ABSTRACT

While budgetary (and corporate) planning behaviour typically focuses on meeting financially oriented constraints, especially the rate of return to invested capital or bottom line profits, the implicit production technology, or productivity, is effectively ignored. This paper outlines a method whereby the production technology, in the form of a "productionivity" measure, is explicitly introduced as a constraint parameter for aggregate budgetary (and corporate) planning. It effectively issues the process with a global perspective. It is shown how this methodology introduces an important measure of both efficiency and accuracy into the planning process. Further demonstration of the consistency of our approach, whereby productivity is used in an accounting framework, with the classical econometric analysis of constrained cost minimizing or profit maximizing behaviour.

INTRODUCTION

Development and control are the two most important aspects of any planning process. It is not enough to simply make corporate objectives known irrespective of the originating level of authority, without an appropriate system of control the likelihood of achievement is greatly diminished. This phenomenon has its roots in the vagueness, or more appropriately, the extreme generality in which company objectives are usually couched. The results are of course not surprising. Following hard on the heels of upper level direction is an interpretation and execution of convenience. this does not want to imply that those responsible would ignore the spirit of upper management's goals, only that in their haste to fulfill inexact directives the originally intended sense of optimality might undergo distortions. An example (admittedly somewhat extreme) can be drawn from a hypothetical system of central planning. Due to its key role in military and industrial expansion, the continual and rapid growth of steel output was strongly emphasized. Given a rather strict system of reward and punishment, plant managers were very quickly and deeply committed to the task. Steel production climbed at an astounding rate. However, the final outcome was nothing if not sub-optimal. Although output increased exponentially, it was primarily of steel rods, with fairly specialized applications, because through this choice, given the tooling and input requirements, management was able to ensure maximum growth. It became painfully evident that maximum, or better still, an unconstrained maximum and optimum are not necessarily synonymous. Furthermore, not only would the introduction of an appropriate constraint have increased the probability of more functional production patterns but it would also have given the central planners an excellent control tool.

Apart from the evident need to cover the difference between optimal goals and unconstrained maximization (or minimization) drives, with sometimes opposing goals, there is another appealing reason for the introduction of constraints. In fact, the more (or less, as the case may be) the merrier, just to the point where the number of constraints equals the number of unknowns. For example, the decision to maximize production creates a problem with a number of unknowns equal to the number of inputs with no upper limits. Theoretically, output would continue to increase towards infinity as more and more inputs are added. Aiming, instead, for maximum profits, introduces cost constraints equal to the number of inputs and ensures a unique solution. Unlike the unconstrained version of maximizing output, which left the choice of possible input configurations at infinity, the restructured problem offers the distinct advantage of a universe with strictly limited choice.

Having established certain propositions concerning control and constraints in planning, the objective of this paper can now be presented. It is to outline an upper management planning system which offers tight control over the future directions of the corporation, particularly within the company budgeting activity (which, as will become apparent, can, in any event, incorporate most of the firm's aspirations). This is made possible by adding one more constraint to the existing body in current use by expanding the current financial constraint horizon beyond the standard targets of rate of return (RONA), demand (D) and unit cost (UC) to include the physical side of corporate activity in the form of Total Factor Productivity (TFP) measurement. This is essentially a measure which compares the movements of output and input on a global basis. By the use of an appropriate set of aggregator functions, all outputs generated by the firm's production process and inputs which comprise this production process, are aggregated into global index numbers. In the section describing the actual model we discuss the problems of using a traditional production function approach for the measure of productivity, as well as the justification of using TFP, in the form to be developed further on. And of course, quite apart from the control engendered through the introduction of TFP, must be considered the advantage of incorporating, for direct scrutiny, a variable which represents the only source of long-term wealth.

1) Assuming, of course, the appropriate homogeneity conditions.

2) Excellent definitions of TFP are available in Romuvist (15) Jorgenson & Griliches (9), Denny & May (11), Star (14), Werner (17) and Werner & Routledge (18).

