (Diewert (1976)) we show that the final discrete accounting statement is exactly derived.

The traditional NIPA assumptions are based on product exhaustion and factor prices equal to the value of their marginal products. If, in addition, revenues are equal to costs in every period, where costs include a required return to invested capital then this implies that the entire process is characterized by constant returns to scale. Thus, given the definition of Total Factor Productivity

$$\dot{TFP} \equiv \dot{Q} - \dot{X} \qquad (1)$$

where $Q = Q(q_1,\ldots,q_n|p_1,\ldots,p_n)$ is an index of output

$X = X(x_1,\ldots,x_m|w_1,\ldots,w_m)$ is an index of input where q_i and p_i denote respectively the quantity and price of the i-th output and x_j and w_j that of the j-th input. A dot over the symbol indicates a logarithmic differential (i.e., a proportional rate of change). The above assumptions state that if and only if,

$$\dot{R} \equiv \dot{C} \quad \text{then} \quad \dot{TFP} = \dot{W} - \dot{P} \qquad (2)$$

where $\dot{R} = \dot{P} + \dot{Q}$ and $\dot{C} = \dot{W} + \dot{X}$

and W and P are price indices of input and output, either of Q and P and of X and W being implicit, respectively.

Combining (1) and (2) we have

$$\dot{Q} - \dot{X} = \dot{W} - \dot{P} \qquad (3)$$

which is the point of departure of the standard NIPA model. Each of the terms is a weighted aggregate where

$$\dot{Q} = \sum_i s_i \dot{q}_i \quad ; \quad \dot{X} = \sum_j \sigma_j \dot{x}_j \quad ; \quad \dot{W} = \sum_j \sigma_j \dot{w}_j \quad ; \quad \dot{P} = \sum_i s_i \dot{p}_i$$

If we let the x_j, $j = 1$ to 3 represent K, L and M respectively and w_j, $j = 1$ to 3 represent the prices of K, L and M, denoted as r, w and m, respectively, then (3) can be rewritten as

$$\dot{TFP}_t + \dot{P}_t = \sigma_{w_t} \dot{w}_t + \sigma_{m_t} \dot{m}_t + \sigma_{r_t} \dot{r}_t \qquad (4)$$

which tells us that the changes in input prices will be exactly offset, in any period by some combination of TFP gains and output price changes. By adding $\sigma_{r_t} \dot{K}_t$, a term commonly referred to as "Capital Growth", to both sides of (4) we have the new expression

$$\dot{TFP}_t + \dot{P}_t + \sigma_{r_t}\dot{K}_t = (\sigma_{w_t}\dot{w}_t + \sigma_{m_t}\dot{m}_t) + (\sigma_{r_t} \, d\ln r_t k_t) \qquad (5)$$

The last term on the RHS, σ_{r_t} dln rK , is the proportional change in capital costs which is composed of a price and quantity component, $\sigma_{r_t}\dot{r}_t$ and $\sigma_{r_t}\dot{K}_t$ respectively. The Capital Growth term $\sigma_{r_t}\dot{K}_t$ can be more easily understood by noting that if TFP, $\dot{P}_t$ $(\sigma_{w_t}\dot{w}_t + \sigma_{m_t}\dot{m}_t)$ were all zero and if the firm could expand its capital stock while maintaining the same rate of return on that stock, then it would then be able to increase its net income by the same proportion. The components of dln rK are changes in depreciated expenses, debt service costs, taxes and the return to invested capital. For each of the components, we can define ex post ratios r_ℓ , $\ell = 1,..,4$ as the ratio of the particular expense to the total stock of capital such that

$$rK = \sum_{\ell=1}^{4} r_\ell K$$

Then

$$d\ln r_t K_t = \sum_{\ell=1}^{4} \varepsilon_{\ell,t} \, d\ln r_{\ell,t} K_t$$

where $\varepsilon_{\ell,t} = \frac{r_{\ell,t}}{r_t}$ is the share of each of the four components of the capital cost to total capital cost. We may now rewrite (5) as

$$\dot{TFP} + \dot{P}_t + \sigma_{r_t}\dot{K}_t = [\sigma_{w_t}\dot{w}_t + \sigma_{m_t}\dot{m}_t] + \sigma_{r_t}\varepsilon_{1_t}(d\ln r_{1,t}K_t) + \sigma_{r_t}\varepsilon_{2t}(d\ln r_{2,t}K_t)$$

$$+ \sigma_{r_t}\varepsilon_{3t}(d\ln r_{3t},K_t) + \sigma_{r_t}\varepsilon_{4t}(d\ln r_{4,t}K_t) \qquad (6)$$

The elements on the RHS of (6) are all identifiable components of the standard income statement (in terms of proportional changes), weighted by their share of the total cost, they represent:

$\dot{w}_t$ and $\dot{m}_t$	=	the price movements of labour and other operating expenses
$d\ln r_{1,t}K_t$	=	depreciation expenses
$d\ln r_{2,t}K_t$	=	debt service and other financial instrument expenses
$d\ln r_{3,t}K_t$	=	relevant tax expenses
$d\ln r_{4,t}K_t$	=	net income

Expression (6) is nothing more than a decomposition of the basic accounting identify,

$$\dot{NI} = \dot{R} - \dot{C}^*$$

$$\text{where} \quad \dot{C}^* = \dot{C} - \dot{NI} \quad ; \quad \text{i.e. } \dot{NI} \text{ includes all capital costs}$$

The discrete approximation of (6) takes account of the facts that

(a) $\dot{z} = d\ln z = \frac{dz}{z}$; for z representing any of the dotted variables

(b) $\sigma_{z_t} = \frac{P_z z}{R}$; for P_z representing any input price

(c) $\varepsilon_{\ell,t} = \frac{r_{\ell,t}K_t}{r_t K_t}$ and $\sigma_{r,t}\varepsilon_{\ell,t} = \frac{r_{\ell,t}K_t}{R_t}$ where $\ell = 1,\ldots,4$

(d) $\dot{P}_t = \frac{PQ}{R}\frac{dP}{P}$

(e) $\dot{TFP} = \frac{1}{R}(PQdQ - WXdX)$.

Multiplying (6) by R and cancelling all the common terms leaves,

$$dTFP + QdP + rdK = [Ldw + Mdm] + [Kd\delta + \delta dK] + [Kd\phi + \phi dK] + [Kd\theta + \theta dK] + [Kd\pi + \pi dK] \qquad (6a)$$

where the last term is, of course, the change in Net Income. While we can now fairly closely approximate dz by $\Delta z \equiv z_t - z_{t-1}$, the choice of t or $t-1$ as the subscript for the non-differenced variables is arbitrary. By convention the prices would carry a $(t-1)$ subscript while (t) would be used for the quantity. Naturally, there is no compelling reason not to alter the convention.

