TOTAL PERFORMANCE MEASUREMENT

CASE APPLICATION: PHILLIPS PETROLEUM COMPANY

BY:

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Scope and Method of Study: The study relates profitability of an organization with the productivity and pricing over or under recovery on resources. The theory was based on cost accounting price -volume - cost concepts and upon research done by the American Productivity Center and Phillips Petroleum Company. Data from accounting and manufacturing statements in plants owned by Phillips Petroleum Company was gathered and used to test the applicability of the proposed performance measurement methods.

Findings and Conclusions: The results of the study showed that profitability in a firm is directly related to productivity and pricing over or under recovery. All the data necessary to perform a total performance analysis was as shown to be readily accessible in the accounting information system. When the total performance analysis was performed using representative data from the accounting information system at Phillips Petroleum, the results were tied back to the income of the business unit analyzed. Establishing a relationship between the income of the business unit and the productivity and pricing over or under recovery allowed the manager of the unit to more fully understand his operation.

ADVISOR'S APPROVAL: ______________________________

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PREFACE

The research report on application of Total Performance Measurement to Phillips Petroleum Company grew out of the need to develop a performance measurement system which relates profitability to productivity. The end result of the study will be the implementation of these concepts in plants throughout the Company. This study has layed the foundation upon which a meaningful measurement system can be built. I am excited about the next steps which involve refining the concepts to apply to the specific situation at each plant and training plant personnel as well as company management in the use of the system. The many hours of learning and developing theory and gathering data for application to the system were well spent.

I wish to express my thanks to my advisor, Maryanne M. Mowen. Her support in the early stages of concept development and report organization was very beneficial. Also, I wish to thank Larry Hammer for working with Maryanne and me on the report. My thanks also to my employer, Phillips Petroleum Company, and especially those for which I have had the pleasure to work, Bill, Art, and T.J. They have given much support by allowing me time on the job to pursue my degree, and also have given me a valuable learning experience to complement that which I got while in the MBA program.

My special thanks to my wife Jane, for her support, understanding and report typing over the last four years. I greatly appreciate the sacrifices she has made for me in order that I could accomplish my goal.

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SYMBOLS

Ci	=	Cost per unit of input in period i
Li	=	Units of input in period i
Pi	=	Price per unit of output in period i
Voi	=	Value of output in period i
V_{Ii}	=	Value of input in period i
X_i	=	Units of output in period i
M	=	Total margin change
MI	=	Margin variance due to input effects
MIPR	=	Margin variance due to pricing over or (under) recovery
MIPROD	=	Margin variance due to change in productivity of the inputs
MO	=	Margin variance due to output effects
MOPR	=	Margin variance due to output quantity and price change.
MOQ	=	Margin variance due to output quantity change assuming base period conversion efficiency
MPR	=	Margin variance due to total effect of pricing
MQ	=	Margin variance due to total quantity effect

CHAPTER I

INTRODUCTION

Managers and planners in an organization need to understand why their business is growing and where the key sources of profit and growth are located. To be able to accomplish this they show know (22):

- o How much was due to improved productivity
- o Which products utilized resources well
- o What needs to be done to reallocate key manpower, materials, and capital.

As inflation continues rampant and the economy fluctuates with periods of extremely high product demand to periods of low product demand, it is critical that a performance measurement system be utilized which separates operations into components which are meaningful in analyzing the efficiency of the organization in utilizing resources and recovering costs due to changes in market conditions.

The Total Performance Measurement System described in this study is a system for measuring profit contribution due to each resource used in production. The results can be used to identify areas where productivity improvement is needed and helps in more fully understanding the profit impact on one production strategy over another. It also helps with better resource allocations and pricing decisions.

Profit growth which results from increased productivity will give the firm a long term competitive advantage by lowering per unit costs. On the other hand, profit growth can result from product price increases which exceed the rate of increase of resource costs. Temporary profitability gains can be achieved at the expense of long-run competitive advantage. Pricing over recovery gains can hide deteriorating productivity and will increase the likelihood of competitive entry and undercutting.

The data necessary to perform total performance measurement is available in the accounting and operations management information systems of most business units. The information requires only a small amount of additional effort when generating the other performance measures for the organization.

Profit growth from productivity is a major concern since the general outlook for the future suggests that productivity is the one most important issue for our society. Concern is being shown nationally about the declining productivity growth rates. Productivity growth rates are of concern because their movement is integrally related to the nation's general economic health in relation to inflation control, economic growth, foreign competition and balance of payments(8). Corporations are also concerned with productivity because it is felt to be a representative indicator of the overall efficiency of their firms.

In spite of these interests, productivity remains one of the most elusive concepts in business and economic literature. It remains elusive because of the lack of definitive theoretical work, particularly at the firm level. There has been very little work done to develop measurement and calculation procedures that match information available from management information systems data bases already in use in a firm(10). Many firm level productivity calculations used today are either extrapolations of the Bureau of Labor Statistics productivity indexes or very rough "rules of thumb" which have been developed by firms. The Bureau of Labor Statistics indexes are based on productive output compared to the labor hours required to produce that output. Measures developed internally usually measure such things as conversion efficiencies of raw material to finished material or maintenance manhours as compared to total machine hours operated. Both the Bureau of Labor Statistics indexes and internally developed indexes only measure small portions of the input which makes up the production output. A system must be developed for firm level which comprehensively measures all the factors which contribute to production output.

Productivity measurement at firm level is important for the three following reasons(7). First, measurement of any form is a base for continuous analysis and goal setting. Little productivity improvement efforts that are substantial and organized can be done unless there is some benchmark against which management can look at past performance and then set future goals. Secondly, productivity measurement can save a great deal of operational analysis by showing where in a productive unit there might be trouble. Isolation of the physical location of the unit can be done easily and also the input factors causing the trouble is shown. If productivity improvement work is based on cursory examination a risk on sub-optimization is encountered. Finally, people usually work more efficiently when they know that they are being measured, if the measurement is perceived to be reasonable and meaningful(20).

In the mid 1970's American Industry began a concerted effort to define meaningful firm level productivity measures. Phillips Petroleum Company has taken an active part in these efforts. The initial phases of the productivity program at Phillips has consisted of making management aware of productivity concepts and stressing the importance of a productivity program as an aid in making short range operating decisions and in developing long range strategic plans. The managers in key functional areas in the organization have been primarily involved with the initial phases of the productivity program. Extremely general comprehensive measures have been developed for initial management presentations, but little refinement to plant level measures has been done to develop a total system.

In order to generate meaningful, comprehensive productivity measures all the inputs into the manufacturing process must be considered. These inputs fall within one of four general catagories: (1) capital, (2) labor, (3) materials, and (4) energy(4). When one of these inputs is compared to the total output, the result is called a "partial" productivity measure. Some examples of partial productivity measures are shown in Figure 1.

$$\frac{\text{Output}}{\text{Labor Hour}} \qquad \frac{\text{Output}}{\text{Barrels of Oil}}$$

$$\frac{\text{Output}}{\text{Btu}} \qquad \frac{\text{Output}}{\text{Capital Employed}}$$

Figure 1. Partial Productivity Measures

In a system which consists of several partial productivity measures, there are trade offs between the factors. For example, if the installation of energy saving capital equipment results in a reduction in fuel consumption without a change in quantity output, energy productivity increases and capital productivity decreases. The energy productivity would increase because the output is the same with less energy input. Capital productivity would decrease because the output is the same with more capital required to produce it. If the investment is good for the company, the total productivity would improve.

From partial measures of output compared to labor, materials, energy, and capital, a total productivity factor can be developed. The total productivity equation is shown in Figure 2.

$$\frac{\text{Output}}{\text{Labor + Materials + Energy + Capital}} = \text{Total Productivity Ratio}$$

Figure 2. Total Productivity Measure

The partial productivity ratios are combined using a weighting for relative importance of each factor in the total output. Total productivity has been discussed in the national statistics literature, but because of its complexity, has received relatively little application at the company or plant level.

An important factor to management is the ability to relate changes in profitability with changes in productivity. It must be realized that profitability is not synonymous with productivity. Profitability and productivity are separated by such things as sales prices, input prices, and accounting conventions. A production process can remain unchanged physically, but profitability would decline if sales prices weaken while all the input costs stay the same.

In most circumstances, an improvement in productivity will lead directly to an improvement in profitability. However, the reverse is not true. If there is an improvement in profitability nothing can be concluded about productivity until a further examination of the data is made. Several industries in the United States in the last few years have significantly increased profitability while experiencing a decline in total productivity.

Another way of looking at the distinction between profitability and productivity is represented in the diagram in Figure 3(20). In the core, there is a physical process of units with inputs, conversion and a finished product output. The core represents the productive process and the measurement of this process is productivity. The outer circle represents the prices of inputs and outputs, taxes, accounting conventions and all other items which influence profitability.

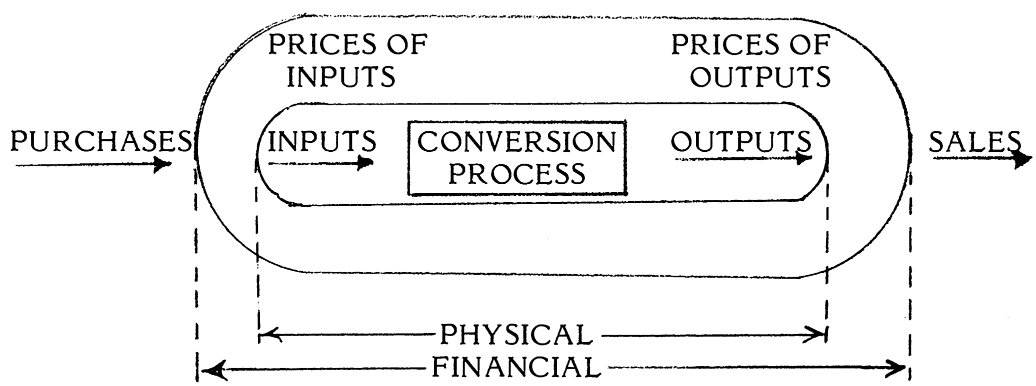

Figure 3. Profitability/Productivity Relationship

The objective of this study is to develop a system to measure productivity at plant level which allows relationships to be established between profitability, productivity, and price/cost related items. This system must utilize existing data in the management information system.

CHAPTER II

LITERATURE REVIEW

A literature review was performed in order to gain a basic understanding of work performed by others. Sources were obtained from references inside Phillips, from library facilities at Oklahoma State and Tulsa Universities, and from the American Productivity Center. Since total performance measurement is a relatively undeveloped area, sources were somewhat limited, but some very good references were found and the most significant findings are discussed in this Chapter.

Total performance measurement is a relatively undeveloped area, thus literature sources are somewhat limited. The Bureau of Labor Statistics is the basic source of most thoughts on measurement. The Bureau of Labor Statistics Handbook describes the method of productivity measurement employed by the government in construction of the national productivity index(19). This index is a good base from which a performance measurement system can be developed. The theory for utilizing inputs and outputs which can be used to construct indexes is basic and easy to understand. The value of the BLS measure for firm level or micro-measurement is limited because it only measures labor inputs in production of output, other factors such as energy, materials, and capital are not considered. Also, the factor has limited applicability to Phillips objectives because a direct relationship between profitability, productivity, and price/cost effects cannot be established.

Greenburg (9) expands upon the Bureau of Labor Statistics concept of utilizing inputs and outputs to construct an index. Greenburg compares the advantages and disadvantages of using value added productivity systems as compared to constant dollar productivity systems. His conclusion is that, if properly used, either system is an effective method of measuring productivity. The main point in this article was the use of constant dollar production value as the output factor and constant dollar inputs for labor, materials, energy, and materials. The Davis (5) study on productivity measures is very detailed and directed toward the extraction of productivity measurement data from an accounting system. His discussion is oriented toward a constant-dollar measurement system. His discussion on labor, energy, capital, and feedstock retrieval form the accounting system is valid and sufficiently detailed to be useful. A particularly good discussion is given on revaluation of capital employed, which consists of cash, accounts receivable, inventories and fixed assets. He discusses several methods to adjust to comparable capital values for measured periods and base period. Davis does not address the relationship of profitability with productivity and price/cost relationships.

Hamlin's article (10) briefly summarizes performance mesurement theory. He makes no attempt to explain how the data necessary to calculate the measures can be obtained from an accounting system and does not define what items make up the different input categories of labor, material, energy, and capital. The most important contribution made by his article is to relate profitability to productivity with an item called pricing recovery. Pricing recovery deals with the cost/price relationships of the outputs and inputs in the accounting data. Hamlin states that change in profitability is equal to the variance related to productivity plus the variance related to pricing recovery.

The American Productivity Center Measurement Manual(20) defines the output and input measurement equations. It also defines what should be included in output and input measurement and the general philosophy behind the measures. The manual does not describe in detail how to obtain the information for the equations from an accounting system nor does it describe the relationship of profitability and productivity. The equations for calculating productivity dollars variances and ratios became the basis for developing the relationship of changes productivity to the changes on the income statements of a business unit. The American Productivity Manual was the most important literature source to help in developing the performance measurement theory in this study.

