A Multiple Case Study Research to Determine and Respond to Management Information Needs Using Total-Factor Productivity Measurement

by

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A MULTIPLE CASE STUDY RESEARCH TO DETERMINE AND RESPOND TO MANAGEMENT INFORMATION NEEDS USING TOTAL-FACTOR PRODUCTIVITY MEASUREMENT (TFPM)

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(ABSTRACT)

This study (1) determines the information managers commonly need to make decisions and initiate actions to improve performance, based on selected case studies, (2) investigates and explains the features and issues involved with how the different versions of TFPM address these information needs, and (3) develops a teaching model of TFPM.

Based on the literature review, interviews with experts, and experiences with applications, the features and differences of the available TFPM versions were explained, providing sample applications whenever necessary. Using four selected cases, common user information needs were identified and compared with results of previous surveys. Alternative TFPM applications for each case were developed and evaluated using Archer's (1978) Design Process as implemented with VPC's (1990) PRFORM software. Based on the evaluations of the TFPM applications in each of the case studies, a teaching TFPM model was developed incorporating the features of the available TFPM versions that most appropriately responded to the common information needs. Some other features not portrayed in the available TFPM versions were added to facilitate portrayal, understanding, and acceptance for new users.

There are basically two models of TFPM - the Productivity Indices (PI) Model and the Profitability = Productivity + Price Recovery (PPPR) Model. I proved that as

implemented with discrete variables, Gollop's Model is equivalent to the PPPR Model. Various versions of these two models feature differences in deflation, aggregation of outputs, inputs, and/or organizational units, treatment of capital, computation of dollar effects of changes in performance, and how to use TFPM for planning.

The common information needs identified were (1) measures of a firm's past performance using physical productivity related to profitability; (2) measures of individual organizational units' productivity aggregated into plant, division, or firm level productivity; (3) partial measures to explain what factors drive the total performance measures; and (4) evaluations of plans/budgets to ensure performance improvement.

Based on the evaluations of possible TFPM versions appropriate for each application, REALST stands out as the most advanced and flexible version. However, it has become too complicated for first-time users. Hence, the teaching TFPM model I have developed is a simplified version of REALST.

Acknowledgements

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Finally, I dedicate this dissertation to my wife, Marvy, and our girls, Trixie, Trina, Crissy, and Vica. I know you had to make sacrifices so I could achieve this goal. You not only provided the inspiration that kept me going but you were always there when I needed you.

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Chapter 1: The Problem and Its Setting

Problem Statement

Despite the availability of at least 13 models/versions of the Total-Factor Productivity Measurement (TFPM) in the literature (see Table 1.1), TFPM is still underutilized as a management tool for helping managers make decisions and initiate actions to improve performance and productivity (Thor, 1986; Craig and Harris, 1973; Loggerenberg and Cucchiaro, 1982; Kaplan, 1984; Skinner, 1986; Cosgrove, 1987; Steedle, 1988); and even those managers and industrial engineers who want to measure performance and productivity are not sure about how to do it. There is no "generally-accepted" TFPM model from which first-time users can learn.

This study (1) determines the information managers commonly need to make decisions and initiate actions to improve performance, based on selected case studies and, (2) investigates and explains the theoretical and methodological issues involved with how the different versions of TFPM and Cost Accounting Systems address these information needs, and (3) develops a teaching model of TFPM that will provide these common information needs.

Subproblems and Research Questions

The problem can be broken down into the following subproblems and their corresponding research questions:

Subproblem 1: Determining Common User Information Needs

What are managers' main concerns regarding performance improvement? What information do they commonly need to make decisions and initiate actions?

Table 1.1: There Are at Least 13 TFPM Models/Versions

MODELS	VERSIONS	MAIN FEATURES
Productivity Indices (deflates all values to constant dollars; productivity index = sum of all output values over sum of all input values)	Davis (1955)	- inclusion of all inputs (including capital)
	Kendrick and Creamer (1965)	- book value used for capital input
	Craig and Harris (1973)	- lease value used for capital input
	Hines (1976)	- productivity per product
	Mundel (1983)	- added details for computing input values
	Sumanth (1979)	- firm productivity is the weighted sum of productivity of all products - firm productivity related to profit breakeven
	LTV/Vought Aero Products Division	- "challenge budgets"
Profitability = Productivity + Price Recovery (Productivity is related to accounting profitability and price recovery)	American Productivity and Quality Center (APQC,1978)	- use of Laspeyres and Paasche indices - dollar effects, partial productivities and price recoveries portrayed in base period dollars - capital compensation
	REsource ALlocation STrategist (REALST, 1982)	- clarified conceptual models - concept of resource variability to break down productivity into capacity utilization and efficiency - strategic grids - attributes: data aggregation/level of detail - dollar effects portrayed in current period dollars - difference operators
	Miller (1984)	- cumulative deflation
	Virginia Productivity Center (VPC,1985)	- multi-factor concept (capital may be excluded) - graphics/portrayal development
	Financial Productivity Measurement (FPM, 1988)	- productivity, quantity, and price grids - import/export of data with other software
Econometric	Gollop (1982)	- uses growth rates of outputs and inputs

Subproblem 2: What Information Do Available TFPM Versions and Related Cost Accounting Systems Provide?

Do the present versions adequately address the common user information needs? Are the common information needs identified in the first research question presently addressed by available accounting systems?

Subproblem 3: What Constitutes a Teaching TFPM Model for First Time Users?

How can common user information needs not presently provided by available versions be addressed? How can alternative ways of addressing a particular user requirement be evaluated?

Desired Outcomes and Outputs of the Research

To eventually solve these subproblems and find answers to the research questions, the following outputs were obtained:

- I reviewed previous surveys and documented new case studies. The case studies identify a number of user requirements and the alternative methods that may be used to develop an appropriate TFPM application for each case. The assumption here is that case examples can help identify user requirements, differences, similarities, strengths, and weaknesses of each version (how and why their methods work), and help readers understand the distinctions between various models/versions. This output addresses subproblems 1 and 2, and provides alternative solutions for subproblem 3.

- From the case studies, I compiled a list of the common user requirements. These user requirements are in the form of information needs, desirable characteristics of the model, and user/application conditions that models need to address. This output addresses subproblem 1.

- Based on the literature review and my experience with the cases, a thorough explanation of each available model and/or version, their similarities, differences, strengths and weaknesses, theoretical foundation, assumptions and implications, data requirements and information generated was made. The assumption here is that there is a need to clarify the differences and similarities of each of the models, versions, and features so as to facilitate use of TFPM. In particular, I shall analyze different deflation , data structure/aggregation, including the treatment of capital input, and information portrayal methods. This output addresses subproblem 2.

- A prototype structure and process for designing and evaluating a TFPM application was developed. This output addresses subproblems 2 and 3.