3) Apart from the obvious economic advantages of scrutinizing TFP, the importance of such an arrangement for a regulated company, constantly required to demonstrate its productivity, cannot be overstated.

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As will become evident, the model does nothing more than make explicit the technological and scale parameters which are in any event already present in any constrained cost minimization or profit maximization problem. That is, given a profit maximization problem, for example, where,

\[ \text{Profits} = \text{Revenues} - \text{Costs} \]

the Revenue figure implicitly assumes a production technology and consequently, productivity. That is,

\[ \text{Revenues} = (\text{Output Prices}) \times (\text{A Production Technology}) \]

The system, it should be emphasized, is designed to generate a theoretical budget which becomes a guideline to be used by upper management as a check on the actual departmental budgetary process. It provides a statement of what to expect if certain constraints, or targets are to become effective. The actual budget may, in the final analysis, never resemble the theoretical one, but at least upper management will have been in an excellent position from which to demand justification.

Another, and probably more important justification for including a TFP constraint is its role as a focal point in finetuning towards desired financial results. After all is said and done the only ways to meet a given return target are to alter input volumes, input prices, output prices, marketing strategy or, more likely, a combination of these alternatives. Since input prices can, in many cases, be very rigid, the field of options is really more limited. Changes in input volumes really amount to changes in TFP and changes in output prices reflect directly on changes in revenues available for ROR (except in the case of price elasticity being the first) is introduced: the reference point to measure impact or even determine empirical feasibility, input volume (or cost), output price and marketing strategy adjustments become arbitrary. Tying these changes to movements in TFP, creates a feasibility spectrum which judges the impact of volume changes as well as determines the point at which dependence must be shifted to the price and marketing mechanisms. For example, if rate of return considerations require input cutbacks, but the input price elasticity being the first) is far beyond that experienced historically, legitimate consideration could then be given to other strategies.

A PROBLEM OF CONSTRAINTS

Traditionally, the most important test of an evolved plan or budget examines the level of profits or ROR (which two terms are here considered as interchangeable) to ensure that they are either maximized or, more often than not, at least above a certain minimum. The problem is of the constrained type with revenues and costs comprising the necessary countervailing force. Within this system are four different activities which are potentially subject to manipulation in order to control the ROR present in any constrained cost minimization problems.

1) The output pricing activity
2) The level of production activity, increasing (decreasing) the volume of inputs in order to increase (decrease) the volume of output and thus take advantage of existing scale economies.
3) Technological activity in a case where the existing technology has already taken full advantage of scale economies and new innovation is required for further gains.
4) The input pricing activity whereby the firm can negotiate favourable input prices.

These four activities should most appropriately be examined in light of the associated costs or constraints of any choice. Beginning with (1), the cost of increasing the unit price of output may be measured in terms of lost market share (or in the case of a regulated company, the risk as well as the cost of pleading before a regulatory body). This constraint will, therefore, provide one excellent initial guideline for pricing policy, keeping the unit price constant(2).

Whereas overhead costs remain fixed, the level of production activity is constrained by the shape of the variable cost curves as well as the output pricing possibilities. This now brings the total number of major constraints to three. Activity (2) being limited to cost and demand curve configurations while (1) is subject to market share (and regulatory) considerations.

Given the radical nature of activity (3), unless the corporation was following a rigid long-term policy which went beyond simple budgetary considerations, it would probably finally take precedence. The actual budget may, in the status of a last resort option, with (1), (2) and (4) taking precedence. Its constraints would involve a reshaping of all the cost curves (fixed as well as variable) with close attention being paid to the output price (or demand) curve possibilities.

The existence of the last activity, as an available option, will depend on such things as the size of the corporation, the degree of competitiveness (monopsony) and the availability of substitutes. It is, however, an option that should not be depended on other than as icing to the cake. In the final analysis it becomes, whether prices are set to maximize some determinants of the cost curve configurations, and as such is itself a constraint on the general budgetary planning problem.