Another method of deriving (6a) but this time with the time dimension of the variables exactly specified is to begin with the technology

$$F(\underset{\sim}{Q},\underset{\sim}{X},t) = 0 \qquad ; \qquad \underset{\sim}{z} \text{ is a vector}$$

where F is quadratic and by Diewert's Quadratic Lemma (Diewert (1976)) we get

$$\tfrac{1}{2}\sum(F_{Qt} + F_{Q,t-1})\Delta Q = \tfrac{1}{2}\sum(F_{Xt} + F_{X,t-1})\Delta X + \Delta TFP \quad ;$$

$$\Delta TFP = TFP_t - TFP_{t-1} \quad . \qquad (7)$$

From profit maximization

$$F_Q = P \quad \text{and} \quad F_X = W$$

we can rewrite (7) as

$$\tfrac{1}{2}\sum(P_t - P_{t-1})\Delta Q = \tfrac{1}{2}\sum(w_t - w_{t-1})\Delta X + \Delta TFP \quad . \qquad (8)$$

$R \equiv C$ implies that $\Delta R \equiv \Delta C$, from the Quadratic Lemma

$$\Delta R = \tfrac{1}{2} \sum (P_t + P_{t-1}) \Delta Q + \tfrac{1}{2} \sum (Q_t + Q_{t-1}) \Delta P \qquad (9)$$

$$\Delta C = \tfrac{1}{2} \sum (w_t + w_{t-1}) \Delta X + \tfrac{1}{2} \sum (X_t + X_{t-1}) \Delta w \qquad (10)$$

and substituting (9), (10) and $\Delta R \equiv \Delta C$ into (7) we get

$$\Delta TFP = -\tfrac{1}{2} \sum (Q_t + Q_{t-1}) \Delta P + \tfrac{1}{2} \sum (X_t + X_{t-1}) \Delta w \ .$$

Separating the inputs as per equation (6a) we can now write

$$\begin{aligned} \Delta TFP + \tfrac{1}{2}(Q_t + Q_{t-1})\Delta P + \tfrac{1}{2}(T_t + T_{t-1})\Delta K = {} & [\tfrac{1}{2}(L_t + L_{t-1})\Delta w + \tfrac{1}{2}(M_t + M_{t-1})\Delta m] \\ & + [\tfrac{1}{2}(K_t + K_{t-1})(\Delta r_{1t} + \Delta r_{2t} + \Delta r_{3t}) \\ & + \tfrac{1}{2}\{(r_{1t} + r_{1,t-1}) + (r_2 + r_{2,t-1}) \\ & \quad + (r_{3t} + r_{3,t-1})\}\Delta K] \\ & + [(K_t + K_{t-1})\Delta r_{4t} + (r_{4t} + r_{4,t-1})\Delta K) \qquad (11) \end{aligned}$$

The last expression, except for the form of the coefficients, which are now explicit, is identical to equation (6a). While (11) may be less arbitrary it is not entirely clear that it is superior for every choice of coefficient variable in (6a).

While the above model provides an extremely useful disaggregation of the financial/accounting income statement, it must be noted that nowhere in the model is anything said about the adequacy of the NI, upon which the relative impact of all the other items is being measured. Given that it is a residual in the cost of capital after payments to depreciation, debt service and taxes, we are led to believe that, within the context of the model, the return to invested capital, i.e., NI, is in fact also identically equal to its cost. Until now, the cost of capital has been defined residually, but this may not be useful in the long run, since it does not reflect the option the firm has to invest its internal generated fund in the capital market. Nevertheless, despite that drawback, this type of income statement presentation can only be a major improvement over the standard format since above all, it isolates the impact of inflation. In addition, while it presents the crucial information to be garnered from a knowledge of the relative impacts of TFP and individual price movements, it preserves all the key information normally found on an income statement including, of course, the critical net income results, now decomposed into inflationary price movements and productivity increases.

III. UNIPA (Unconstrained NIPA)

i) the model

The corner stone of the NIP model is $R = C$. However, once the cost of capital is defined exogenously, then it does not necessarily follow that R equals C. The cost of capital in the NIPA, through r_4, is whatever balances costs and revenues and nothing in the NIPA analysis prevents r_4 from being very high or very low or even negative, reflecting a very good or a very poor performance on the part of the firm. Evidently a good or a poor performance is a concept which has to be defined. This is not a problem since it has a common sense meaning which is formalized in economic analysis as the opportunity cost. To the extent the firm could dispose in some alternative way of its capital stock so as to receive at most a return of $\rho_t K_t$, then any return below ρ_t will be a poor performance since the firm could reorganize its resources to earn ρ_t . Similarly, a return above ρ_t will be a good performance. Now if we define the cost faced by the firm, where $\rho_t K_t$ is the opportunity cost of capital, such that

$$C_t' \equiv C(\rho_t) = w_t L_t + m_t M_t + \sum_{\ell=1}^{3} r_{\ell,t} K_t + \rho_t K_t \qquad (12)$$

then

$$PL \equiv R - C'$$

where PL is the profit or loss due to the unanticipated returns (positive or negative), and C' represents all incurred costs with the capital cost portion including the required return to invested capital. Nevertheless, since the definition of productivity still holds, given

$$\dot{TFP} = \dot{Q} - \dot{X}$$

then

$$\dot{TFP} = \dot{W} - \dot{P}$$

if, and only if $\dot{PL} = 0$. That is, PL is the repository of all deviations from plan. Noting that the plan was based on $PL = 0$, i.e., $R^* = C^*$,

$$PL = (R-R^*) - (C'-C^*)$$

where the asterisks denote desired or planned values. Considering that $R = PQ$ and $C' = W'X'$ the complete revised NIPA expression can now be derived from $R \equiv C' + \dot{PL}$, which can be rewritten in terms of proportional charges,

$$\dot{R} = \frac{C'}{R}\dot{C}' + \frac{PL}{R}\dot{PL} \quad .$$

From $\dot{R} = \dot{Q} + \dot{P}$; $\dot{C}' = \dot{X}' + \dot{W}'$ and the expression for $\dot{PL}$ above, as well as the fact that Q, P, X' and W' are indices of output quantities, output prices, input quantities and input prices, respectively, it follows that

$$\dot{Q} + \dot{P} = \frac{C'}{R}[\dot{X}' + \sigma_w \dot{w}' + \sigma_m \dot{m}' + \sigma_r \dot{r}'] + \frac{PL}{R}\dot{PL}$$

$$\left[\dot{Q} - \frac{C'}{R}\dot{X}'\right] + \dot{P} + \frac{C}{R}\sigma_r \dot{K}' = \frac{C'}{R}[\sigma_w \dot{w}' + \sigma_m \dot{m}'] + \frac{C'}{R}[\sigma_r \dot{r}' + \sigma_r \dot{K}] + \frac{PL}{R}\dot{PL} \quad (13)$$

where $\dot{PL} = 1$ and where we recognize $[\sigma_r \dot{r} + \sigma_r \dot{K}']$, with one difference, as the combination of depreciation, tax and financial and Net Income growths of the standard NIPA analysis. The difference is that the weights σ_i ' are based on C' which is equal to R if and only if $PL = 0$.