- Based on the preceding outputs, a simple teaching model that can be used by first-time users to learn and gain experience and insights into TFPM was developed. The assumption is once users start correctly and achieve initial success, they will gain enough momentum to develop their application to better fit their needs. This output addresses subproblem 3.

<u>As a result of having these outputs, the following desired outcomes are achieved:</u>

- Academicians and practitioners will have a starting point for resolving the apparent debate on how to do Total-Factor Productivity Measurement. Possible users will more easily understand the differences, strengths, weaknesses, and features of each model and/or version.

- Having a simple teaching model that can later be customized will facilitate the development and implementation of TFPM applications which can lead to better performance measurement, evaluation, control and improvement; and generate more data to continuously evaluate and develop TFPM models and versions.

- I learned how to do innovative and independent research and how to design and implement TFPM, in particular, and performance measurement, in general.

Why Am I Doing This Research?

There are several organizational performance measurement approaches in the literature. I have chosen to study Total-Factor Productivity Measurement (TFPM) for the following reasons: (1) Organizations have traditionally used macro financial accounting and micro operating measures based on IE standards. Kaplan (1984) points out the inadequacy of traditional measures for summarizing organizational performance and helping decision makers achieve and maintain world-class competitiveness. TFPM responds to this concern as it measures the contributions of changes in productivity and price recovery to changes in profitability over at least two periods. Since productivity and price recovery have strategic implications (Loggerenberg and Cucchiaro, 1982; Parsons, 1986) not presently portrayed by most financial reports, TFPM should appeal to managers and controllers who are not just concerned with short-term profits but also with long-term survival, growth, and excellence. (2) TFPM is state-of-the-art in measuring productivity (Sink, Tuttle, and DeVries, 1984). It's one of the more developed measurement methods as evidenced by at least 13 versions in the literature; however, (3) it's still underutilized (Thor, 1986). In fact, Craig and Harris (1973), Loggerenberg and Cucchiaro (1982), Kaplan (1984), Skinner (1986) and Cosgrove (1987) observed that few companies (<3%) have a system for measuring macro productivity, although a more recent survey of 1000 U.S. controllers shows 28% using TFPM (Steedle, 1988).

According to a survey done by UCCEL Corp. and the American Productivity and Quality Center (APQC) and the survey of controllers just mentioned, lack of management support and difficulties in data collection are the main reasons more firms have not adopted a total productivity measurement system (APQC, 1985). Figure 1.1 shows the reasons why 63% of those who have previously attended APQC workshops on TFPM are not using it. However, Miller (1989) said data collection is not really a problem as long as there is support from management and the controller. This observation is supported by his experience with Ethyl and GM and VPC's experience with LTV, Xaloy, a food and beverage company in the Philippines, a defense contractor, and a pharmaceutical plant.

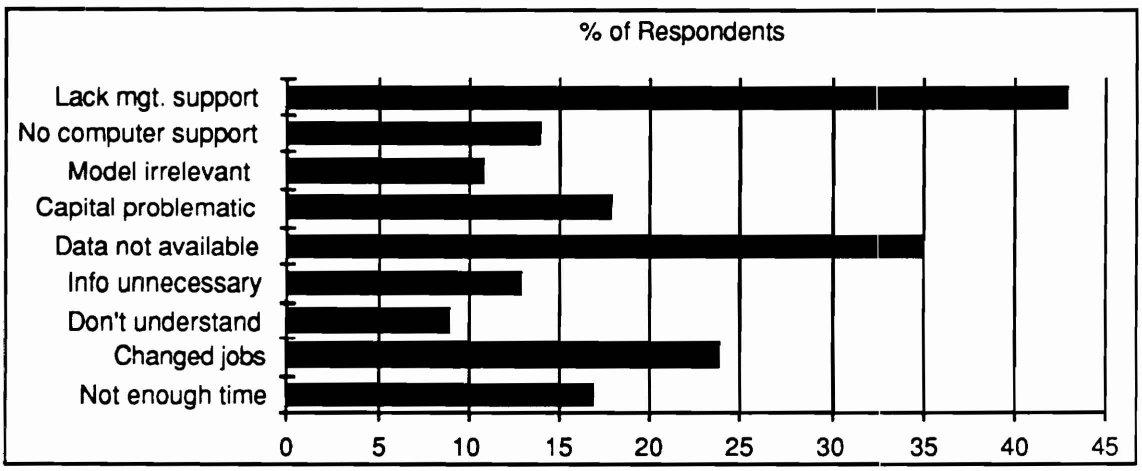


Figure 1.1: Reasons For Not Using TFPM (APQC, 1985)

There is a need then for managers to realize the value of TFPM as a management tool. This means having to portray it such that it responds to information needs they are not presently getting from their information systems. Most of the accountants I've met don't see any new information and believe they can also provide whatever information

TFPM can provide. Some of them think that accounting profit, volume, and price variance analysis provide the same information. I believe TFPM provides information beyond what most accounting reports provide. Kaplan (1984, 1985) has strongly advocated the need for new performance measures in his articles that have influenced the development of what is now called "Activity-Based Cost" (ABC) Accounting. I've investigated these issues and new developments to show that TFPM does provide some vital information that decision makers need.

Figure 1.2 shows a cause-and-effect diagram of possible reasons why TFPM is underutilized. The two previously mentioned surveys and my experience with VPC TFPM projects have pointed out that lack of management support is not only the main reason why TFPM has not been widely used; it has also caused other problems such as difficulties in data collection. My research, therefore, addressed questions such as "what information do managers commonly need to make decisions about improving productivity and performance in general, and does TFPM or any other management tool provide such information?" The lack of management support may be due to the lack of a "generally-accepted" TFPM model from which first-time users can learn. There are at least 13 versions of Total-Factor Productivity Measurement. As shown in Table 1.1, each version has some features distinguishing it from the previous versions. Each version was developed to address particular design specifications and based on the discipline of the designer. There have been claims that one version is better than another in some respects. If a manager wants to use TFPM, what version should he/she use? There is no clear answer to this question.

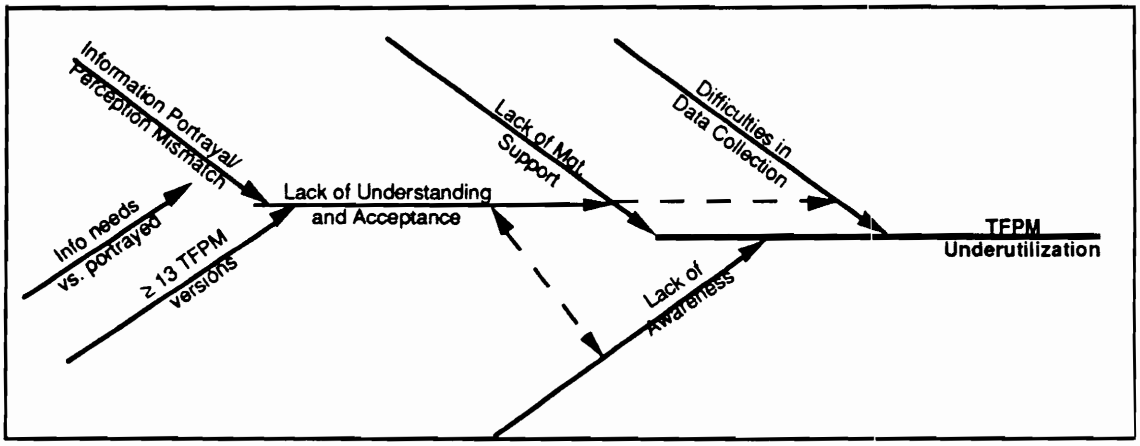


Figure 1.2: Why Is TFPM Underutilized?