The question that must now be addressed is whether the traditional system without TFP, has a sufficient number of constraints in order to arrive at a unique solution. Using the interdependence discussed above, a general scenario of the planning problem can be constructed. Beginning with the fairly incontestable proposition that the firm is in business to generate sales, the demand forecast becomes the first and most important datum. This should ideally provide, as well as require quantities, some elasticity estimates showing the variation in demand at different prices. This is also the step at which a second constraint (with elasticity being the first) is introduced: the pricing decision. Output price decreases for market penetration purposes; constant, unchanging prices or actual increases for a variety of reasons such as rationing, government policy, etc.7). Given the pricing decision (along with constraints on the input side) it imposes an upper limit on input factor expenses equal to the total value of revenues8). The final step in this process (somewhat simplified, but nevertheless completely realistic and applicable)

4) This should of course not be taken to imply that the policy would continue in the face of adverse financial performance.
5) It should be noted that a pricing decision also implies a unit cost decision.
6) This total value of inputs includes the appropriate return to capital and adheres to the accounting identify whereby all revenue is spent.
What is equally apparent is that the final solution will also be optimal only by coincidence. This is because there still remain two unknowns. Since there is no compelling reason to utilize inputs exactly up to the maximum allowable quantities, an additional constraint is required in order to determine the level of inputs. And secondly, some constraints must be introduced to provide guidelines for appropriate input proportions. The latter unknown can easily be handled through the combined mediums of statistical forecasting and taking cognizance of existing corporate long-term technological policy. In the case of levels, by utilizing the fact that with a given output, the productivity of the production process will rise and fall with the quantity of inputs, a targeted TFP change becomes the ideal constraint with which to guarantee a unique optimal solution. As will be seen in the following detailed outline, TFP will serve to not only set optimal (or desired) input levels but also to question the feasibility of the output pricing constraints.

THE MODEL

The planning system has been designed in such a way as to allow maximum participation by analysts at every major step in the process. Although it could just as easily have been fully automated, without subjective intervention at certain decision junctures much confidence would be lost in the quality of the results. Solutions are thus generated through an iterative process whereby certain initial values are chosen through a combination of statistical and subjective procedures. The process is repeated, with changing initial values, until it converges to a satisfactory solution, which meaning will become apparent below.

Our choice of methodology is based on the fact of severe data limitations. Ideally we would have chosen a production function as well as the appropriate side conditions such as profit maximization and then proceeded with some variation of classical regression analysis to estimate all the relevant parameters. However, given the constrained circumstances, it can be demonstrated that our choice of TFP as well as the form of aggregator function offers a very reasonable approximation to a full econometric analysis with traditional functional forms.

Beginning with the three input, one output production function,

\[ Q_t = f(K_t, L_t, M_t) \]

de the form of 'f' determines the maximum output \( Q_0 \) possible with any combination of Capital \( K_t \), labour \( L_t \) and materials \( M_t \). By restricting technical change to this factor augmenting variety we can relate it to measures of productivity. Now

\[ O_t = f(A_1(t)K_t, A_2(t)L_t, A_3(t)M_t) \]

where \( A_i(t) \) is a function of time alone that augments factor \( i \). By assuming that the function 'f' is linear homogeneous and that \( A_i(t) \geq A(t) \) for all \( i \) we can rewrite the factor augmented function as

\[ O_t = A(t) f(K_t,L_t,M_t) \]

where \( A(t) \) is a 'Hicks Neutral' measure of technical change. We have now shifted from measures of technical change to measures of productivity. By defining a measure of aggregate input as

\[ I_t = f(K_t,L_t,M_t) \]

Total Factor Productivity can be compared to the 'Hicks Neutral' measure of technical change

\[ TFP = \frac{O_t}{I_t} \]

