A DSS ON PRODUCTIVITY MEASUREMENT, EVALUATION AND IMPROVEMENT

by

SİBEL COŞKUNER

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A DSS ON PRODUCTIVITY
MEASUREMENT, EVALUATION AND IMPROVEMENT

APPROVED BY

Prof.Dr.İbrahim Kavrakoğlu ______________________
(Thesis Supervisor)

Doç.Dr.M.Akif Eyler ______________________

Prof.Dr.Özer Ertuna ______________________

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*To the memory of my father; Akif Coşkuner
without whose encouragement this work
could never have been accomplished.*

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ABSTRACT

Organizations have control systems for behaviors, costs, prices, information, decisions, financial performance, production, quality and so forth. We can classify them with respect of the type of "organizational system performance" they are attempting to control or manage. Productivity being an important component of organizational system performance measures, although much attention has been paid to productivity, is still one of the most confusing concepts of the management area.

This thesis covers a systematic approach for productivity measurement, evaluation and improvement; analyzing profitability as a function of productivity and price recovery. Selected methodology for productivity measurement is tested on an existing company in the Glass Industry.

An interactive package is designed as a Decision Support System for managers who are not accustomed to use computers, and they are allowed to make scenerio analysis for future applications.

ÖZET

Organizasyonlar; maliyetler, fiatlar, kararlar, davranışlar, üretim, kalite ve finansal performans için kontrol sistemleri kurarlar. Bunlara "organizasyonal sistem performans ölçümleri" denir. Üretkenlik bu organizasyonal sistem performans ölçümlerinin önemli bir birimidir ve taşıdığı öneme rağmen işletme konularında karışık bir kavram olarak kalmıştır.

Bu tez üretkenlik ölçümü, değerlendirmesi ve geliştirmesi konusunda; kârlılık, üretkenlik ve fiat artışı ilişkisi kurarak sistematik bir yaklaşım izlemiştir. Seçilen method Cam Endüstrisinde uygulanmıştır.

Etkileşimli bir paket program, yöneticiler için karar destek sistemi olarak hazırlanmıştır. Yöneticiler bu paket yardımı ile gelecek dönemler için senaryo analizleri yapabileceklerdir.

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I. INTRODUCTION

1.1. Basic Concepts and Definitions

Organizations have control systems for behaviors, costs, prices, information, decisions, financial performance, production, quality and so forth. We can classify control systems with respect to the resource they are supposed to manage (eg. financial control systems, production control systems, and behavioral control systems) or we can clasify them with respect to the type of "organizational system performance" they are attempting to control or manage. In general, there are at least seven distinct "organizational system performance" measures:

1. Effectiveness
2. Efficiency
3. Quality
4. Profitability
5. Productivity
6. Quality of Work life
7. Innovation

Let's now examine each of these measures in more detail.

Effectiveness: It is the degree to which the "right" things are completed. The following criteria need to be used to evaluate the degree of effectiveness.

1. Quality: Did we do the "right" things according to predetermined specifications?
2. Quantity: Did we get all of the "right" things done?
3. Timeliness: Did we get the "right" things done on time?

The goals, objectives, activities are set and we work toward them. To measure effectiveness, we compare what we intended to accomplish against what we actually accomplished. Effectiveness is therefore an "output" or "accomplishment" issue.

Efficiency: It is the degree to which the system utilized the "right" things. Efficiency can be represented by the following equation:

$$\frac{\text{Resources expected to be consumed}}{\text{Resources actually consumed}}$$

We utilize budgets, standards, estimates, forecasts, projections and so forth to develop quantitative expressions for the numerator, and accounting systems, records, estimates and so forth to develop quantitative expressions for the denominator of the equation. Efficiencey is therefore a measure of organizational system's performance that is related to the input side.

Quality: It is the degree to which the system conforms to requirements, specifications, or expectations. Key-quality related questions are: Was the product built or delivered the way it was intended or required? Is the customer satisfied with the good and/or service? Will the good or service do what it was intended to do? and so forth.

Profitability: It is the relationship between total revenues and total costs.

Quality of Work Life: It is the way participants in a system respond to sociotechnical aspects of that system. People's psychological reactions to working in an organization are the factors affecting performance.

Innovation: It can be defined as applied creativity. It is the process by which we come up with new, better, more functional products and services. An organization that does not innovate in product, service and process will likely not be able to compete for the long run.

Productivity: It is a relationship between quantities of output produced by a given organizational system and quantities of inputs utilized by that organizational system to produce those same outputs.

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

Input variable is any controlable factor or resource eg. materials energy, capital, labor.

Output variable is any controlable factor or resource that result from a transformation of the input variable (Fig.1.1).

Productivity is connected with the other organizational system performance measures. All these seven measures are highly interrelated with each other.

The next step is to analyze what productivity is. Productivity appears to be a concept capturizing the attention of managers in all types of organizations and at all levels within those organizations. However it is still a very confused term. Following questions will help to define productivity;

- Is productivity equal to performance?
  No, productivity is not equal to performance, it is a component of a performance measure.

- Can productivity be measured in all organizations?
  Yes, in both service and manufacturing industries productivity can be measured, usually with considerable success.

- Is productivity a critical component of the organizational systems performance?

  If the answer is "yes" to the following questions, then productivity is a critical component.

  (1) Would productivity relationships give you new insights into the performance of your organization?
  (2) Could productivity relationships improve the diagnostic face of management and help to see where management interventions are required?

Inputs such as; labor, materials, energy, capital and other are transformed into outputs; goods and services. Productivity is the relationship between outputs and inputs. In otherwords, productivity measures effectiveness in the numerator, and efficiency in the denominator.

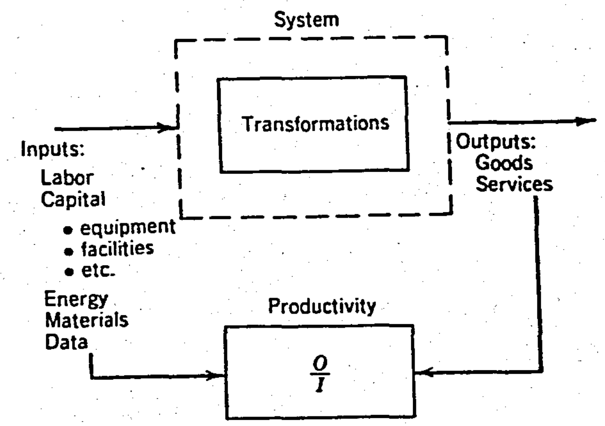

Figure 1.1. General Productivity Concept

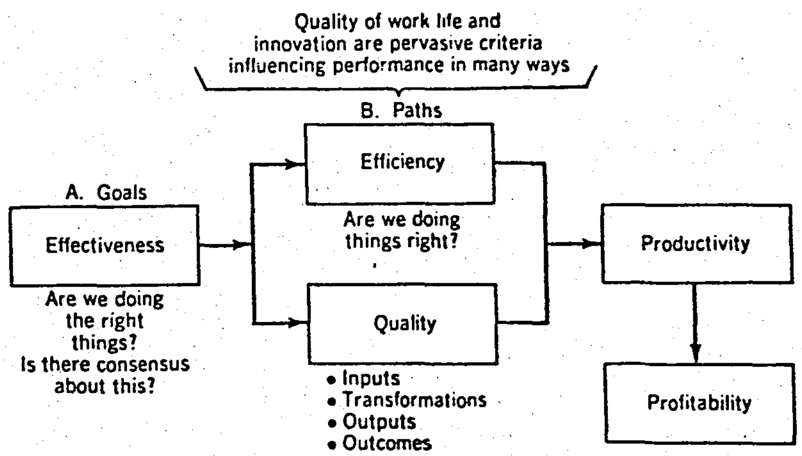

Figure 1.2. Interrelationships of Seven Performance Criteria

Productiviy increase or decrease makes significant effects on prices, market and sales power, profitability, and people. The following figure gives the effects of increasing and decreasing productivity.

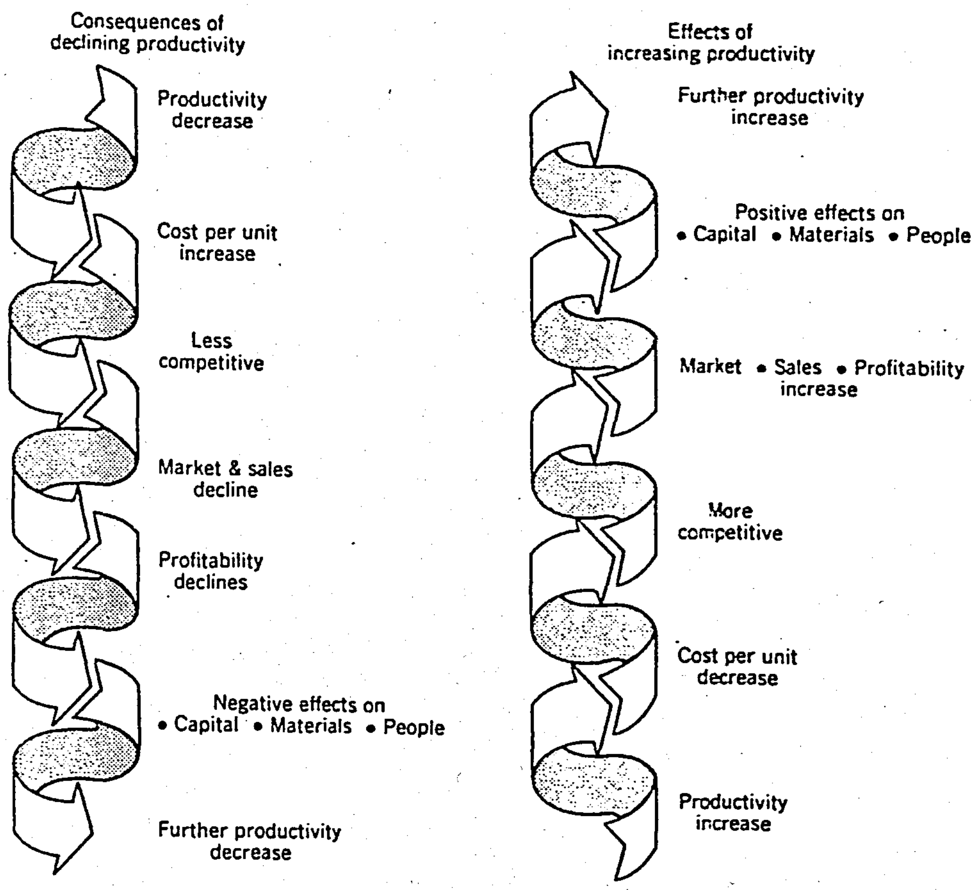

Figure 1.3. Effects of Increasing and Decreasing Productivity

In general there are two basic categories of pure productivity measures:

a) Static Productivity Ratios - simply a measure of output divided by input for a given period of time, in other words it is a "snapshot" of a particular period of time.

b) Dynamic Productivity Ratios - a measure of a given static productivity ratio at one point in time divided by the same ratio at some previous period in time. A dimensionless index is obtained which reflects the change in productivity from one period to the next.

There are: also three types of productivity measures within each category:

a) Partial factor measure - only one class of input is captured
b) Multi factor measure - more than one class of input is captured
c) Total factor measure - all classes of inputs are captured

TABLE 1.1. Examples of Productivity Measures

TOTAL	$\frac{\text{Total outputs}}{\text{Total inputs}}$,	$\frac{\text{All Goods and Services Produced}}{\text{All Resources Utilized}}$		
MULTI	$\frac{\text{Output}}{\text{Labor, Materials, Energy}}$,	$\frac{\text{Output}}{\text{Labor, Materials, Capital}}$		
PARTIAL	$\frac{\text{Output}}{\text{Labor}}$,	$\frac{\text{Output}}{\text{Materials}}$,	$\frac{\text{Output}}{\text{Energy}}$,	$\frac{\text{Output}}{\text{Capital}}$

Once a productivity measurement system is developed, the system can be operationalized and standards can be generated. That is the ratios and/or indexes can be implemented.

Standards can be generated by using the following methods:

I. Economic, accounting based, absolute measurement systems
   a. Estimation
   b. Engineering Approach
   c. Comparison; previous period or historical

II. Normative, participative, relative measurement systems (NPMM)

Actual performance is evaluated against standards and appropriate management actions range from doing nothing to immediate intervention are set in motion.

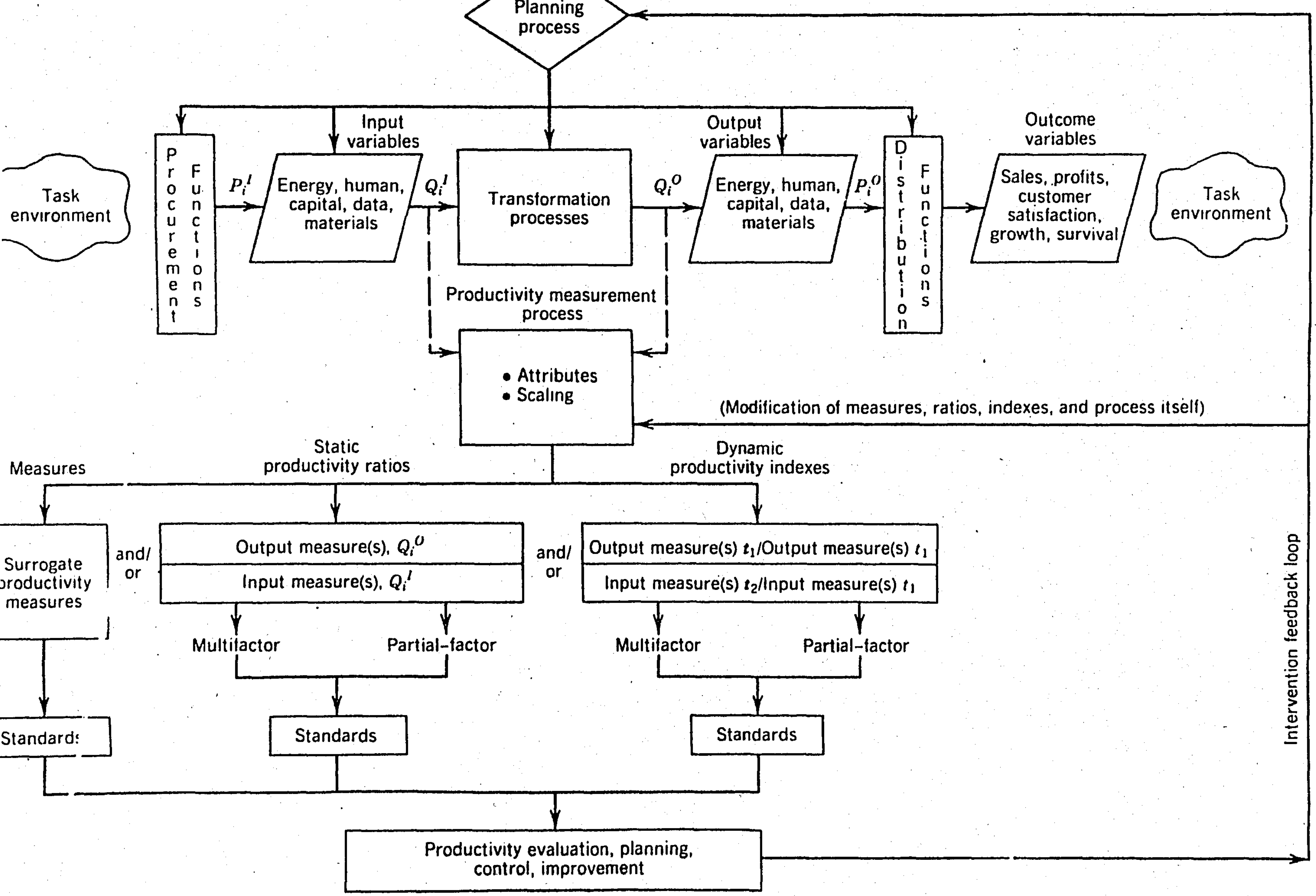

Figure 1.4. The Basic Productiviy Management Process

NPMM is an action-research, involvement-participative, organizational, development oriented approach to productivity measurement. The comments, assumptions, premises or statements laid much of the foundation for the research of NPMM. Nominal Group Technique (NGT) is a kind of NPMM which is a special-purpose technique useful for situations where individual judgements must be tapped and combined to arrive at decisions that cannot be reached by one person. Since NGT is not itself a program but a participative data collection and consensus-forming device, it can be an important component of participative, group-oriented programs. It is because of its participative character, appropriate primarily for smaller units of analysis, such as the work group and the department. If sampled representation, delphi technique, coupling of the various measurement systems were used, these approaches could also be utilized for larger units of analysis eg. Many organizations substitute other performance attributes for actual output and input measures. These substitutes are called "surrogate measures" (sales/operating costs≡Profitability, Earned Hours/Actual Hours≡Efficiency, Jobs Completed/Jobs Scheduled≡Effectiveness). Advantages of NPMM are shared commitment, understanding, higher probability of successful implementation and positive behavior change.