In a recent project of the VPC, a recommendation had to be made on a productivity measurement methodology and it wasn't immediately clear what TFPM version to recommend. What are the differences and similarities of these versions in theory and in practice? Are the versions different because they are meant for different applications or are they different ways of approaching the same problem?

This Research Supports the Development of a Management Tool

The Management System Model (Kurstedt, 1986) and Management Systems Analysis (Sink, 1989) provide the framework for the phenomenon I'm researching.

A management system (Kurstedt, 1986; see Figure 1.3) has three components: who manages, what is managed, and what are used to manage; and three interfaces: decisions/actions, measurement/data, and information portrayal/perception. For the decisions/actions interface, Sink (1989) has adapted and focused the model on performance improvement interventions. Management tools have also been focused on performance measurement and evaluation tools rather than all possible management tools. My research further zeroes-in on TFPM as one management tool.

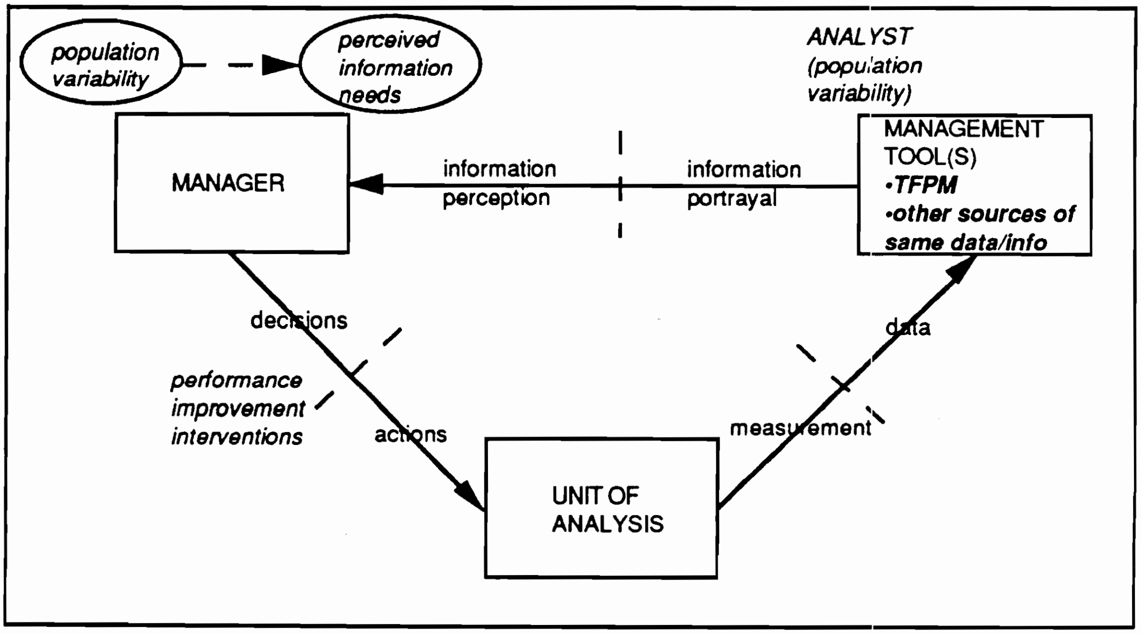


Figure 1.3: TFPM Is a Management Tool (adapted from Kurstedt,1986 and Sink, 1989)

In developing management tools, the logical starting point would be the information needs of the manager. In my experience, however, there may be a need to ask managers other questions such as, "what are your main concerns and what decisions/actions do you make/initiate to improve performance?" rather than directly ask them, "what are your information needs...?" This subproblem would have been more straightforward had we been concerned with only one manager. Since the main problem is developing a TFPM model that provides the common information needs of managers regarding performance improvement, we need to consider a population of managers and the inherent variability of this population. There are three main classifications: managers who have used TFPM and therefore know not only what it can do but also the implementation issues; managers who have a conceptual knowledge either from reading or workshops; and, managers who have not had any exposure to TFPM. The critical concern is to determine the common information needs of these managers regarding performance improvement. This is the first subproblem of this research.

Once the common information needs are identified, the next subproblem is to understand and explain whether the available TFPM models/versions and other management tools such as cost accounting, address these information needs. The solution to this subproblem will identify what and why features from the available TFPM models/versions work, and what features need to be redesigned. This will facilitate my addressing the third subproblem of recommending a "teaching" TFPM model that provides for the common information needs of managers.

This Research Provides a Significant Contribution to the Productivity Measurement Field

The following checklist answers the questions: Why should anyone do this research? What is its contribution to the Productivity Measurement field? The checklist is based on Miller's (1983) adaptation from Ackoff's (1953) *The Design of Social Research.*I have picked eight out of his eleven items that are relevant to my research.

Several authors (Craig and Harris, 1973; Friedman, 1980; Thurow, 1984; Sink, 1988; Du Plooy, 1988; and Grayson and O'Dell,1988) have written about the need to improve productivity for a nation's long-run economic welfare. Craig and Harris (1973), Drucker (1980), Loggerenberg and Cucchiaro (1982), Kaplan (1984), and Sink (1985) emphasize the need for productivity measurement as a means to attain control and improvement. Numbers 1 - 5 of the following checklist are based on these premises.

1. The study is timely as measurement plays a critical role in improving productivity. As Grayson and O'Dell (1988) warn, America may have only two decades to improve or lose its competitive lead. TFPM measures both short-term profitability and long-term strategic stance through productivity and price recovery.

2. The study relates to a practical problem. It's not only for academicians. Business, industry, governments, and nations can use it.

3. The study relates to a wide population, not just to companies or America. It has international significance.

4. The study relates to an influential or critical population - managers, leaders of nations, anyone concerned with productivity.

5. The study has many implications on a wide range of practical problems: measurement, evaluation, control, improvement, productivity comparisons, etc.

6. The study fills a research gap; there is an apparent debate on what is the best model or version of TFPM. This study will take the initial step towards the resolution of this debate. Miller (1988) suggested that research should focus on the investigation of the existing measurement models - an attempt at understanding their basic structure. I believe this is a necessary step even before looking into relationships of productivity with other performance criteria such as quality - a topic I was tempted to pursue.