Ideally we would now specify and estimate a production technology with a minimum of constraints and subsequently test a variety of different constraints in order to provide the best estimate of \( A(t) \). From the same data we would then calculate an index of TFP which should provide a similar estimate of technical change. Unfortunately, given data limitations, very limited econometric estimation is feasible. However, we can solve the problem by using Diewert's results \( 4 \) on "exact" and "superlative" index numbers, which basically ensure that any input aggregation (or indexing) formula is exact for some functional form. By choosing the Tornqvist discrete approximation to the continuous Divisia \( 6 \) index, which is exact for the "Homogeneous Transcendental Logarithmic" Production Function, as an aggregator function, we ensure the consistency of TFP with the functional form of a production function. Furthermore, Diewert \( 4 \) labels this TFP as superlative because its functional equivalent, the "Translog" is itself a second order approximation to any linear homogeneous production function. Thus our measure of TFP does not suffer the drawback of being tied to some of the most restrictive forms of production function such as the Cobb-Douglas, the CES and so on.\(^7\)

Development of the system begins with the basic accounting identify that the total value of output \( (TVO) \) in any period is always identically equal to the total value of input \( (TVI) \). This tells us that the compensation to factors of production always exhausts the total value of product. Thus, if we consider the three basic factors 'capital', 'labour' and 'materials' and denote the shares of total product going to each as \( S_{kt}, S_{lt} \) and \( S_{mt} \), respectively, then

\[ \sum S_i = S_{kt} + S_{lt} + S_{mt} = 1 \]

These shares are simply the proportion of total compensation that each receives and are defined as

\(^7\) Most of this explanation is taken from Denny et al \( 2 \).
\[ S_{kt} = \frac{P_{kt} K_t}{\sum P_{it} X_{it}} + \frac{P_{k,t-1} K_{t-1}}{\sum P_{i,t-1} X_{i,t-1}} \]  
\[ S_{lt} = \frac{P_{lt} L_t}{\sum P_{it} X_{it}} + \frac{P_{l,t-1} L_{t-1}}{\sum P_{i,t-1} X_{i,t-1}} \]  
\[ S_{mt} = \frac{P_{mt} M_t}{\sum P_{it} X_{it}} + \frac{P_{m,t-1} M_{t-1}}{\sum P_{i,t-1} X_{i,t-1}} \]

where

\[ P_{it} (i = k, l, m) = \] the price per unit of the \( i \)th input in year \( t \)

\[ K_t = \] the volume of fixed assets in place in year \( t \)

\[ L_t = \] the number of manhours worked in year \( t \)

\[ M_t = \] the volume of materials inputs in year \( t \)

It may be noted that the proportions are actually two-year averages. The principal explanation for this procedure lies in the choice of indexing methodology. The weights in the Tornovist discrete approximation to the continuous Divisia index are in fact two period averages. The periodic compensation values are the \( P_{it} \) where

\[ P_{kt} K_t = \] All items which may legitimately be considered as a return to capital, including depreciation, dividend payments, retained earnings, long-term debt servicing and all income and property taxes.

\[ P_{lt} L_t = \] The total value of labour compensation including wages, salaries, all fringe benefits while excluding all capitalized labour compensation.

\[ P_{mt} M_t = \] The value of all intermediate input expenses which includes everything not already accounted for by either capital labour or those amounts dedicated to the servicing of short term borrowing.

The basic TFP gain expression,

\[ TFP = \frac{O_t}{I_t} \]

where \( O_t \) and \( I_t \) are Divisia indices of output and input volume respectively and denote (as is always the case when a dot appears above the notation) one plus the percent change in those volumes, can be expanded to

\[ TFP_t = \frac{O_t}{S_{kt} S_{lt} S_{mt}} \]

Equation (4), and the fact that \( K_t = K_t/K_{t-1} \), \( L_t = L_t/L_{t-1} \), etc., can be used to solve for \( K_t \), \( L_t \) and \( M_t \), respectively.

\[ K_t = \frac{O_t}{S_{kt} S_{lt} S_{mt}} \]

where \( a_t = K_t/L_t \) and \( b_t = L_t/M_t \).