The resource material which related directly to the objectives manual was limited. Several of the articles discussed were very beneficial in developing the basic relationships which were needed to develop the accounting information desired. The most useful information was in Hamlin's article and the American Productivity Center Manual.

CHAPTER III

RESEARCH DESIGN

The research was empirical in nature and centered around the development of a productivity measurement system which ties to the gross profit line on profit and loss income statements for Phillips Chemical Company. Phillips Chemical Company is engaged in Chemicals processing plastics manufacturing, plastics extrusion, carbon black manufacturing, and making fibers products. The organization has almost ten thousand employees and over one billion dollars in assets. Plants in the Chemical Company were used as a data source to test the theory which was being developed. This emperical testing was very important because it provided encounters with actual problems in a business environment. The example in Chapter 6 is a disguised application of concepts on a typical set of Phillips Chemical Company accounting statements.

The main dependent variables used to generate indexes in the research design consisted of a profitability index variable, productivity index variable, and pricing recovery index variable. The independent variables used in generating the dependent variables were output quantities in base and measured period, input quantities in base and measured period, output prices in base and current period, input costs in current and base periods. Other dependent bariables were profitability variance variables, productivity variance variables, and pricing recovery variance variables. The same independent variables were ussed to generate dependent variance variables that were used in calculating the dependent index variables.

The theory to utilize these variables in the system was developed from information obtained from literature and also from contact with individuals in companies experienced in working with productivity measures. The expertise to utilize and adjust accounting data to a form applicable to the new measurement system was obtained from accounting texts and review with accounting personnel.

The basic theory involved the use of Laspeyres equations for the productivity indexes and Paasche equations for the pricing indexes.

The research design involved an empirical study of systems which have been successful in other petroleum companies and other industries. Also, a close review of literature supplied useful information. After the preliminary research was completed, the information was correlated and the initial systems work completed. Data from actual operating statements for plants was used as inputs into the model to test results.

Statistical tests are not applicable to this study. The results were in a form which tied to the operating statements. The statistical validity of the data generated had to be insured when the equations in the model were selected. The equations used in development of the system were closely reviewed and tested against proven cost accounting price-volume-cost methodology to establish concurrent validity.

CHAPTER IV

TOTAL PERFORMANCE MEASUREMENT CONCEPTS

For general definition and theory underlying the relationship of profitability and productivity, a basic understanding of price and efficiency relationships of cost accounting is required. Price and efficiency relationships are used to help a manager better understand his business by separating the areas under his financial responsibility into those items which are subject to his direct influence and those which are not directly under his influence. In cost accounting, the general approach is to identify factors relating to price, cost and efficiency. The efficiency factors are more directly controllable by the manager than the price and cost factors, because price and cost factors are principally determined by exogenous factors of supply and demand for both resources and products.

The best way to illustrate the use of price efficiency analysis is with an example in which there is one output and one resource.

	Base Period			Measured Period		
	Vo_1	X_1	P_1	Vo_2	X_2	P_2
	Value $	Quantity Units	Price $/Units	Value $	Quantity Units	Price $/Units
Output						
Production	100	10	10	150	12.5	12
	Vo_1	X_1	P_1	Vo_2	X_2	P_2
	Value $	Quantity Units	Price $/Units	Value $	Quantity Units	Price $/Units
Input						
Labor	8	4	2	18	6	3
Margin	92			132		

The contribution can be analyzed as follows assuming sales equals production.

The margin variance is attributable to volume and price changes of the inputs and outputs as shown below:

(1)	Output Price Variance $MOPR = (P_2 - P_1)X_2 = (12 - 10)12.5$	\$ 25
(2)	Output Quantity Variance $MOQ = (X_2 - X_1)P_1 = (12.5 - 10)10$	25
(3)	Input Price Variance $MIPR = (C_1 - C_2)L_2 = (2 - 3)6$	(6)
(4)	Input Quantity Variance $MIQ = (L_1 - L_2)C_1 = (4 - 6)2$	(4)
	Total Margin Variance	\$ 40

These format of the variances can be restated in the following manner with the volume and pricing effects of outputs and inputs netted against each other as shown below:

	Variances		
	Value	Volume	Pricing
Outputs	\$ 50	\$ 25	\$ 25
Inputs	(10)	(6)	(4)
Margin	40	19	21

The example shows the margin increase of \$40 was due to a net output and input volume change of \$19 and due to a net out and input price change of \$21.

Further analysis can be done to determine the effect on profitability that the input has had in the measured period as compared to the base period(16). By performing this analysis the performance of each element of the resources, in relationship to profitability, can be expressed in dollars, and can indicate if action needs to be taken for improvement of performance of the resource or if an analysis of the resource needs to be performed to determine why the resource was better than base and implement this cause of better performance in similar resources.

To perform the input variance analysis, an analysis must be made for the profitability variance attributable to a resource. The profitability variance is the ratio of the value of the output in the measured period as compared to the base period less the ratio of the value of the input in the measured period as compared to the base period.

The quantity variance and the pricing variance discussed in the preceding pages can be broken into components. The quantity variance can be broken into a productivity variance and an incremental quantity variance. The productivity variance is the change in profits due to different conversion efficiencies from base to measured period. The incremental effect on profits due to quantity is the effects on profits due to a change in throughput while base period conversion efficiencies are held constant.

On the price side, the change in profits due to pricing can also be divided into two components. The components are pricing over or under recovery on the input costs and an incremental pricing recovery due to changes in throughput and output pricing volumes, while base period conversion efficiencies and price/cost ratios are held constant. The concept is illustrated in Figure 4.

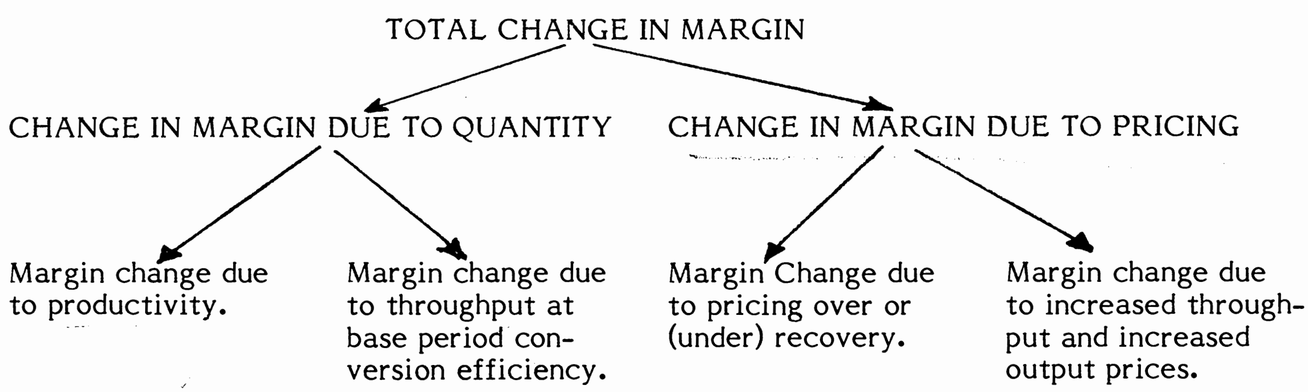

Figure 4. Components of Change in Margin

From the previous concept, the effects on profits can be summarized as shown in the effects on profits summary in Figure 5.

EFFECTS ON PROFITS

MI		MIPROD		MIP
(Profitability Change due to inputs effect.)	=	(Margin Variance due to Productivity.)	+	(Margin Variance due to Pricing Recovery.)
+		+		+
MO		MOQ		MOPR
(Profitability Change due to throughput effects.)	=	(Margin variance due to output quantity change at base period conversion efficiency.)	+	(Margin change due to output quantity change along with output price change.)
M		MQ		MPR
(Total Change in margin.)	=	(Change in margin due to quantity.)	+	(Change in margin due to pricing.)

Figure 5. Change in Margin Relationships

Using the previous example to illustrate this concept, we obtain the following results:

$$
\begin{aligned}
MI &= 8\left(\frac{150}{100} - \frac{18}{8}\right) \\
&= 8\,(1.5 - 2.25) \\
&= 8\,(-.75) \\
&= (6)
\end{aligned}
$$

The profitability of labor was \$6 lower in the measured period than in base period. In a multiple resource case, a similar analysis can be made for each of the resources.

After an analysis of profitability contribution is made for each resource, an examination can be made of the portion of the change profitability due to productivity and the portion due to pricing.

The variance in profitability due to productivity change can be calculated by taking the ratio of the quantity of the output produced in the measured period as compared to the quantity of output produced in the base period minus the input quantity in current period and this difference multiplied by the input value of the resource in the base period. The equation is stated as follows:

$$\text{MIPROD} = V_1^{I}(QI^{u} - QI^{I})$$

Using date from the example, the following results are obtained:

$$\begin{aligned} \text{MIPROD} &= 8\left(\frac{12.5}{16} - \frac{6}{4}\right) \\ &= 8(1.25 - 1.5) \\ &= (2) \end{aligned}$$

If labor productivity had been at the same level as base period then \$2 more in profits would have been generated.

The change in profitability due to inputs is equal to the variance due to productivity plus the variance due to pricing over or under as illustrated in the equation below:

$$\text{MI} = \text{MIPROD} + \text{MIPR}$$

Thus, the variance due to pricing is equal to the variance due to productivity minus the variance due to profitability:

$$\text{MIPR} = \text{MI} - \text{MIPROD}$$

From the example, the variance due to pricing would be as illustrated below:

$$\begin{aligned} \text{MIPR} &= (6) - (2) \\ &= (4) \end{aligned}$$

This analysis shows that of the \$6 negative profitability, \$4 was due to not recovering cost increases with sufficient price increases.

A similar analysis can be done for each resource in a multiple resource case, and an idea of the total effect of resources on profitability broken between productivity and pricing variances can be analyzed.

Change in Profit Due to Increased Throughput (Volume)

The incremental increase in profits due to increased volume of production while efficiencies and prices are held constant is calculated by the following equation:

$$MOQ = (X_2 - X_1)\left[-C_1\left(L_1/X_1\right) - P_1\right]$$

For the example, increased profitability due to increased throughput is:

$$MOQ = (12.5 - 10.0)\left[-2\,(2/10) - 10\right]$$
$$MOQ = 23$$

Change in Profits Due to Increase Price of Output

The change in profits due to increased prices of the output at current period volumes while efficiency and price/cost ratios are held the same as in base period can be calculated from the following equation:

$$MOPR = \left[(L_1/X_1)\ (X_2)\ (C_1) - (X_2)\ (P_1)\right]\left[(P_2/P_1) - 1\right]$$

For the example, the increase profitability due to pricing recovery is:

$$MOPR = \left[(4/10)\,(12.5)\ (2) - (12.5)\ (10)\right]\left[(12/10 - 1)\right]$$

$$= (10 - 125)\ (12/10 - 1)$$

$$= (115)\ (.2)$$

$$= 23$$

Effect on Profits

To total change margin is the sum of the input and output effect and can be expressed in the following equation:

$$M = MI + MO \quad \text{or} \quad M = MQ + MPR$$

For the example total change in margin is as shown below:

$$M = (6) + 46 \quad \text{or} \quad M = 21 + 19$$
$$= 40 \qquad\qquad = 40$$

The effects on profits for the example problem can be summarized as shown below:

MI	=	MIPROD	+	MIPR		(6)	=	(2)	+	(4)
MO	=	MOQ	+	MOPR		46	=	23	+	23
M	=	MQ	+	MPR		40	=	21	+	19

Total Output Effect On Margin

The change in profits is the sum of the profit change due to increased throughput and pricing recovery and can be expressed by the following equation:

$$MO = T + PO$$

For the example, the change in margin due to throughput and pricing recovery is:

$$MO = 23 + 23$$
$$= 46$$

Summary of Total Performance Measure Example

The total performance measure shows the margin change due to input effects and output effects. These effects are then divided into quantity and pricing components. Awareness of the effects of components which make of the margin change allows a better understanding of the environment of the business. Using the example as an illustration. The profitability due to input effects was ($6) with productivity contributing ($2) and pricing was under recovered by ($4). The reason for lower productivity should be investigated and corrections made if possible. Also, input prices increased at a faster rate than output prices which means that the market place should be analyzed to see why this occured. If input productivity and pricing recovery had stayed at the same level as base period, then the margin would have changed by $46 rather than $40.

The total performance measure can be a powerful tool in the management of a business for both the short and long term. It can be used to analyze past performance to point out areas of concern and can be used for analyze the impact of changes which effect the quantities and prices of outputs and inputs.

Problems Encountered

Commonly encountered problems in performance measurement are: (1) introduction of new products (or resources), (2) deletion of old products, (3) product quality changes, (4) inventory adjustments, and (5) internally consumed products. Other measurement problems which are unique to output measurement are reviewed after the discussion on common concepts.

Introduction of New Products When a base-period price weighting system is employed, the introduction of a new product causes a special problem. Since the product was not sold in the first period, a representative price for that period may be difficult to obtain. If the product is a standard item that was marketed by other firms in the base-period, an average price for that period may be obtained from an industry publication. If the product is new to the market or if a base period price can not be found directly, the current price can be deflated to the base period by another index to provide an estimate of the base period price. A deflator might be obtained from either a wholesale price index or it can be calculated internally from the company's price experience with other similar products during the same period.