7. The study may create or improve an instrument for observing and analyzing data - this is the third subproblem of this research. As discussed earlier, TFPM is an instrument for measuring quantities and prices of inputs and outputs of an organization, converting these data into information on profitability, productivity, and price recovery, and portraying the information so managers can use it for making decisions. This research is aimed at improving the usefulness and accuracy of TFPM as a management tool. (Please see Figure 1.4.)

8. The study provides the possibility for a fruitful exploration with known techniques - this research will build on available TFPM versions using case study methods.

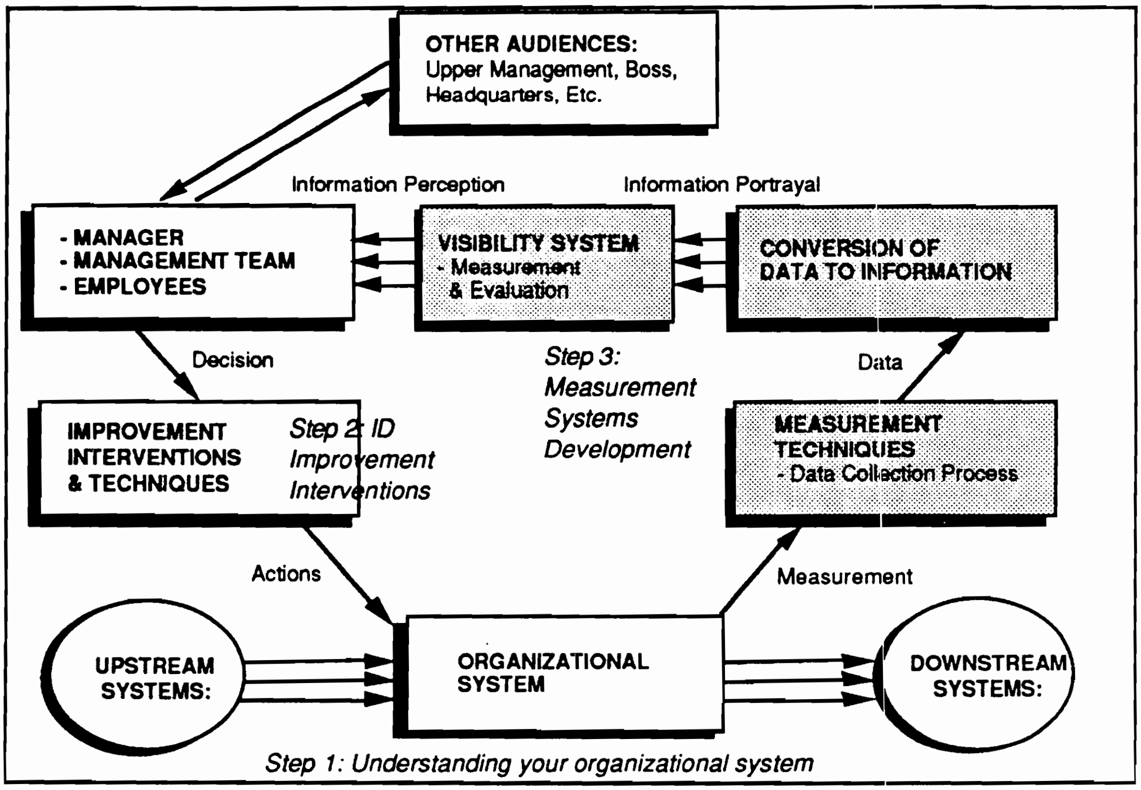


Figure 1.4: Management Systems Analysis Step 3 Focuses on Measurement Systems Development (Kurstedt, 1986 as adapted by Sink, 1989)

Background Information and Definitions Relevant to this Research

All references I've seen basically define productivity as output over input. Three points arise from this definition. First, different units can be used for measuring productivity depending on what outputs and inputs are considered. This can pose a problem when making comparisons as we may be comparing "apples and oranges." Hence, Davis (1955) suggested the use of dollar values as units of input and output. However, this poses another problem: dollar values change over time. Therefore, deflation methods need to be used so the unit of measure will be constant dollars. This leads to the second point associated with the definition of productivity: static measures and dynamic measures. Static measures are productivity ratios for a single period, e.g. total cost per unit of a car; while dynamic measures are ratios of static measures of two periods. The latter compares two periods and shows changes. The third point is the use of partial productivity measures against total-factor productivity measures. Productivity is sometimes equated with labor productivity, e.g. output per manhour. This is just a partial measure as it only considers one input. Total-factor productivity considers all inputs, namely, labor, capital, materials, energy, etc. This research will focus on Total-Factor Productivity Measurement which uses dynamic productivity ratios and their effects on profitability in dollars.

TFPM directly measures and relates productivity with profitability. It also measures price recovery: the rate costs of production or services are passed on to customers, i.e., the ratio of output prices to input costs. Note that price recovery is a related concept but not the same as inflation. Inflation measures the aggregate changes in prices of both outputs and inputs over time in the entire economy, not just for a firm. Price recovery is the relationship of output prices and input costs in one firm. Inflation measures the general trend of costs of goods and services in the macro economy while price recovery measures the rate at which firms pass on the costs of their inputs to their customers. In this context, price recovery may be considered as the firm's contribution to overall economic inflation; a positive price recovery contributes to overall inflation while a negative price recovery can help prevent inflation.

Some clarifications need to be made at this point regarding the terms system, methodology, model, version, tools, and methods. These terms are frequently used in different disciplines, hence, they have different shades of meaning. The following definitions are what I will use for this research:

System: Kurstedt (1986) defines "system" as converting inputs into outputs resulting in throughput to meet some objective(s) and incorporates measures of performance to determine how well the objectives are being met.

Methodology: The dictionary (Flexner, 1987) defines "methodology" as a set or system of methods, principles, and rules for regulating a given discipline, as in the arts or sciences; or the study of the principles underlying the organization of the various sciences and the conduct of scientific inquiry.

Model: is defined as a simplified representation of a system or phenomenon, as in the sciences or economics, with any hypotheses required to describe the system or explain the phenomenon, often mathematically; or to simulate (a process, concept, or the operation of a system), commonly with the aid of a computer.

The TFPM model deals with the mathematical concepts, relationships, and derivations. This model is the theoretical basis for the set of methods, principles, and rules or the methodology for doing Total-Factor Productivity Measurement. I have identified three TFPM models (shown earlier in Table 1.1) as they are based on different concepts and underlying principles. For two of the three models, there are various versions of TFPM.

Version: is defined as a particular form or variant of something. TFPM versions differ from each other as they use different features such as deflation and aggregation. These distinctions were earlier shown in Table 1.1.

Feature: is defined as distinctive characteristics of a version.