The economic, accounting-based, absolute measurement systems are based on the premise thet profitability is a function of productivity and price recovery, that is an organization can generate profit growth from productivity improvement and/or price recovery.

Two famous approaches in that area are Sumanth's Total Productivity Factor (TPF) and Sink's Multifactor productivity measurement model (MFPMM). Sumanth measures productivity for each type of input and output, whereas sink measures productivity for each type of input as an aggregation of outputs.

Ratio of Output Quantity x Ratio of Output Price = Ratio of Revenue

$$\frac{\sum_{i=1}^{n} \left[Q_{i\ period_2}\right]}{\sum_{i=1}^{n} \left[Q_{i\ period_1}\right]} \times \frac{P_{i\ period_2}}{P_{i\ period_1}} = \frac{TR_{period_2}}{TR_{period_1}}$$

$$\frac{\sum_{i=1}^{n} \left[Q_{i\ period_2}\right]}{\sum_{i=1}^{n} \left[Q_{i\ period_1}\right]} \times \frac{P_{i\ period_2}}{P_{i\ period_1}} = \frac{TC_{period_2}}{TC_{period_1}}$$

Ratio of Resource Quantity x Ratio of Resource Costs = Ratio of Costs

Column 1 x Column 2 = Column 3

"Productivity" x "price recovery" = "Profitability"

Figure 1.5. Productivity, Price Recovery, Profitability Relationship

Changes in productivity consist of at least two distinct and often controllable factors: changes in capacity utilization, changes in efficiency (reflects a combination of factors such as product mix, employee satisfaction, sales volume, quality of raw material). Changes in price recovery are largely a function of the market place (uncontrollable element of the organization's performance). An organization can be profitable, without being productive, but not over a long term.

Revenues and costs do not always present a complete picture because of underlying complex relationships between controllable and uncontrollable factors. The net profit figure alone is an inadequate basis for judgement as to whether industrial operations are being carried out efficiently and labor and materials utilized effectively. With essentially the same basic accounting information used to calculate revenues and costs, however it is possible to use the MFPMM to gain additional and significantly more detailed insight into what is driving profits. If other factors are held constant, namely prices and costs, a positive change in the productivity index will cause or translate into a positive change in profits. Similarly if quantities are held constant and price recovery index is positive (output prices increase at a faster rate than resource costs), then profits, at least in the short run, will be positive.

After "obtaining output and input quantities and prices for class-type-level categories either by estimation or actual data MFPMM will be used.

By engineering and estimation approaches, total factor, partial factor and multi factor productivity can also be measured total sales and total expenses for several time periods in the past are used as estimates of (total) output and (total) input values respectively by using regression or time series analysis methods. Linear programming is another method used in the estimation of optimal (total) output and (total) inputs values.

MFPMM provides following advantages:

1. Obtains an overall, integrated measure of productivity for the firm
2. Provides an analytical audit of the past performance
3. Provides budget control of current performance
4. Assesses and evaluates bottom-line impact on profitability, as a result of productivity shifts.
5. Tracks the results of specific productivity improvement efforts, such as quality cricles, quality control, incentive systems, technological innovation
6. Provides common price financial statements
7. Assists with setting productivity objectives and general strategic planning with regard to capacity utilization,

marketing efforts, cost management, staffing, quality management, pricing strategies.

Incase of product variety and multiplicity of various resources utilized, TL (money value) is a convenient common denominator, eg. person-hours cannot be combined with tons of sand, TL of capital, kilowatthours of electricity and so forth for a resource total. However, TL in the current economic period is a variable standard. Therefore a "revaluing", "devaluing" or "indexing" mechanism is required. The MFPMM selects a base period for the model and "automatically" indexing prices and costs back to that period. The analysis simply partials out or removes the influence in price and cost changes from the base period to the current period. When these two values are compared for the base period, we establish a productivity ratio. An organization's financial performance is a result of interactions of a wide variety of controllable and uncontrollable factors.

Typical uncontrollable factors are:

a. Economic environment
b. Industry/Market growth or decline
c. Resource prices (costs) in an inflationary period
d. Budget allocation
e. Organizational processes and procedures

Typical controllable factors are:

a. Technological innovation
b. Resource substitutions
c. Training and motivation of employees
d. Resource quality
e. Asset redeployment

The MFPMM makes it possible to measure explicitly in terms of TL, the profit impacts of the uncontrollable as well as controllable factors and to determine and analyze how various managerial strategies could increase or decrease profitability, with its relationship to productivity and price recovery. It is in contrast to NPMM, consultative, significantly less involvement, participative oriented database/accounting system oriented (primary source of data is not people but system documentation), top-down as opposed to bottom-up in character. More restrictive interms of operationalizations of the definitions of productivity. Diagnostic in a passive, absolute and objective sense, providing a highly developed DSS. Each approach; NPMM and MFPMM has its own individual benefits, costs and risks.

1.2. Prevailing Approaches

Prevailing approaches to productivity can be categorized as follows:

I. Economic, Accounting Based, Absolute Measurement Systems

a. Estimation: Regression or time series analysis are used to estimate output and input values to provide a basis for partial factor, multi-factor and total factor productivity measurement. Sumanth, Yavuz(17)(*).

b. Engineered Approach: Linear programming is used to estimate optimal output and input values to provide a basis for partial factor, multi-factor and total factor productivity measurement. Econometric models are also used to estimate output and input values to be used as a basis of productivity measurement techniques Sumanth, Yavuz(18), Doğramacı(3,4).

By Productivity-Cost-Profitability Model: Three levels of measurement are integrated the network of productivity relationships, the structure of cost relationships and the managerial control ratios.

c. Comparison, Previous Period or Historical: Actual output and input values for different periods are used for comparison purposes, by calculating partial factor, multi-factor and total factor productivity

(*) Numbers enclosed in brackets refer to the references at the end.

values. Sink(8), Miller(7) MFPMM and Sumanth(16), Craig(2), Taylor(21) Total and partial factor productivity measurement model.

II. <u>Normative, Participative, Relative Measurement Systems</u>

Nominal Group Technique (NGT) is a participative data collection and consensus-forming technique, where individual judgements must be tapped and combined to arrive at decisions that cannot be reached by one person, Sink(12). In the place of (normal actual output and input measures other performance attributes are substituted. It is called "surrogate measures" Stewart(14). By sampled representation or delphi technique these approaches can be used for larger units of analysis, Sink(13).

II. THEORETICAL ISSUES

2.1. Productivity Measurement Using a Product-Oriented Total Factor Model

Sumanth (1979, 1984) has developed a total productivity model based on work done by Kendrich and Creamer (1965), Craig and Harris (1973) and Hines (1976). This model relates total outputs and inputs, incorporating product orientation (Fig.2.1.1). The actual computations in Sumanth's model are quite similar to Sink's MFPMM calculations. Productivity indexes are calculated by product and then a weighted total is made for each product (Fig.2.1.2). All MFPMM results by product are then combined to provide a firm-level evaluation of total factor productivity (Fig.2.1.3).

$$\text{Sumanth's TPF} = \sum_{i=1}^{n} (w_i . w_{ij}) PP_{ij} \Rightarrow$$ measures productivity for each type of output and input

$$w_i = \frac{\text{Input}_i}{\text{Total Inputs}}$$

i=product types; domestic, exports, etc.
j=input types; labor, materials, etc.

$$w_{ij} = \frac{\text{Input}_{ij}}{\text{Input}_i}$$

$$PP_{ij} = \frac{\text{Output}_i}{\text{Input}_{ij}}$$

$$\text{Sink's TPF} = w_j . PP_j \Rightarrow$$ measures productivity for each type of input as an aggregation of outputs.

$$w_j = \frac{\text{Input}_j}{\text{Total Inputs}} \qquad PP_j = \frac{\text{Total Outputs}}{\text{Input}_j}$$

Sumanth also develops a break-even concept of total productivity. He relates profits to productivity in an analogous fashion similar to the MFPMM does when it calculates effects on profits. For detailed formulas about Sumanth's TPF refer to Appendix A.

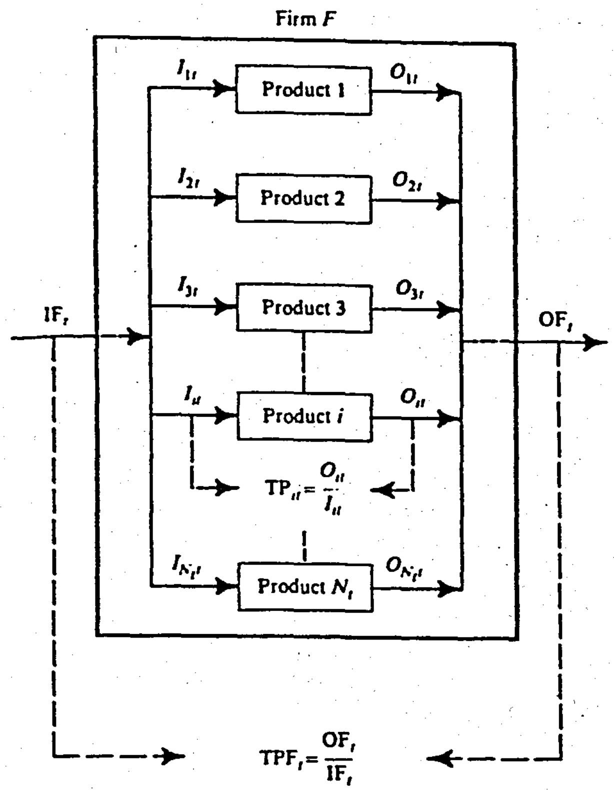

Figure 2.1.1. Total Productivity Model (TPM) for a firm and its individual products in time period t.

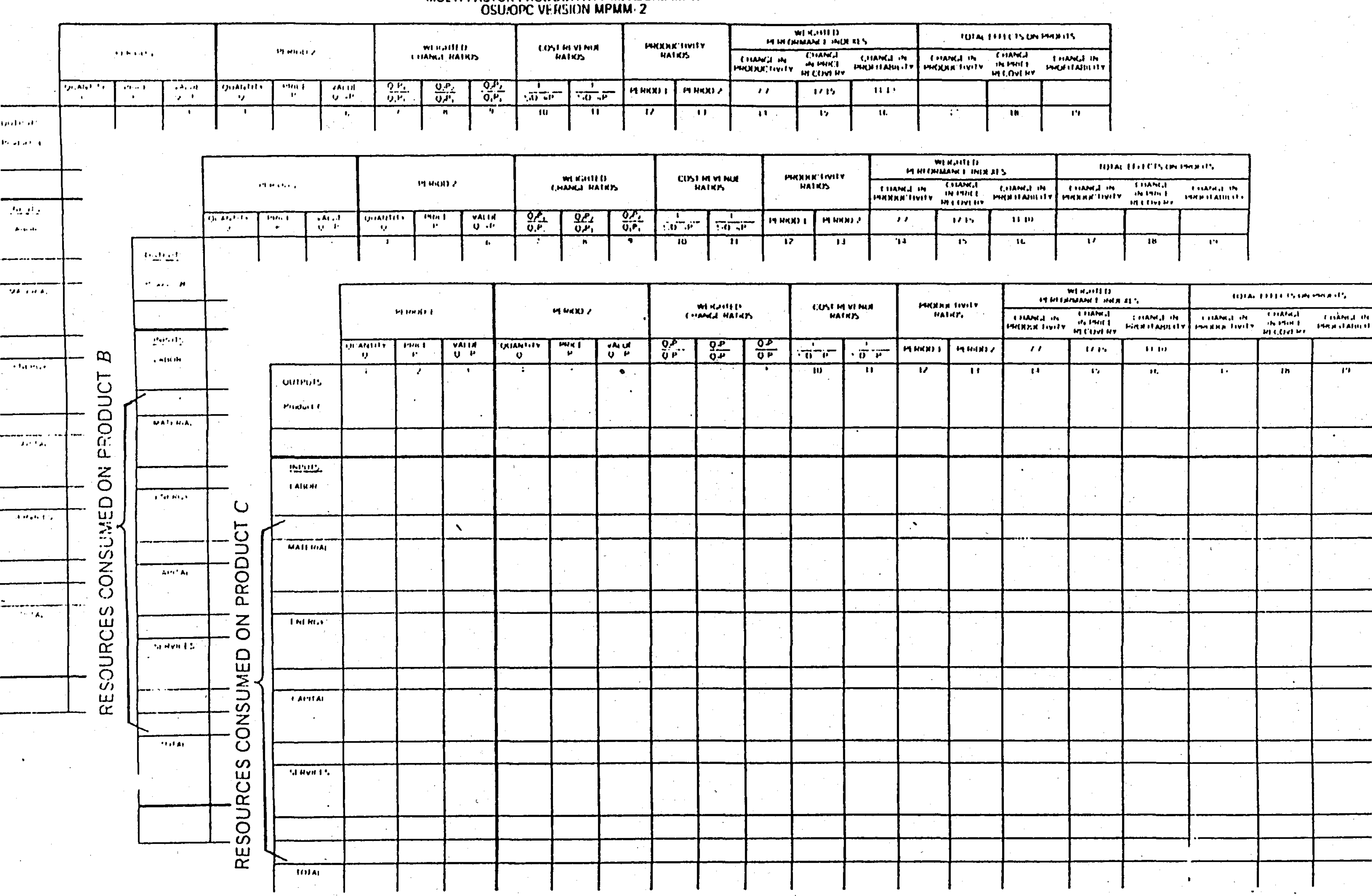

Figure 2.1.2. Product Orientation of MFPMM

BY PRODUCT

MULTI FACTOR PRODUCTIVITY MEASUREMENT
OSU/OPC VERSION MPMM -2

	PERIOD 1			PERIOD 2			WEIGHTED CHANGE RATIOS			COST REVENUE RATIOS		PRODUCTIVITY RATIOS		WEIGHTED PERFORMANCE INDICES			TOTAL EFFECTS ON PROFITS		
														CHANGE IN PRODUCTIVITY	CHANGE IN PRICE RECOVERY	CHANGE IN PROFITABILITY	CHANGE IN PRODUCTIVITY	CHANGE IN PRICE RECOVERY	CHANGE IN PROFITABILITY
	QUANTITY Q	PRICE P	VALUE [illegible]	QUANTITY Q	PRICE P	VALUE [illegible]	$\frac{Q_2P_1}{Q_1P_1}$	$\frac{Q_2P_2}{Q_1P_1}$	$\frac{Q_2P_2}{Q_1P_1}$	[illegible]	[illegible]	PERIOD 1	PERIOD 2	[illegible]	[illegible]	[illegible]			
	1		[illegible]	[illegible]	[illegible]	6	7	8	9	10	11	12	13	14	15	16	[illegible]	[illegible]	[illegible]
OUTPUTS Product 1 Product N Product [illegible]																			
INPUTS LABOR																			
MATERIAL																			
ENERGY																			
CAPITAL																			
OTHERS																			
TOTAL																			

Figure 2.1.3. Multifactor Productivity Measurement Model by Product

2.2. Multifactor Productivity Measurement Model

Figure 2.1.2. depicts the format for the MFPMM. The easiest way to describe the model is to work through the format, moving from left to right from column 1 to column 19.