Deletion of Old Products Conceptually, the deletion of an old product is just the opposite of the problem associated with new products. When base-period price weighting is used, however, no calculation problem occurs since the price weight and both quantities (zero in the second period) would be available. When current-period price weighting is used, then the same approach as described for the new product can be used to determine a current-period price for the delected product.

Quality Changes In performance measurement, it is desirable to treat a change in quality of a product as a change in output. Improvement in quality is equated with an improvement in the usefulness, capability, or life of a product. This characteristic of the product can logically be considered a benefit or incremental output of the process. Since quality is normally reflected in price, a change in price cannot always be assumed to be merely an inflationary effect. The portion of the price change which accounts for quality differences should be incorporated in the output quantity index.

The method for handling quality changes is to treat the original product as a deleted product and the improved product as a new product as described above. When base-period pricing is used, it will be necessary to determine base-period price of the improved product. The major difficulty in this procedure is to determine the magnitude of the quality change.

Inventory Adjustments Performance measurement is concerned with products produced and resources consumed during a given period of time. Sales of products and purchases of resources do not satisfy these requirements. The difference between sales and output (or purchases and input) is the inventory change in finished and in-process products (or resources) between the periods being measured. An increase in product inventory represents added production and a decrease in inventory indicates some of the sales were not taken from production. The same analogy can be applied to resource inventories.

When collecting data for output measurement, production information or sales value of production should be sought. If only sales data are available, this information should be adjusted back to production by the change in product inventories. As the period included in the productivity measurement increases, the magnitude of the inventory change compared to the sales volume over the period tends to diminish. So the correction may not be as critical for periods as long as a year. The reader is reminded, though, that productivity improvements are normally less than 5% per year. So inventory adjustments don't have to be very large to be significant in relation to productivity measurement.

Inventory changes for in-process products are treated essentially the same as any other product inventory change. That is, a decrease in inventory should be an offset to sales in determining output and an increase should be considered as additional output. There is one precaution that should be observed, though, when determing the value or weight to apply to this type of inventory. In-process goods are normally valued at cost. If price weighting is used for finished products then the appropriate weight for an in-process product would be the cost times the average markup rate for that product. If cost weighting is used for other output items, then the cost of the unfinished units would be the appropriate weight for those units.

Internally Consumed Products In some facilities products are produced which are consumed internally rather than marketed. One example of this process is in a petroleum refinery where fuel oil is produced and then burned internally as an energy source for heat and power. This type of transaction is normally not treated as an input or an output in the accounting records. But for performance measurement such products should be included in both the output and the approprite input measures. This treatment prevents the corresponding partial productivity measure from fluctuating due to changes in the proportion of that input which is produced and that which is purchased.

Job Shop Measurement This type of operation presents the most difficult problems for output measurement. Products change from period to period so that very few, if any, of the products produced in one period are identical to those produced in the following period. The performance analysis involves a complex combination of new products, quality changes, and old products being dropped. About the only realistic way to measure output is to deflate the gross value of output by price indexes of similar standard products.

Measuring Output in a Cost Center Some plants operate as cost centers and their output is transferred to another division of the same company rather than sold directly to a consumer. In some cases, the output may have an identifiable market value (price) whereas in other situations there may be no established price. If unit costs of each product or transfer prices are available, naturally that data would provide the best type of weighting. So a market price is not an absolute necessity. Where unit prices are used elsewhere for output weighting, though, an average markup rate could be applied to the unit cost of the transferred product to maintain a consistent weighting system.

Conclusion

Through the use of price-volume-cost principles of cost accounting, the basic concepts of total performance measurement has been developed. The cost accounting principles were broken down into basic components which identified the effects of productivity and pricing over or (under) recovery on the gross margin of an income statement. Several problems such as product additions, quality changes and product deletions have been identified when gathering information from an accounting system and ways to handle these problems discussed. Methods of gathering information will be discussed in the next chapter.

CHAPTER VI
ACCOUNTING INFORMATION

Introduction

The accounting information desired to perform total performance measurement is classified as either output information or input information. Output information refers to data concerned with finished product made during an accounting period. Input information refers to data concerned with the resources of labor, energy, materials, and capital used in the production of the output. The information contained in these accounts and methods of gathering this information is discussed in this chapter.

Output Information

Output is defined as the sales value of proudcts produced during the periods which are being analyzed. The production value should be generated from the quantity of products produced times the average selling price of those products.

The use of quantities and prices is the most accurate and therefore the recommended method to calculate production value, but many times this information is not available. When this information is not available adjustments can be made to the net sales figure shown on an income statement which very closely approximates the sales value of production. This can be done a manner similar to the to that in Figure 7.

The sales value of output in the measured period generated from net sales can then be restated in constant value terms in order to calculate performance and pricing ratios. Restatement can be done two different ways.

1. If net production volumes are known, then the price per unit of product sold can be calculated and this unit price can then be multiplied by reference period production volume to get the production restated for the reference period.

2. If production volumes are not known, then a deflator can be used to restate the measured period production value in reference period values.

	REFERENCE				MEASURED			
Net Sales			XXXXX				XXXX	
Less: Sales of Products Purchased for resale *		XXXX				XXXXX		
Sales of Products Produced				XXXXXX				XXXXX
Plus: Inventory Adjustments								
Beginning								
Total Inventory	XXXX				XXX			
Less: Goods in inventory purchased for resale	XXXX				XXX			
Net Beginning Inventory		XXX				XXX		
Ending								
Total Inventory	XXXX				XXXX			
Less: Goods in inventory purchased for resale	XXXX				XXXX			
Net Ending Inventory		XXX				XXX		
Net Increase or (Decrease)		XXX				XXX		
Finished Goods Inventory Change		XXX				XXX		
Transfers of Product Out of Plant at Cost		XXX				XXX		
Sub-Total								
Times: Average Markup on Inv. Sold			XXX				XXX	
Total Value of Markup			XXX				XXX	
Transfers of Product Out of Plant at Cost				XXX				XXX
Inventory Change of Products Produced				XXX				XXX
Sales Value of Output				XXX				XXX

* For Internal Accounting Information

Figure 7. Composition of Sales Value of Output

Input Information

Inputs are resources which contribute to the generation of output. Inputs fall within one of the four following broad categories.

- o Materials
- o Labor
- o Energy
- o Capital

Each of these inputs constitute a partial index for the performance of the firm.

Materials

In most high technology industries such as the petroleum industry or industrial and consumer products industries, materials are the major input. At Phillips Petroleum, measures show that materials constitute over 60% of the total inputs. A partial list of items which make up the materials category is:

- o Raw Materials
- o Maintenance Materials
- o Catalysts
- o Lubricants
- o Miscellaneous Operating Supplies
- o Purchased Services

- o Communication
- o Travel
- o Computing Services
- o Moving Expenses

The materials inputs for both reference and measured period should include only those resources which were actually consumed during those periods. It is not correct to include as input the value for materials which were actually used in a prior period or inventoried for a future period.

Raw Materials consumption is usually the most significant portion of materials input and should be monitored very closely. The data for a raw materials performance measure should be generated from the financial and operations accounting system. The data for the base and refrence period should recorded in a manner similar to that for output. The quantities of raw material consumed and the average price paid should be gathered in order to generate raw material values in the base and reference period.

If the data for raw materials utilization is not available in the form of quantities and prices then the net value of materials utilization can be approximated very closely from the accounting data available. An example of a procedure to calculate this value from cost of sales on an income statement is shown below.

Raw material used	XXXX	
Adjustment to Raw Material	XXXX	
Raw Materials Cost		XXXXX

The above procedure is necessary if net sales value was generated from the procedure outlined on page 22.

After the raw materials cost is generated, a deflator must be applied to revalue the current period raw materials cost to a base period cost.

Other Materials and Purchased Service Inputs Portion of Materials

Other materials and purchased service inputs consist of items such as:

Other Materials

- o Catalyst
- o Chemicals
- o General Supplies
- o Packaging Supplies
- o Repair Materials
- o Water

Purchased Services

- o Travel
- o Computer Services
- o Rent
- o General Supplies
- o Communications

If possible, service costs should be broken between labor and materials costs. This is important because not all services should be accumulated in the materials input section. For example, a sub contracted job which is 100% labor should not be included in other materials, instead it should be included in the labor input catagory.

The major problem with the other materials and service catagory is that quantity and price information is not readily available and/or is made up of too many input pieces for feasibility in recording quantities and prices. Thus, the normal quantity and price calculation for value determination of each separate kind of input is not feasible. This input catagory should be recorded as a single value or as the sum of as many catagories as felt reasonable to apply a deflator and then add the other materials and services together in order to arrive at an input measure for the catagory.

Energy

Stated very broadly, energy is the power and heat which is consumed in the production of output. Energy includes:

- o Fuel Oil
- o Natural Gas
- o Electricity
- o Steam
- o Off Gas

Since productivity measures for Total Performance Measurement is defined as both physical and economic relationship of output and input, weighing on both energy content and energy prices per unit must be considered. All plants which report data for the energy reporting system furnish data which is converted to barrels of oil equivalent (BOE's) which gives a common basis for reporting quantity utilization.

Even though the quantities reported are on a common basis, the price of each type of energy must be considered separately because of different utility values of each. For example, 1 BOE of crude oil is worth approximately $35 while 1 BOE of natural gas is worth $15. The value of the crude is higher because it is a scarcer resource and this value should be reflected in its weighting in an energy productivity measure. By calculating the value for each type of energy used from quantities of BOE's consumed multiplied by the unit price, it is much easier to account for of mix changes.

In some cases, energy is an output as well as an input. The steam plant serving Borger Philblack is a producer of energy as well as a consumer and should be treated as a separate entity from the Philblack Plant. Off-gas from the carbon black plant is the energy consumed or input and the steam produced is the product of the plant and productivity ratios should be generated which are based on this premise. The off-gas produced by the carbon black plant is a product of the process and should be included in the output value of the carbon black plant.

Labor

The labor input is the total value of labor directly or indirectly consumed in production of the output. It is very important to generate this value from the quantity of labor hours times the average cost per hour. Labor input should include the following:

- Direct Operating Labor
- Indirect Operating and Supervisory Labor
- Maintenance Labor
- Contract Services Labor
- Benefits
  - Social Security
  - Payroll Taxes
  - Health Insurance
  - Retirement
  - Thrift

The recommended approach is to sum individual pay grade values generated from quantity times the cost per hour calculations. For hourly employees, the number of pay grades may be very large and not be feasible to calculate individually. In such cases, the calculations can be simplified by grouping pay grades and using average pay rates for the group. Within these groupings if the mix changes, then adjustments should be made in the base period such as rearranging the group to make the mixes for the periods compatible.

The most convenient way to obtain information for hourly employees is to get the total value of labor and hours paid from the check register and then divide the value by hours paid to obtain an average direct hourly cost. The value for salaried employees can be obtained in a similar manner pay scales for salaried employees can be converted to an hourly base by multiplying the number of people in the period times eight hours per day.

Capital

Capital input evaluation is a method to analyze how effective an organization is utilizing its capital resources. The capital resources include:

- o Accounts Receivable
- o Inventories
- o Cash
- o Property, Plant and Equipment
- o Prepaid and Deferred Charges

Capital evaluation is important because the capital intensive nature of the petroleum industry makes capital utilization a significant resource. The evaluation procedure for capital is heavily influenced by the end result desired. It is necessary for a business unit to develop a procedure which satisfies its own needs. The following discussion will give some general conceptual guidelines for capital evaluation which will aid in generating meaningful measures for capital.

The best way to begin a discussion on meaningful capital evaluation is to first describe what it is not, and then talk about what it is. It is very difficult to conceptualize what capital productivity means and many times is confused with return on assets. In the evaluation format which is being discussed here, return on assets does not fit our evaluation definition because profit is not a measure of the output of the business unit. Instead of an output of the business unit, profit is actually a portion of the input. Capital will be addressed from the view point that the output is the sales value of production rather than profit being the output.

Capital Employed Capital employed is the average value of capital used in the production of output during the reference and measured periods. The value of all capital employed in the production of output should be accounted for, whether it is leased or owned by a firm. Capital employed consists of current assets and fixed assets. Current Assets includes accounts receivable, inventory, cash, and prepaid and deferred charges. Fixed Assets consist of property, plant, and equipment.

Accounts Receivable Each division has financial records on accounts receivable. However, many of the sub-divisions do not keep track of their accounts receivable on an actual basis, because the receivables for the total division are prorated to each subdivision based on either sales or net assets. This proration obviously distorts the real receivables and therefore if the receivables have been prorated then a better method of approximating receivables should be performed. The easiest and best way to approximate receivables is by dividing the net sales by the average days outstanding.

Accounts receivable are expressed in current dollars in the accounting records. To revalue to receivables to a reference period constant value, they should be deflated by product price indices. Accounts receivable should be expressed as the average account balance during the periods analyzed.

Inventory The most accurate way to value inventories is to count the units of inventory and multiply by the production costs. For most business units the multitude of different priced products in inventory makes this impractical. An alternative is to estimate the mark up which should be applied to the current value of inventories to arrive at production value. The mark up factor must be derived by judgement or a sampling technique developed by the business unit.