Finally in order to make (13) operational it must be transformed. We expand (13) to

$$\left[\frac{PQ}{R}\frac{dQ}{Q} - \frac{W'X'}{R}\frac{dX'}{X'}\right] + \frac{PQ}{R}\frac{dP}{P} + \frac{C'}{R}\;\frac{r'K'}{C'}\frac{dK'}{K'} = \frac{C'}{R}\left[\frac{w'L'}{C'}\frac{dw'}{w'} + \frac{m'M'}{C'}\frac{dm'}{m'}\right]$$

$$+ \frac{C'}{R}\frac{r'K'}{C'}\left[\frac{dr'}{r'} + \frac{dK'}{K'}\right]$$

$$+ \frac{PL}{R}\frac{dPL}{PL} \quad (14)$$

Multiplying through by R and cancelling all other denominator terms and replacing the continuous differential sign 'd' by 'Δ' , we get,

$$[P\Delta Q - W'\Delta X'] + Q\Delta P + r'\Delta K' = [L'\Delta w' + M'\Delta m'] + [K'\Delta r' + r'\Delta K'] + \Delta PL \quad (15)$$

Expression (15) is now amenable to tabulation in dollar terms for management. The only remaining question, as with the NIPA analysis above, pertains to the choice of (t) or (t-1) as the subscript for the coefficient variables. We could of course have derived the same expression using Diewert's Quadratic Lemma, except that then the coefficient variables would have been exactly defined to give $\frac{1}{2}(Z_t + Z_{t-1})\Delta Y$.

ii) <u>post-mortem utilisation of UNIPA</u>

The UNIPA model is here modified to do a post-mortem analysis in which we recognize that deviations from plan are an unavoidable phenomena which will generate positive or negative unanticipated earnings (UE) . Whereas ex ante the firm will plan to earn a "desired" return, ex post realities will usually differ from anticipations. It should be noted that when we refer to "desired" returns we mean those amounts required to exactly offset all costs, including labour, capital and materials. As before, the firm plans for revenues which, after paying labour, intermediate goods and services suppliers, depreciation expenses, financial obligations and taxes, will leave a residual to "adequately" compensate the providers of equity capital. However, as is the nature with any residual, in situations of uncertainty, it will equal its planned level, in the short run, only by coincidence. In this version of the NIPA model we both account for as well as explain these deviations from plan. The accounting identity $R \equiv C + PL$ is now replaced by

$$UE = (R - R^*) - (\tilde{C} - C^*)$$

However the exogenous return on capital is now defined not in terms of the opportunity cost the firm would reach were it to shift its operation but rather in terms of <u>the rate of return it was expected to reach when it developed its plan</u>. This rate will be denoted by γ_t, such that

$$\tilde{C}_t = \tilde{C}(\gamma_t) = w_t L_t + m_t M_t + \left(\sum_{\ell=1}^{3} r_{\ell,t} + \gamma_t \right) K_t \quad .$$

For simplicity, let $\tilde{C}_t = W_t X_t$ where W_t and X_t are appropriate price and quantity input indexes, then

$$dUE = R\dot{Q} + R\dot{P} - R^*\dot{Q}^* - R^*\dot{P}^* - \tilde{C}\dot{X} - \tilde{C}\dot{W} + C^*\dot{X}^* + C^*\dot{W}^* \quad .$$

Dividing through by R, we obtain the unanticipated earnings as a ratio expressed in terms of the realized revenue:

$$\frac{dUE}{R} = \dot{Q} + \dot{P} - \left(\frac{R^*}{R}\right)\dot{Q}^* - \left(\frac{R^*}{R}\right)\dot{P}^* - \left(\frac{\tilde{C}}{R}\right)\dot{X} - \left(\frac{\tilde{C}}{R}\right)\dot{W}$$

$$+ \left(\frac{R^*}{R}\right)\dot{X}^* + \left(\frac{R^*}{R}\right)\dot{W}^*$$

where we used $R^* = C^*$ through which γ_t was defined.

Denoting the inverse of the realized revenue as a ratio of the planned revenue by γ , i.e., $\gamma = R^*/R$, and regrouping terms to isolate the TFP components, we obtain, noting that $UE^* = 0$,

$$\frac{UE}{R} = [\dot{TFP} - \gamma\ \dot{TFP}^*] + [\dot{P} - \gamma\ \dot{P}^*] - [\dot{W} - \gamma\ \dot{W}^*] + \frac{UE}{R}\dot{\tilde{C}}$$

where we have used $\dot{\tilde{C}} = \dot{X} + \dot{W}$.

Finally

$$\frac{UE}{R} = (1 - \dot{\tilde{C}})^{-1}\{[\dot{TFP} - \gamma\ \dot{TFP}^*] + [\dot{P} - \gamma\ \dot{P}^*] - [\dot{W} - \gamma\ \dot{W}^*]\}$$

i.e., the unanticipated earning as a ratio of revenue is a weighted sum of the difference between the planned and the realized values. The first term in brackets is that proportion of the unanticipated earnings due to the difference between planned and actual productivity growth while the second and third terms reflect the degrees to which planned and actual price recovery differs. It is to be noted that the planned rates of growth are corrected for the error in revenue forecast, γ . The entire expression of course reflects the degree to which the productivity divergence and price recovery divergence offset each other. These can of course be broken down into all the same elements as the actual UNIPA statement.

The post-mortem analysis adds a new dimension to analysis of the net income in that it enables one to study the impact of the various forecasting errors, be they of exogenous variables such as w_t, m_t, ... or of endogenous terms such as L_t, P_t, ... through costs and revenues on the income statement. For instance the impact of a strike which might significantly lower L_t but which may be associated with an unforeseen wage settlement which, in turn, might increase significantly w_t can now be traced, ...