Column 1-6

The first 6 columns of MFPMM are input data, Column 1 represents quantities of outputs the organizational system produced (not sold) and quantities of input resources consumed in order to produce those outputs for period 1 (base period). Base period is the period that normal operating conditions are achieved for an organization. In otherwards base period is a representative period in time against which a current period performance is compared. Another parameter to be determined prior to application of this model is the length of the analysis period. Depending on decision-maker needs and interests, data availability, product cycle time, and so forth, the length might be almost any period of time (weekly, monthly, quarterly, semiannually, annually). When determining the length of period, data collection requirements should be kept in mind. The goal is to match outputs produced during a given period to the input resources utilized during the same period in time.

So Column 1: Represent quantities of outputs produced during the base period and quantities of inputs utilized to produce those outputs during the same base period. The categorization of outputs and inputs by class-type-level hierarchy is a decision that can be made by the analyst or the decision maker(s) or the user(s) of the model. Since the model is computerized, it can handle, depending on how it is programmed, almost any number of rows.

Column 2: Represents the unit price for outputs and unit cost for inputs during period 1 (base period). Since the analyst or the user of the model can define the unit of measurement to be utilized for each output and input, the unit price and cost is also controllable. For instance, labor cost can reflect base salary, or wage rate plus bonuses or benefit calculation. The only requirement is that unit cost remain consistent with the units of quantity.

Column 3: Reflects the value (quantity x price) for each row element (outputs and inputs). In otherwords Column 3 shows revenues for outputs and costs for inputs. Column 3 is calculated automatically in the programmed version of this model.

Columns 4-6: are the same as Column 1-3, except that the data inputted is for period 2 (current period). Column 4 represents quantities of outputs produced, and quantities of input resources consumed producing those outputs in period 2.

Columns 5: represents the unit price for outputs and unit cost for inputs during period 2.

Column 6 is simply column 4 x Column 5.

Columns 7-9

The next 3 columns in the MFPMM are titled as "Weighted Change Ratios". The following indexing methods are generally used to calculate "Weighted Change Ratios".

1. Laspeyrex Index: Uses base year prices as weight.
2. Paasche Index : Uses currentyear prices as weight.
3. Edgeworth Index: Uses arithmetic means of the base and current year prices as weight
4. Fabricent Index: Uses geometric means of the base and current year prices as weight.

Sink in his MFPMM utilizes Laspeyres Index in the calculation of price weighted quantity changes and Paasche Index in the calculation of quantity weighted price changes. Refer to Appendix B for the detailed information of Laspeyres and Paasche Indexes.

The basic purpose of designing columns 7-9 and formulas are as follows:

Column 7: Price weighted and base period price indexed ratios in quantities. The effect of prices are hold constant and price weighted changes in quantities of outputs and inputs are calculated through the rows considering all output and input class-type-level (categorization) items.

$$\text{Column 7} = \frac{\sum_{i=1}^{n} \text{Quantity}_{t_2} \times \text{Price}_{t_1}}{\sum_{i=1}^{n} \text{Quantity}_{t_1} \times \text{Price}_{t_1}}$$

Down through column 7, each row element quantities of output/ input type i for period 2 will be multiplied by the unit price/unit cost of the same output/input type i of period 1. Similarly quantitiy of output/input type i of period 1 will be multiplied by the unit price/unit cost of the same output/input type of period 1. The former multiplication result will then be divided to the latter one. Summation for each output categorization will be calculated for the row indicating total outputs and similar to that summation of each input class-type-level categoraziton will be calculated for the rows indicating total raw materials, total labor, total energy, total capital etc.

If the calculated figure is less than 1, it indicates a decrease in the quantity of the output/input type i while the effects of prices are held constant, when the current period is compared to the base period.

eg. If 0,95 is the price-weighted base period price indexed change of output A, it means 5 per cent decrease is observed in the quantities of output A, when the effect of prices are partialed out, comparing current period to base period.

If the figure is greater than 1, it indicates an increase in the quantity of the output/input item while the effects of prices are held constant.

eg. If 1.20 is the index of output B, it means 20 per cent increase is observed in the quantities of output B, when the effects of prices are partialed out, comparing current period to base period.

Column 8: Quantity-weighted and current period quantity indexed ratios in unit prices and unit costs. Column 8 partials out or holds constant the changes in quantities of outputs andinputs, just examines the changes in unit prices and unit costs from base period to current period.

$$\text{Column 8} = \frac{\sum_{i=1}^{n} \text{Quantity}_{t_2} \times \text{price}_{t_2}}{\sum_{i=1}^{n} \text{Quantity } t_2 \times \text{price}_{t_1}}$$

Down through column 8, each row element quantity of output/input type i of period 2 will be multiplied by the unit price/unit cost of the same output/input type i of period 2. Similarly, quantity of output/input type i of period 2 will be multiplied by the unit price/unit cost of the same output/input type i of period 1. The former multiplication result will then be divided to the latter one. Summation of each output/input categorization items will be calculated for the rows indicating total outputs, total materials, total labor, total energy, total capital, etc.

If the calculated figure is less than 1, it indicates a decrease in the unit price/unit cost of output/input type i, while the effects of changes in quantities are held constant, when the current period is compared to the base period.

eg. If 0,80 is the quantity-weighted and current period indexed change by output A, it means 20 per cent decrease is observed in the unit price of output A, when the changes in quantities are partialed out, comparing current period to base period.

If the figure is greater than 1, it indicates an increase in the unit price/unit cost of output/input type i, while the effects of changes in quantities are partialed out.

eg. If 1.30 is the quantity weighted and current period indexed change of output B, it means 30 per cent increase is observed in the unit price of output B.

Column 9: Examines the simultaneous impact of ratios in price and quantity from period 1 to period 2 (from base period to current period).

$$\text{Column 9} = \frac{\sum_{i=1}^{n} \text{Quantity}_{t_2} \times \text{price}_{t_2}}{\sum_{i=1}^{n} \text{Quantity}_{t_1} \times \text{price}_{t_1}}$$

Down through column 9, each row element quantity of output/input type i of period 2 will be multiplied by the unit price/unit cost of the same output/input type i of period 2. Similarly, quantity of output/input type i of period 1 will be multiplied by the unit price/unit cost of the same output/input type i of period 1. The former multiplication result will then be divided to the latter one. Summation for each output/input items (i=1,...,n) will be calculated for the rows indicating total outputs, total materials, total labor, total energy, total capital etc. If the calculated value is less than 1, it indicates a decrease in the value (price x quantity) of output/input type i, when the current period is compared to the base period. If the calculated value is greater than 1, it indicates an increase in the value of output/input type i comparing period 2 to period 1.

Columns 10-11

Columns 10 and 11 are labeled as "Cost/Revenue" ratios. They indicate the ratio of input row elements for Columns 3 and 6 to total output row elements for columns 3 and 6. Column 10 is the cost/revenue ratio for period 1 (base period), and column 11 is for period 2 (current period).

The purpose of these two columns is not to provide new information but to integrate this information into the MFPMM, so as to provide a manager with insights as to where leverage exists. The manager can make productivity improvement decisions interms of cost reduction.

$$\text{Column 10} = \frac{\text{Input elements, Columns 3}}{\text{Total outputs, Column 3}}$$

Down through column 10, input element quantitiy of i class, j type, k level of period 1 will be multiplied by the unit cost of the same input element (class-type-level). In otherwords the cost of each input element will be divided by total revenues, for period 1.

$$\text{Column 11} = \frac{\text{Input elements, column 6}}{\text{Total outputs, column 6}}$$

Down through column 11, input element quantity of i class, j level, k type of period 2 will be multiplied by the unit cost of the same input element, for period 2.

eg. If 0,10 is the Cost/Revenue ratio of labor costs for period 1 and 0.20 is the Cost/Revenue ratio of labor costs for period 2, it shows that 10 per cent of total revenues is labor costs for the base period, and an increase is observed in the labor costs for the current period (labor costs increased to 20 per cent of total revenues).

Columns 12-13

Columns 12 and 13 are labeled as "productivity Ratios", Column 12 reflects the output-to-input ratios for period 1, while column 13 reflects the output-to-input ratios for period 2.

$$\text{Column 12} = \frac{\text{Total outputs, Column 3}}{\text{Input elements, Column 3}}$$

$$\text{Column 13} = \frac{\text{Base period price weighted value for total outputs}}{\text{Base period unit cost weighted value for each input element}}$$

Column 12 is the division of the value of total outputs for period 1 (Column 3), to the value of input elements i class, j type, k level for period 1 (column 3). Therefore productivity ratio (static) for each input element (class-type-level) will be calculated for period 1.

Column 13 gives productivity ratio (static), again for each input element for period 2, while effects of unit prices and unit costs are partialed out. Quantity of outputs for type i of period 1 is multiplied by the unit price of the same type of output for period 1. Each input element (i class, j type, k level) quantity for period 2 is multiplied by the unit cost of the same type input element for period 1. The former multiplication is divided by the latter one, in order to obtain productivity ratio for period 1 considering base period price weighted values for outputs and inputs.

eg. If labor productivity index is 28.18 for period 1 and 37,75 for period 2, it indicates that output-to-inputs ratio is increased in the current period compared to base period.

Columns 14-16

Columns 14,15 and 16 are titled as "Weighted Performance Indexes" (dynamic). Column 15 shows quantity-weighted price recovery indexes and column 16 indicates profitability indexes. Column 14-16 calculate and depict dynamic performance indexes. Fig.2.3 shows what MFPMM is doing.

The above figure indicates formulas and development of dynamic productivity indexes. A snapshot of the organizational system's partial, multi and even total static productivity ratio is developed for period 2. An equivalent snapshot of the organizational system's productivity ratio is also developed for period 1. Then the productivity ratio for period 2 is divided by the productivity ratios for period 1, and this calculation is shown in Column 14 of the MFPMM.

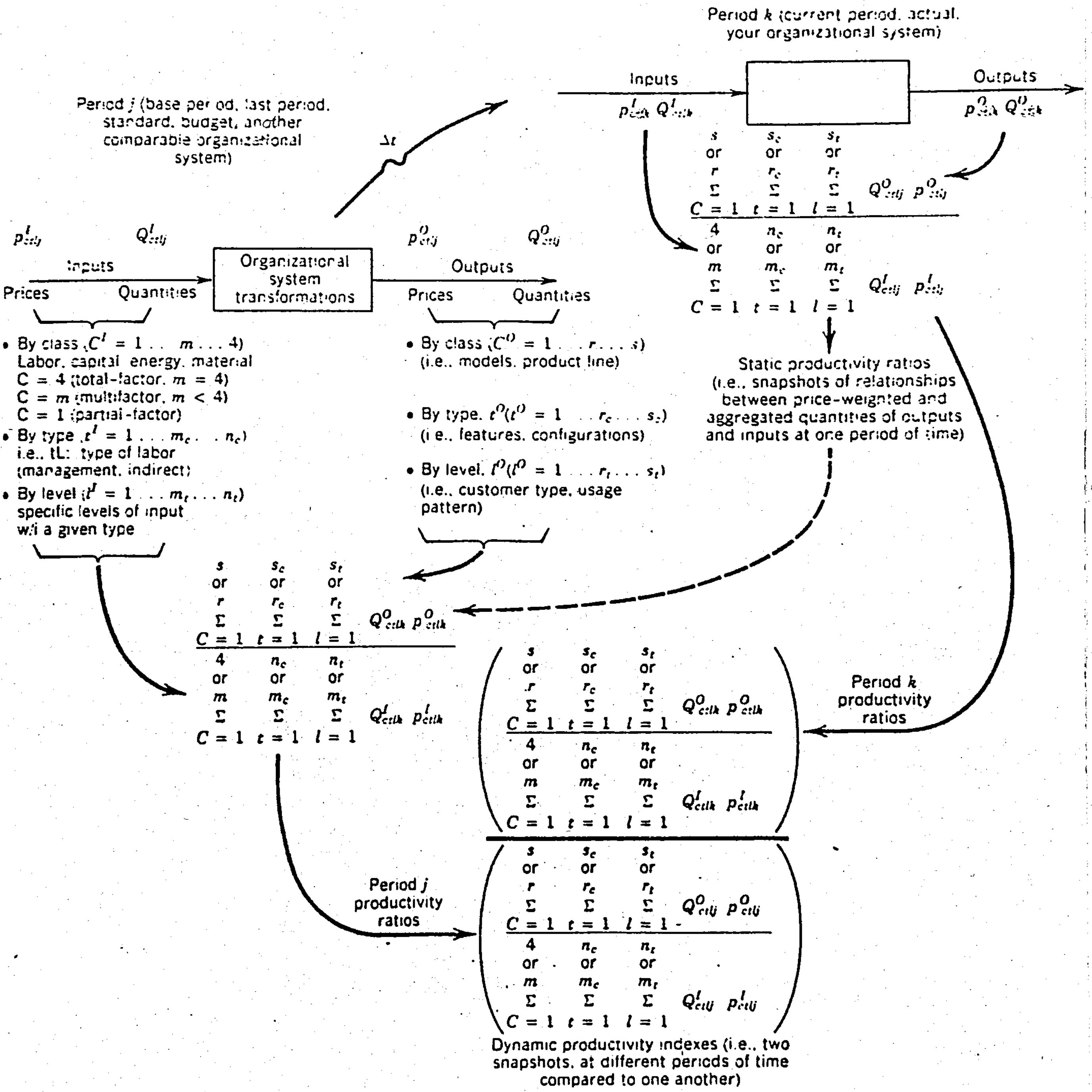

Figure 2.2.2. Price weighted and aggregated multifactor productivity measurement model.

$$\text{Column 14} = \frac{\text{Column 7, for total outputs}}{\text{Column 7, for each individual input element}}$$

Down through column 14, price weighted and base period price indexed changes in the quantity of total outputs is divided by the base period price indexed changes in the quantity of each input element.

eg. $\frac{\text{Column 7 for total outputs}}{\text{Column 7 for total labor}} = \frac{1.27}{0.95} = 1.34$, means that the

quantity of total outputs increased by 27 per cent, when the current period is compared to the base period, holding the effects of prices constant. Quantity of total labor, holding labor costs constant, is decreased by 5 per cent. As a conclusion the labor productivity is increased by 34 %.

or if $\frac{\text{Column 7 for total outputs}}{\text{Column 7 for total materials}} = \frac{1.27}{1.36} = 0.93$, means that the

quantity of total material, when the material costs are partialed out is increased by 36 per cent. As a conclusion material productivity is decreased by 7 per cent.

$$\text{Column 15} = \frac{\text{Column 8, for total outputs}}{\text{Column 8, for each individual input element}}$$

Down through column 15, quantity weighted and current period indexed changes in unit prices for total outputs is divided by the current period quantity indexed changes in the unit costs of each input element. This column reflects rate of price increases in relation to the rate of cost increase. In other words it reflects the degree to which the organizational system was able to increase its price in relation to elemental input costs.

eg. If $\frac{\text{Column 8 for total outputs}}{\text{Column 8 for total labor}} = \frac{1.15}{1.10} = 1.045$

The costs of total labor, when the quantities are partialed out comparing period 2 to period 1 are increased by 10 % and the prices of total outputs are increased by 15 per cent. As a conclusion prices of total outputs is increased by 5 per cent faster than the increase in the costs of total labor, in other words price recovery for total labor was up 5 per cent.

$$\text{or if, } \frac{\text{Column 8 for total outputs}}{\text{Column 8 for total materials}} = \frac{1.15}{1.70} = 0.67$$

The costs of total materials, when the quantities are held constant are increased by 70 per cent. Costs for total materials are increased by 33 per cent faster than the management was able to raise the prices of outputs, in otherwords price recovery fell off by 33 per cent.

$$\text{Column 16} = \frac{\text{Column 9, for total outputs}}{\text{Column 9, for each individual input element}}$$

Down through column 16 the simultaneous impact of changes in prices and quantity from period 1 to period 2 of total outputs is divided by the simultaneous impact of changes in price and quantity for each individual input element.

$$\text{eg. } \frac{\text{Column 9, for total outputs}}{\text{Column 9, for total labor}} = \frac{1.46}{1.075} = 1.36$$

The value of outputs is increased by 46 per cent, also the value of total labor is increased by 7,5 per cent. As a conclusion labor contributed by 36 per cent increase to profitability.

$$\text{or if, } \frac{\text{Column 9, for total outputs}}{\text{Column 9, for total materials}} = \frac{1.46}{2.298} = 0.64$$

The value of total materials, comparing period 2 to period 1 is increased by 129.8 per cent. As a conclusion, total materials declined profitability by 36 per cent.