Cash and Prepaid and Deferred Charges The cash employed and prepaid and deferred charges should be obtained from the balance sheet. Each business unit has a cash allocation on its balance sheet.

Plant and Equipment Plant and equipment is the most subjective of all of the inputs. In order to properly evaluate plant and equipment, these resources must be restated in terms of replacement value. The most meaningful replacement value is generated as technological replacement instead of with like-and-kind or identical replacement of assets. Technological replacement value is the cost of providing plant or equipment of the same functional capability as the existing facility but utilizing the latest technology. Like-and-kind replacement entails stating the current cost of replicating existing plant and equipment but is not a realistic estimate of the current utilizable value of the assets.

Land Land should be valued at replacement cost according to its sales value. An appraisal based on tracts of land which have sold nearby or based on an estimate by the real estate branch is the best way to obtain a fair value.

Capital Consumed Approach This method has been adopted by Phillips as the measure of capital performance. Under this approach capital is defined in terms of its use during the period. In compensating for the service of capital stock in a particular time period, both physical usage and financial return to owners must be taken into account. Specifying capital input in this manner allows it to be aggregated with other inputs to obtain a total productivity measure.

Recovery of Depreciable Capital Production facilities deteriorate and become obselete over time. They are "consumed" in producing output; thus an appropriate capital input charge must be made which reflects the quantity of capital used in producing output during the particular time period under consideration. This amount is based upon the cost of the facility and its useful economic life.

Return on Capital Return on capital is payment for the use of investors money after depreciation allowances. It includes debt interest and equity interest. Return on capital is a real cost and it must be included as a capital input in the capital consumed approach to productivity analysis. The cost of using capital is the amount which must be provided to the owners of capital to induce them to make it available to the business. Capital has a continuing charge to the owners regardless of the degree of utilization.

Capital financed by debt and equity is identified as liabilities and net worth on the balance sheet. Accounts payable is a short-term source of funds for which no explicit interest is paid; however, the other sources of funds require payment for their use.

Lenders furnish debt capital to a firm in return for the interest they receive. This is the cost of debt capital. Equity capital received from shareholders likewise has a cost. Investors furnish equity capital to a firm with the expectation of receiving a return. This return may be in the form of current dividends, a higher market value for their shares or some combination of all of these.

Since depreciation and debt interest are before profit, pretax profit should be selected for equity interest to keep all items on the same basis.

Using "pretax" profit as a cost can be justified on the basis that a firm is distributing the profit before tax to the shareholder. The shareholder pays the government the necessary tax, retains a portion for dividend and returns the remainder for reinvestment (retained earnings) and future income.

Conclusion

Specific output and input information is different among business units but the general principles in the discussion in this chapter can be applied on a universal basis. Every business unit has output and has to utilize inputs to produce that output. The inputs in the units consist of labor, energy, materials, and capital. In order to effectively gather data for the analysis of a business unit, the information must be considered in a manner which will give meaningful results for that unit. The concept application in the following chapter will show how meaningful results can be obtained for a representative business unit.

CHAPTER VI

APPLICATION OF CONCEPTS

The information contained in the operations statements at the end of this chapter is typical of information available in the accounting and management information systems in many of the operations at Phillips. In the example, the data to perform a total performance evaluation will be gathered in several ways to illustrate how to generate the data in situations where the information is limited. After the data is tabulated in a form where a total performance evaluation can be performed, then the data will be input into the total performance measurement model.

Output Information

The sales value of production using this equation when quantity and price is known for reference and measured period is as follows:

	REFERENCE			MEASURED		
	(000) Value	(000) Quantity	Price	(000) Value	(000) Quantity	Price
Product A	6,300	7,000	.90	9,500	10,000	.95
Product B	1,100	1,000	1.10			
Product C	4,254	5,000	.85	3,000	3,000	1.00
Product D			1.25	2,765	2,000	1.38
Total	11,654			15,265		

The same results can be obtained if the price has not been calculated for the products in either period by generating a sales value of production from the accounting statements as shown on the following page:

			REFERENCE				MEASURED	
Net Sales			11,669				15,120	
Less: Sales of Products Purchased for resale *		250				350		
Sales of Products Produced				11,419				14,770
Plus: Inventory Adjustments								
Beginning								
Total Inventory	900				1,000			
Less: Goods in inventory purchased for resale	50				80			
Net Beginning Inventory		850				920		
Ending								
Total Inventory	1,000				1,300			
Less: Goods in inventory purchased for resale	60				100			
Net Ending Inventory		940				1,200		
Net Increase or (Decrease)		90				280		
Finished Goods Inventory Change		90				280		
Transfers of Product Out of Plant at Cost		40				50		
Sub-Total			130				330	
Times: Average Markup on Inv. Sold			.50				.50	
Total Value of Markup				65				165
Transfers of Product Out of Plant at Cost				40				50
Inventory Change of Products Produced				130				280
Sales Value of Output				11,654				15,265

* From Internal Accounting Information

The following summary can be made:

	REFERENCE PERIOD			MEASURED PERIOD		
	Value	Quantity	Price	Value	Quantity	Price
Production	11,654	13,000	.896	15,265	15,000	1.018

In the above case, value and quantity was known and price was obtained by dividing value by quantity.

If production volumes are not known, then sales value of production can be derived by the method in the preceding example, and then a deflator can be applied to the measured period which will deflate current period value to reference period value. The deflators can be obtained through internally generated indexes or national indexes as discussed in Appendix B. An example of use of a deflator is as follows:

	REFERENCE PERIOD			MEASURED PERIOD		
	($000) Value	($000) Quantity	(Index) Price	($000) Value	($000) Quantity	(Index) Price
Output	11,654	11,654	1.00	15,265	13,437	1.136

The quantity calculations for both reference period and measured period were derived by dividing the sales value of production by the price deflator. The quantity column represents sales value of production in constant dollar terms.

The following data generated by the model analyzes the data with respect to value ratios, quantity ratios, and price ratios.

	CHANGE RATIOS			DOLLAR VARIANCES		
Product	Value	Quantity	Price	Value	Quantity	Price
Revenues						
Product A	1.508	1.429	1.056	3200.	2700.	500.
Product B	0.0	0.0	0.0	-1100.	-1100.	0.
Product C	0.705	0.600	1.175	-1254.	-1702.	448.
Product D	0.0	0.0	0.0	2765.	2500.	265.
Total	1.310	1.206	1.086	3611.	2398.	1213.

The equations for the change ratios are:

$$\text{Value} = \frac{\sum(X_2 \times P_2}{\sum(X_1 \times P_1)}$$

$$\text{Quantity} = \frac{\sum(Q_2 \times P_1)}{\sum(Q_1 \times P_1)}$$

$$\text{Price} = \frac{\sum P_2 \times X_2}{\sum P_1 \times X_1}$$

The equations for the dollar variances of the output are to:

$$\begin{aligned} \text{Value} &= V_{02} - V_{01} \\ \text{Volume} &= P_1 (Q_2 - Q_1) \\ \text{Price} &= Q_2(P_2 - P_1) \end{aligned}$$

In the preceding output, Product B was produced in the reference period but not in the measured period and Product D was produced in the current period but not in the base period. Product B is commonly called a "death" and Product D is called a "birth". In the measurement model when outputs are listed, a price should be established in the reference period for a birth. In the example, reference period price would have probably been 10% less the measured period price, thus, \$1.38 divided by 1.10 = \$1.25. It is not necessary to approximate a current period price for a "death".

Energy Input

Inputs for the example are: (1) energy, (2) materials, (3) labor, and (4) capital. Generating energy from price and quantity data which is available in plant operating records we obtain the following:

	REFERENCE			MEASURED		
	Value ($000)	Quantity Units	Price $/Unit	Value ($000)	Quantity Units	Price $/Unit
Fuel	6	3.24	1.85	11	4.68	2.35
Electricity	97	2,771	.035	176	4,400	.04
Total	103			187		

	CHANGE RATIOS			DOLLAR VARIANCES		
Resource	Value	Quantity	Price	Value	Quantity	Price
Fuel	1.833	1.444	1.269	5.	3.	2.
Electricity	1.814	1.588	1.143	79.	57.	22.
Total Energy	1.816	1.580	1.149	84.	60.	24.

Materials

Materials data can and should be broken between feedstocks and other materials costs. Feedstock costs can be obtained directly from the manufacturing cost portion of the income statement in the example and is generally easily available in plant accounting records. Statistics on the quantity of feedstock usage is also usually available in plant production records. In the Profitable Company example, the feedstock data is illustrated as follows:

	REFERENCE PERIOD			MEASURED PERIOD		
	Value ($000)	Quantity (000) Units	Price $/Unit	Value ($000)	Quantity (000) Units	Price $/Unit
Feedstocks	6,450	13,650	.472	8,600	15,450	.557

Value and quantity was known and price per unit was calculated from that information. Total value of materials was obtained from cost of raw material used account was netted against the raw materials used adjustment.

A deflator could also have been used to accomplish gathering data for the analysis. The results from the model input is shown below.

Resource	CHANGE RATIOS Value	Quantity	Price	DOLLAR VARIANCES Value	Quantity	Price
Feedstocks	1.333	1.132	1.178	2150.	851.	1299.

Other Materials

This category consists of all materials and purchased services not input as feedstocks. In the example the following items would fit this category.

	Reference Period Value ($000)	Current Period Value ($000)
o Contract Repairs and Maintenance	20	34
o Repairs - Material and Other	324	260
o Quality Control Supplies	9	11
o Supplies - General	81	147
o Packaging Supplies	158	286
o Water	8	14
o Communication	15	27
o Auto and Truck	16	29
o Travel	20	36
o Computer Services	38	69
o Rent	15	27
o Rental Equipment	14	25
o Insurance	4	9
Total	722	974

NOTE: Ad Valorum tax and Sales and Use tax should be included with taxes when reconciling to a statement. Engineering service should be included in labor costs. Depreciation should not be included as a resource input since the term does not reflect actual capital consumption.

In order to put this data in a form to perform an analysis, the revaluation of current period to base period must be done with deflators. Upon examination of the values of the other materials inputs, most of the value is concentrated in contract repairs and maintenance along with packaging supplies. It is known that the cost of repairs has escalated 15% over base period and the cost of packaging supplies has escalated 10% over base period. This data could have been generated from in plant data or for an appropriate published index. From a general index the other input items are estimated to have inflated 12%. A composite escalator can be worked up for this category from the preceding information using composite weighting as shown below.

$$\text{Composite weighted Index} = \frac{(324 + 260)\ 1.15 + (158 + 286)\ 1.10 + (240 + 428)\ 1.12\%}{(722 + 974)}$$

$$= \frac{671 + 488 + 748}{1696}$$

$$= 1.125$$

The input data would be in the following form:

	REFERENCE PERIOD			MEASURED PERIOD		
	Value ($000)	Quantity (000)	Price $/Unit	Value ($000)	Quantity (000)	Price $/Unit
Other Materials	722	722	1.00	974	866	1.125

The results from the measurement model are as follows:

	CHANGE RATIOS			DOLLAR VARIANCES		
Resource	Value	Quantity	Price	Value	Quantity	Price
Other Materials	1.349	1.199	1.125	252.	144.	108.

Labor

Labor costs are usually readily available from plant operating statements. If they are not readily available, they can be obtained from a check register for the business unit. In the example, labor value is set out in the processing expense report and the number of hourly labor hours was recorded in the statistical portion of the operations statement. The number of salaried employees was also listed in the operations statement statistical section and this number was multiplied by the number of standard hours in the time period (which in this case was one year). The results are lised below:

	REFERENCE PERIOD			MEASURED PERIOD		
	Value ($000)	Quantity (000 Units)	Price $/Unit	Value ($000)	Quantity (000 Units)	Price $/Unit
Hourly	400	50.00	8.00	1036	121.84	8.50
Salaried	626	58.23	10.75	806	67.20	12.00
Engineering	6	6.000	1.00	76	68.00	1.115
TOTAL	1032			1918		

The values for labor were derived as follows from the manufacturing expense statement.

	REFERENCE	MEASURED
Direct Operating Labor	350,000	897,000
Indirect and Supervisory	520,000	650,000
Engineering Service	6,000	76,000
Employee Benefits	48,000	87,000
Moving	31,000	56,000
Social Security	77,000	152,000
Total	1,032,000	1,918,000

Direct Operating Labor Values

$$\text{Base:} \quad 350 + (48 + 77)\frac{350}{(350 + 520)} = 400$$

$$\text{Measured:} \quad 897 + (87 + 152)\frac{897}{(897 + 650)} = 1{,}036$$

Indirect and Supervisory

$$\text{Base:} \quad 520 + (48 + 77)\frac{520}{(350 + 520)} + 31 = 626$$

$$\text{Measured:} \quad 650 + (87 + 152)\frac{650}{(897 + 650)} + 56 = 806$$

In the above calculations benefits and social security were prorated between hourly and salaried labor based on value. If a better breakdown for assignment of benefit costs is available, it should be used.