By decomposing as in the NIPA and UNIPA analysis $[\dot{W} - \gamma_t \dot{W}^*]$, we obtain

$$[\dot{W}_t - \gamma_t \dot{W}_t^*] = [\sigma_{L,t} \dot{w}_t - \gamma_t \sigma_{L,t}^* \dot{w}_t^*] + [\sigma_{m,t} \dot{m}_t - \gamma_t \sigma_{m,t}^* \dot{m}_t^*]$$

$$+ \sum_{\ell=1}^{3} [\sigma_{r,t} \varepsilon_{\ell,t} \dot{r}_{\ell,t} - \gamma_t \sigma_{r,t}^* \varepsilon_{\ell,t}^* \dot{r}_{\ell,t}^*]$$

$$+ [\sigma_{r,t} \varepsilon_{4,t} (d \ln \gamma_t K_t) - \gamma_t \sigma_{r,t}^* \varepsilon_{4,t}^* (d \ln \gamma_t K_t^*)]$$

$$- [\sigma_{r,t} \varepsilon_{4,t} \dot{K}_t - \gamma_t \sigma_{r,t}^* \varepsilon_{4,t}^* \dot{K}_t^*]$$

and substituting in the previous equation, we have

$$(\frac{UE}{R}) = (1 - \dot{\tilde{C}})^{-1} \{([\dot{TFP} - \gamma \dot{TFP}^*] + [\dot{P} - \gamma \dot{P}^*] + [\sigma_{r,t} \varepsilon_{4,t} \dot{K}_t - \gamma_t \sigma_{r,t}^* \varepsilon_{4,t}^* \dot{K}_t^*]$$

$$- ([\sigma_{L,t} \dot{w}_t - \gamma_t \sigma_{L,t} \dot{w}_t^*] + [\sigma_{m,t} \dot{m}_t - \gamma_t \sigma_{m,t} \dot{m}_t^*]$$

$$+ \sum_{\ell=1}^{3} [\sigma_{r,t} \varepsilon_{\ell,t} \dot{r}_{\ell,t} - \gamma_t \sigma_{r,t}^* \varepsilon_{\ell,t}^* \dot{r}_{\ell,t}^*])$$

$$- ([\dot{\sigma}_{r,t} \varepsilon_{4,t} (d \ln \gamma_t K_r) - \gamma_t \sigma_{r,t}^* \varepsilon_{4,t}^* (d \ln \gamma_t K_t^*)])\}$$

The three terms on the RHS are respectively the positive NIPA factors of productivity, output price and capital growth, the negative NIPA factors of errors in forecasting in wages, price of materials, depreciation, taxes and financial charges, and finally the weighted impact on net income of an error in the construction program.

In expanding the elements of (3) as we did for the standard UNIPA analysis, each individual item from the NIPA statement can be matched with its own unique variance. In essence we would have something resembling:

Plan	Actual	Variance
Positive Factors		
TFP	TFP	Due to TFP
+ Output Price Changes	+ Output Price Changes	Due to Output Price Changes
+ Capital Growth	+ Capital Growth	Due to Capital Growth
Negative Factors		
- Input Price Changes	- Input Price Changes	Due to Input Price Changes
- Capital Cost Changes (excluding NI)	- Capital Cost Changes	Due to Capital Cost Changes
= NI	= NI	UE
UE = 0	U = NI plan - NI actual $\neq$ 0	

IV. Integrated Planning Model

a) Introduction

The two versions of NIPA, presented above, while providing a good analytical framework for the intelligent evaluation of bugetary plans, are essentially ex post models. NIPA intervenes in the budgetary process in a sequential manner, taking an active role only after the laborious planning exercise produces its game plan. At that juncture NIPA analyses the budget's implicit productivity performance, which may or may not justify another round of the planning process. Given the scope of the bugetary process in any large firm, it is unlikely that a bad productivity picture, along with good built-in financial results, will move the planners to modify an already overly complex structure. The most natural solution to this dilemma would be to ensure that NIPA results are always favourable. This can be done by including productivity as an explicit consideration during the planning process. Such a model is the subject of this section. We will present a model which can be used to develop a complete, theoretical, corporate plan (budgetary and otherwise), explicitly incorporating all essential physical and financial targets such as return to investment and productivity. In this way, top management, who ultimately have to approve any budget, will have available a set of guidelines, incorporating all essential corporate objectives, through which to more closely guide the development of the actual budgetary process. They will be in a position to set spending guidelines that, if exceeded, will ensure that some or all of the target constraints are not fulfilled.

It is a mixed model, using econometrics only when the constraints of a pure accounting approach detract significantly from its ability to mirror the real world. In particular, as well be seen below, econometrics are used to estimate the relative input factor cost shares which ultimately translate into the basic technological ratios of the production process.

The major advantage of the following model lies in its simultaneous approach to the planning problem. In most purely financial planning models the distinct identifiable input sector is, to a large extent, independently sized and then fitted into the framework of certain corporate constraints, which include the financial rate of return. It is of course only by coincidence that such a process will end with a perfect fit after a first attempt. Some of the items will be recycled and returned for a new round of integration. We do not mean to imply that there is no prior interaction between the various sectors or that productivity is not an important consideration, only that the interactions and productivity considerations are partial in nature.

If we look at Figure 1, which assumes a capital intensive firm, thus placing a large importance on the capital budgetary process, we can trace the evolution (in very general terms) of a corporate budgetary plan. The most important driving forces are prior and present period demand forecasts. The former creates a requirement for ongoing capital projects, pretty well divorced from present demand conditions, while the latter determines present and longer term capital projects as well as, to a certain extent, replacement requirements. "Other" reasons for increasing the capital budget vary from industry to industry. In telecommunications, for example, international standards and interface exigencies would play significant roles. Regulated industries, in general, would find their capital budgets subject to pressures other than market demand. Ultimately, all the capital requirements are evaluated at current asset prices and a capital budget is derived.