Columns 17-19

Columns 17,18 and 19 reflect the TL equivalence of corresponding cells in columns 14, 15 and 16. In otherwords, these columns indicate what impact an increase in productivity, or price recovery has on profits. The total impact on profits from productivity and price recovery is indicated in column 19.

$$\text{Column 17} = \left\{\begin{array}{l}\text{Column 3, for each}\\ \text{individual input}\end{array}\right\} \left[\left\{\begin{array}{l}\text{Column 7, for}\\ \text{total outputs}\end{array}\right\} - \left\{\begin{array}{l}\text{Column 7 for}\\ \text{each indivi-}\\ \text{dual input}\end{array}\right\}\right]$$

The difference between the base period price weighted changes in the total outputs and the base period price weighted changes in each individual input element, is multiplied by the value for each individual input element of period 1.

eg. If Column 17 (for total labor) = 6400(1.27-0.95) = 2065 TL

Labor productivity contributed to profits by 2065 TL, from period 1 to period 2.

Column 18 = Column 19 - Column 17

Column 18 indicates the effect of price recovery on profits.

$$\text{Column 19} = \left\{\begin{array}{l}\text{Column 3 for}\\ \text{each indivi-}\\ \text{dual input}\end{array}\right\} \left[\left\{\begin{array}{l}\text{Column 9, for}\\ \text{total outputs}\end{array}\right\} - \left\{\begin{array}{l}\text{Column 9 for}\\ \text{each indivi-}\\ \text{dual input}\end{array}\right\}\right]$$

eg. If Column 19 (for total labor) = 6400(1.46-1.045) = 2679 TL

Labor contributed positively to profits between period 1 and period 2, by means of 2679 TL. 2065 TL came from productivity gains and 613 TL came from price recovery gains. A minus value in TL value of price recovery section reflects the drain on profits caused by an inability to recover rising costs from period 1 to period 2.

This section of the MFPMM allows the user to make sensitivity analysis. How much a percentage increase in productivity will make an increase in profitability, and what is its total TL effect on profits.

The description of the MFPMM is completed by 19 columns. It is a relatively simple model and yet it has tremendous potential as an integrative decision support system. Like any decision support system, the model itself is a critical but rather minor component of an application. Integrating the model into an existing control system, collecting the data, getting management to accept and feel comfortable with the system actually play a more critical role.

For detailed information about formulas refer to Appendix C, and for capital section in MFPMM refer to Appendix D.

III. APPLICATION

3.1. Description of the Company

MFPMM is applied to a Glass Manufacturing Company. Since it is a capital intensive production system, capital costs as a part of input class-type-level categorization carry essential importance.

Outputs are divided into two main classes; domestic and exports. Domestic production is also divided into two (sub-classes) types; construction and manufacturing. Demand for outputs is generally seasonal; 3 mm, 4 mm, 5 mm and 6 mm are the thicknesses of glass that are generally produced. Accounting records of the firm are kept as TL/ton on monthly basis for output prices, without considering the differences in thicknesses, as well as m^2 prices for each thickness. As far as the ease in the application of the model and the interview made by the assistant general manager of the firm are considered, prices will be calculated as TL/ton on monthly basis without taking into consideration the thickness variation of glasses produced.

Inputs are divided into four main classes; labor, material, energy and capital. Each class is also divided into types and levels.

3.2. Productivity Measurement System for A Glass Manufacturing Company

The critical decisions to be made before starting a productivity measurement study are as follows:

1. Thinking productivity and performance are synonymous, and therefore viewing productivity measurement as being a larger and more complex task.

2. Matching outputs with the corresponding inputs. Outputs and inputs will be categorized by class-type-level hiearchy.

3. Understanding how to use indexed prices and costs as a weighting and aggregating device in the productivity ratios and indexes.

4. Being unwilling to accept precise definitions of productivity, thus causing ambiguity in the measurement process.

Organizations should have a strategic plan for measuring productivity. Productivity measurement strategies are characterized by the following parameters:

1. Planning horizon
2. Desired outcomes
3. Scope
4. Development plans and procedures.

Those parameters focus on how the organizational system will design, develop, implement and maintain a productivity measurement system.

Planning horizon does not only mean the length of the planning process itself, it also means the length of time that needs to reach some stage of accomplishment of the project.

Desired outcomes are as follows:

1. To end up with a productivity measurement system that accurately identifies areas for productivity improvement.

2. To end up with a productivity measurement system that is well understood and accepted by the users of the model.

3. To end up with a dynamic, flexible measurement system over time.

4. To end up with a productivity measurement system that is as simple as possible and cost effective.

The scope of the plan refers essentially to the units of analysis to be covered by the development of the productivity measurement system. For instance the scope could be defined as the firm.

The strategic plan will obviously need to contain system development plans and procedures. This planning will include the specific measures such as; how the data will be collected, how the measures will be built into a decision support system since capacity utilization is a critical factor for cost reduction, productivity measuremenet and improvement becomes also, a critical factor for a Glass Manufacturing Company. Referring to the introduction and theoretical issues sections of the thesis, clear definitions of productivity and its integration as a critical component of performance measures are given. It is decided to design a decision support system based on productivity measurement, evaluation and improvement for A Glass Manufacturing Company.

In a glass manufacturing company the only output produced is glass, the main difference between domestic and exports glass is packaging costs. Type of production is a continuous flow system. The firm cannot distribute its total costs on the types of outputs produced. Therefore productivity will be calculated for each type of input as an aggregation of outputs. Database/accounting source of data is present in the firm. Finally, making sensitivity analysis for measuring the impact of changes in productivity and price recovery on profits, carries an essential importance in a glass manufacturing company.

Therefore, providing all above mentioned advantages MFPMM will be used in a glass manufacturing company, as a computerized, dynamic productivity measurement model, with a software support which will be used for operational and educational applications.

IV. MODELLING WITH COMPUTER

4.1. Description of the Spreadsheet Design

Lotus (package program) is used do design "A DSS on Productivity Measurement Evaluation and Improvement" package. The package will allow the user to play a "what if" game. Projected period section will provide data for future applications.

35 columns are designed considering the whole MFPMM (Refer to Fig. 4.1.1). The first 9 columns (3x3) are used for data input; quantity, price and value columns for each base, current and projected periods. Projected period section will allow the user to forecast the price index and cost index for each class-type-level categoraziton of outputs and inputs for a future period. Considering the years 1987-1990, a table of forecasted price and cost indexes for different units of outputs and inputs are provided taking Turkey's economic conditions into consideration, to the user on the screen. The user will either choose an index from the table or he/she will enter his/her own index. Matrix will automatically calculate the projected period unit price/unit cost by multiplying the current period unit price/unit cost with the selected index. Quantities of the projected period will be entered by the user. Price and cost indexes are given in Table 4.1.

The model calculates weighted Ratios, Cost/Revenue Ratios, Productivity Ratios, Weighted Performance Indexes, and TL Effects on Profits for Base/Current period analysis as well as Base/Projected period analysis.

The following 13 columuns are designed for Base/Current period analysis; ratios and indexes and an additional 13 columns are designed for Base/Projected period analysis. Weighted Change Ratios are made of 3 columns; Quantity, price and value, Cost/Revenue Ratios are made of two columns; period 1 and period 2 (base and current periods for Base/current period analysis, base and projected periods for Base/Projected period analysis). Similarly Productivity Ratios are made of 2 columns; Period 1 and Period 2. Weighted Performance Indexes contain 3 columns; Productivity, price Recovery and Profitability, similarly TL Effects on Profits contain 3 columns; Productivity, price Recovery and Profitability. Formulas related to each column are inputted to the spreadsheet (Refer to the theoretical issues section of the thesis for detailed information on formulas). Rows of the spreadsheet indicate input-output class-type-level categorization.

The major aim in designing the package is to make it userfriend. Therefore macro keywords of lotus is used in order to generate menues; and to design an interactive package. 35 columns designed generates the main file, also 23 columns are designed for macrokeywords. Data file; 1985, 1986 is also designed in another lotus file. All macrokeywords (menu items) are connected to letter A. When (Alt) and (A) are pressed simultaneously, menu items appear on top of the screen. The following tree shows the menu items connected each other. For detailed information about menu items refer to Appendix E. User's Manual Section.