Tool: is anything used as a means of accomplishing a task or a purpose. I use the word tool in the same sense as Kurstedt's (1986) management tool. TFPM is a tool that management can use to measure productivity, price recovery, and profitability.

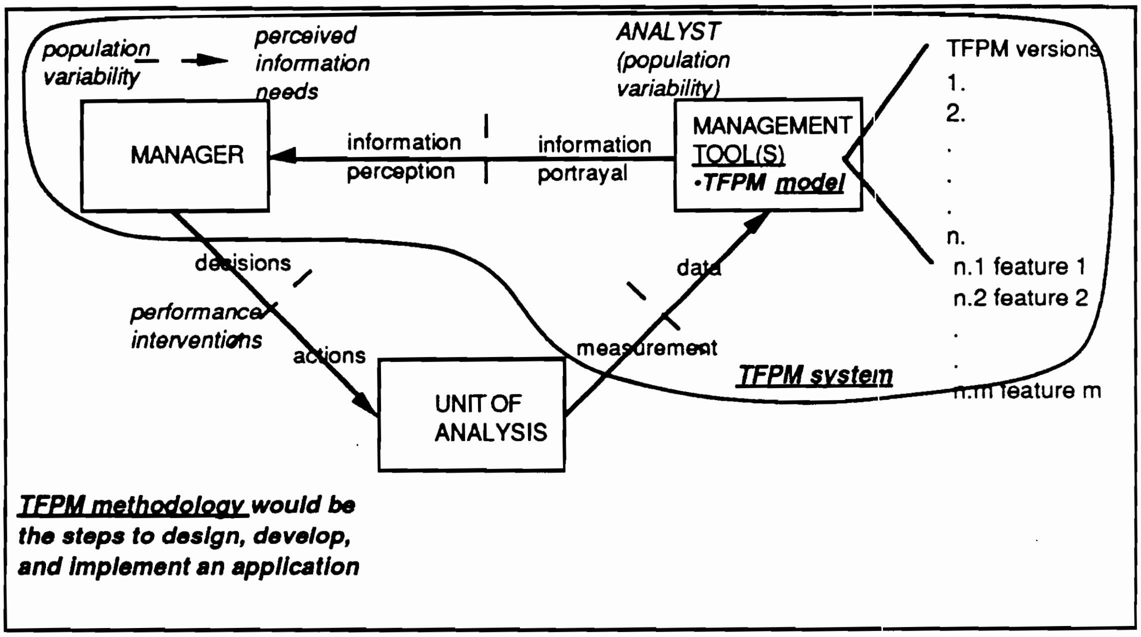


Figure 1.5: Picture Definition of Terms

This chapter has described the research problem, the subproblems, desired outcomes and outputs, the phenomenon surrounding the problem, my motivation for doing the research, background information, and definitions. The next chapter will discuss how the research was conducted.

Chapter 2: How This Research Was Conducted

What is Research? What Type of Research Is This?

Different authors have different definitions of research. The common thread I see running through the definitions I have come across is the following: Research is the process of arriving at dependable solutions to problems through the planned and systematic collection, analysis, and interpretation of data. (Mouly, 1970; Emory, 1980; Leedy, 1980; Miller, 1983; Sekaran, 1984). There are three interrelated key points. (1) What is a research question or problem? It is a question that no one else has been able to answer beyond reasonable doubt or a problem that has not been completely solved. (2) The solution to the problem or the answer to the question can be obtained by a systematic approach which includes collecting, analyzing and interpreting or giving meaning to data. (3) Knowledge is expanded as a result - either finding new truths or reconfirming what was doubted to be true.

The next question is: What is Management Systems Engineering research? The first distinction between MSE research and other disciplines is the subject. MSE deals with solving organizational problems by designing, developing, and implementing management systems using an engineering approach. According to Tompkins (1989), "Scientists discover, mathematicians solve and *engineers design.*" The Graduate Policy Manual of IEOR states that Management Systems Engineering offers formal professional education with a focus on the management of complex socio-technical systems. I believe MSE should focus on the design, development, and implementation of management systems.

Would designing and implementing new management systems for particular organizations constitute MSE research? If designing means following a predetermined or generally-accepted method, this is obviously not research. The National Science

Foundation (NSF, 1982) defines this as development: the systematic use of knowledge or understanding gained from research directed towards the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. The point is, while design and implementation per se may not be research, if they are done to collect, analyze, and interpret data and answer research questions, they become part of research. NSF defines applied research as " directed toward gaining knowledge or understanding necessary for determining the means by which a recognized and specific need may be met. In industry, applied research includes investigations directed to discovery of new scientific knowledge having specific commercial objectives with respect to products and processes." Based on these definitions, what I've done is applied research. This research combines analytical methods (in dealing with mathematical models and underlying principles behind each TFPM model) and qualitative methods particularly using case studies. This integration of "hard and soft" approaches, I believe, is typical of MSE research.