The technological characteristics of the capital budget create part of the demand for the other input factor. These include the general categories of labour and other expenses (henceforth to be referred to as "materials"). They comprise such items as maintenance, direct operating labour, rental of

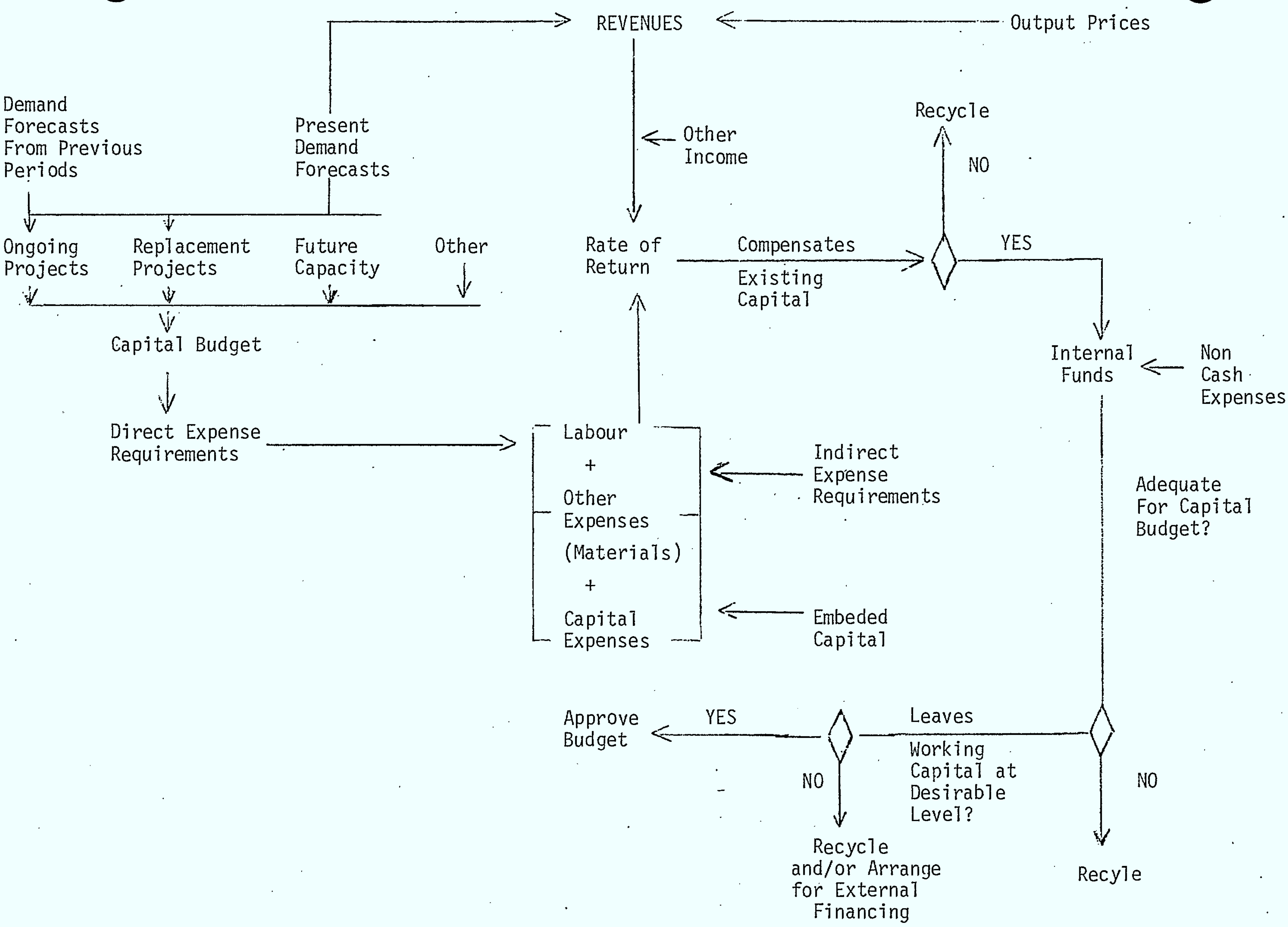

REVENUES
Output Prices
Demand Forecasts From Previous Periods
Present Demand Forecasts
Other Income
Recycle
NO
Ongoing Projects
Replacement Projects
Future Capacity
Other
Rate of Return
Compensates Existing Capital
YES
Capital Budget
Internal Funds
Non Cash Expenses
Direct Expense Requirements
Labour
+
Other Expenses (Materials)
+
Capital Expenses
Indirect Expense Requirements
Embeded Capital
Adequate For Capital Budget?
Approve Budget
YES
Leaves Working Capital at Desirable Level?
NO
NO
Recycle and/or Arrange for External Financing
Recyle

Figure 1

facilities, etc. In addition, the various components of the capital budget, as well as embedded capital, determine the value of capital costs. These include depreciation expenses, interest payments, taxes and, ultimately, the value of earnings applicable for dividend payments to equity holders. This is the residual, after payment to all factors, including debt capital, that ultimately compensates the owners of the firm. When calculated as a percentage of total invested catpial, then it is known as the rate of return.

It is within this capital/other factor interaction that "quasi" partial productivity considerations make their first appearance. Quasi, because these are really measures of worker efficiency rather than true overall productivity measurements. They are industrial engineering measures such as "work units" which compare performance against established standards. They take no account of the negative contribution to overall productivity when capital is used to increase work units per unit of time. Naturally, the link between these measures and overall corporate performance is difficult to establish.

The other determinants of total expenses are only indirectly related to capital budgeting and are determined more as a result of overall business size and prosperity. These include all those luxury factors such as marketing, training, special studies, etc. That is, the entire set of indirect, non-operating expenses.

Total revenues, including forecast demand at given prices and other, non-operating income, are combined with the total value of current input to determine the residual and, ultimately, the rate of return. If the RIR is inadequate, in that it either fails to compensate existing capital at a fair rate or does not cover all capital expenditures without excessive external financing requirements then there occurs a budgetary recycling process where all or part of the plan is altered. Usually it is the latter, concentrating on the expense rather than capital budget items. Corrective action may include labour cuts, material cuts, output price changes and, as a last resort, capital budget cuts.

Significant by their absence are the aspects of simultaneity and some overall explicit recognition of productivity. The advantage of simultaneously calculating all the unknowns are obvious, but what are the advantages of including productivity? Simply that the implied technological relationship of a production function, as embodied in the explicitly reocgnized productivity number allows for a combination of inputs, given the output, that is in some sense optimum. This optimum provides an additional constraint to the general planning problem which serves to narrow the choice between the various input options to more manageable proportions.

b) The Model

The model postulates the existence of some cost function

$$C = g(w,m,r,Q,t) \tag{1}$$

where w = the price of labour

m = the price of materials (or intermediate expense items)

r = the periodic (say, annual) cost of using the capital stock. It includes:

δ = depreciation rate

ϕ = the rate of taxation

θ = the return to outstanding debt

π = the return to equity

Q = the volume of output produced

t = the technology indicator.