The results from the measurement model are as follows:

	CHANGE RATIOS			DOLLAR VARIANCES		
Resource	Value	Quantity	Price	Value	Quantity	Price
Labor						
Hourly Labor	2.590	2.437	1.063	636.	575.	61.
Salaried Labor	1.288	1.154	1.116	180.	96.	84.
Engineering	12.667	11.360	1.115	70.	62.	8.
Total Labor	1.859	1.711	1.086	886.	733.	153.

Capital

The gross capital input consists of current assets plus fixed assets. In the example the current assets consist of, (1) cash, (2) accounts receivable, (3) inventories, and (4) prepaid expenses and deferred charges. The fixed assets consits of gross property, plant, and equipment and, also, investment AFE's. The data necessary to perform a total performance evaluation is shown in the following:

	REFERENCE PERIOD			MEASURED PERIOD		
	Value ($000)	Quantity (000 Units)	Price $/Unit	Value ($000)	Quantity (000 Units)	Price $/Unit
Current Assets						
Cash	4	10	.37		11	.36
A/R	388	1,031	.37		1,111	.36
Inventories	883	2,345	.37		2,676	.36
Prepaid & Deferred	2	4	.37		9	.36
Fixed Assets						
Property, Plant and Equip.	2,165	5,750	.38	236	6,431	.37
Total	3,442			3,758		

Quantity Data The quantity of capital for each of the period reflects the replacement value of each of the asset accounts. The values stated on the balance sheet are used for cash, accounts receivable, inventories, and prepaid and deferred expenses for the reference period. Technological replacement value was used for property, plant and equipment.

For measured period cash and prepaid and deferred were calculated by taking the values from the balance sheet and deflating those values by a GNP deflator. The quanties for accounts receivable and inventories were obtained by taking the values from the balance sheet and deflating them by a general price deflator for the product lines that Profitable produces. The quantity for fixed assets was derived by first establishing a replacement value for assets and then deflating the replacement value to base period by guidelines for general construction deflators.

Capital Price Data The price of capital was established by taking the ratio of income before reserves and taxes (IBRT) from production to replacement value for each period as shown in the following equation.

$$\text{Price of Capital} = \frac{\text{IBRT}}{\text{Replacement Value of Assets}}$$

The calculations for the two periods are as follows:

Capital Price Data:

$$\text{Reference Period} = \frac{3,347}{9,140} = .38$$

$$\text{Measured Period} = \frac{3,586}{10,238} = .37$$

Capital Value Data The values for capital consumption for each of the asset catagories was obtained by multiplying the quantity of the asset employed times the price calculated for capital consumption.

Measurement Information For Capital The measurement model gives the following results for the capital input:

	CHANGE RATIOS			DOLLAR VARIANCES		
	Value	Quantity	Price	Value	Quantity	Price
Resources:						
Cash	1.052	1.100	.957	0	0	0
A/R	1.031	1.078	.957	12	29	(18)
Inventories	1.092	1.141	.957	79	121	(43)
Prepaid & Deferred	2.152	2.250	.957	2	2	0
Property, Plant & Equip.	1.070	1.118	.957	147	249	(102)
Subtotal	1.071	1.120	.957	239	402	(163)

Total Measurement Performance Ratios

The mesurement model utilizes the input data to calulate profitability ratios, productivity ratios, and pricing recovery ratios for each of the catagories of inputs. The ratios are calculated as follows:

$$\text{Profitability Ratio} = \frac{\dfrac{\sum \text{Value of Output in Current Period}}{\sum \text{Value of Input in Current Period}}}{\dfrac{\sum \text{Value of Output in Reference Period}}{\sum \text{Value of Input in Reference Period}}} = \frac{\dfrac{\sum X_2P_2}{\sum L_2C_2}}{\dfrac{\sum X_1P_1}{\sum L_1C_1}}$$

$$\text{Productivity} = \frac{\dfrac{\sum \text{Restated Value of Output in Current Period}}{\sum \text{Restated Value of Input in Current Period}}}{\dfrac{\sum \text{Value of Output in Base Period}}{\sum \text{Value of Input in Base Period}}} = \frac{\dfrac{\sum X_2P_1}{\sum L_2C_1}}{\dfrac{\sum X_1P_1}{\sum L_1C_1}}$$

$$\text{Pricing Recovery Ratio} = \frac{\dfrac{\sum \text{Ratio of Prices of Outputs in Current Period}}{\sum \text{Ratio of Prices of Inputs in Current Period}}}{\dfrac{\sum \text{Ratio of Prices of Outputs in Base Period}}{\sum \text{Ratio of Prices of Inputs in Base Period}}} = \frac{\dfrac{\sum X_2P_2}{\sum L_2C_2}}{\dfrac{\sum X_2P_1}{\sum L_2C_1}}$$

The performance ratios for Profitable are as summarized below:

	Performance Ratios		
	Profitability	Productivity	Pricing Recovery
Energy	.721	.763	.945
Materials	.981	1.059	.927
Labor	.705	.705	1.000
Capital	1.222	1.076	1.136
Total	1.000	1.015	.985

Total productivity was up 1.5% while prices were under recovered at a rate of only 98.5% of base.

Effects on Profits

The measurement model calculates dollar variances on profitability due to each input. The dollar variances consist of profitability, productivity, and pricing recovery. The model also calculates the effect on margin of increased throughtput. The effects of profits are calculated using the theory described in Chapter IV.

The effect on profits for Profitable are as summarized below:

	Effect on Profits		
	Profitability	Productivity	Pricing Over or (Under) Recovery
Energy	(52)	(38)	(14)
Materials	(180)	482	(661)
Labor	(566)	(521)	(45)
Capital	798	287	511

The analysis shows that profitability due all inputs except capital was negative. Energy profitability was negative because of unfavorable variances for productivity and pricing under recovery. Materials had a negative contribution to profitability because of a large under recovery on pricing even though the productivity variance was positive. Labor had a negative effect on profitability because the productivity and pricing variance were both negative. Capital showed a very large favorable profitability effect with a positive variances for productivity variance and pricing recovery.

The analysis indicates that prices were under recovered of materials which means that the ratio of the prices of outputs in current and reference period did not increase as fast as the ratio of the prices of the inputs. An investigation would be warranted to determine the reason for this occurence. Labor productivity should also be investigated to find why the productivity was so drastically negative. The favorable profitability variance of capital is primarily due to increasing the capital utilization by producing more units of output in the current period as compared to the reference period.

Relationship of Performance Results to the Income Statements

There is a direct relationship between the financial results in the income statement and the data used in the performance analysis. The data used in the performance analysis can be reconciled to the income statement as shown in the Table I.

TABLE I

RECONCILIATION TO INCOME STATEMENTS

	Reference Value	Meausred Value
Net Sales:		
Revenues from Production	$ 11,654	$ 15,265
Revenues from Sales of Resale Items	250	350
Adjustments to Inventory	(130)	(280)
Transfers from Plant at Cost	(40)	(50)
Markup Adjustment	(65)	165
Net Sales	11,669	15,120
Costs:		
Ad Valorum	2	4
Sales & Use Tax	-	-
Other Income	-	(5)
Inventory Fluct	(100)	(300)
Depreciation	141	271
Outside Purchases	400	500
Transfers & Receipts	5	5
Intra Company Purchases	100	200
Energy	103	187
Materials	7,172	9,574
Labor	1,032	1,918
Total Input	$ 8,855	$ 12,355
Margin	2814	2765

Relating the effect on profits data to the gross margin implies that if productivity of the energy input in the measured period had maintained the same level as in the reference period, then the margin would have been $38,000 larger. The same inference can be made for each of the results for pricing recovery and productivity of each of the input.

The computer printout for a total performance measure analysis is in Appendix A. It contains the reports which are generated by measurement model. The first report summarizes all of the data entered into the model and shows change ratios and dollar variances for all output and input data. The second report gives change ratios and dollar variances for data subtotals on the first report. The third report shows performance ratios and effects on profits for data subtotals.

PROFITABLE COMPANY

BALANCE SHEET

REFERENCE PERIOD

Assets

Current Assets:		
Cash		10,000
Accounts Receivable		
Trade	1,000,000	
Less: Reserve For Bad Debts	30,000	
Other	1,000	1,031,000
Inventories		
Finished Goods	1,000,000	
Raw Materials	300,000	1,300,000
Prepaid Expenses and Deferred Charges		4,000
Total Current Assets		2,345,000
Fixed Assets:		
Property, Plant and Equipment	3,000,000	
Less: Reserve for Depreciation	500,000	2,500,000
Investment - AFE's		200,000
Total Fixed Assets		2,700,000
Total Assets		5,045,000

Liabilities and Advances

Current Liabilities:	
Accounts Payable	50,000
Sales Commissions Payable	10,000
Accounts Payable - Intra Company	1,000,000
Payroll Taxes	30,000
Employee Benefit Deductions	5,000
Sales and Use Taxes	25,000
Accrued Taxes	2,000
Wages Payable	30,000
Accrued Vacations	50,000
Total Current Liabilities	1,202,000
Owners Equity	3,843,000
Total Liabilities	5,045,000

PROFITABLE COMPANY

INCOME STATEMENT

REFERENCE PERIOD

Sales:	
Outside	
Domestic	10,000,000
Export	50,000
Inside	
Domestic	2,000,000
Export	20,000
Total Sales	12,070,000
Less: Discounts and Allowances	1,000
Less: Freight	400,000
Net Sales	11,669,000
Cost of Sales:	
Opening Inventory	900,000
Product Purchases Outside	400,000
Manufacturing Costs	8,500,000
Transfers and Receipts	5,000
Adjustment to Raw Material	(50,000)
Intra Company Purchases at Cost	100,000
SubTotal	9,855,000
Less: Ending Inventory	1,000,000
Total cost of Sales	8,855,000
Plant Level Profit or (Loss)	2,814,000

MANUFACTURING EXPENSE

REFERENCE PERIOD

Summary:	
Raw Material Used	6,500,000
Processing Expense	2,000,000
Less: Other Income	-
Total Manufacturing Expense	8,500,000
Processing Expense:	
Direct Operating Labor	350,000
Indirect and Superv.Labor	520,000
Contract Repairs and Maintenance	20,000
Repairs - Matl. and Other	324,000
Quality Control Supplies	9,000
Supplies General	81,000
Packaging Supplies	158,000
Fuel Oil	6,000
Water	8,000
Electricity	97,000
Communication	15,000
Auto and Truck	16,000
Travel	20,000
Computer Services	38,000
Rent	15,000
Rental Equipment	14,000
Insurance	4,000
Employee Benefits	48,000
Moving	31,000
Engineering Service	6,000
Ad Valorum Tax	2,000
Sales and Use Tax	-
Social Security	77,000
Depreciation	141,000
Miscellaneous	-
Total Processing Expense	2,000,000

PROFITABLE COMPANY

STATISTICS

REFERENCE PERIOD

PRODUCTION

Pounds of Spec. Production	13,000,000
Pounds to Scrap	650,000
Pounds to Regrind from Current Production	
Pounds of Raw Material	13,650,000

MANPOWER

Number of Hourly Employees	19
Number of Salaried Employees	20
Manhours Worked by Hourly Employees	43,750

PROFITABLE COMPANY

BALANCE SHEET

MEASURED PERIOD

Assets

Current Assets:		
Cash		12,000
Accounts Receivable		
Trade	1,200,000	
Less: Reserve For Bad Debts	20,000	
Other	2,000	1,222,000
Inventories		
Finished Goods	1,300,000	
Raw Materials	400,000	1,700,000
Prepaid Expenses and Deferred Charges		10,000
Total Current Assets		2,944,000
Fixed Assets:		
Property, Plant and Equipment	3,500,000	
Less: Reserve for Depreciation	600,000	2,900,000
Investment - AFE's		250,000
Total Fixed Assets		3,150,000
Total Assets		6,094,000

Liabilities and Advances

Current Liabilities:	
Accounts Payable	60,000
Sales Commissions Payable	10,000
Accounts Payable - Intra Company	1,100,000
Payroll Taxes	30,000
Employee Benefit Deductions	5,000
Sales and Use Taxes	25,000
Accrued Taxes	2,000
Wages Payable	30,000
Accrued Vacations	50,000
Total Current Liabilities	1,312,000
Owners Equity	4,782,000
Total Liabilities	6,094,000

PROFITABLE COMPANY

INCOME STATEMENT

MEASURED PERIOD

Sales:	
Outside	
Domestic	13,000,000
Export	50,000
Inside	
Domestic	2,500,000
Export	20,000
Total Sales	15,570,000
Less: Discounts and Allowances	-
Less: Freight	450,000
Net Sales	15,120,000
Cost of Sales:	
Opening Inventory	1,000,000
Product Purchases Outside	500,000
Manufacturing Costs	12,000,000
Transfers and Receipts	5,000
Adjustment to Raw Material	(50,000)
Intra Company Purchases at Cost	200,000
SubTotal	13,655,000
Less: Ending Inventory	1,300,000
Total Cost of Sales	12,355,000
Plant Level Profit or (Loss)	2,765,000

PROFITABLE COMPANY

MANUFACTURING EXPENSE

MEASURED PERIOD

Summary:	
Raw Material Used	8,650,000
Processing Expense	3,355,000
Less: Other Income	5,000
Total Manufacturing Expense	12,000,000
Processing Expense:	
Direct Operating Labor	897,000
Indirect and Superv. Labor	650,000
Contract Repairs and Maintenance	34,000
Repairs - Matl. and Other	260,000
Quality Control Supplies	11,000
Supplies General	147,000
Packaging Supplies	286,000
Fuel Oil	11,000
Water	14,000
Electricity	176,000
Communication	27,000
Auto and Truck	29,000
Travel	36,000
Computer Services	69,000
Rent	27,000
Rental Equipment	25,000
Insurance	9,000
Employee Benefits	87,000
Moving	56,000
Engineering Service	76,000
Ad Valorum Tax	4,000
Sales and Use Tax	1,000
Social Security	152,000
Depreciation	271,000
Miscellaneous	-
Total Processing Expense	3,355,000

PROFITABLE COMPANY

STATISTICS

MEASURED PERIOD

PRODUCTION

Pounds of Spec. Production	15,000,000
Pounds of Off-Spec.	450,000
Pounds of Raw Material	15,450,000

MANPOWER

Number of Hourly Employees	90
Number of Salaried Employees	30
Manhours Worked by Hourly Employees	187,000

CHAPTER VII

CONCLUSION

The use of the total performance measurement model allows management in an organization to determine; (1) how much profit change was due to improved efficiency in utilizing resources; (2) how much profit change was due to pricing over or under recovery; (3) how much profit change was due output quantities increasing; and (4) how much profit change was due to price changes of the output. Information from this analysis indicates which products had favorable conversion efficiencies and indicates the resource reallocations which should be done to improve overall profitability.