Equation (5) has eight unknowns without which the volume of capital cannot be calculated. These include the percent change in output (\( O_t \)), the TFP gain (TFP), the capital-labour ratio (\( a_t = K_t/L_t \)), the three variables representing the two-year average share of product going to compensate each of the input factors (\( S_{kt} \), \( S_{lt} \) and \( S_{mt} \)), and finally, the labour-materials ratio (\( b_t = L_t/M_t \)). This seems like quite a large number of unknowns, but through judicious use of constraints, each will assume a unique value.

The determination of \( O_t \) rightfully belongs to another system. It is estimated within the framework of a demand model and is assumed to depend entirely on factors outside of the production process of the firm. It is therefore exogenous to the system. All increases in deny are properly accounted for as improvements in quantities and configurations.

The periodic gain in TFP cannot be forecast but only targeted. Since TFP, as can be seen from equation (4) depends on the movements in all the input factors, its prediction would imply a knowledge of all the input factors. The system, however, has a diametrically opposing view of the situation. Here, input quantities depend, for their value, on an imposed TFP constraint, without which they must remain indeterminate. It must therefore be targeted. In practice there are several possibilities for an indication as to appropriate level. A guideline may be established from the TFP performance of another firm in very similar circumstances. Or, alternatively, it may be a long term average of the firm's own historical TFP performance that is used as a standard below which not to fall in any given period. This latter method has the advantage of avoiding the pitfall of comparing companies which may have natural advantages making one firm naturally more or less productive than its industry brother. TFP then (along with the level of demand) becomes part of the constraint boundary of the planning problem.

The capital-labour ratio (\( a_t = K_t/L_t \)) presents a bit more difficulty. There are basically two hurdles to overcome: one being the level of disaggregation while the other concerns forecasting methodology. Examining capital and labour at the total levels, although the least time consuming would most certainly have a questionable relevance. This would be mainly due to the interaction of two distinctly different types of labour. Technological advances impact in entirely different degrees on direct and indirect labour. For example, a particular innovation may halve operational labour input requirements while at the same time doubling the necessary administrative personnel. The obvious solution is to look at the two ratios

8) Although we have chosen one particular indexing scheme, the system could just as easily, without any qualitative changes, have been built around another index number formula.

9) For example one firm may have far less of one input, such as transportation, because of its proximity to markets.
Capital = \( K_t = r_{1t} \) \( \text{(6)} \)

Direct Labour = \( \frac{L_{1t}}{r_{1t}} \) \( \text{(7)} \)

Indirect Labour = \( \frac{L_{2t}}{r_{2t}} \) \( \text{(7)} \)

Direct Labour = \( \frac{L_{1t}}{r_{1t}} \)

and dividing (6) by (7) we get

Capital = \( \frac{R_1}{r_{1t}} = K_t = \frac{R_2}{r_{2t}} \) \( \text{(8)} \)

from which we can derive

\[ \frac{1}{r_{1t}} - \frac{1}{r_{2t}} = \frac{1}{a_t} = \frac{L_t}{K_t} \]

where \( L_t = L_{1t} + L_{2t} \) = total labour

It will certainly be easier to predict the movements of \( r_{1t} \) and \( r_{2t} \) (in order to arrive at \( t_{2t} \) and subsequently \( a_t \) which pairs the related variables of capital with the capital using direct labour and direct labour with its indirect counterpart. Although the latter combination does not have an exact link to production, it nevertheless provides the vehicle which allows the incorporation of total employed labour into the \( K/L_t \) ratio. The desirability of this variable is further enhanced by the flexibility it adds to forecasting. Since indirect labour (beyond a certain basic minimum) can sometimes be considered as a luxury (viz. extra marketing services, special studies, personnel services, etc.), we can easily link its growth to exogenous proxies of prosperity such as demand, rate of return, unemployment rate etc. The more technologically oriented variable \( r_t \) must be forecast both statistically, through an appropriate model, and subjectively, through consultations with engineers and planners. The basic statistical models, are of the form, \( r_{it} = f (r_{i, t-1}, O_t, O_{t-1}) \).