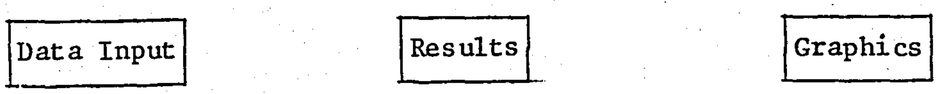

Figure 4.1.2. Initial Menu Items

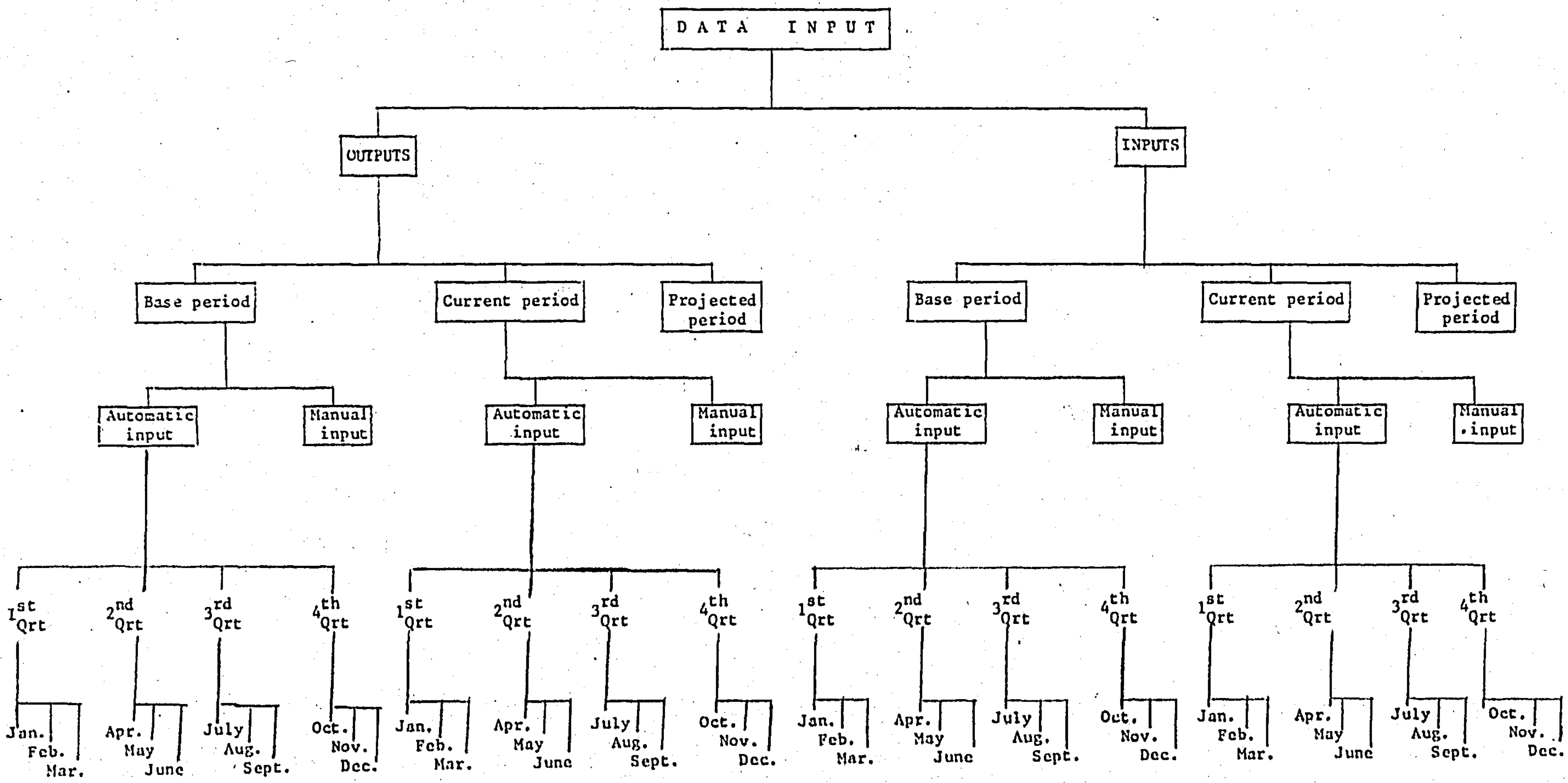

Figure 4.1.3. Sub Menu Items Related to Data Input

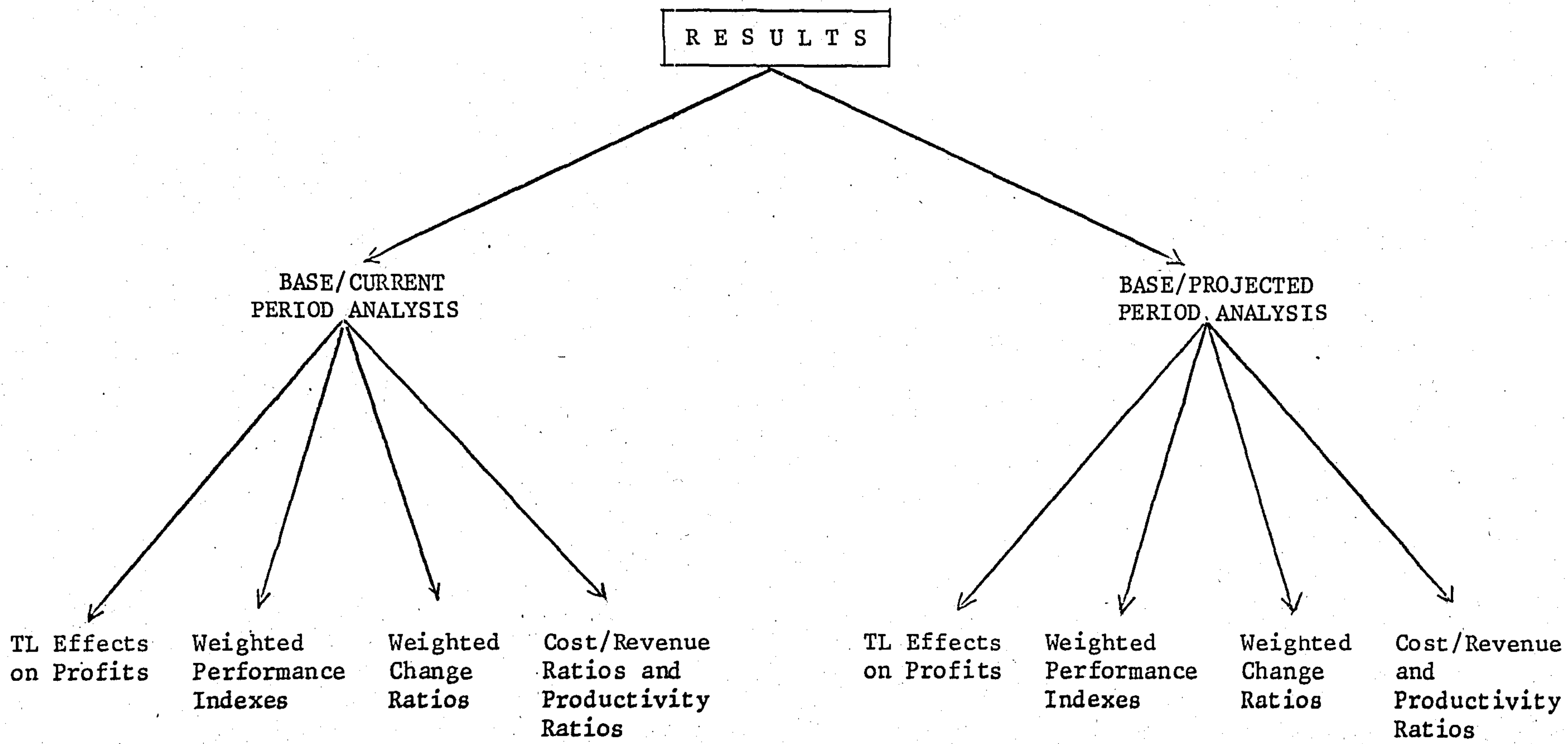

Figure 4.1.4. Sub Menu Items Related to Results

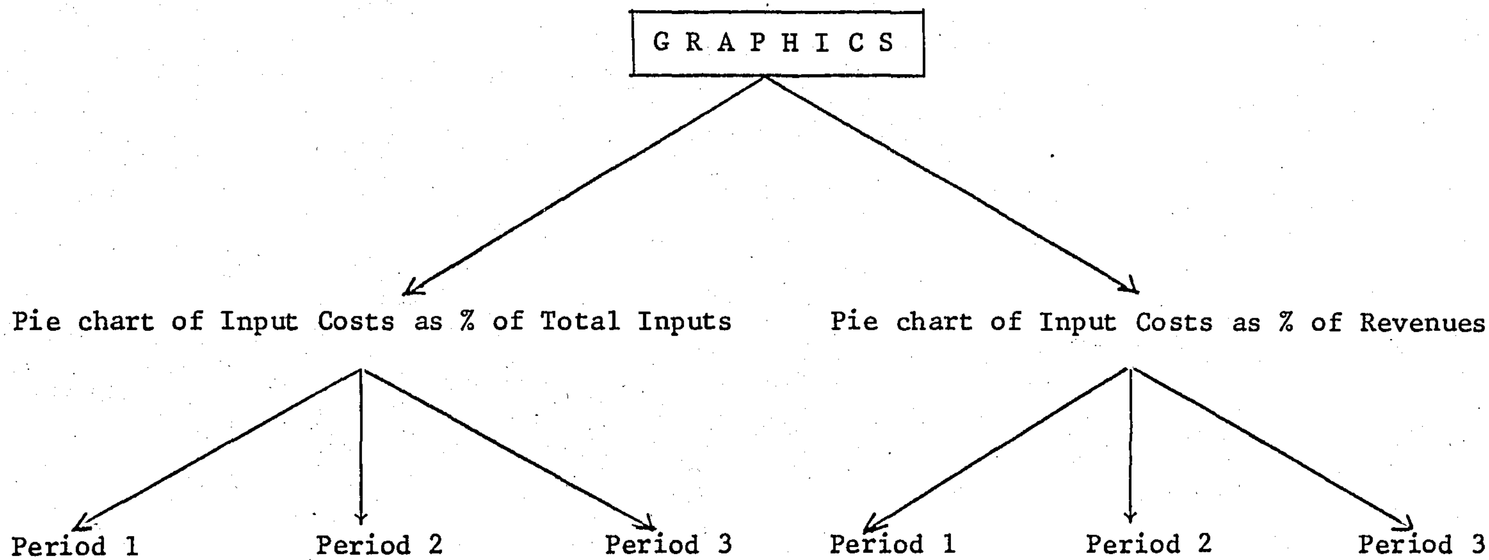

Figure 4.1.5. Sub Menu Items Related to Graphics

4.2. Evaluation of the MFPMM Applied to Glass Works Industry

January (1986)/January (1985) Analysis

A. Weighted Change Ratios

a) Outputs

Quantity of Domestic goods is increased by 13 per cent in January 1986, compared to January 1985, and quantity of Exports is decreased by 39 per cent, as a total quanty of outputs of January 1986 did not change, when compared to January 1985. Price of Domestic goods is increased by 52 per cent and price of Exports is increased by 53 per cent, as a total price of outputs is increased by 52 per cent, when January 1986 is compared to January 1985. Value of Domestic goods is increased by 72 per cent, and value of exports is decreased by 6 per cent, as a total value of outputs is increased by 53 per cent.

b) Inputs

Quantity of total materials is decreased by 11 per cent, quantity of total labor did not change when January 1986 is compared against January 1985, quantity of total energy is decreased by 12 per cent and quantity of total capital is increased by 45 per cent, as a total quantity of inputs is increased by 41 per cent, when January 1986 is compared against January 1985. Price of total materials is increased by 27 per cent, price of total labor is increased by 52 per cent, price of total energy is increase by 67 per cent, and price of capital is decreased by 2 per cent, as a total inputs' price did not change, when January 1986 is compared to January 1985.

Price of Capital is the cost of capital, the decreasing value of Cost of capital indicates positive financial leverage, although liabilities increased, its vaule is decreased by 2 per cent.

Value of total materials is increased by 14 per cent, value of total labor is increased by 53 per cent, value of total energy is increased by 33 per cent, value of capital is increased by 42 per cent, and as a total, value of inputs is increased by 41 per cent, when January 1986 is compared to January 1985.

B. Cost/Revenue Ratios

For January 1985, total materials/Revenue is 0,27, (and) total labor/Revenue is 0.066, (and) total energy/Revenue is 0.17, whereas capital is 7.27 times of Revenue.

For January 1986, total materials is 20 per cent of Revenues, total labor is 6 per cent of Revenues and total energy 16 per cent of Revenues, and whereas capital is 6.76 times of Revenue.

C. Productivity Ratios (Static)

For January 1985 Outputs-to-total materials ratio is 3.64, outputs-to-total labor ratio is 15.11, outputs-to-total energy ratio is 5.78, and outputs-to-total capital ratio is 0.13.

For January 1986 outputs-to-total materials ratio is 3.68, outputs-to-total labor ratio is 15.25, outputs-to-total energy ratio is 5.83, and outputs-to-total capital ratio is 0.09.

D. Weighted Performance Indexes (Dynamic)

Total materials is 12 per cent more productive, total labor; 1 per cent less productive, total energy is 14 per cent more productive total capital is 31 per cent less productive, and as a total, inputs are 29 per cent less productive when 1986 January is compared to 1985 January.

Prices of total outputs are increased by 19 per cent faster than the prices of total materials, prices of total outputs are increased with the same rate in the prices of total labor, prices of total energy are increased by 10 per cent faster than the prices of total outputs, prices of total outputs are increased by 54 per cent faster than the prices of total capital, as a total, the prices of outputs are increased by 51 per cent faster than the prices of total inputs.

Total materials increased profitability by 34 per cent, total labor-declined profitability by 1 per cent, total energy increased profitability by 14 %, total capital increased profitability by 7 per cent, as a total, total inputs increased profitability by 5 per cent, when January 1986 is compared to January 1985.

E. Total Effects on Profits

Total material's productivity contributed to profits by 55.453.398,54 TL, total labor's productivity contributed to profits by -223.984,60 TL (it is a loss), total energy's productivity contributed to profits by 38.109.034,26 TL., total capital's productivity contributed to profits by -5.705.777.783,2 TL and as a total, total inputs' productivity contributed to profits by -370.171.313,23 TL.

This conclusion is a result of the maintenance program of the furnaces during the early months of 1986.

Total material's price recovery contributed to profits by 135.967.200,6 TL, total labor's price recovery contributed to profits by 92.213,72 TL, total energy's price recovery contributed to profits by 23.488.998,75 TL, total capital's price recovery contributed to profits by 7.093.850.965,1 TL and as a total, total inputs price recovery contributed to profits by 478.401.674,01 TL.

Total material's contribution in profitability is by 191.420.599,15 TL, total labor's contribution in profitability is by -131.770,8 TL (it is a loss), total energy's contribution in profitability is by 61.598.033,01 TL, as a total, total inputs' contribution in profitability is by 108.230.360,7 TL, when January 86 is compared with January 85.

For detailed information on input class-type-level items categorization of January (86)/January(85) analysis Refer to Appendix F.

4.3. Differences and Similarities With the M.S.Thesis Prepared by Vedat Verter in 1985 in Boğaziçi University of Industrial Engineering Department

Both of the thesis are concentrated on a systematic approach of productivity measurement, evaluation and improvement. Sink's productivity measurement system, named MFPMM is suggested, by analyzing potential factors for productivity improvement.

The thesis prepared by Vedat Verter in 1985 in the Department of Industrial Engineering of Boğaziçi University is applied on an existing wheel producing company. Multiplan of B20 series is used to obtain ratios and indexes for the comparison of current to Base period. It is not an interactive design of spreadsheet and the model does not provide a projected period analysis option. Weights of input items are calculated as potential factors for productivity improvement. In otherwords, the ratio of each input cost is divided to the total input costs.Capital is included in the model as an input item, but only fixed assets are calculated as quantity and depreciation rates are calculated as prices.

This thesis is applied on an existing Glass Manufacturing Company. An interactive program is designed using Lotus package on an IBC pc. By the help of menu items provided, especially managers who do not know using computers will be able to work with the package as a decision support system. The package using MFPMM not only compares current period to the base period, but also provides a scenerio analysis option for future applications. It provides a comparison option of projected period to the base period (for detailed information, refer to section 4. Modelling with computer). Since capital is an important input item in Glass Works industry, it is included in the model. Total assets are calculated for quantity and cost of capital is calculated for price (for detailed information, refer to section 2.3.2. Theoretical Issues Capital Section).

This thesis added two sections; named Cost/Revenue ratios and static productivity ratios to the MFPMM used in Verter's thesis. Cost/ Revenue ratios section is added to provide an insight to managers to make productivity improvement decisions, in terms of cost reduction, on the higher priority input resources. Static productivity ratios section is also added to reflect output-to-input ratios for both periods; period 1 (base period), period 2 (current or projected period), seperately. Static productivity ratio of period 2 is calculated by partialing out the effects of prices and costs. Therefore this section will give an immediate insight to managers, how their output-to-input ratios are changed from period 1 to period 2. The program also provides a graphs option by the help of menu items. Two pie charts as potential factors for productivity improvement are drawn on the screen if graphs is selected among the menu items. One is the ratio of each input cost to the total input costs and the other is the ratio of each input cost to the total revenues.

V. CONCLUSION

Organizations have control systems, with respect to the resource they are supposed to manage, or we can classify them with respect to the type of "organizational system performance" they are attempting to control. In general there are seven distinct "organizational system performance measures".

1. Effectiveness
2. Efficiency
3. Quality
4. Profitability
5. Productivity
6. Quality of Work Life
7. Innovation

Productivity is a critical performance measure for organizational systems. It is a relationship between quantities of outputs produced by a given organizational system and quantities of inputs utilized by that organizational system to produce those same outputs. Once a productivity measurement system is developed, the system can be operationalized and standards can be generated. Standards can be generated by two methods; Normative, participative, relative measurement systems (NPMM), and Economic, accounting based, absolute measurement systems. Economic, accounting based, absolute measurement systems are based on the premise that profitability is a function of productivity and price recovery. Sink's MFPMM is a model uses this relationship. MFPMM is applied to an existing glass manufacturing company considering following advantages:

1. Obtains an overall, integrated measure of productivity for the firm
2. Provides an analytical audit of the past performance
3. Provides budget control by current performance
4. Assesses and evaluates bottom-line impact on profitability, as a result of productivity shifts
5. Tracks the results of specific productivity improvement efforts, such as quality circles, quality control, incentive systems
6. Provides common price financial statements
7. Assists with setting productivity objectives and general strategic planning with regard to capacity utilization, marketing efforts, cost management, staffing, quality management, pricing strategies.

In case of product variety and multiplicity of various resources utilized, TL (money value) is a convenient common denominator. However, TL in the current economic environment is a variable standard. Therefore "devaluing", "revaluing" or "indexing" mechanism is required. MFPMM selects a base period for the model and automatically indexing prices and costs, partials out or removes the influence in price and cost changes from the base period to the current period. A detailed output and input class-type-level categorization is the initial step of MFPMM. Then monthly data is collected for the analysis. Since glass works industry is a capital intensive industry, capital is also added to the input items. Total assets are calculated as the quantity of capital, and cost of capital is calculated as the price of capital.

An interactive program is designed on Lotus (a package program) on IBM pc, named productivity Improvement, Evaluation and Measurement. The package is designed as a Decision Support System that also provides scenerio analysis option to the user. By projected period analysis section, the user not only makes Current period/Base period analysis but also projected period/Base period analysis. The main aim of the package is to make managers get used to the model, even if they are not accustomed to use computers.

Simply, by obeying the commands on the screen, users will be able to work on the model, make the analysis of their organizational system.

Finally, being a critical but a confused component of organizational system performance measures; productivity measurement and analysis applications will gradually increase. This study should be treated successful if it contains any useful material for the future.

APPENDIX

APPENDIX A

Sumanth's TPF Model

$$TPF = \frac{OF}{IF} = \frac{\sum_{i=1}^{n} O_i}{\sum_{i=1}^{n} I_i} = \frac{\sum_{i=1}^{n} O_i}{\sum_i \sum_j I_{ij}}$$

Where; OF = Total tangible output of a firm

O_i = Tangible output corresponding to product i

IF = Total tangible input to the firm

I_i = Total tangible input corresponding to product i

$$= \sum_{j=1}^{m} I_{ij}$$

j = H,M,C,E,X
i = 1,...,n
n = total number of product manufactured

H = Human
M = Material
C = Capital

E = Energy
X = Others

TP_i = Total productivity of product i

PP_i = Partial productivity of product i, for tangible input types

$$TP_i = \frac{O_i}{I_i} = \frac{O_i}{\sum_j^m I_{ij}}$$

$$PP_{ij} = \frac{O_i}{I_{ij}} \Longrightarrow \quad O_i = TP_i \cdot \sum_j I_{ij} \qquad TP_i = \sum_j^m I_{ij} = PP_{ij} \cdot I_{ij}$$

$$O_i = PP_{ij} \cdot I_{ij} \qquad TP_i = PP_{ij} \cdot \frac{I_{ij}}{\sum_j I_{ij}} \Rightarrow w_{ij}$$

$$TP_i = W_{ij} \times PP_{ij}, \text{ for all } j$$

$$TPF = \sum_{i=1}^{N} W_i TP_i \text{ (by substituting the first expression in the second expression)}$$

$$TPF = \sum_{i=1}^{N} W_i (W_{ij} . PP_{ij}), \text{ for all } j$$

$$= \sum_{i=1}^{N} (W_i . W_{ij})\ PP_{ij}, \text{ for all } j$$

$$W_i = \frac{I_i}{IF}, \quad W_{ij} = \frac{I_{ij}}{I_i}, \text{ for all } j$$

$$W'_{ij} = W_i \cdot W_{ij} = \frac{I_i}{IF} \times \frac{I_{ij}}{I_i} = \frac{I_{ij}}{IF}, \text{ for all } j$$

$$TPF = \sum_{i=1} W'_{iH} . PP_{iH} = \sum_{i=1} W'_{iM} . PP_{iM} = \sum_{i=1} W'_{iC} . PP_{iC} = \sum_{i=1} W'_{iE} . PP_{iE} = \sum_{i=1} W'_{iX} . PP_{iX}$$

$$5TPF = \sum_{i=1} W'_{iH} . PP_{iH} + \sum_i W'_{iM} . PP_{iM} + \sum_i W'_{iC} . PP_{iC} + \sum_i W'_{iE} . PP_{iE} + \sum_i W'_{iX} . PP_{iX}$$

$$TPF = \frac{1}{5} \left(\sum_i W'_{iH} . PP_{iH} + \sum_i W'_{iH} . PP_{iM} + \sum_i W'_{iC} . PP_{iC} + \sum_i W'_{iE} . PP_{iE} + \sum_i W'_{iX} . PP_{iX} \right)$$

Sumanth also develops a breakeven concept of total productivity. He relates profits to productivity in an analogous fashion to what the MFPMM does when it calculates effects on profits.