This study has shown how the information necessary to perform a total performance measure analysis can be obtained from the accounting information system in a business unit. The data is usually readily accessible and the results of the analysis can be reconciled to the income statement of the business unit. Reconciliation to an income statement is very important because a direct link is made between the productivity and pricing policies in an organization and the profitability of the organization.

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APPENDIX A

TOTAL PERFORMANCE EVALUATION SYSTEM

COMPUTER PROGRAM APPLICATION INSTRUCTIONS

APPENDIX A

TOTAL PERFORMANCE EVALUATION SYSTEM

COMPUTER PROGRAM APPLICATION INSTRUCTIONS

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Summary of Methods and Interpretation

The Performance Measurement System is a total productivity analysis method that calculates the productivity of each input and of all inputs combined in relation to total output. It also demonstrates the dollar effects of both productivity and relative cost-price movements in relation to changes in profitability over time. It can be used at many organizational levels and in most types of industries.

The data required for the Performance Measurement System are value, quantity and price for each time period and for each output and input of the entity being analyzed. The System can treat two time periods, two plants, actual vs. budget, or any other two element comparison.

Value, quantity, and price of the various outputs and of most inputs (Labor, Capital, Materials and Energy) are straightforward and can be derived from most basic accounting systems. Each input category should generally be further broken into appropriate sub-factors (i.e., Labor Type #1, Labor Type #2, Benefits, etc.). However, special care is needed in development of quantity and price data for capital because the method suggested presents a departure from most accounting systems.

The Performance Measurement System includes as an input not only the depreciation of capital but also a return component, i.e., opportunity cost, represented by typing up that capital in this particular entity. Thus, included in capital inputs is a factor that represents either a profit "standard" for that entity or simply the actual base-period profit level for that entity. If the latter approach is used, the base-period output value will equal the input value by definition and there will be no residual. If another approach is taken to Capital, then there is little expectation that the profit level specified will equal the actual profit level in the base year. Thus, there will be a residual between output and input. In year two, there will certainly be a residual regardless of approach. The difference between these residuals represents the year-to-year change in profitability, and that becomes the number the rest of the analysis aims at explaining.

Once an array is constructed with quantity, price and value data for each sub-input and sub-output, in each time period, calculation of the fractional change of each from period to period is made. These results are called Change Ratios. The Change Ratios of the individual outputs are straightforward. For later calculations, however, Change Ratios are also required for total output. This is done using base-period-price-weighting for the total output Quantity Change Ratio and current-period-quantity-weighting for the total output Price Change Ratio.

Next, the Change Ratios for each sub-input are divided into the appropriate Change Ratio for total output to develop a Performance Ratio. The Performance Ratios on value relationship, quantity relationship, and price relationship are called respectively profitability, productivity and price recovery. Thus, Productivity Performance Ratios are the change in quantity of output between the two periods compared to the change in quantity of each of the individual sub-inputs. Similarly, the change in price of total output is compared to the change in price (i.e., unit cost) of each of the sub-inputs. These are called Price Recovery Performance Ratios. In effect, price recovery measures the extent to which changes in unit cost are passed on or not passed on through changes in output price. Productivity and price recovery together fully explain changes in profitability. The Performance Ratios can be organized vertically in such a way that relative improvements or declines in productivity of each sub-input factor can be read from the Quantity Performance Ratio column and in price recovery can be read from the Price Performance Ratio column.

The Total Performance Ratios for the sum of all inputs (i.e., total input) are the total productivity and total price recovery ratios. These, in one sense, can be considered the purpose of the analysis. While there is clear value in having a total productivity ratio, the importance of the total price recovery ratio is often overlooked. However, just having overall ratios is not sufficient for interpretation. The Performance Measurement System goes beyond these ratios and also calculates their exact dollar effects on profitability.

The Performance Measurement System indicates the number of dollars involved when a performance ratio is above or below unity. Thus, for example, if a productivity ratio for one sub-input is 1.05 instead of 1.00, this System calculates the dollar effect of that 5% change in productivity. The total dollar effects of both productivity and price recovery are combined for all inputs and collectively become the total explanation of the change in profit (i.e, the difference in the residuals) from one period to another.

The Performance Measurement System is completely reconcilable with normal accounting systems. The major differences are:

1. Since capital return has been included as an input, it must be removed to get to standard accounting practice.
2. Outputs are based on sales value of production or equivalent rather than sales, and the appropriate finished product inventory adjustment is required to get to a sales basis.

With these two adjustments, and assuming that all expense categories have been included in one of the sub-inputs for productivity analysis, the reconciliation should be straightforward.

In summary, the great value of this system is that it analyzes in a convenient and systematic way both productivity and price recovery. It makes that analysis in detail by input factor, and makes the analysis in terms of both ratios and dollar effect. Though most businesses have a very good track on their profitability, they are unable to conveniently and routinely analyze whether their profitability changes are the result of productivity or price-cost movements. In a period of greatly increasing inflation, where unstable price and cost relationships mask quantity changes, this sort of tool is vital for an understanding of the true likely future direction of the operational entity.

Program Description

The program is written in FORTRAN IV which may be easily modified to operate on a variety of computer systems and interface with whatever input devices are available. This description assumes that data will be entered from 80-column punched cards and that results will be printed on a line printer.

The program calculates productivity and other performance measures from the output and input data provided. (Note that references to 'output' and 'input' made here are in context with productivity measurement systems; the terms are not intended to computer outputs and computer inputs.)

As illustrated in Figure 8, the System provides for entering data relative to any number of outputs grouped into a limited number of Subtotal categories. A single Total output grouping is made by the computer program. Likewise, the System provides for any number of inputs to be grouped to form a limited number of Subtotal categories, and further grouped to form up to nine Total categories. The maximum number of output and input Subtotal categories provided for is 50.

Change Ratios and Dollar Variances are calculated for each output and input, each Subtotal grouping, and each Total grouping. However, Performance Ratios and Effects of Profits are calculated only for Subtotal and Total groupings. Thus, if these calculations are wanted for an individual output or input item, it must be identified at data entry as a Subtotal category.

Output A1		
Output A2		
SUBTOTAL OUTPUT A	= S1 ←	Up to 50
Output B1		Subtotal
SUBTOTAL OUTPUT B	= S2 ←	Categories
Output C1		
Output C2		
Output C3		
SUBTOTAL OUTPUT C	= S3	
TOTAL OUTPUT	= T1	
Input 1a		
Input 1b		
SUBTOTAL INPUT 1	= S4	
Input 2a		
Input 2b		
Input 2c		
SUBTOTAL INPUT 2	= S5	
TOTAL INPUT 1/2	= T2	
Input 3a		
SUBTOTAL INPUT 3	= S6	
Input 4a		
Input 4b		
SUBTOTAL INPUT 4	= S7	
TOTAL INPUT 3/4	= T3 ←	Up to 10
		Total
TOTAL INPUT	= T4 ←	Categories

Figure 8. Illustration of Subtotal and Total categories.

This system has the ability to calculate the performance measures for individual departments or divisions (up to nine) within an organization. It will then combine output and intput data for each suborganization with data applicable to the organization as a whole and compute the performance measurements for the total organization. For example, suppose an organization is made up of four divisions and a corporate office. Data is entered individually for each division and for the corporate staff. The calculations are made for each division individually and then again using the sum of the entries for the four divisions plus entries applicable to the corporate staff only.

Data Entry

To illustrate the procedures for data entry, the sample program in the previous chapter has been used to illustrate the use of the model.

In using the keypunch forms, "Title" and "Name" entries should be left justified in their appropriate fields so as to appear properly on the printouts. "Heading #1" and "Heading #2" are headings over multiple columns on the printout and should be centered in the fields provided.

Code numbers "T", "S" and "C" are integers and should be entered right justified, with or without leading zeros.

"Value", "Quantity" and "Price" data should be entered right justified with or without leading zeros. A decimal point may be entered anywhere in the field; if none is entered, the decimal point is assumed to be at the right of the number. Negative numbers are indicated by a minus sign (-) to the left of the number.

The card deck must be sequenced in the following order as indicated by the sample problem:

1. The heading card;
2. The Total (T) title cards, in sequence by T number;
3. The Subtotal (S) title cards, in sequence by S number;
4. The Suborganization (C) title cards, in sequence by C numbers;

5. A control card indicating the end of the heading/title entries;
6. The "Value", "Quantity" and "Price" data cards, in sequence by S number within C grouping; and
7. A control card indicating the end of the data entries.

In the section that follows, the data applicable to the sample problem is used to illustrate the procedure.

Data Input Instructions

1. The first card contains two headings identifying the two time periods measured. These are used as column headings on the printout pages. Each heading may be entered anywhere in its 12 position field, however, centering will provide the neatest appearance. Data entry on the first card is illustrated on Form 1 on page 71.

2. The next set of cards contains the titles for the "Total" categories you have established. A maximum of ten categories are provided for with the first always being Total Output. Cards must be entered in the numeric sequence established by the T numbers. The fields of the card are as follows:

Columns 2-3	Sequence number assigned to the Total category (T); leading zero may be omitted. Total "01" or "1" must be Total Output.
Columns 11-30	Title corresponding to the Total category. The work "Total" should not be entered as it will be automatically printed preceeding each title. (For example, enter "OUTPUT" on the first T card; "TOTAL OUTPUT" will appear on the printout.)
Columns 32-33	Enter the sequence number S1 of the first Subtotal category associated with the Total category.
Columns 35-36	Enter the sequence number S2 of the last Subtotal category associated with this Total category. (For example, if Subtotal categories 1, 2 and 3 combine to make Total Output, you would enter S1 as 1 and S2 as 3 -- or 01 and 03.)

Data entry on the title cards is shown on Form 1 on page 72.

3. The next set of cards contains the titles for the "Subtotal" categories you have established. A maximum of 50 such categories are possible and cards must be entered in the the numeric sequence established by the S numbers. The fields of the card are as follows:

Columns 5-6	Sequence number assigned to the Subtotal category (S); leading zeros may be omitted. Be sure that each of the S1 and S2 numbers appearing on the Total title cards is defined on a Subtotal title card.
Columns 8-9	Blank
Columns 11-30	Title corresponding to the Subtotal category. The word "Subtotal" should not be entered as it will be automatically printed preceeding each title. (For example, enter "PRODUCT A" on the first S card; "SUBTOTAL PRODUCT A" will appear on the printout.)

Data entry on the Subtotal title card is shown on Form 2 on page 72.

4. If calculations are to be made for individual departments or divisions of an organization, the next set of cards is required to identify the suborganizations. The titles entered appear as page headings on the printouts for each suborganization. Even if this program option is not used, one title card for the total organization (C = 1 or 01) may be entered to provide a page heading for the printout. The fields of the cards are as follows:

Columns 5-6	Blank
Columns 8-9	Sequence number assigned to the suborganization (C); leading zeros may be omitted. The maximum number of suborganizations is 10, and C = 1 (or 01) always applied to the total organization.
Columns 11-30	Title of the suborganization.

Data entry on the Suborganization card is shown on Form 3 on page 73.