Statistical methods, subjective analysis or a combination of both may be used to determine the average share of product received by each of the input factors. The mechanics of determination require a prediction of the share within the planning period while the averaging stage is simply a matter of arithmetic. Only the first term within the parentheses of equations (1) to (3) must be known. That is the \( P_{it} \) 's with \( \sum P_{it} X_{it} \) 's are estimated.

Let

\[ \sum P_{it} X_{it} = Y_{kt} \] \( \text{(9a)} \)

\[ \sum P_{it} L_{it} = Y_{lt} \] \( \text{(9b)} \)

\[ \sum P_{it} M_{it} = Y_{mt} \] \( \text{(9c)} \)

Of the various methods, purely statistical estimation is the least satisfactory, while, given the important policy implications of fixing the shares going to each input factor, the potential benefits of a proportionally high subjective input are enormous. The final values of the variables play a role in the major aspects of the planning problem. Input configurations, price ratios as well as input substitution possibilities are all affected. As far as practical determination is concerned the relative compensation levels would depend on both long term trends as well as current business cycle configurations. It is well known, for example, that during a trough in business activity there is a tendency to hoard labour. Due to the expense of hiring and firing, business is willing to support idle staff during temporary slumps. Consequently, after paying labour, the reduced size of available product leaves less for the other input factors. The share going to labour, therefore, would be expected to increase on the way down during the business cycle while decreasing on the ascent. But this is only the mechanical side of the variable. More important is a long term corporate policy that can be related directly to these shares. For example, decisions to aim for a reduced dependence on labour in order to counter powerful union pressures would require fixing a declining labour share. Alternatively, government subsidy programs, lowering the relative price of labour might make a constant labour share, with growing employee coercion, more desirable. The list of possibilities is long, but the point is evident: targeted compensation shares should be closely linked to policy decisions. Once the \( Y_{it} \) have been estimated, then it is simply a question of plugging these values into equations (1) to (3) and calculating the average shares, \( S_{kt}, S_{lt} \) and \( S_{mt} \).

In order to calculate the final unknown, the labour-materials ratio \( (b_t = L_t/M_t) \) certain price information, hitherto mentioned only in connection with the shares, must be precisely detailed. Specifically we are concerned with the prices of labour \( (P_{lt}) \) and materials \( (P_{mt}) \). The latter, being identical to certain national rates of inflation, are determined entirely outside the system and, from the corporation's point of view, are immutable. Labour prices, on the other hand, may have a certain degree of flexibility. However, once a contract is signed this is no longer the case. Thus, in assigning a value to \( P_{lt} \), it may come from previously cemented, long term contractual obligations, or it might be possible to set a minimum level of increase tied to the expected rate of inflation. If the first method is unavoidable, then no further flexibility exists and the price of labour (as with \( P_{mt} \)) becomes fixed. The latter method, however, allows \( P_{lt} \) to evolve through successive iterations of the system towards an affordable level which maintains consistency with all the other constraints.

Irregardless of the final selection procedure, the values of \( P_{lt} \) and \( P_{mt} \) combine with equations (9a) to (9c) in order to calculate \( b_t = L_t/M_t \). Dividing equations (9a) by (9b) or (9b) by (9c) respectively, results in,

\[ P_{kt} = \frac{L_t}{P_{lt}} \] \( \text{(9d)} \)

and,

\[ \frac{P_{lt}}{P_{mt}} = \frac{M_t}{L_t} \] \( \text{(9e)} \)
From equation (9d) we can compute $P_{kt}$, which since $P_{it}$ is given, allows us to calculate a value for the price of capital ($P_{kt}$). And from equation (9e) $b_t = L_t/M_t$ becomes known.