O_i = Output in value terms for product i
C_i = Total Costs associated with the production of product i
P_i = Total Profits for product i

$$O_i = C_i + P_i$$

$$TP_i = \frac{O_i}{I_i}, \text{ by definition} \qquad TP_i = \frac{C_i + P_i}{I_i}$$

$I_{i,cw}$ = Working Capital used for product i, expressed in constant dollars of base period.

$$C_i = I_i - I_{i,cw}$$

$$TP_i = \frac{I_i - I_{i,cw} + P_i}{I_i}$$

$$TP_i . I_i = I_i - I_{i,cw} + P_i$$

$$P_i = (TP_i - 1)\ I_i + I_{i,cw}$$

PF = total profit at the firm level

$$PF = \sum_i P_i = \sum_i \left((TP_i - 1) I_i + I_{i,cw}\right)$$

$$= \sum_i \left((TP_i - 1) I_i\right) + \Sigma I_{i,cw}$$

$$= \sum_i TP_i . I_i - \sum_i I_i + \sum_i I_{i,cw}$$

$$TPF = \frac{OF}{IF} \Longrightarrow PF = OF - IF + I_{cw}$$

$$OF = TPF\ .\ IF$$

$$PF = (TPF-1) IF + I_{cw}$$

$$PF = (TPF-1)(I_H + I_M + I_{CF} + I_E + I_X) + I_{CW}$$

$$= TPF\ (I_H + I_M + I_{CF} + I_E + I_X + I_{CW}) - (I_H + I_M + I_{CF} + I_E + I_X)$$

$a = I_H\ I_M\ I_{CF}\ I_E\ I_X\ I_{CW}$ = total input for a given period

$b = I_H\ I_M\ I_{CF}\ I_E\ I_X$ = all inputs other than working capital

$$PF = a(TPF) - b$$

Case 1: TPF = 0, Than PF = −b

Case 2: TPF = 1, Than PF = a−b

$= I_{cw}$

If these situations are plotted on a graph, the breakeven point of TPF is observed.

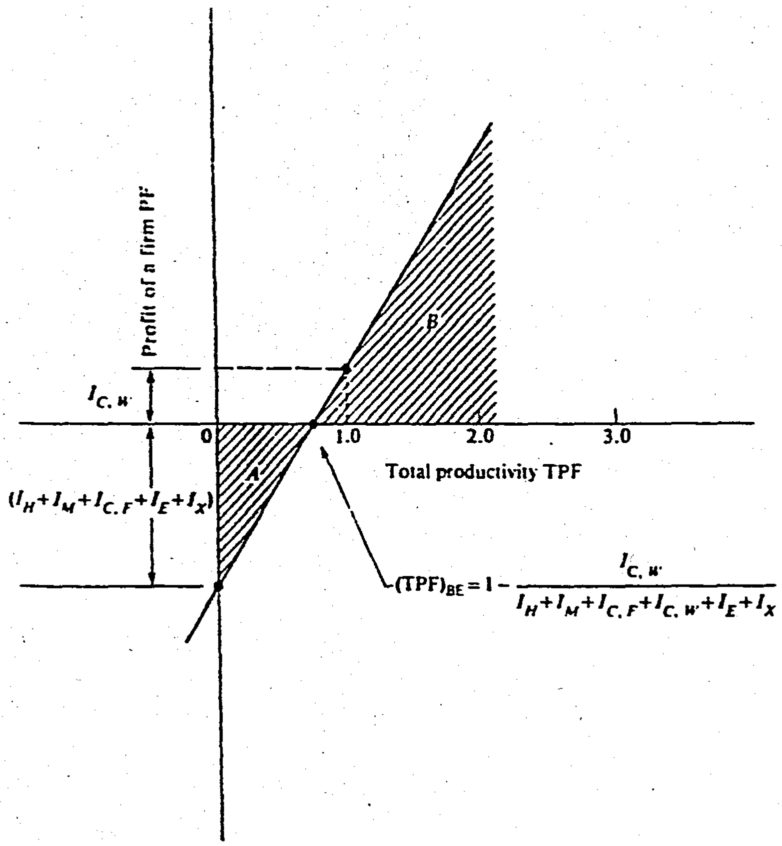

Figure A. Relation between profit and total productivity

APPENDIX B

Laspeyres Index - Base period price weighted, quantity change ratios:

$$\frac{\sum_{i=1}^{n} Q_{it}.P_{io}}{\sum_{i=1}^{n} Q_{io}.P_{io}} \quad \frac{\sum_{i=1}^{n} Q_{it}.P_{io} \cdot \frac{Q_{io}}{Q_{io}}}{\sum_{i=1}^{n} Q_{io}.P_{io}} \quad \frac{\sum_{i=1}^{n} Q_{io}.P_{io} \cdot \frac{Q_{it}}{Q_{io}}}{\sum_{i=1}^{n} Q_{io}.P_{io}}$$

$$\frac{\sum_{i=1}^{n} m_{io}.y_{i}}{\sum_{i=1}^{n} m_{io}}$$

Q_{it} = Quantity of output/input type i in the current period
Q_{io} = Quantity of output/input type i in the base period
P_{it} = Price/cost of output/input type i in the current period
P_{io} = Price/cost of output/input type i in the base period
M_{io} = Base period money value of output/input type i
Y_{i} = Quantity relative output/input type i = Q_{it}/Q_{io}
X_{i} = Price relative of output/input type i = P_{it}/P_{io}

Since different input and output types have different unit prices and unit costs and used with different quantities, for example when total materials is considered taking only the ratio of current period quantity to the base period quantity will not actually give the quantity change ratio of total materials. However when the summation of quantity change ratios of all material types times their base period values are taken and divided to the summation of base period values of all material types, base period price weighted quantity change ratios will be calculated.

Assumed that cost of material type A is 100 TL/unit and 20 per cent more in quantity is used, cost of material type B is 1 TL/unit and 50 per cent more in quantity is used in the current period when compared to the base period. As a total, it is wrong to say that 70 per cent more material A and B is used in quantity. Actually 20 per cent more material A and B is used in quantity.

$$\frac{100 \times 1.2 + 1 \times 1.5}{101} = 1.20 \Longrightarrow 20 \text{ per cent}$$

Paasche Index: Current period quantity weighted unit price change and unit cost change ratios.

$$\frac{\sum_{i=1}^{n} P_{it}.Q_{it}}{\sum_{i=1}^{n} P_{io}.Q_{it}} \quad \frac{\sum_{i=1}^{n} P_{it}.Q_{it} \cdot \frac{P_{io}}{P_{io}} \cdot \frac{Q_{io}}{Q_{io}}}{\sum_{i=1}^{n} P_{io}.Q_{it} \cdot \frac{Q_{io}}{Q_{io}}} \quad \frac{\sum_{i=1}^{n} P_{io}.Q_{io} \cdot \frac{P_{it}}{P_{io}} \cdot \frac{Q_{it}}{Q_{io}}}{\sum_{i=1}^{n} P_{io}.Q_{io} \cdot \frac{Q_{it}}{Q_{io}}}$$

$$= \frac{\sum_{i=1}^{n} M_{io}.X_{i}.Y_{i}}{\sum_{i=1}^{n} M_{io}.Y_{i}}$$

Since different input and output types used with different quantities, for example when total materials is considered, taking only the ratio of current year costs to the base year costs will not actually give the unit cost changes of total materials. However when the summation of quantity change ratios of all material types times cost change ratios times their base period values are calculated and divided to the summation of base period values times quantity changes ratios of all material types, when current period is compared to the base period. If significant changes in quantity of output or input items are made between current and base period those will be reflected to the unit price or unit cost changes.

Assumed that price of finished good type A is 100 TL/unit. It is 20 per cent expensive in price and 10 per cent more in quantity, comparing base period to the current period price of finished good type B is 1 TL/unit. It is 50 per cent expensive in price and 15 per cent more in quantity. As a total it is wrong to say that finished goods A and B is 70 per cent expensive in prices. Actually goods A and B are 20 per cent expensive in prices.

$$\frac{100 \times 1.2 \times 1.10 + 1 \times 1.5 \times 1.15}{100 \times 1.10 + 1 \times 1.15} = 1.20 \Longrightarrow 20 \text{ per cent}$$

APPENDIX C

Weighted Change Ratios

$$\text{Column 7} = \frac{\sum_{i=1}^{n} Q_{i2} \cdot P_{i1}}{\sum_{i=1}^{n} Q_{i1} \cdot P_{i1}}$$

$i=1,\ldots,n$

i=Output/input categorized item

$$\text{Column 8} = \frac{\sum_{i=1}^{n} Q_{i2} \cdot P_{i2}}{\sum_{i=1}^{n} Q_{i2} \cdot P_{i1}}$$

$$\text{Column 9} \quad \frac{\sum_{i=1}^{n} Q_{i2} \cdot P_{i2}}{\sum_{i=1}^{n} Q_{i1} \cdot P_{i1}}$$

Where;

Q_{i2} = Quantity of output/input type i for period 2

P_{i1} = Unit price/unit cost of the same output/input type i for period 1

Q_{i1} = Quantity of output/input type i for period 1

P_{i2} = Unit price/unit cost of output/input type i for period 2.

Cost/Revenue Ratios

$$\text{Column 10} = \frac{I_{ijk} \cdot C_{ijk1}}{\sum_{i=1}^{n} O_{i1} \cdot P_{i1}} = \frac{\text{Input elements, Column 3}}{\text{Total outputs, Column 3}}$$

$$\text{Column 11} = \frac{I_{ijk_2} \cdot C_{ijk_2}}{\sum_{i=1}^{n} O_{i2} \cdot P_{i2}} = \frac{\text{Input elements, Column 6}}{\text{Total outputs, Column 6}}$$

Where;

I_{ijk_1} = Quantity of input element of i class, j level, k type of period 1 (base period)

C_{ijk_1} = Unit cost of input element of i class, j level, k type of period 1.

O_{i_1} = Quantity of output type i, period 1.

P_{i_1} = Unit price of output type i, period 1

I_{ijk_2} = Quantity of input element of i class, j level, k type of period 2 (current period)

C_{ijk_2} = Unit cost of input element of i class, j level, k type of period 2.

O_{i_2} = Quantity of output type i, period 2

P_{i_2} = Unit price of output type i, period 2.

Productivity Ratios

$$\text{Column 12} = \frac{\sum_{i=1}^{n} O_{i1} \cdot P_{i1}}{I_{ijk_1} \cdot C_{ijk_1}} = \frac{\text{Total outputs, Column 3}}{\text{Input elements, Column 3}}$$

$$\text{Column 13} = \frac{\sum_{i=1}^{n} O_{i2} \cdot P_{i1}}{I_{ijk_2} \cdot C_{ijk_1}} = \frac{\text{Base period price weighted value for total outputs}}{\text{Base period unit cost weighted value for each input element}}$$

Weighted Performance Indexes

$$\text{Column 14} = \frac{\dfrac{\sum_{n=1}^{n} O_{i2} \cdot P_{i1}}{\sum_{i=1}^{n} O_{i1} \cdot P_{i1}}}{\dfrac{I_{ijk_2} \cdot P_{i1}}{I_{ijk_1} \cdot P_{i1}}} = \frac{\text{Column 7, for total outputs}}{\text{Column 7, for each individual input element}}$$

$$\text{Column 15} = \frac{\dfrac{\sum_{i=1}^{n} O_{i2}.P_{i2}}{\sum_{i=1}^{n} O_{i2} \cdot P_{i1}}}{\dfrac{I_{ijk_2} \cdot C_{i_2}}{I_{ijk_1} \cdot C_{i_1}}} = \frac{\text{Column 8, for total output}}{\text{Column 8, for each individual input element}}$$

$$\text{Column 16} = \frac{\dfrac{\sum_{i=1}^{n} O_{i2}.P_{i2}}{\sum_{i=1}^{n} O_{i1}.P_{i1}}}{\dfrac{I_{ijk_2} \cdot P_{i_2}}{I_{ijk_1} \cdot P_{i_1}}} = \frac{\text{Column 9, for total outputs}}{\text{Column 9, for each individual input element}}$$

Total Effects on Profits

$$\text{Column 17} = (I_{ijk_1}.C_{ijk_1})\left[\left(\frac{\sum_{i=1}^{n} O_{i2}.P_{i1}}{\sum_{i=1}^{n} O_{i1}.P_{i1}}\right) - \left(\frac{I_{ijk_2} \cdot C_{ijk_1}}{I_{ijk_1} \cdot C_{ijk_1}}\right)\right]$$

$$= \left(\begin{array}{l}\text{Column 3, for each}\\ \text{individual input}\end{array}\right)\left[\left(\begin{array}{l}\text{Column 7, for}\\ \text{total outputs}\end{array}\right) - \left(\begin{array}{l}\text{Column 7, for each}\\ \text{individual input}\end{array}\right)\right]$$

Column 18 = Column 19 - Column 17

$$\text{Column 19} = (I_{ijk_1} \cdot C_{ijk_1}) \left[\left(\frac{\sum_{i=1}^{n} O_{i2} \cdot P_{i2}}{\sum_{i=1}^{n} p_{i1} \cdot P_{i1}} \right) - \left(\frac{I_{ijk_2} \cdot C_{ijk_2}}{I_{ijk_1} \cdot C_{ijk_1}} \right) \right]$$

$$= \begin{pmatrix} \text{Column 3, for} \\ \text{each individual} \\ \text{input} \end{pmatrix} \left[\begin{pmatrix} \text{Column 9, for} \\ \text{total outputs} \end{pmatrix} - \begin{pmatrix} \text{Column 9, for each} \\ \text{individual input} \end{pmatrix} \right]$$

APPENDIX D

Capital Section in MFPMM

In general Capital section is being left out as an input while applying MFPMM. However for the companies where capital productivity is very important, especially under dynamic economic conditions, capital section will be added to the model.

When investment in new technology increased, so have productivity rates. Potential solution to the problem is to find ways to spark increases in capital investment. Uncertainty and risk are important terms associated with the cost of capital. Therefore since it reflects the company's own conditions, to calculate cost of capital instead of minimum attractive rate of return is a better decision for the price of capital.