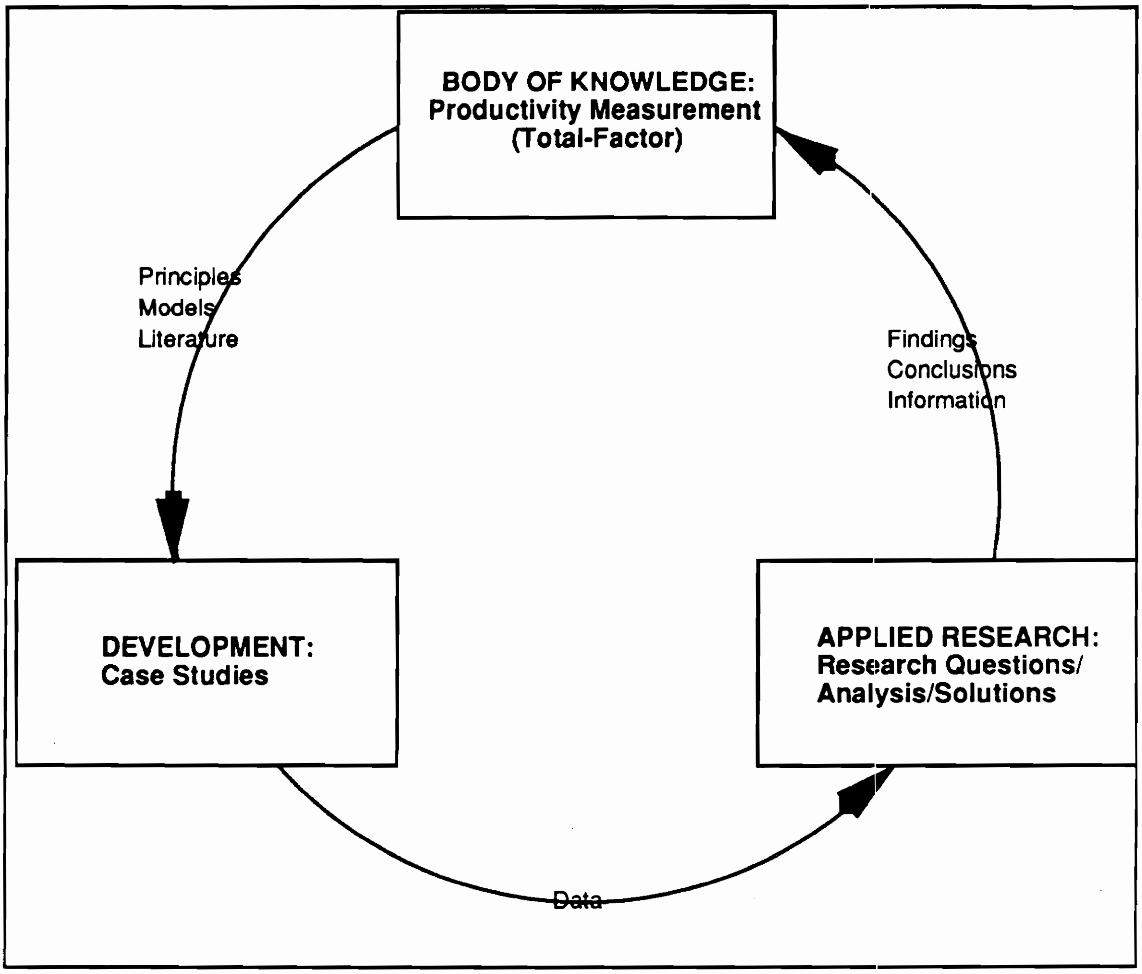


Figure 2.1: Research and Development Process

Conceptual Framework of this Research

This research is related to previous work by Kurstedt (1986) on the Management System Model as adapted by Sink (1989). As shown in Figure 2.2, after management has understood and defined the organizational system and implemented improvement interventions, the next step is to develop performance measurement systems. This entails (a) defining information needs, (b) identifying data needs, and (c) using the appropriate tools to collect, process, store, retrieve, and portray data and information. This research focuses on developing TFPM as an effective and efficient measurement, evaluation, and portrayal tool. This is the conceptual framework of the phenomenon I'm researching.

The critical variable in this research is user information needs. This is why I consider it my "independent variable": it determines what model, version, and/or features (my "decision variable") need to be used to satisfy such information needs. In Figure 2.2, the data and information are collected, analyzed, and portrayed to satisfy the information needs. My research starts with the determination of common user information needs to determine how TFPM should address those needs (the decision variable). The actual information provided by a TFPM application is the dependent variable. Ideally, the dependent variable should approximately equal the independent variable, i.e. the information provided should be the same as the information needed. However, this may not always be the case. Archer's (1978) Design Process evaluates the extent a TFPM application satisfies user information needs.

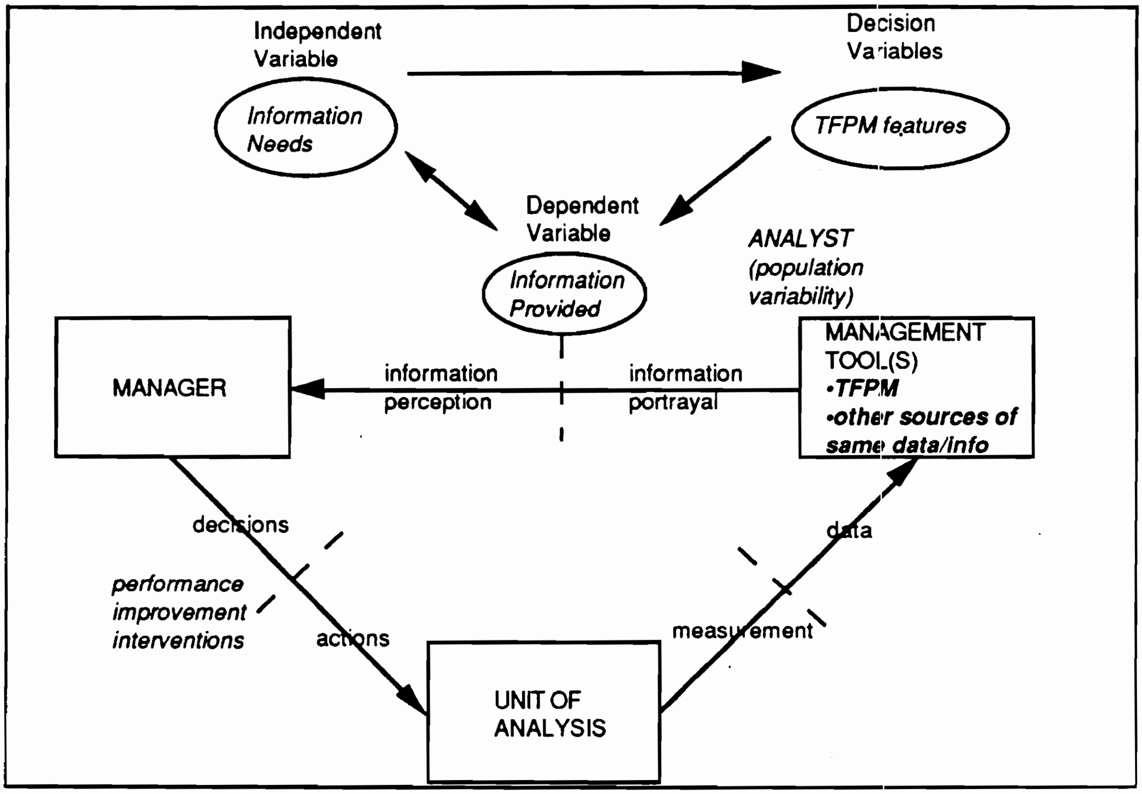


Table 2.2: Conceptual Framework of this Research

Case study methods were used for collecting and analyzing data. Within the case studies, various sources of data such as documents, interviews, and participant-observation (Yin, 1987) were used to determine common information needs and other intervening and moderating variables (referred to as context variables in Figure 2.3) such as organizational conditions in the user's environment. Coding and analysis of data were based on Archer's (1978; Smith, 1989) *The Structure of Design Processes* as operationalized in Sink's (1985) Multi-Criteria Performance Measurement Technique (MCPMT) and its software, PRFORM. According to Archer and Smith, design is an iterative problem-solving process of satisfying goals. There are "arbiters" in the design process who identify and give weights (i.e. relative weight or importance) to the goals or objectives of a design. For this research, the arbiters are managers/users who need TFPM information and analysts/designers who develop the system to provide the needed information. $\{(G_1, r_1), (G_2, r_2), (G_3, r_3), \ldots(G_n, r_n)\}$ represent the goals and their weights, i.e., weighted information needs. "Measuring overall impact on performance" or "measuring partial productivities" are examples of goals.

Each case has its set of weighted user information needs. By getting the sum of weights of the common user information needs across all cases, a set of the most common user information needs was determined. (Variation issues will be dealt with in the next section -- detailed research methodology.) This answers the first research question.