Having derived values for all the unknowns in equation (5), the capital stock ($K_t$) can now be determined. Consequently, using $a_k = K_t/L_t$ and $b_t = L_t/M_t$, $L_t$ and $M_t$ also assume specific values. At this stage, given the prices and quantities, a total value of input is calculated and compared to the constraint value originally selected through a decision on pricing policies. We have

$$P_{kt}K_t' + P_{lt}L_t' + P_{mt}M_t' = TVI_t$$

If the estimated $TVI_t$ is not equal to $TVO_t$, then adjustments must be made to the components. Which of the six should be changed? Since the price of materials, $P_{mt}$, and in some instances the price of labour, $P_{lt}$, must remain at a fixed level, they cannot undergo adjustment. Furthermore, the fact that equations (9d) and (9e) used certain price ratios, including the previously fixed $P_{mt}$ and $P_{lt}$, would imply that the value of $P_{kt}$ also becomes fixed. Prices can therefore be eliminated from further consideration. It is, therefore, the volumes that must undergo adjustment subject, however, to the constraints of the previously fixed ratios, $a_k = K_t/L_t$ and $b_t = L_t/M_t$. This dictates that any percentage adjustment must be homogeneously applied to each of the individual volumes. That is, if

$$TVI_t = \propto TVI'_t \text{ where } TVI'_t = TVO_t$$

then,

$$K_t' = K_t/\lambda; \quad L_t' = L_t/\lambda; \quad M_t' = M_t/\lambda;$$

and,

$$P_{kt}K_t' + P_{lt}L_t' + P_{mt}M_t' = TVI'_t = TVO_t$$

At this point, all the data necessary to test the final constraint is available. We now turn to the financial side and examine whether the ROR, implicit in the system, is acceptable.

To do this the ROR must first be defined. There are many different forms available. For purposes of this paper we define a return to total average capital as:

$$ROR_t = \frac{NI_t + LI_t}{(LB_t + RET_t) + (LB_{t-1} + RET_{t-1})}$$

where,

- $T_t = $ Taxes payable
- $DT_t = $ Deferred taxes
- $D_t = $ Depreciation charges

then,

$$NI_t + LI_t = P_{kt}K_t' - T_t - DT_t - D_t$$

and combined with the fact that current period liabilities can be estimated through,

$$LB_t = NI_t + LB_{t-1} = P_{kt}K_t' - T_t - DT_t - D_t - LI_t + LB_{t-1} + RET_t$$

then,

$$ROR_t = \frac{P_{kt}K_t' - T_t - DT_t - D_t}{\frac{1}{4} [(LB_{t-1} + RET_{t-1}) + (P_{kt}K_t' - T_t - DT_t - D_t - LI_t + LB_{t-1} + RET_t)]}$$

However, in order to calculate the $ROR_t$ we must first estimate $K_t, T_t$ and $DT_t$.

This can be effected through

$$D_t = d_t (K_{t-1} - TD_t - R_t + (K_t' - K_{t-1}) TPPI_t)$$

where,

- $d_t = $ The depreciation rate in "t"
- $K_{t-1} = $ The original cost of fixed assets in service in "t"
- $TD_t = $ Accumulated depreciation charges in "t"
- $R_t = $ Fixed assets retired in "t"
- $(K_t' - K_{t-1}) = $ Gross additions to fixed assets in constant value in "t"
- $TPPI_t = $ A telecommunications plant price index used to reprice fixed assets from constant to current value.

Thus,

$$ROR_t = \frac{NI_t + LI_t}{(LB_t + RET_t) + (LB_{t-1} + RET_{t-1})}$$

where,

- $NI_t = $ Net Income after taxes in "t"
- $LI_t = $ Interest payments in "t"
- $LB_t = $ Long term liabilities in "t"
- $RET_t = $ Retired debt in "t"

However, in order to calculate the ROR we must first estimate $D_t, T_t$ and $DT_t$.

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- $TPPI_t = $ A telecommunications plant price index used to reprice fixed assets from constant to current value.