Quantity of capital will be calculated as a single value. It is the summation of current assets, fixed assets and other assets, in otherwords total assets generate the quantity of capital. Price of capital will be calculated as cost of capital. It is the weighted average of the costs of liabilities and stockholder's equity. Current assets of a company can be obtained from accounting department. However, book value of fixed assets can not be used as its current value, instead mortgage or insurance value of fixed assets or consensus of the manager can be used as the current value of fixed assets. Since companies get their funds from liabilities, credits and stockholder's equity, calculation of cost of capital becomes important.

Example for the calculation of cost of Capital:

Liabilities	Quantity	(%)	Cost(%)	Weighted Average
Short-term credits	100	50	70	0.35
Long-term credits	+100	50	50	+0.25
	200			0.60

Since liabilities are tax deductable:

0.60(1-046) = 0.32

	Quantity	(%)	Cost (%)	Weighted Average
Liabilities	200	50	0.32	0.16
Equity	+200	50	0.35	+0.18
	400			0.34

↓ opportunity cost of using equity

Cost of Capital is 34 per cent.

If profitability leverage is greater than 1, increase in debt will result with decrease in the cost of capital at the first step. However than with more increase in debt, risk of the company will also increase with a greater speed than before, hence with an increase in the cost of capital.

If the profits obtained by a company are greater than the cost of credits, the difference will be working capital and profitability leverage of the company will be positive.

$$\text{Profitability Leverage} = \frac{\dfrac{\text{Profits}}{\text{Equity}}}{\dfrac{\text{Profits} + \text{Financial Costs}}{\text{Total Assets}}}$$

If profitability leverage is greater than "1", it means leverage is positive, otherwise it is negative.

Capital Section of MFPMM:

Column 7: Base period cost of capital weighted changes in assets. Since quantity of capital section is a single figure, as total assets, column 7 gives the change in assets when current period is compared to the base period. If the figure calculated is less than one, it means asset quantity is decreased (in the current period relative to base period), or if it is more than one, it means assets quantity is increased.

Column 8: Base period total assets weighted changes in the cost of capital. Column 8, since quantity of capital section is accepted as a single figure of total assets, gives the change in the cost of capital from period 1 (base period) to period 2 (current period). If the figure calculated is less than one, it means cost of capital is decreased, if greater than one, it means cost of capital is increased.

Column 9: Examines the simultaneous impact of changes in the cost of capital and total assets figures, from period 1 to period 2. If the calculated figure is less than one, it indicates a decrease in the value of capital (total assets x cost of capital), if greater than one, it means an increase in the value of capital.

Column 10: Examines Cost/Revenue ratios for period 1, in other-words total assets are divided by revenue. If calculated figure is greater than one, total assets of the company is greater than the revenue of the company for the base period. If calculated figure is less than one, it means total assets is less than the revenue of the company.

Column 11: Similar to Column 10, for period 2 (current period).

Column 12: Examines static productivity ratios, in otherwords reflects output-to-input ratios for period 1. Calculated figure is the total revenue divided by, total assets times cost of capital for the base period. It gives the ratio of total revenue to the value of capital. If the calculated figure is greater than one, it means total revenue is greater than the value of capital, if less than one, it means total revenue is less than the value of capital.

Column 13: Similar to column 12, for period 2. The ratio of base period price weighted value of total output to the base period cost of capital weighted value of total assets.

Column 14: Examines dynamic productivity indexes. Calculates the ratio of price weighted quantity change of outputs (from period 1 to period 2) to the total assets change in quantity. If the calculated figure is greater than 1, it means capital productivity is increased, if it is less than 1, it means capital productivity is decreased.

$$\text{eg. } \frac{\text{Column 7 for total outputs}}{\text{Column 7 for capital}} = \frac{1.27}{0.95} = 1.34$$

The quantity of total outputs, when prices are partialed out is increased by 27 per cent and total assets is decreased by 5 per cent, when cost of capital is partialed out. As a conclusion total assets productivity is increased by 34 per cent.

Column 15: Examines current period quantity weighted price recovery indexes. Calculates the ratio of current period quantity weighted price changes of outputs (from period 1 to period 2) to the change in the cost of capital. If the calculated figure is greater than one, it means price recovery of total outputs is greater than the cost of capital, if it is less than one, it means price recovery of total outputs is less than the cost of capital.

Column 16: Examines the ratio of simultaneous impact of changes in prices and quantity of outputs to the ratio of changes in the cost of capital and total assets from period 1 to period 2. If calculated figure is greater than 1, it means change in the total revenue is greater than the change in the value of capital, if less than 1, it means change in the total revenue is less than the change in the value of capital.

Column 17: Examines TL equivalance of the corresponding cell column 14, in otherwords what impact has an increase in capital productivity on profits. Base period value of capital is multiplied by the difference of the base period price weighted change in outputs quantity from the base period cost of capital weighted change in capital.

eg. $\begin{bmatrix}\text{Base period} \\ \text{value of} \\ \text{Capital}\end{bmatrix} \left[\begin{Bmatrix}\text{Column 7} \\ \text{for total} \\ \text{outputs}\end{Bmatrix} - \begin{Bmatrix}\text{Column 7 for} \\ \text{capital}\end{Bmatrix} \right]$

= 1000 TL x (1.27) - (0.95)

= 320 TL.

If base period cost of capital weighted change in capital is greater than the price weighted change in outputs quantity from period 1 to period 2, profitability figure will be a minus value, indicating loss as an impact of capital productivity on profits.

Column 18: Examines TL equivalence of the corresponding cell column 1 in otherwords what impact has an increase in price recovery of capital on profits.

Column 18 = Column 19 - Column 17

Column 19: Examines TL equivalence of the corresponding cell column 16, in otherwords what impact has an increase in capital productivity and capital price recovery on profits. Base period value of capital is multiplied by the difference of the change in the value of outputs from the change in the value of capital. If the change in the value of the outputs is less than the change in the value of capital, the calculated figure will be a minus value, indicating losses.

APPENDIX E

User's Manual

"DSS on Productivity Measurement Evaluation and Improvement Package" of MFPMM is made off 2 diskettes, Containing the main file (named Sibel) and the data files (named 1985 and 1986) on seperate diskettes. Initially Lotus file is located in drive A and main file diskette is located in drive B. After Lotus is loaded, Lotus diskette is taken out of drive A, and data files; 1985, 1986 diskette is located in drive A. In order to load the main file; Sibel, the following commands are made;

/,Worksheet, File, Retrieve, Sibel

When the main file; Sibel is loaded, the heading of the package and commands to start menu items occur on the screen. (Alt) and (A) are pressed simultaneously to see menu items on top of the screen:

[DATA INPUT] [RESULTS] [GRAPHICS]

By the help of the arrows, the user will move the curser on the selected menu item and press (Return).

Data Input: In order to start the package, first "Data Input" will be selected. Then another menu comes to the screen:

[OUTPUTS] [INPUTS]

Sink's MFPMM categorizes outputs and inputs by class-type-level hierarchy. Each of the menu items will be selected for data input, either outputs or inputs is selected another menu will appear on the screen:

[BASE YEAR] [CURRENT YEAR] [PROJECTED YEAR]

In order to be able to see the results, one of the following will be entered:

a) Base and Current period data
b) Base and Projected period data
c) Base, Current and Projected period data

Either Base Year or Current Year is selected another menu will come to the screen:

AUTOMATIC INPUT	MANUAL INPUT

a) Automatic Input (Inputs 1985 data for the base year and 1986 data for the current yera).

If automatic input is selected another menu appears.

1st QUARTER	2nd QUARTER	3rd QUARTER	4th QUARTER

One year is divided into 4 quarters and each quarter represents 3 months, if 1st QUARTER is selected another menu appears showing the months.

JANUARY	FEBRUARY	MARCH

If second is selected

APRIL	MAY	JUNE

If third is selected

JULY	AUGUST	SEPTEMBER

and finaly is forth is selected

OCTOBER	NOVEMBER	DECEMBER

appears on top of the screen. By the help of the arrows, the user will move the curser on the selected item and press (Return).

Program automatically inputs the selected month's data from the data file on the main file. While the data is copied, at the upper right corner "WAIT" command appears, after copying is completed "READY" command appears. If the user of the package wants to change some quantity or unit price or unit cost data of outputs or inputs, after the completion of data input, he or she may reach to the data region that is going to be changed by the help of arrows, in otherwords he/she will move the curser on the region that will change and will type the new data and press (Return). The package also allows the user to make a moving index comparison. eg. He/she may compare the data of January, 1985 (base year) to the data of January, 1986 (current year) or he/she may compare the data of December of the base year with the January of the current year, and so on.

b) Manual Input: Brings the data input part onto the screen to allow the user to input his or her own data. User of the package will enter the data of a month, he/she wants to compare. The manual input section of the package allows the user to make validation of the model. User of the package may forecast next month's data and enter them to the projected year and obtain results by Base/Projected period analysis. When actual data is collected for that month, he/she may enter them to the current year section by selecting manual input. This time Base/Current year analysis will be selected to obtain results. Comparison of the two analysis will also indicate the reliability of the forecasted data, and forecasting power of the user.

If projected year is selected, the data input part for the projected year appears on the screen. Either outputs or inputs is selected, the user will enter the quantity part by his/her experience. The package allows unit price and unit cost indexes for outputs and inputs to the user for 1987-1990. He/she may either choose and index from the table, according to the year he/she is making analysis or he/she may enter his/her own index. The package automatically multiplies the index with the current period data and inputs the result to the price section.

Results: After data is entered, results part will be selected; by moving the curser on it and pressing (Return).

Another menu appears on the screen:

BASE/CURRENT	BASE/PROJECTED

If Base/Current year analysis is selected, base and current period data are inputted, if Base/Projected year analysis is selected Base and projected period data are inputted. If the three periods' data are inputted, both of the analysis can be selected. Either of them will provide the same menu.

The Effects on Profits	Weighted Performance Indexes	Weighted Change Ratios	Cost/Revenue and Productivity Ratios

1. Weighted Performance Indexes: Calculate dynamic performance indexes: productivity: price-weighted productivity indexes are calculated for each input element (class-type-level categorization), comparing current period or projected period to the base period.

Price Recovery: Quantity weighted price recovery indexes are calculated for each input element (class-type-level categorization) comparing current period or projected period to the base period. It reflects the degree to which the organizational system was able to increase its price in relation to elemental input costs.

Profitability: Indicates profitability indexes comparing current period or projected period to the base period.

2. TL Effects on Profits: Productivity: indicates what impact an increase in productivity has on profits from base period to current period or projected period in TL values.

Price Recovery: Indicates the effect of price recovery on profits from base period to current period or projected period in TL values.

Profitability: The total effects of productivity and price recovery on profits comparing current period or projected period to the base period in TL values.

3. Weighted Change Ratios: Quantity: Price-weighted and base period price indexed changes in quantities when the current period or projected period is compared against base period. It indicates decrease or increase in the quantities of output/input class-type-level categorization when the effects of prices are held constant.

Price: Quantity-weighted and current period quantity indexed changes in unit prices and unit costs, when the current period (or projected period) is compared against base period. It indicates a decrease or increase in the unit price (unit cost) of the output (input) class-type-level categorization, when the effects of quantity are held constant.

Value: Examines the simultaneous impact of changes in price and quantity from the base period to the current or projected period. It indicates a decrease or increase in the value (price x quantity) of output/input class-type-level categorization.

4. Cost/Revenue and Productivity Ratios: Cost/Revenue Ratios indicate the ratio of the value of each input element (class-type-level categorization) to total output's value for the base period (period 1) and the current period or projected period (period 2). Those ratios will help managers to make productivity improvement decisions interms of cost reduction.

Productivity Ratios reflect output-to-input ratios for period 1 (base period) and period 2 (current or projected period) (Static productivity indexes are calculated for each individual input element).

GRAPHICS: If the graphics option is selected, another menu will appear on the screen:

pie chart of Inputs as % of tot. Input Costs	pie chart of Inputs as % of Revenues

If either of the pie charts are selected another menu will appear:

PERIOD 1	PERIOD 2	PERIOD 3

1. Pie chart of Inputs as % of total Input Costs: According to the Selected period; period 1 (base period), period 2 (current period), period 3 (projected period), a pie chart showing the percentages of input costs; total energy cost, total labor cost, total material cost and total capital cost to the total input costs will be drawn on the screen.

2. Pie chart of Input Costs as % of total Revenues: According to the selected period; base, current or projected, a pie chart showing input costs (total labor cost, total material cost, total energy cost, total capital cost) as percentage of total revenues will be drawn on the screen. If input costs are greater than revenues, pie chart will not be drawn as it will be meaningless. A message will warn the user saying "If costs > Revenue, do not draw the pie chart". Otherwise to draw the pie chart will be meaningful and total labor, total material, total energy and total capital costs as % of revenue will be observed on the chart, the remaining portion of the pie will indicate the profit.

By pressing 2 times (ESC) and afterwards (Home) the user will return to the beginning of the package and pressing (Alt) and (A) simultaneously, may call menu items again and may observe any section of the package over and over. If the user wants to make sensitivity analysis, he/she may change quantity or price of certain elements and observe differences obtained in the "Results" section.

APPENDIX F

January(86)/January(85)

NOTE: "ERR" observed in the outputs, indicates that type of material is not used in that period.

B A S E Y E A R

OUTPUTS	QUANTITY (TON)	PRICE (TL/TON)	VALUE (MILLION T
I. DOMESTIC	7395.50	182111.70	1346.8
II.EXPORTS	3854.80	111652.50	430.40
TOTAL OUTPUTS			1777.21

PRESS {HOME}

B A S E Y E A R

INPUTS	QUANTITY	PRICE	VALUE
I.MATERIAL			
Direct Material			
a.Sand (kg)	10294097.00	4.02	41.38
b.Soda-Ash (kg)	2926469.00	112.58	329.46
c.Dolomite (kg)	2379102.00	6.28	14.94
d.Kalker (kg)	333530.00	5.82	1.94
e.Lime Stone (kg)	334399.00	12.44	4.16
f.Cullet (kg)	149770.00	27.17	4.07
2.Indir. Material			
a.Tin			
b.Nitrogen (Nm^3)	1116000.00	26.64	29.73
c.Hydrogen (M^3)	6704.00	379.65	2.55
d.Cutting oil(kg)	57.00	1217.10	0.07
e.Cut.Wheel (Ad)	256.00	1243.51	0.32

PRESS {Pg Dn} TO CONTINUE

B A S E Y E A R

INPUTS			
3.Packaging Mat.			
a.PVC Powder (kg)	400.00	832.01	0.33
b.Nail (kg)	6909.00	186.89	1.29
c.Lumber (m^3)	1735.00	23746.85	41.20
d.Strap (kg)	12583.90	196.22	2.47
e.Paper (kg)	39898.00	184.75	7.37
f.Talas (m^3)	71.00	44397.45	
g.Kavak (m^3)	36.00	34000.00	1.22
h.Mukavva (kg)	1890.00	117.02	0.22
i.Kraft (kg)	5926.00	290.60	1.72
j.Branda (kg)	112.00	272.24	0.03
TOTAL MATERIALS			484.49

PRESS {Pg Dn} TO CONTINUE

INPUTS			
II.LABOR (man)			
1.Direct Labor	300.00	146523.00	43.96
2.Indirect Labor	524.00	140516.00	73.63
TOTAL LABOR			117.59
III.ENERGY			
1.Furnaces			
a.Fuel Oil (kg)	1380716.00	85.68	118.30
b.Nat. Gas (Nm^3)	1807479.00	71.94	130.03
c.Electricity(kwh)	335000.00	18.71	6.27
2.Other			
a.Nat. Gas (Nm^3)	405316.00		0.00
b.Electricity(kwh)	2556266.00	18.71	47.83
c.Diesel Oil (lt)	42138.00	117.42	4.95
d.LPG (kg)	135.00	115.88	0.02
TOTAL ENERGY			307.39