From (Denny, Fuss & Everson (1979)) and (Denny, de Fontenay & Werner (1980)) we totally differentiate the cost function with respect to time to yield:

$$\frac{dC}{dt} = \frac{\partial g}{\partial w}\frac{\partial w}{\partial t} + \frac{\partial g}{\partial m}\frac{\partial m}{\partial t} + \frac{\partial g}{\partial r}\frac{\partial r}{\partial t} + \frac{\partial g}{\partial Q}\frac{\partial Q}{\partial t} + \frac{\partial g}{\partial t} \qquad (2)$$

Rearranging through division by C and from Sheppard's Lemma setting $\frac{\partial g}{\partial q_i} = X_i$; $q_i = w,m,t$ and $X_i = L, M$ and K respectively, we get

$$\frac{1}{C}\frac{dC}{dt} = \sigma_w \frac{dw}{dt}\frac{1}{w} + \sigma_m \frac{dm}{dt}\frac{1}{m} + \sigma_r \frac{dr}{dt}\frac{1}{r} + \frac{\partial g}{\partial Q}\frac{Q}{C}\left(\frac{\partial Q}{\partial t}\frac{1}{Q}\right) + \frac{1}{C}\frac{\partial g}{\partial t} \qquad (3)$$

where $\sigma_i = \frac{q_i X_i}{C}$; for $q_i = w, m, r$ and $X_i = L,M,K$.

which are the cost shares of each input and

L = manhours of input

M = materials inputs

K = the stock of physical capital .

From the definition of costs

$$C = wL + mM + rK \quad .$$

By totally differentiating with respect to time and rearranging we get

$$\sum_{i=1}^{3} \frac{q_i X_i}{C}\frac{dq_i}{dt}\frac{1}{q_i} = \frac{1}{C}\frac{dC}{dt} - \sum_{i=1}^{3} \frac{q_i X_i}{C}\frac{dX_i}{dt}\frac{1}{X_i}$$

or

$$\sum \sigma_i \frac{dq_i}{dt_i} \frac{1}{q_i} = \frac{1}{C}\frac{dC}{dt} - \sum \sigma_i \frac{dX_i}{dt}\frac{1}{X_i} \quad .$$

Substituting this into (3) above we get

$$-\frac{1}{C}\frac{\partial g}{\partial t} = \left(\frac{\partial g}{\partial Q}\frac{Q}{C}\right)\left(\frac{\partial Q}{\partial t}\frac{1}{Q}\right) - \sum \sigma_i \left(\frac{dX_i}{dt}\frac{1}{X_i}\right) \quad .$$

If we assume that the cost elasticity, $\frac{\partial g}{\partial Q}\frac{Q}{C}$, is approximately equal to 1 over the period under consideration, then

$$-\frac{1}{C}\frac{\partial g}{\partial t} = \frac{\partial Q}{\partial t}\frac{1}{Q} - \sum \sigma_i \left(\frac{dX_i}{dt}\frac{1}{X_i}\right)$$

where the right hand side is the shift in the production function due to technology, and, by definition, is equal to the change in total factor productivity, $\dot{TFP}$ and

$$\dot{TFP} = \frac{\partial Q}{\partial t}\frac{1}{Q} - \sum \sigma_i \left(\frac{dX_i}{dt}\frac{1}{X_i}\right) \quad . \tag{4}$$

We may rewrite (4) in discrete form:

$$\dot{TFP} = (\ln Q_1 - \ln Q_0) - \sum \tfrac{1}{2}(\sigma_{i1} + \sigma_{i0})(\ln X_{i1} - \ln X_{i0}) \tag{5}$$

where $\sigma_i = \frac{1}{2}(\sigma_{i1} + \sigma_{i0})$. We can now rearrange equation (5) so that it can be solved for any one of the X_i , say K , then:

$$\ln K = \left[\ln\left(\frac{Q_1}{Q_0}\right) + \sigma_L \ln L_0 + \sigma_M \ln M_0 + \sigma_K \ln K_0\right]$$

$$+ (1-\sigma_K)\left[\ln\left(\frac{K_1}{L_1}\right)\right] - \sigma_M \left[\ln\left(\frac{M_1}{L_1}\right)\right] - \dot{TFP} \tag{6}$$

Equation (6) has several unknowns and is at present not soluble. From the cost function g as a translog we can derive equations for each of the cost shares σ_{i1} .[5]

$$\sigma_{L1} = \alpha_L + \alpha_{LL} \ln w_1 + \alpha_{LM} \ln m_1 + \alpha_{LK} \ln r_1 + \alpha_{LQ} \ln Q_1 + \alpha_{Lt} t$$

$$\sigma_{M1} = \alpha_M + \alpha_{ML} \ln w_1 + \alpha_{MM} \ln m_1 + \alpha_{MK} \ln r_1 + \alpha_{MQ} \ln Q_1 + \alpha_{Mt} t$$

$$\sigma_{K1} = \alpha_K + \alpha_{KL} \ln w_1 + \alpha_{KM} \ln M_1 + \alpha_{KK} \ln r_1 + \alpha_{KQ} \ln Q + \alpha_{Kt} t$$

In the above system since $\sum \sigma_{i1} = 1$, we need only estimate any two and then solve for the third set of coefficients from the following conditions

$$\sum_i \alpha_i = 1 \quad ; \quad \sum_i \alpha_{ij} = 0 \quad ; \quad \sum_i \alpha_{iQ} = 0 \quad ; \quad \sum_i \alpha_{it} = 0$$

For our model we assume that w_1, m_1 and t are known and r is unknown. Therefore, in order to get estimates for the α_i and α_{ij} , we estimate the equation only to period 0 . Then the $\sigma_{i1} = h(r)$.

Further, from the definition:

$$\sigma_{i1} = \frac{q_{i1} X_i}{C}$$

we can find the ratios:

$$\frac{K_1}{L_1} = \frac{w_1}{r_1} \frac{\sigma_{K1}}{\sigma_{L1}} \qquad \text{and} \qquad \frac{M_1}{L_1} = \frac{w_1}{m_1} \frac{\sigma_{M1}}{\sigma_{L1}} \qquad (7)$$

where the ratios are each functions, by virtue of the share equations, only of r . We now have two unknowns, r and K and one equation, (6).

Given that our aim is to integrate our model directly into the corporate planning routine, the cost of capital r, which has economic meaning must be related to the financial cost of capital, r^* where

$$r^* = \delta + \lambda\theta + (1-\lambda)(1-\phi)\pi \qquad (8)$$

where λ is the proportion of total financial capital in the form of debt. The relation then can be postulated as:

$$rK = r^*K^B \qquad (9)$$

where K^B = the net original value of physical capital which, by definition equals the value of financial capital. In addition we also have, by definition:

$$A_0 = K_1^B - K_0^B + R_1(R_1-R_1^*) = K_1^B - (K_0-K_1^*)$$

$$A_1 = q_1(K_1-K_0) + R_1^*$$

where A_1 = the value of gross additions to the plant

R_1^* = the value of retirements that are actually replaced

R_1 = the value of retirements .