Thus,

$$ROR_t = \frac{NI_t + LI_t}{(LB_t + RET_t) + (LB_{t-1} + RET_{t-1})}$$

where,

- $I_t = $ Corporate income taxes assessed in "t"
- $i_t = $ Corporate income tax rate in "t"

Thus,

$$ROR_t = \frac{NI_t - DT_t + D_t}{(LB_t + RET_t) + (LB_{t-1} + RET_{t-1})}$$

where,

- $CCA_t = $ The capital cost allowance rate which is usually greater than "i" and allows for the calculation of a higher depreciation charge which is then applied to the calculation of deferred taxes.
- $AD_t = $ An adjusted depreciation charge used in the calculation of deferred taxes.

$$DT_t = AT_t - i_t (P_{kt}K_t' - LI_t - AD_t)$$
and finally,

\[ T_t = AT_t - DT_t \]  
(10c)

Equation (10) can now be used to calculate the ROR implicit in the system. If this rate is unacceptable then equations (10), (10a), (10b) and (10c) can be combined to calculate a required price of capital, \( P^*_t \), which depends on the required rate of return, \( ROR^*_t \) (whereby \( ROR^*_t \) is substituted for \( ROR_t \) in equation (10)).

\[ P^*_t = \left( i_t L_t - D_t \right) (1-2i_t) - \left( i_t AD_t \right) \left( 2 - ROR^*_t \right) - \frac{ROR^*_t}{K^*_t (ROR^*_t - 2) (1 - i_t)} \]

Although we now know the required price of capital, it must be viewed within the context of a highly interdependent system. Changing any one item requires that all others adjust to the change. Our point of departure is the input-output value constraint,

\[ P^*_t K^*_t + P^*_t L^*_t + P^*_t M^*_t = TVO_t \]

Substituting \( P^*_t \) for \( P^*_t \) will destroy the equality constraint,

\[ P^*_t K^*_t + P^*_t L^*_t + P^*_t M^*_t \neq TVO_t \]

In order to force equality, there are basically three alternative courses of action available: make compensating value changes in some or all of the other input prices and quantities; change the value of \( TVO \) through judicious adjustment of prices, in accordance with the demand curve characteristics; or, some combination of the first two. The first alternative, given the market and regulatory implications of changing output prices, is preferred.

We first examine prices. Wages, since these have already been chosen at a minimum, just to cover cost of living, can only be adjusted upwards. Thus, if \( P^*_t \) moved up then \( P^*_t \) is eliminated as a possibility. Similarly, given that \( P^*_t \) is exogenous, it too is eliminated from consideration. Given that productivity is already at a targeted high, input volumes, other than the administrative portion of output and materials should not be altered. If these limited adjustments do not suffice then by the process of elimination, output prices, and consequently \( TVO \), must be changed. Finally, the effect on \( TFP \) of all these adjustments must be examined. If it has been substantially altered then the entire process must be restarted with new assumptions.

The final result is a configuration and level of input volumes and prices consistent with a given demand, required ROR and targeted TFP. From this information it is a simple matter to calculate "income statements", "balance sheets", "sources and use of funds statements", etc. In fact all the required financial information.

CONCLUSION

Recognizing that productivity gains provide the only real source of new wealth, the system has given them explicit recognition. Furthermore, since effective planning must take account of all interdependency inherent within a complex organization, a total factor productivity measure was used. Assuming that the firm is aiming for a global optimum, the benefits of introducing another constraint of course lie in the fact that it causes a significant shrinkage in the choice of feasible input-output configurations. That is, it carries the system beyond the stage of its traditional role whereby a financially constrained upper limit is imposed on input resource usage. The process takes cognizance of the upper financial constraint and then searches for an exact configuration between it and the lower limit of zero.\(^{10}\)

It is the properties of \( TFP \), as well as the mechanics of its measurement, which allow it to provide this invaluable dimension to the planning process.

BIBLIOGRAPHY


\(^{10}\) While zero base budgeting has a similar goal, it does not have a unifying parameter, as \( TFP \) is within this system.