INPUTS			
IV.CAPITAL (TL)	9573434100.00	1.35	12924.14
TOTAL INPUTS			709.46

PRESS {HOME}

C U R R E N T Y E A R

OUTPUTS	QUANTITY (TON)	PRICE (TL/TON)	VALUE (MILLION TL)
. DOMESTIC	8387.90	277000.50	2324.01
I.EXPORTS	2378.80	171000.80	406.78

OTAL OUTPUTS	2730.78

PRESS (HOME)

C U R R E N T   Y E A R

INPUTS	QUANTITY	PRICE	VALUE
.MATERIAL			
irect Material			
.Sand (kg)	8700109.00	7.27	63.25
.Soda-Ash (kg)	2511560.00	125.08	314.15
.Dolomite (kg)	2021164.00	10.05	20.31
.Kalker (kg)	283039.00	9.77	2.77
.Lime Stone (kg)	293177.00	15.06	4.42
.Cullet (kg)	317980.00	37.52	11.93
.Indir. Material			
.Tin			0.00
.Nitrogen (Nm^3)	1116000.00	40.89	45.63
.Hydrogen (M^3)	46920.00	730.04	34.25
.Cutting oil(kg)	80.00	1217.10	0.10
.Cut.Wheel (Ad)	180.00	1246.31	0.22

PRESS (Pg Dn) TO CONTINUE

INPUTS			
.Packaging Mat.			
.PVC Powder (kg)	400.00	1381.79	0.55
.Nail (kg)	6225.00	219.41	1.37
.Lumber (m^3)	1350.00	32325.78	43.64
.Strap (kg)	12097.00	194.57	2.35
.Paper (kg)	19313.00	302.81	5.85
.Talas (m^3)			0.00
.Kavak (m^3)			0.00
.Mukavva (kg)	2300.00	220.87	0.51
.Kraft (kg)	16063.00	408.49	6.56
.Branda (kg)			0.00
OTAL MATERIALS			557.86

INPUTS			
I.LABOR (man)			
.Direct Labor	353.00	180358.00	63.67
.Indirect Labor	478.00	245074.00	117.15
TOTAL LABOR			180.81
II.ENERGY			

1.Furnaces			
a.Fuel Oil (kg)	1387504.00	113.54	157.54
b.Nat. Gas (Nm^3)	1596288.00	99.96	159.56
c.Electricity(kwh)	358400.00	39.69	14.22
2.Other			
b.Nat. Gas (Nm^3)	453810.00	99.96	45.36
c.Electricity(kwh)	1917256.00	39.69	76.10
c.Diesel Oil (lt)	11396.00	148.68	1.69
d.LPG (kg)	7000.00	164.62	1.15
TOTAL ENERGY			455.63

INPUTS			
IV.CAPITAL (TL)	13887702000.00	1.33	18470.64
TOTAL INPUTS			1194.30

PRESS (HOME)

BASE / CURRENT YEAR ANALYSIS
WEIGHTED CHANGE RATIOS

	QUANTITY	PRICE	VALUE
I. DOMESTIC	1.13	1.52	1.73
II.EXPORTS	0.62	1.53	0.95
TOTAL OUTPUTS	1.01	1.52	1.54
I.MATERIAL			
Direct Material			
a.Sand (kg)	0.85	1.81	1.53
b.Soda-Ash (kg)	0.86	1.11	0.95
c.Dolomite (kg)	0.85	1.60	1.36
d.Kalker (kg)	0.85	1.68	1.42
e.Lime Stone (kg)	0.88	1.21	1.06
f.Cullet (kg)	2.12	1.38	2.92

PRESS (Pg Dn) TO CONTINUE

BASE / CURRENT YEAR ANALYSIS
WEIGHTED CHANGE RATIOS

	QUANTITY	PRICE	VALUE

2.Indir. Material			
a.Tin	ERR	ERR	ER
b.Nitrogen (Nm^3)	1.00	1.53	1.5
c.Hydrogen (M^3)	7.00	1.92	13.4
d.Cutting oil(kg)	1.40	1.00	1.4
e.Cut.Wheel (Ad)	0.70	1.00	0.7
3.Packaging Mat.			
a.PVC Powder (kg)	1.00	1.66	1.6
b.Nail (kg)	0.90	1.17	1.0
c.Lumber (m^3)	0.78	1.36	1.0
d.Strap (kg)	0.96	0.99	0.9
e.Paper (kg)	0.48	1.64	0.7
f.Talas (m^3)	0.00	ERR	0.0
g.Kavak (m^3)	0.00	ERR	0.0

PRESS {Pg Dn} TO CONTINUE

W E I G H T E D   C H A N G E   R A T I O S

	QUANTITY	PRICE	VALUE
h.Mukavva (kg)	1.22	1.89	2.3
i.Kraft (kg)	2.71	1.41	3.8
j.Branda (kg)	0.00	ERR	0.0
TOTAL MATERIALS	0.90	1.28	1.1
II.LABOR (man)			
1.Direct Labor	1.18	1.23	1.4
2.Indirect Labor	0.91	1.74	1.5
TOTAL LABOR	1.01	1.52	1.5
III.ENERGY			
1.Furnaces			
a.Fuel Oil (kg)	1.00	1.33	1.3
b.Nat. Gas (Nm^3)	0.88	1.39	1.2
c.Electricity(kwh)	1.07	2.12	2.2

PRESS {Pg Dn} TO CONTINUE CONTINUE

	QUANTITY	PRICE	VALUE
2.Other			
b.Nat. Gas (Nm^3)	ERR	ERR	ER
c.Electricity(kwh)	0.75	2.12	1.5
c.Diesel Oil (lt)	0.27	1.27	0.3
d.LPG (kg)	51.85	1.42	73.6
TOTAL ENERGY	0.89	1.68	1.3
IV.CAPITAL (TL)	1.45	0.99	1.4
TOTAL INPUTS	1.41	1.00	1.4

PRESS {HOME}

B A S E / C U R R E N T   Y E A R   A N A L Y S I S

INPUTS	COST/REVENUE RATIOS PERIOD 1	COST/REVENUE RATIOS PERIOD 2	PRODUCTIVITY RATIOS PERIOD 1	PRODUCTIVITY RATIOS PERIOD 2
I.MATERIAL				
Direct Material				
a.Sand (kg)	0.02	0.02	42.95	51.28
b.Soda-Ash (kg)	0.19	0.12	5.39	6.34
c.Dolomite (kg)	0.01	0.01	118.95	141.30
d.Kalker (kg)	.00	.00	915.54	1088.76
e.Lime Stone (kg)	.00	.00	427.22	491.76
f.Cullet (kg)	.00	.00	436.74	207.59

PRESS {Pg Dn} TO CONTINUE

B A S E / C U R R E N T   Y E A R   A N A L Y S I S

	COST/REVENUE RATIOS PERIOD 1	COST/REVENUE RATIOS PERIOD 2	PRODUCTIVITY RATIOS PERIOD 1	PRODUCTIVITY RATIOS PERIOD 2
2.Indir. Material				
a.Tin	0.00	0.00	ERR	ERR
b.Nitrogen (Nm^3)	0.02	0.02	59.78	60.33
c.Hydrogen (M^3)	.00	0.01	698.26	100.69
d.Cutting oil(kg)	.00	.00	25617.48	18419.79
e.Cut.Wheel (Ad)	.00	.00	5582.75	8012.70
3.Packaging Mat.				
a.PVC Powder (kg)	.00	.00	5340.10	5389.05
b.Nail (kg)	.00	.00	1376.37	1541.61
c.Lumber (m^3)	0.02	0.02	43.14	55.94
d.Strap (kg)	.00	.00	719.75	755.58
e.Paper (kg)	.00	.00	241.10	502.65
f.Talas (m^3)	0.00	0.00	ERR	ERR
g.Kavak (m^3)	.00	0.00	1451.96	ERR

PRESS {Pg Dn} TO CONTINUE

	COST/REVENUE RATIOS PERIOD 1	COST/REVENUE RATIOS PERIOD 2	PRODUCTIVITY RATIOS PERIOD 1	PRODUCTIVITY RATIOS PERIOD 2
h.Mukavva (kg)	.00	.00	8035.55	6663.66
i.Kraft (kg)	.00	.00	1032.00	384.22
j.Branda (kg)	.00	0.00	58286.45	ERR
TOTAL MATERIALS	0.27	0.20	3.67	3214973.35
II.LABOR (man)				
1.Direct Labor	0.02	0.02	40.43	34.65
2.Indirect Labor	0.04	0.04	24.14	26.70
TOTAL LABOR	0.07	0.07	15.11	9919144.94
III.ENERGY				
1.Furnaces				
a.Fuel Oil (kg)	0.07	0.06	15.02	15.09

b.Nat. Gas (Nm^3)	0.07	0.06	13.67	15.62
c.Electricity(kwh)	.00	0.01	283.54	267.46

PRESS {Pg Dn} TO CONTINUE

	COST/REVENUE RATIOS PERIOD 1	COST/REVENUE RATIOS PERIOD 2	PRODUCTIVITY RATIOS PERIOD 1	PRODUCTIVITY RATIOS PERIOD 2
2.Other				
b.Nat. Gas (Nm^3)	0.00	0.02	ERR	ERR
c.Electricity(kwh)	0.03	0.03	37.16	50.00
c.Diesel Oil (lt)	.00	.00	359.19	1340.31
d.LPG (kg)	.00	.00	113604.44	2211.03
TOTAL ENERGY	0.17	0.17	5.78	3936281.94
IV.CAPITAL (TL)	7.27	6.76	0.14	0.10
TOTAL INPUTS	7.61	7.04	1.95	1501712.21

PRESS {HOME}

B A S E / C U R R E N T Y E A R A N A L Y S I S
W E I G H T E D P E R F O R M A N C E I N D E X E S

INPUTS	PRODUCTIVITY	PRICE RECOVERY	PROFITABILITY
I.MATERIAL			
Direct Material			
a.Sand (kg)	1.19	0.84	1.01
b.Soda-Ash (kg)	1.18	1.37	1.61
c.Dolomite (kg)	1.19	0.95	1.13
d.Kalker (kg)	1.19	0.91	1.08
e.Lime Stone (kg)	1.15	1.26	1.45
f.Cullet (kg)	0.48	1.10	0.52

PRESS [PG Dn] TO CONTINUE

B A S E / C U R E N T Y E A R A N A L Y S I S
W E I G H T E D P E R F O R M A N C E I N D E X E S

	PRODUCTIVITY	PRICE RECOVERY	PROFITABILITY
2.Indir. Material			
a.Tin	ERR	ERR	ERR
b.Nitrogen (Nm^3)	1.01	0.99	1.00
c.Hydrogen (M^3)	0.14	0.79	0.11
d.Cutting oil(kg)	0.72	1.52	1.09
e.Cut.Wheel (Ad)	1.44	1.52	2.18
3.Packaging Mat.			
a.PVC Powder (kg)	1.01	0.92	0.93

b.Nail (kg)	1.12	1.30	1.4
c.Lumber (m^3)	1.30	1.12	1.4
d.Strap (kg)	1.05	1.54	1.6
e.Paper (kg)	2.08	0.93	1.9
f.Talas (m^3)	ERR	ERR	ER
g.Kavak (m^3)	ERR	ERR	ER

PRESS [PG Dn] TO CONTINUE

B A S E / C U R E N T Y E A R A N A L Y S I S

	PRODUCTIVITY	PRICE RECOVERY	PROFITABILITY
h.Mukavva (kg)	0.83	0.81	0.6
i.Kraft (kg)	0.37	1.08	0.4
j.Branda (kg)	ERR	ERR	ER
TOTAL MATERIALS	1.13	1.19	1.3
II.LABOR (man)			
1.Direct Labor	0.86	1.24	1.0
2.Indirect Labor	1.11	0.87	0.9
TOTAL LABOR	1.00	1.00	1.0
III.ENERGY			
1.Furnaces			
a.Fuel Oil (kg)	1.00	1.15	1.1
b.Nat. Gas (Nm^3)	1.14	1.10	1.2
c.Electricity(kwh)	0.94	0.72	0.6

PRESS [PG Dn] TO CONTINUE

	PRODUCTIVITY	PRICE RECOVERY	PROFITABILITY
2.Other			
b.Nat. Gas (Nm^3)	ERR	ERR	ER
c.Electricity(kwh)	1.35	0.72	0.9
c.Diesel Oil (lt)	3.73	1.20	4.4
d.LPG (kg)	0.02	1.07	0.0
TOTAL ENERGY	1.14	0.91	1.1
IV.CAPITAL (TL)	0.70	1.55	1.0
TOTAL INPUTS	0.71	1.52	1.0

PRESS (HOME)

B A S E / C U R R E N T Y E A R A N A L Y S I S

T O T A L E F F E C T S O N P R O F I T S

	PRODUCTIVITY	PROFITABILITY	PRICE RECOVERY
INPUTS			
I.MATERIAL			
Direct Material			

a.Sand (kg)	6.79	0.34	-6.4
b.Soda-Ash (kg)	49.73	192.09	142.3
c.Dolomite (kg)	2.38	2.64	0.2
d.Kalker (kg)	0.31	0.22	-0.0
e.Lime Stone (kg)	0.55	1.98	1.4
f.Cullet (kg)	-4.53	-5.68	-1.1

PRESS (Pg Dn) TO CONTINUE

B A S E / C U R E N T Y E A R A N A L Y S I S

T O T A L E F F E C T S O N P R O F I T S

	PRODUCTIVITY	PROFITABILITY	PRICE RECOVERY
2.Indir. Material			
a.Tin	ERR	ERR	ER
b.Nitrogen (Nm^3)	0.27	0.05	-0.2
c.Hydrogen (M^3)	-15.24	-30.34	-15.1
d.Cutting oil(kg)	-0.03	0.01	0.0
e.Cut.Wheel (Ad)	0.10	0.26	0.1
3.Packaging Mat.			
a.PVC Powder (kg)	.00	-0.04	-0.0
b.Nail (kg)	0.14	0.62	0.4
c.Lumber (m^3)	9.52	19.67	10.1
d.Strap (kg)	0.12	1.44	1.3
e.Paper (kg)	3.87	5.48	1.6
f.Talas (m^3)	0.00	0.00	0.0
g.Kavak (m^3)	1.24	1.88	0.6

PRESS (Pg Dn) TO CONTINUE

T O T A L E F F E C T S O N P R O F I T S

	PRODUCTIVITY	PROFITABILITY	PRICE RECOVERY
h.Mukavva (kg)	-0.05	-0.17	-0.1
i.Kraft (kg)	-2.93	-3.92	-0.9
j.Branda (kg)	0.03	0.05	0.0
TOTAL MATERIALS	55.09	190.18	135.0
II.LABOR (man)			
1.Direct Labor	-7.36	3.88	11.2
2.Indirect Labor	7.14	-4.01	-11.1
TOTAL LABOR	-0.22	-0.13	0.0
III.ENERGY			
1.Furnaces			
a.Fuel Oil (kg)	0.50	24.24	23.7
b.Nat. Gas (Nm^3)	16.39	40.23	23.8
c.Electricity(kwh)	-0.38	-4.59	-4.2

PRESS (Pg Dn) TO CONTINUE

	PRODUCTIVITY	PROFITABILITY	PRICE RECOVERY
2.Other			
b.Nat. Gas (Nm^3)	ERR	ERR	ER

c.Electricity(kwh)	12.39	-2.61	-15.(
c.Diesel Oil (lt)	3.66	5.91	2.2
d.LPG (kg)	-0.80	-1.13	-0.3
TOTAL ENERGY	38.11	61.60	23.4
IV.CAPITAL (TL)	-5705.78	1388.07	7093.8
TOTAL INPUTS	-368.89	107.86	476.7

PRESS {HOME}

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