The next set of research questions (on available models/versions) was answered by the literature review and the TFPM model(s)/version(s)' applicability to the cases. Each case study was an independent effort to provide the user's information requirements. This was done by using available models/versions whenever applicable or by trying out new methods to provide information needs present versions could not provide and/or resolving conflicting methods for providing for the same information needs.

Again, Archer's structure was used to process the data from the TFPM applications. To achieve goals, certain TFPM model/version properties ($P_1, P_2, P_3, \ldots P_n$) need to address each goal, i.e., $G = g(P)$. The properties are a function of decision or design variables (D1, D2, D3, ... Dm) and context variables (C1, C2, C3, ...Ck), i.e. $P = f(D,C)$. Decision variables are the features that make up each TFPM model/version while context variables are organizational conditions that affect the TFPM application. For example, "model formulation and how information is portrayed" are properties of TFPM models/versions. "Measuring productivity, price recovery, and/or profitability" and "using static or dynamic measures" are decision variables that influence or contribute to the property: "measuring overall impact on performance." Base period and period length are context variables, not decision variables because the states or values they can take are more influenced by the conditions imposed by the application rather than the design of the TFPM model/version. This is discussed in detail in the research methodology section and a complete example from the pilot case is shown.

Archer also defined an index of merit which is the overall performance rating of a design proposal against the goals previously set. In the case studies on TFPM applications, this would represent on a scale from 0-10, how each TFPM model or version has satisfied the user requirements. This analysis helped me write a survey which describes, compares, and contrasts the available TFPM models/versions. This answers my second set of research questions.

At this point, three of the desired outputs of the research have been completed: the case studies, the common information needs, and the survey/review of the present available versions. Bits and pieces of the fourth desired output are also available from the case studies. Note that the case studies were aimed at developing TFPM applications and features that would provide for the user's information needs. It was a matter of putting together into a teaching model the features that provided for the common user information needs. This teaching model was then compared and contrasted against similar and contradictory literature and results of the case studies.

I mentioned earlier that Archer's concepts were operationalized using MCPMT and PRFORM. PRFORM has three levels of measures: criteria, attributes and sub-attributes. Each criterion may be broken down into attributes which may further be broken down into sub-attributes. The lowest level of measure is normalized into a nominal scale from 0 to 10 by a transformation curve or a function that maps natural scales into the 0-10 nominal scale. Each criterion, attribute, and sub-attribute is weighted so that a weighted average of the transformed or normalized scores may be obtained (Sink, 1985). An example is shown in the next section.

Figure 2.3 shows how I operationalized Archer's concepts of goals, properties, decision and context variables, and their functional relationships into PRFORM's criteria, attribute, sub-attribute, and transformation curves, respectively. Archer's index of merit is the weighted average of transformed scores from each criteria, attribute, and sub-attribute in PRFORM.

In summary, I have:

• developed case studies and in each case study:
  - determined weighted information needs
  - developed and evaluated alternative TFPM applications using PRFORM
• determined common information needs by summing up their weights across all cases
• written an evaluation survey of all available TFPM models/versions based on the literature review and results of the case studies
• recommended a teaching TFPM model based on what has worked in the case studies for satisfying common information needs
• using the common user information needs as the goals or criteria, PRFORM was used on all the available TFPM models/versions, including the teaching model I'm recommending.

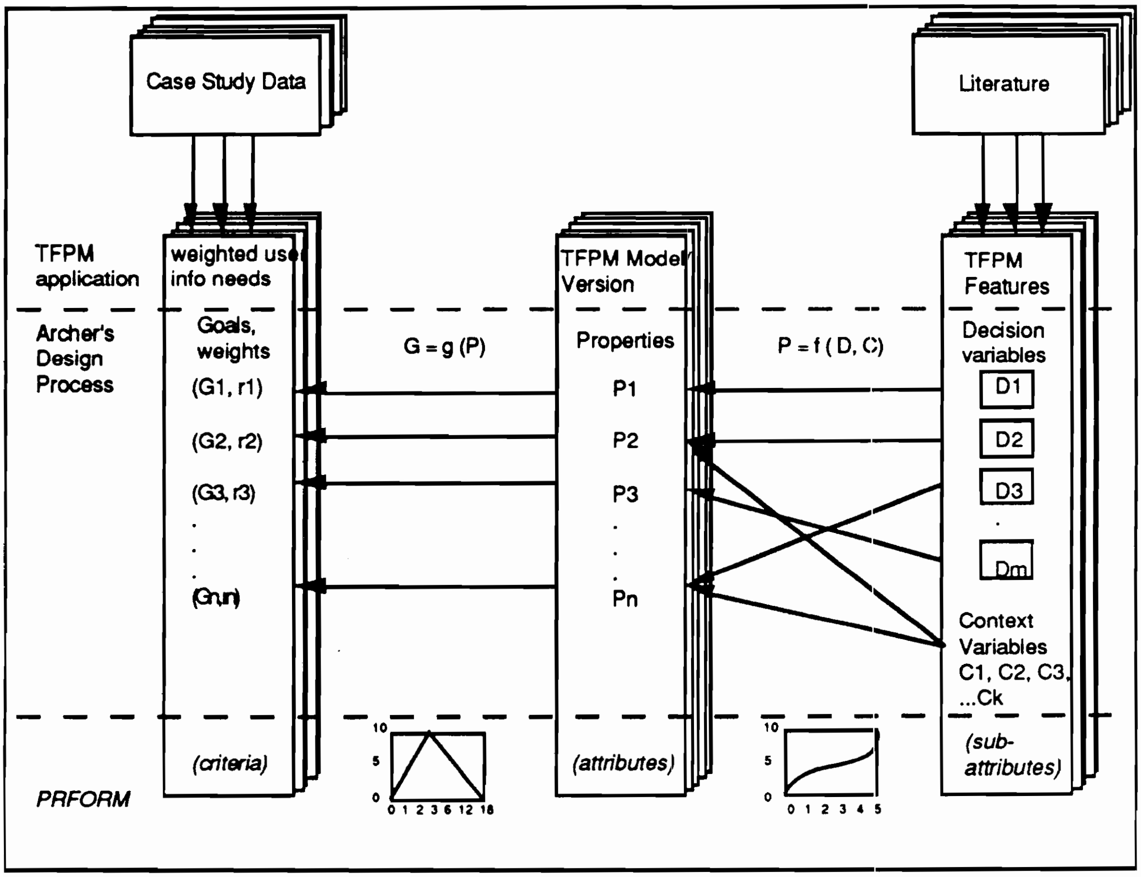


Figure 2.3: Another Perspective of the Conceptual Framework of My Research

Research Methodology

1. To come up with the problem definition and research methodology, the following were done:

- initial literature review on productivity measurement, TFPM, and research
- interviews of both experts, users, and possible users
- observations on previous applications and a pilot case study
- mathematical model formulation for the available models/versions

Chapter 3 includes what I learned from the initial literature review. The initial literature review has helped me know what has been done and what needs to be done in the productivity measurement field, particularly using TFPM.