5. The next card is a required control card signifying the end of the title cards. It must contain 9999 in columns 5-9.

6. The next cards are the data cards. If you are performing the calculations for more than one suborganization, you will require a group of data cards for each suborganization. The cards must be sequenced by C number assigned to the suborganization. Within each such group, the cards are sequenced by S number corresponding to the Subtotal category to which the data applies. If there are multiple data cards within a given C-S category, those cards may be in any order, but you will want to sequence them in the order in which they should appear on the printout. If the multiple organization option of the program is not being used, or if the data applies only to the total organization for which C = 1 or 01, the C columns may be left blank. The fields of the card are as follows:

Columns 1-2	S number corresponding to the Subtotal category to which this data applies.
Columns 3-4	C number corresponding to the Suborganization to which this data applies; is left blank if multiple organization option is not being used; may be left blank if the data applies to the total organization (C = 1 or 01).
Columns 5-29	Name identifying this data. This name will print on the line on which the data appears on the printout.
Columns 30-53	Value (cc 30-37), Quantity (cc 38-45) and Price (cc 46-53) data for the base period. If only two of the three fields are entered, the third will be calculated by the program using the relationship V = Q x P. If all three are entered, they will be used as entered even if V = Q x P. For outputs or inputs for which there is no base period value or quantity (e.g., a new product or input), it is necessary that you enter a base period price.
Columns 54-77	Value (cc 54-61), Quantity (cc 62-69) and Price (cc 70-77) data for the period being compared. As for the base period, any two or all three may be entered. For outputs or inputs which there is no value or quantity for this

period (e.g., a discontinued product or input) it is necessary that you enter a price applicable to this period.

See Form 4 on page 74 for an illustration of the data format used; the final control card, item 7, is illustrated in Figure 4.

7. The last card is a required control card signifying the end of the input data. It must contain 9999 in columns 1-4.

Data Entry Forms

The attached four pages illustrate the layout of the 80-column card input records used with the program. Note that the program will handle a greater number of T, S, and C Titles than are provided for on the forms as illustrated.

Results Reports

The results reports follow the data entry forms. The information in the results reports were described on page 47.

PRODUCTIVITY MEASUREMENT
PROGRAM 9079

FORM 1

1 HEADING #1	13 HEADING #2 24
REFERENCE	MEASURED

TOTAL CARDS. MAXIMUM OF 10.

1	2 I		11 TITLE	32	S1	35	S2
	1		PRODUCTION REVENUES				
	2		ENERGY				
	3		MATERIALS				
	4		LABOR				
	5		CAPITAL				

PRODUCTIVITY MEASUREMENT PROGRAM 9079

FORM 2

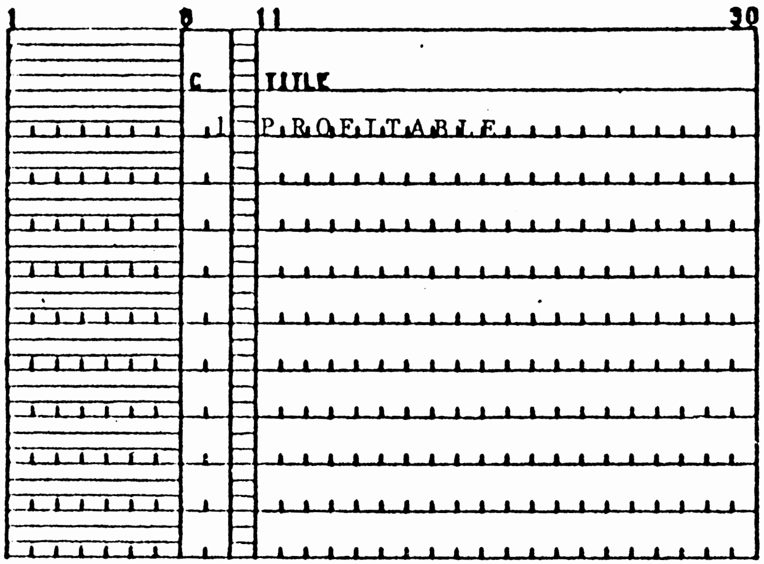
SUBTOTAL CARDS, MAXIMUM OF 50 (Two sheets)

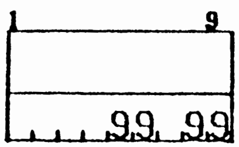
1–5	6	7–10	11–30 TITLE
	1		PRODUCTION REVENUES
	2		ENERGY
	3		MATERIALS
	4		LABOR
	5		CAPITAL

PRODUCTIVITY MEASUREMENT
PROGRAM 9079

FORM 3

SUBORGANIZATION CARDS , MAXIMUM OF 10.





PRODUCTIVITY MEASUREMENT
PROGRAM 9079

FORM 4

B	C	NAME	Base Period VALUE	Base Period QUANTITY	Base Period PRICE	Measured Period VALUE	Measured Period QUANTITY	Measured Period PRICE
1 (col. 1)	3	5	30			54		77
1	1	PRODUCT A	6300	7000		9500	10000	
1	1	PRODUCT B	1100	1000				
1	1	PRODUCT C	4254	5000		3000	3000	
1	1	PRODUCT D			1.25	2765	2000	
2	1	FUEL	6	324		11	4.68	
2	1	ELECTRICITY	97	2771		176		.04
3	1	FEEDSTOCKS	6450	13650		8600	15640	
3	1	OTHER MATERIALS	627		1.0	802		1.125
4	1	HOURLY LABOR	400	50		1036	121.84	
4	1	SALARIED LABOR	626	58.23		806	67.2	
4	1	ENGINEERING	6		1.0	76		1.115
5	1	CASH		10	.3766		11	.3671
5	1	A/R		1031	.3766		1111	.3671
5	1	INVENTORIES		2345	.3766		2676	.3671
5	1	PREPAID AND DEFERRED		4	.3766		9	.3671
5	1	PROPERTY PLANT AND EQUIP		5750	.3766		6431	.3571

1 4

9999 Delete when a continuation of form 4 follows below.

PROFITABLE

PRODUCT OR RESOURCE	REFERENCE VALUE	REFERENCE QUAN.	REFERENCE PRICE	MEASURED VALUE	MEASURED QUAN.	MEASURED PRICE	CHANGE RATIOS VALUE	CHANGE RATIOS QUAN.	CHANGE RATIOS PRICE	DOLLAR VARIANCES VALUE	DOLLAR VARIANCES QUAN.	DOLLAR VARIANCES PRICE
REVENUES												
PRODUCT A	6300.	7000.	0.90	9500.	10000.	0.95	1.508	1.429	1.056	3200.	2700.	500.
PRODUCT B	1100.	1000.	1.10	0.	0.	0.0	0.0	0.0	0.0	-1100.	-1100.	-0.
PRODUCT C	4254.	5000.	0.85	3000.	3000.	1.00	0.705	0.600	1.175	-1254.	-1702.	448.
PRODUCT D	0.	0.	1.25	2765.	2000.	1.38	0.0	0.0	0.0	2765.	2500.	265.
SUBTOTAL REVENUES	11654.			15265.			1.310	1.206	1.086	3611.	2398.	1213.
TOTAL REVENUES	11654.			15265.			1.310	1.206	1.086	3611.	2398.	1213.
ENERGY												
FUEL	6.	3.	1.85	11.	5.	2.35	1.833	1.444	1.269	5.	3.	2.
ELECTRICITY	97.	2771.	0.04	176.	4400.	0.04	1.814	1.588	1.143	79.	57.	22.
SUBTOTAL ENERGY	103.			187.			1.816	1.580	1.149	84.	60.	24.
TOTAL ENERGY	103.			187.			1.816	1.580	1.149	84.	60.	24.
MATERIALS												
FEEDSTOCKS	6450.	13650.	0.47	8600.	15450.	0.56	1.333	1.132	1.178	2150.	851.	1299.
OTHER MATERIALS	722.	722.	1.00	974.	866.	1.13	1.349	1.199	1.125	252.	144.	108.
SUBTOTAL MATERIALS	7172.			9574.			1.335	1.139	1.172	2402.	994.	1408.
TOTAL MATERIALS	7172.			9574.			1.335	1.139	1.172	2402.	994.	1408.
LABOR												
HOURLY LABOR	400.	50.	8.00	1036.	122.	8.50	2.590	2.437	1.063	636.	575.	61.
SALARIED LABOR	626.	58.	10.75	806.	67.	11.99	1.288	1.154	1.116	180.	96.	84.
ENGINEERING	6.	6.	1.00	76.	68.	1.11	12.667	11.360	1.115	70.	62.	8.
SUBTOTAL LABOR	1032.			1918.			1.859	1.711	1.086	886.	733.	153.
TOTAL LABOR	1032.			1918.			1.859	1.711	1.086	886.	733.	153.
CAPITAL												
CASH	4.	10.	0.37	4.	11.	0.35	1.052	1.100	0.957	0.	0.	-0.
A/R	378.	1031.	0.37	389.	1111.	0.35	1.031	1.078	0.957	12.	29.	-18.
INVENTORIES	859.	2345.	0.37	937.	2676.	0.35	1.092	1.141	0.957	79.	121.	-43.
PREPAID AND DEF	1.	4.	0.37	3.	9.	0.35	2.152	2.250	0.957	2.	2.	-0.

PROP. PLANT, & EQUIP	2106.	5750.	0.37	2253.	6431.	0.35	1.070	1.118	0.957	147.	249.	-102.
SUBTOTAL CAPITAL	3347.			3586.			1.071	1.120	0.957	239.	402.	-163.
	--------			--------			-----	-----	-----	--------	--------	--------
TOTAL CAPITAL	3347.			3586.			1.071	1.120	0.957	239.	402.	-163.

PROFITABLE

PRODUCT OR RESOURCE	REFERENCE VALUE	REFERENCE QUAN.	REFERENCE PRICE	MEASURED VALUE	MEASURED QUAN.	MEASURED PRICE	CHANGE RATIOS VALUE	CHANGE RATIOS QUAN.	CHANGE RATIOS PRICE	DOLLAR VARIANCES VALUE	DOLLAR VARIANCES QUAN.	DOLLAR VARIANCES PRICE
SUBTOTAL REVENUES	11654.			15265.			1.310	1.206	1.086	3611.	2398.	1213.
TOTAL REVENUES	11654.			15265.			1.310	1.206	1.086	3611.	2398.	1213.
SUBTOTAL ENERGY	103.			187.			1.816	1.580	1.149	84.	60.	24.
TOTAL ENERGY	103.			187.			1.816	1.580	1.149	84.	60.	24.
SUBTOTAL MATERIALS	7172.			9574.			1.335	1.139	1.172	2402.	994.	1408.
TOTAL MATERIALS	7172.			9574.			1.335	1.139	1.172	2402.	994.	1408.
SUBTOTAL LABOR	1032.			1918.			1.859	1.711	1.086	886.	733.	153.
TOTAL LABOR	1032.			1918.			1.859	1.711	1.086	886.	733.	153.
SUBTOTAL CAPITAL	3347.			3586.			1.071	1.120	0.957	239.	402.	-163.
TOTAL CAPITAL	3347.			3586.			1.071	1.120	0.957	239.	402.	-163.
TOTAL INPUT	11654.			15265.			1.310	1.188	1.103	3611.	2189.	1422.
TOTAL MARGIN	-0.			-0.						-0.	209.	-209.

PROFITABLE

	REFERENCE VALUE	MEASURED VALUE	PERFORMANCE RATIOS: PROFIT-ABILITY	PERFORMANCE RATIOS: PRODUC-TIVITY	PERFORMANCE RATIOS: PRICING RECOVERY	EFFECT ON PROFITS: PROFIT-ABILITY	EFFECT ON PROFITS: PRODUC-TIVITY	EFFECT ON PROFITS: PRICING RECOVERY
SUBTOTAL ENERGY	103.	187.	0.721	0.763	0.945	-52.	-38.	-14.
TOTAL ENERGY	103.	187.	0.721	0.763	0.945	-52.	-38.	-14.
SUBTOTAL MATERIALS	7172.	9574.	0.981	1.059	0.927	-180.	482.	-661.
TOTAL MATERIALS	7172.	9574.	0.981	1.059	0.927	-180.	482.	-661.
SUBTOTAL LABOR	1032.	1918.	0.705	0.705	1.000	-566.	-521.	-45.
TOTAL LABOR	1032.	1918.	0.705	0.705	1.000	-566.	-521.	-45.
SUBTOTAL CAPITAL	3347.	3586.	1.222	1.076	1.136	798.	287.	511.
TOTAL CAPITAL	3347.	3586.	1.222	1.076	1.136	798.	287.	511.
TOTAL INPUT	11654.	15265.	1.000	1.015	0.985	-0.	209.	-209.
OUTPUT EFFECT ON MARGIN						-0.	-0.	-0.
TOTAL MARGIN						-0.	209.	-209.

APPENDIX B

DEFLATOR INDEXES

APPENDIX B

DEFLATORS

Application

Productivity calculations frequently require a means to adjust prices or valuations from one time period to another to provide constant dollar comparisons. Published data which permit this conversion are called deflators, price indexes or cost indexes.

Expression of the various outputs and inputs in constant dollars is a necessary surrogate for quantity in many productivity measurements.

Perhaps the most widely known deflator is the Consumer Price Index. It claims to represent the weighted average price of the contents of an urban wage earners shopping basket in a particular year compared to the price in a base year. But it is known that the contents of that basket for the averge family has changed over time. The Bureau of Labor Statistics (BLS) periodically adjusts its index calculation to account for this change. It also is known that everyone does not fit into the category of "urban wage earner and clerical worker."

This points out the merit of matching the proper deflator to the specific application. Market forces move prices of different commodities at different rates and, at times, even in different directions. Appropriate components of general price indexes must be selected which correspond to the particular items or group of items being deflated.