We can now derive the following relation:

$$(K_1-K_0) = (r_1-r_1^*q_1)^{-1}\{-r_1K_0 + r_1^*[K_0^B - (R_1-R_1^*)]\}$$

Of course, if all retired plants are ultimately replaced, either by exact reproductions or new technology then $(R_1-R_1^*) \approx 0$ and

$$(K_1-K_0) = (r_1-r_1^*q_1)^{-1}[-r_1K_0 + r_1^*K_0^B] \tag{10}$$

Equations (6) and (10) now form a system of two equations in the two unknowns r_1 and K_1. All the other unknowns of the general planning problem can now be derived from the solution to the system (6) and (8). Given a value for r_1, the share variable σ_{i1} assume values which, from (7), produce solutions for L_1 and M_1. This, along with the prices w_1, m_1 and r_1, puts a value on total cost which of course implies a total revenue requirement. Thus, we can see, that given the key constraints of demand forecasts, rate of return requirements and desired productivity growth we have calculated a cost equation whose components all embody the constraints:

$$C = r_1K_1 + w_1L_1 + m_1M_1$$

Further, taking account of the accounting identity whereby total revenues should be identically equal to total costs,

$$R \equiv C$$

$$PQ \equiv C$$

then we have a required price level for output as well. For all the other details of a full-blown financial plan we can use equations (8) and (9) to calculate depreciation expenses, taxes, interest payments, the various balance sheet items, source and uses statements and so on.

V. Conclusion

The notion that productivity is an important part of business success, as stated at the outset, may not be a new concept, but to incorporate it explictly into an overall corporate/budgetary plan is. In this paper we have demonstrated two ways of going about this integration. The first, involve more of a static budgetary analysis in the form of NIPA and UNIPA. They take, as given, the financial/accounting information in any plan, and compute the relative impact of productivity, among other variables, on the growth in Net Income, which, after all, is the firm's ultimate measure of management success. While NIPA imposes the constraint that all returns to factor are always identically equal to their costs, UNIPA does not.

The other method of introducing productivity into the corporate/ budgetary planning exercise involves a direct intervention in the process. TFP itself becomes a target variable and thus a parameter in the actual derivation of a complete guideline plan. Based on the desired levels of productivity, financial return and production (to meet anticipated demand), the planning model simultaneously calculates all the relevant variables of an entire plan which includes the income statement, balance sheet and funds flow information. While it does provide all the pertinent operating information the results of the model are not meant to replace the normal bottom-up planning process. Instead they offer a complete set of guidelines for upper management on the values of key operating indicators such as employee expenses, manhours, capital budgeting, etc. which, if not attained, will imply the untenability of management's key task targets, including financial return to investment, production level and productivity gains.

Footnotes

1. The original work on the management use of TFP by a firm must be credited to the Electricité de France (EDF), and its surplus analysis (Reimeringer, 1980) is the forerunner of all NIPA models. Certain multinational corporations, such as IBM, Xerox, ... are known to use TFP measures as general guidelines and DRI is in the process of formalizing such an idea. In 1977, Teleglobe Canada and the British Columbia Telephone Company organized two symposia at which a number of Canadian telecommunications carriers came together to discuss the concept and measurement of TFP. Nevertheless, the active and systematic use of TFP as a management tool, introduced analytically in the management process, but for EDF, appears to have been pioneered by telecommunications carriers, with Teleglobe Canada and AT&T in the process of incorporating it in the formal budgeting and planning process and with Bell Canada developing similar internal uses. In addition, two other Canadian telecommunications carriers have on-going productivity studies, British Columbia Telephone Company and Alberta Government Telephone. Finally, nine Canadian telecommunications carriers are participating with the Canadian Department of Communications in a major productivity project, which has, as one of its goals the development of management uses of TFP analysis.

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IV. MANAGEMENT USES

(b) Management Uses of Productivity: Disaggregation and Control

Management Uses of Productivity: Disaggregation and Control

It has sometimes been claimed that TFP is useful only as an aggregate measure of the performance of the company. A similar criticism has often been directed at profits. While there is a kernel of truth in these suggestions they are misleading and incorrect in general. As we have argued before (Denny, de Fontenay and Werner, 1980a), the measurement of costs and revenues in current and constant dollars at the boundary of the firm is relatively easy because there are market transactions. Internal operations of the firm do not require these transactions by definition. However transactions occur continuously between sub-groups within the firm and management must control and evaluate these internal transactions to ensure efficient,i.e., productive and profitable, operations for the firm.

Although not explored here, the history of the development of cost accounting as a management tool is directly related to our work. One might recall the state of the Ford Motor Co. before the Department of Defense 'whiz kids' entered after WWII to save it from bankruptcy through improved evaluation and control of internal operations.

In the relatively brief development of disaggregated productivity presented here, we will explore some general possibilities. It must be remembered that use of any management tool requires effective application in the concrete context of a firm's operation. An overview such as ours cannot provide all the detailed possibilities.

Efficiency Centers: An Introduction

For many years it has been recognized that it would be desirable to be able to evaluate and provide incentives for sub-groups within a firm. Two basic problems exist. First, it may be difficult to define sub-groups which have control over their inputs, outputs, costs and revenues. Given these problems an incentive system for a sub-group may not be optimal for the firm as a whole. This has slowed down but not halted the growth of management practices that incorporate cost and or profit centers. We are going to discuss efficiency centers but the difficulties and possibilities of these centers are similar to those of profit and cost centers. The growth of relatively sophisticated cost accounting procedures makes all these tasks feasible. For a useful application of the efficiency center concept, the cost accounting system will have to include the required information. It is extremely important that the data systems are integrated.

Suppose the firm is divided into a number of centers. How would one evaluate their efficiency? First, one must have information on the prices and quantities of inputs used and outputs produced. Due to the internal nature of transactions in many of the inputs and outputs this data probably is not available. Some firms have altered their record-keeping systems in order to reduce these problems but there are some difficulties which are not easily eliminated. Remember that to the extent that these problems persist, management's capabilities of running the firm successfully are also reduced.

For many centers, the measurement of the quantities of outputs and their prices are particularly difficult. This is due to the lack of any markets to evaluate the demand price for the output compounded by the qualitative nature of the outputs. Problems on the input side often seem less severe but this may be an illusion. Inputs for one center may be the outputs of another center which are difficult to measure. Alternatively, inputs may be shared by several centers and the allocation of the input prices and quantities amount centers may be difficult.