Another widely publicized index is the Gross National Product (GNP) price deflator. The overall GNP averages individual price movements for the total economy. An inspection of price deflators from 1972 to 1977 shows a wide spread when the first division is made between structures, durable and non-durable goods and services (see chart). A greater variation can be expected when dealing with individual inputs or outputs at the plant level.

Published Indexes

Indexes are complied and published by a number of organizations. Each has specific objectives and purposes. However, all, to a greater or lesser degree, depend on basic data collected by the Bureau of Labor Statistics and published monthly as Wholesale Prices and Price Indexes. Table II lists the major price indexes needed in performance evaluation. Table III shows a list of published price indexes which may be referenced for additional information.

TABLE II

DEFLATOR INDEXES

Adjusted to 1979 Year Average Base

		GNP DEFLATOR	PRODUCER PRICE INDEX	PRODUCER PRICE INDEX INDUSTRIAL COMMODITIES	CONSTRUCTION COST INDEX FOR THE PETROLEUM INDUSTRY	WAGE COST GUIDELINES FOR THE PETROLEUM INDUSTRY
1979	1st Quarter	.968	.950	.942	.968	.973
	2nd Quarter	.990	.984	.979	.988	.991
	3rd Quarter	1.010	1.015	1.019	1.010	1.009
	4th Quarter	1.032	1.050	1.062	1.034	1.027
	Annual Average	1.000	1.000	1.000	1.000	1.000
% Increase from Prior Year		8.8%	12.6%	12.9%	9.3%	7.5%
1980	1st Quarter	1.054	1.099	1.120	1.085	1.098
	2nd Quarter	1.081	1.120	1.149	1.121	1.107
	3rd Quarter	1.100	1.158	1.188	1.153	1.123
	4th Quarter	1.125	1.190	1.224	1.178	1.131
	Annual Average	1.090	1.140	1.170	1.135	1.115
% Increase from Prior Year		9.0%	14.0%	17.0%	13.5%	11.5%
1981	1st Quarter	1.150	1.222	1.256	1.213	1.205
	2nd Quarter	1.177	1.256	1.296	1.250	1.229
	3rd Quarter	1.200	1.296	1.345	1.285	1.244
	4th Quarter	1.225	1.336	1.394	1.313	1.252
	Annual Average	1.188	1.277	1.323	1.266	1.232
% Increase from Prior Year		9.0%	12.0%	13.0%	11.5%	10.5%
1982 Estimated Increase		8.6%	11.0%	11.7%	10.7%	10.0%

TABLE III
Published Price Indexes

Index	Frequency	Source Publication	Base Year
GNP Price Deflators (Dept. of Commerce)	Quarterly	Survey of Current Business	1972
BLS Wholesale Price Index	Monthly	Wholesale Prices & Price Indexes (BLS)	Varies
BLS Industry Price Index			
Engineering News-Record Construction Index	Monthly	Engineering News Record	1913
Engineering News-Record Building	Monthly	Engineering News Record	1913
Nelson Refinery Inflation Index	Monthly	Oil and Gas Journal	1946
Nelson Equal Capability Refinery Index	Quarterly	Oil and Gas Journal	1946
Chemical Engineering Plant Cost Index	Monthly	Chemical Engineering	1957-59
Marshall and Swift Equipment Cost Index	Quarterly	Chemical Engineering	1926

Department of Commerce Deflators

The Bureau of Economic Analysis of the Department of Commerce publishes a series of deflators relating to the gross national product and its various components. The deflators are calculated on a quarterly or annual basis and appear regularly in Survey of Current Business. The magazine is published monthly by the Supt. of Documents, U.S. Printing Office, Washington, D.C. 20402.

GNP deflators were initially assembled for use at the macroeconomic level to gauge the real growth of the economy as a whole. Consequently, these deflators represent large aggregates of output which mask or level price movements of specific product output or factors of production. Escalated use of national income and product account statistics for analysis and guides for economic policy decisions has pushed development of finer detail or subdivisions of accounts. Deflators for these subaccounts may be useful in some cases for industry or firm productivity measurement. However, an elementary understanding of the national income and product accounts appear necessary to make a judicious choice for proper application.

Three types of price deflators are calculated for GNP accounts. The published values of each type can be significantly different. The implicit price deflator is the most widely quoted. Definitions are as follows:

Implicit price deflator - a weighted average of the detailed price indexes used in the deflation of GNP. In each period, the weights are based on the compostion of constant - dollar output in that period. Changes in the implicit price deflator reflect both changes in prices and changes in composition of output.

Fixed - weighted price index - weights the composition of output in 1972. Accordingly, comparison over any time span reflects only changes in prices.

Chain price index	- weights the composition of output in the prior period and, therefore, reflects only the change in prices between the two periods. However, comparison of percent changes in the chain index also reflects changes in the composition of output.

Bureau of Labor Statistics Indexes

The Bureau of Labor Statistics of the Department of Labor publishes two index series of interest to productivity measurement. Wholesale Prices and Price Indexes is published monthly by the Supt. of Documents, U.S. Printing Office, Washington, DC. 20402 ($16 per year). Each year (October) a Supplement is published which tabulates all indexes by month and the average for the prior year. Any changes in commodities, specification or procedures are also tabulated.

The Bureau of Labor Statistics also computes and publishes consumer Price Indexes. These indexes are widely publicized and the general public is aware of the trends even if they don't understand the technical details of its makeup. They are published monthly in CPI Detail Report. The magazine is available from the Supt. of Documents. ($9 per year).

All BLS indexes are widely copied and reported in other publications. Since the indexes are of great current interest, BLS first releases the general results through a press release or through the BLS publication News.

The Bureau of Labor Statistics regularly publishes prices and price indexes on nearly 2800 farm and industrial commodities in 15 major groups. Wholesale prices cover large-quantity sales by producers to wholesalers, jobbers or distributors, The Wholesale Price Index (WPI) was first published in 1902 and is the oldest statistical series reported by BLS with data starting in 1890.

The WPI has been used in many ways:

- o general economic indicator
- o contract -contract escalator
- o aid to buyers and sellers
- o budget making

- o construction planning
- o inventory appraisal
- o replication cost estimates

Most price data is collected monthly by a mail questionnaire, generally from the producing company. Every effort is made to get true transaction prices with all discounts and rebates deducted. Prices are reported for the Tuesday of the week containing the 13th day of the month.

The WPI is calculated according to modified Laspeyres formula with a standard base 1967 = 100. Specification revisions or introduction of new items or commoditites require indexes with a base year after 1967. This applies to many items.

The widespread use of the Wholesale Price Index prompted the Council on Wage and Price Stability to support a general evaluation its appropriateness and adequacy. The Council report, The Wholesale Price Index: Review and Evaulation, was critical of the classification and weighting systems, sampling, reliability and validity of the index. BLS is responding with revisions. It is difficult for the layman to evaluate the seriousness of the critique. Any business dependent on the quality of the WPI is referred to the original report.

This series provides indexes for input or output from selected industries. The basic data comes from the Wholesale Price Index with a sample of commodities weighted according to the production of the industry. Industries are defined by the Standard Industrial Classification (SIC) system.

Indexes are published for selected five-digit product classes and four-digit industries. Coverage has been expanded slowly since the 1950's. For the period 1957-64, 44 manufacturing and eight mineral industries were covered. By 1975, 160 four-digit industries and 453 five-digit product classes were covered. Weights for output indexes are the 1972 value of shipments obtained from the Census of Manufactures, Census of Mineral Industries and Dept. of Agriculture Data.

The three major uses of the Consumer Price Index are:

- index of inflation
- deflator of other economic series (e.g. retail sales, earnings and personal consumption expenditures)
- escalator of income payments

The index may have limited application to firm productivity, but a knowledge of its development is important simply because it is so widely quoted. It is used to deflate current wage earnings to constant dollar or real earnings.

The index attemps to represent the price change for everything people buy for day-to-day. The "market basket" or quantities of these goods and services are kept constant except at times of weight revisions. Price change is measured by repricing the "market basket" at regular time intervals and comparing the aggregate costs with the base period. The weighting of the major expenditure groups has been adjusted about every decade based on extensive surveys.

Building Construction Indexes

Construction cost indexes for buildings are available from a number of sources. The Dept. of Commerce publishes the following indexes in Survey of Current Business:

- Dept. of Commerce Composite
- American Appraisal Co.
- Boeckh
- Engineering News - Record

Building construction covers a spectrum of applications, including private residences, apartments, factory buildings, hotels, and office buildings. Cost indexes vary with the application, so choice of indexes can be very important.

Engineering News - Record

The ENR Construction Cost Index, created in 1921, is one of the earliest indexes. The index assumed that construction costs would follow a simple combination of common labor and materials:

200 hours common labor, 20 cities average
25 cwt structual steel shapes, mill price
1.128 tons Portland cement, 20 cities average
1.088 M bfm 2x4 s4s lumber, 20 cities average

The value of this list was $100 in 1913, the base year of the index.

In the 1930's it was recognized that fringe benefits for common labor was rising much faster than for skilled labor. The Building Cost Index was introduced in 1938 but also has a base of 1913 = 100.

68.38 hour skilled labor, 20 cities average
25 cwt structural steel shapes, mill price
1.128 tons Portland cement, 20 cities average
1.088 M bfm 2x4 s4s, 20 cities average

These indexes give a reproduction or replication cost since no effort is made to account for advanced technology or productivity. The indexes are published regularly in Engineering News - Record. Table IV shows the indexes for building and construction.

TABLE IV

Engineering News-Record Cost Indexes

1913 = 100

Year	Building	Construction	Year	Building	Construction
1911	-	93	1946	262	346
1912	-	91	1947	313	413
1913	100	100	1948	345	461
1914	92	89	1949	352	477
1915	95	93	1950	375	510
1916	131	130	1951	401	543
1917	167	181	1952	416	569
1918	159	189	1953	431	600
1919	159	198	1954	446	628
1920	207	251	1955	469	660
1921	166	202	1956	491	692
1922	155	174	1957	509	724
1923	186	214	1958	525	759
1924	186	215	1959	548	-
1925	183	207	1960	559	824
1926	185	208	1961	568	847
1927	186	206	1962	580	872
1928	188	207	1963	594	901
1929	191	207	1964	612	936
1930	185	203	1965	627	971
1931	168	181	1966	650	1019
1932	141	157	1967	672	1070
1933	148	170	1968	721	1155
1934	167	198	1969	790	1269
1935	166	196	1970	836	1386
1936	172	206	1971	948	1581
1937	196	235	1972	1048	1753
1938	197	236	1973	1138	1895
1939	197	236	1974	1204	2020
1940	203	242	1975	1306	2212
1941	211	258	1976	1425	2401
1942	222	276	1977	1544	2577
1943	229	290	1978	1740	2877
1944	235	299	1979	1898	3129
1945	239	308			

Petroleum Refinery Cost Indexes

W. L. Nelson, a petroleum consultant, developed many cost indexes specificly for petroleum refineries. The indexes cover both operating costs and construction costs. The operating indexes include fuel and catalysts which can be used for inventory adjustments. The most widely used, however, relate to refinery construction. All Nelson cost indices are published regularly in the Oil and Gas Journal.

Construction cost indexes have evolved over the years since the first data was published in 1949. The evolution accounted for technology improvements, design innovation, construction productivity, economy-of-scale and increased complexity. W. L. Nelson identified three types of indexes.

Index Characteristic	Nelson Index
Constant capacity, constant design and labor/ materials	Infaltion
Increasing capacity, increasing complexity	True cost
Constant capacity, constant complexity	Equal capability

For captial productivity calculations, the Nelson Inflation Index is usually selected. This index replicates the existing plant with the same design and, therefore, the same operating, maintenance and utility requirements. The Nelson Equal Capability index gives an estimate of replacement cost which is lower than the replication cost because of technical and managerial innovations accumulated since the original installation date.

Chemical Engineering Plant Cost Index

The Chemical Engineering Plant Cost Index was introduced in 1963 to an index tailored to this particular industry. Indexes are reported for four major components, seven equipment sub-components and the overall plant cost.

The indexes start with 1947, but the base year is 1957-59 = 100. The largest source of data for calculation of the index is the BLS Wholesale Price Indexes and wage and salary surveys.

VITA

Dennis Lynn Burns

Candidate for the Degree of

Master of Business Administration

Report: TOTAL PERFORMANCE MEASUREMENT
CASE APPLICATION: PHILLIPS PETROLEUM COMPANY

Major Field: Business Administration

Biographical:

Personal Data: Born in Elk City, Oklahoma September 10, 1952, the son of John and Violet Burns

Education: Graduated from Salisaw High School, Sallisaw, Oklahoma, May, 1979, received the Bachelor of Science degree from Oklahoma State University with a major in Industrial Engineering, December, 1973; received the Masters degree from Oklahoma State University with a major in Industrial Engineering, December, 1974; completed, requirements for the Master of Business Administration degree at Oklahoma State University, December, 1980.

Professional Experience: Manufacturing Engineer, Lowrance Electronics, Tulsa, Oklahoma, 1974; Cost Estimating Engineer, Phillips Petroleum Company, Bartlesville, Oklahoma, 1975 - 1978; Senior Operations Analysis, and Control Specialist, Phillips Petroleum Company, Bartlesville, Oklahoma, 1979 - 1980.