We will proceed to discuss a variety of possibilities below. The alternatives attempt slightly different approaches to the underlying problems of missing information. For any particular center one is not likely to have adequate price and quantity data for <u>all</u> outputs and inputs. Were this not a problem, one could directly apply the notion of an efficiency or profit center at any level of disaggregation. The alternative approximations are attempts to utilize the very large quantities of disaggregated information available while recognizing the importance of what is missing.

Firms without some approximation to efficiency and profit centers cannot be well managed. If managers do not know the efficiency and profit implications of decisions they will be unable to choose policies that are in the shareholders' interests.

Real Input Control

This is the simplest version of efficiency control and provides a simple link between aggregate efficiency and the disaggregated centers. Assume that all the centers have a budget in dollars. The costs C_{it} of center i during period t may be written

$$C_{it} = \sum_j w^i_{jt} X^i_{jt}$$

where w_{jt} and X_{jt} are the price of and quantity of input j during time period t . The proportional rate of change of costs, $\dot{C}_i$ will be,

$$\dot{C}_i = \sum_j s^i_j \dot{X}^i_j + \sum_j s^i_j \dot{w}^i_j$$

where s_j is the cost share of input j in center i. Changes in costs have been broken down into changes in the quantity of real inputs $\dot{X}^i$ and changes in aggregate input prices $\dot{w}^i$.

$$\dot{X}^i = \sum_j s^i_j \dot{X}^i_j$$

$$\dot{w}^i = \sum_j s^i_j \dot{w}^i_j$$

These rates of changes in price and quantity can be converted into indexes or constant dollar measures of the levels of input quantities, X^i, and prices w^i in center i.

For each center, there will be an index of the prices and real quantities of inputs that are used. How do we relate the disaggregated measures to the overall level of firm efficiency? The rate of growth of total factor productivity ($\dot{TFP}$) equals the rate of growth of aggregate output ($\dot{Q}$) minus the rate of growth of aggregate input ($\dot{F}$). The rate of growth of aggregate input $\dot{F}$ is defined by,

$$\dot{F} = \sum_j s_j \dot{X}_j$$

where $\dot{X}_j$ is the rate of growth of input j and s_j is the cost share of input j. Alternatively define the rate of growth of aggregate input ($\dot{F}$),

$$\dot{F} = \sum_i s_i \dot{X}^i$$

where $\dot{X}^i$ is the rate of growth of real input in centre i and s_i is the share of centre i in the total costs of the firm. This states that the overall rate of growth of the firms aggregate input equals the weighted sum of the rates of growth of real inputs in each centre i. The weights are the budget shares for each centre. There are two alternative ways of disaggregating the aggregate input growth. The more familiar method in TFP analysis is by type of input. The alternative proposed here is by centre. It would be easy to simultaneously do both disaggregations for at least some centers and some inputs. The important point is that one can identify centers in which real input growth is rapid or slow.

This provides a direct link between the overall measurement of efficiency and the use of real inputs in each centre. For any given rate of growth of output, real input control provides the mechanism for the achievement of efficiency growth.

Purchased Inputs, Short Run Productivity and Real Input Control

Valuation and measurement is easiest at the time when market transactions are undertaken. This suggests that one version of disaggregated productivity might have a quite specialized form. Define the short run production function

$$Q = f(L,M;\bar{K})$$

where $\bar{K}$ is a given fixed quantity of capital. Define short run total factor productivity,

$$\dot{TFP}_{SR} = \dot{Q} - w_L\dot{L} - w_M\dot{M}$$

where w_L and w_M are the shares of labour and materials expenditures in variable costs. These are the costs of purchased inputs excluding any capital costs, i.e. depreciation and the purchase of new assets. This efficiency measures attempts to isolate the improvements in efficinecy that are associated with the use of the existing capital stock. Since the latter changes every period one cannot produce an index through time. Rather, the rate of growth of short run efficiency in year t will indicate the efficiency of using the beginning of years capital stock. This reference capital stock will change every year.

One of the primary purposes of using this short run measure is to attempt to align the measurement of efficiency with the budgetary process. For example, suppose budgeting is divided between a capital budget and an non-capital operating concerned with all expenditures other than capital. Two specific real input control measures may be used.

From the definition of short run productivity, we may define a short run real input measure for any centre. That is define $\dot{VX}$, the rate of growth of the variable input quantity index for centre i,

$$\dot{VX}_i = \sum_j w_j \dot{X}_{ij} \quad .$$

The index, VX_i, provides an indication of the level of real variable inputs being used in a particular unit. If progress in improving efficiency is to be achieved VX_i must fall for many units relative to the growth in outputs. Improvements in VX_i may be the result of better methods of using the existing capital stock or they may be the result of additional capital.

To incorporate the change in the capital stock explicitly one can measure the real input quantity to include the change in the capital. This will permit the normal budgetary processes to be linked with efficiency measures. Budgets will normally provide information on the variable inputs for each centre and the capital budget will provide information on any changes in the centre's capital stock. These latter changes will probably imply changes in the variable input quantities. To the extent that explicit information is available the changes in the capital stock and associated variable inputs can be analyzed separately.

Inputs and Outputs in Market and Non-Market Transactions

If one desires to measure efficiency in segments of the firm, one must be able to find adequate indicators of the quantities of inputs and outputs. In this section we will consider the possibilities of moving beyond input control to the measurement of efficiency.

In many production processes and certainly in telecommunications there are a very large number of work standards. These specify a standard time for the completion of a task. The task itself is not an output that is sold on the market. One may presume that the task is required as an intermediate input into a service that is marketed. The work standard is used as a control device and also as part of an incentive scheme. There are certain difficulties with work standards. Focus is placed on only one input, labour time, ignoring the possibility that the task is not done at minimum cost because the cost of other inputs are ignored. Firms must continuously re-evaluate standard practices for this possibility. The primary control purpose of work-time standards is valid but possibilities of perverse incentives cannot be ignored.

Detailed work standards are most useful when a task must be done many times within a firm. This may involve many repetitions by a single employee or a few repetitions by many employees. In telecommunications firms, many of the tasks performed by operators and plant craftsmen are highly suited for work standards.

The design of work standards should explicitly takes into account the other inputs involved in the task. That is, the work norm should be based on a cost evaluation of all the inputs used for the task. It is at this level that some important decisions are made concerning efficiency.

If correct total cost evaluations are not made then the wrong work standard will be chosen and the employee incentives schemes may be perverse.