The literature review has also left me with some questions regarding the various TFPM versions. In order to answer these questions and gain a better understanding of TFPM, I interviewed the experts/authors of the available versions. I have interviewed Gollop, Sumanth, Kendrick, Thor, Parsons, and Miller, and all have agreed (except for Kendrick whom I didn't ask as he is no longer doing any work on TFPM) to review my description of their TFPM versions and confirm that my understanding is accurate. I chose these experts because they are currently most active in and who in my judgment from reading the literature, have contributed most towards TFPM development. I chose Parsons instead of Loggerenberg as Parsons seems to be more user-oriented, pragmatic while also having a solid theoretical knowledge. He is also more accessible.

I had two sets of questions for the experts: one set was asked of all the experts and the other set had questions on their particular version. Chapter 3 documents the salient points from these interviews. The interviews not only helped me obtain answers to my questions but also helped me reinforce what I have learned from the literature review.

Table 1.1 (page 1-2) is an outline of what I considered as the three basic models, the different versions, and the main features of each version, based on the initial literature review, interviews with experts and observations from some applications.

The Appendix presents the mathematical model formulation of the three basic models showing the differences between the models and the versions. These models were my starting point for analyzing, understanding and explaining the differences and their corresponding applicability. The models were formulated using consistent symbols so I could mathematically compare the expressions for different versions.

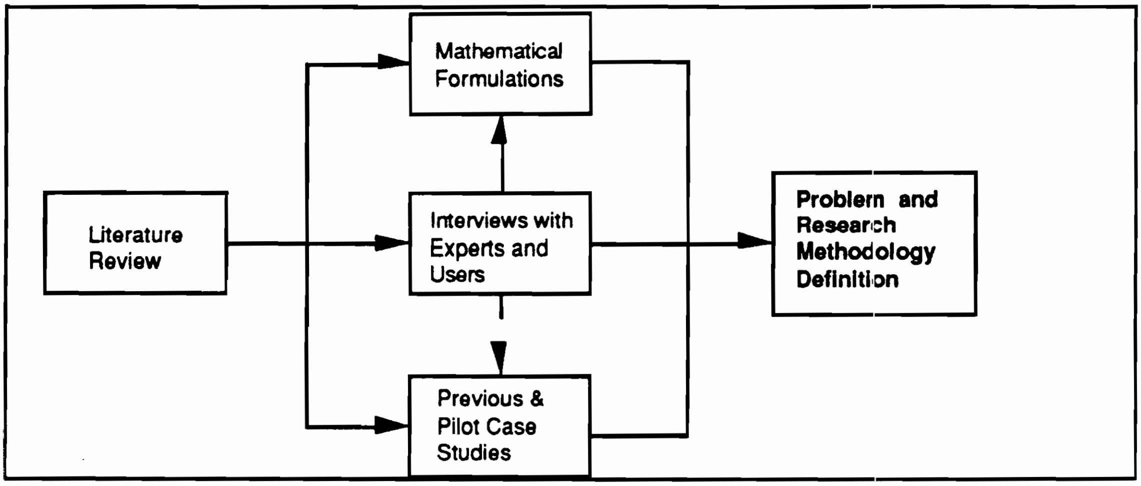


Figure 2.4: How I Defined My Research Problem and Methodology

2. After defining the problem and the research methodology, I reviewed previous surveys and documented new case studies to (a) compile a list of user information needs and other requirements, (b) illustrate and gain a more concrete understanding of the various methodological differences and issues associated with the available TFPM versions, and, (c) develop, test, and evaluate features that will be applicable for providing the common user information.

Selection of cases was based on the following considerations: (1) The first consideration was that the organization should be willing to commit resources to developing a TFPM application. This is the test of how serious they are with the effort. (2) The research will be on TFPM applications at the firm level - cases will therefore be applications ranging from plants, to divisions, to corporate levels; (3) When using case studies, theoretical rather than random sampling is typically used (Glaser and Strauss, 1967; Eisenhardt, 1989), i.e. cases are chosen for theoretical rather than statistical reasons. The cases may be chosen to replicate previous cases or they may be chosen to fill theoretical categories and provide examples of polar types. Since the variable I'm measuring from the cases is user information needs, I chose cases that could potentially have typical and extreme situations illustrating various user information needs. The organizations I selected had different products, geographical locations, and organizational size and structure. Table 2.1 shows demographic data for each of the cases;

Table 2.1: Demographic Data of the Selected Cases

	Plant A	**Division B**	**Company C**	**Center D**
Industry	Pharmaceuticals	Defense Contractor	Food and Beverage	Applied Research and Development
Geographical Location	Southeastern USA	West Coast, USA	Southeast Asia	Southeastern USA
Size (manpower)	500	3,000	20,000	20
Structure	functional/ hierarchical	functional/ business units	divisions/ business units	functional/ self-managing

Other possible cases were available but were not used as they did not "pass" all the three considerations previously discussed and they were no longer needed. (4) How many cases should be used? Eisenhardt (1989) says, "stop adding cases when theoretical saturation is reached, i.e. when incremental learning is minimal because researchers are observing phenomena seen before...In practice, theoretical saturation often combines with pragmatic considerations such as time and money to dictate when case collection ends...Finally while there is no ideal number of cases, a number between 4 and 10 cases usually works well. With fewer than 4 cases, it is often difficult to generate theory with much complexity, and its empirical grounding is likely to be unconvincing,... With more than 10 cases, it quickly becomes difficult to cope with the complexity and volume of the data." After the fourth case, I reviewed the information needs I had compiled from one case to the other and decided "theoretical saturation" had been reached since the common information needs were not changing or increasing. I also compared the common information needs with the results of two recent surveys (APQC, 1985; Steedle, 1988). These surveys came up with the same reasons why firms use TFPM as the common information needs I had compiled.

I used three types of data for this research. The first type is end-user information data. By end-user, I mean the manager(s) who will use the information from TFPM to make decisions and initiate actions. As previously mentioned, these managers were to be classified as: those who have used TFPM, those who have read or attended a workshop, and those who have not had any exposure to TFPM. From my case studies though, all except one manager did not have any exposure to TFPM. The analysts who were interested in developing a TFPM for their managers were the ones who had some exposure to TFPM. I even found I could not ask managers directly what their information needs were. I had to ask tangential questions such as, "what are your main concerns or problems about improving the performance of your firm?"

The primary source of these data (information needs) were meetings or interviews with the managers. These meetings or interviews were done individually or in groups. In either case, they were asked about their main concerns regarding performance improvement and what types of decisions and actions they make and initiate to improve performance. While they discussed their responses, I took notes and later identified and weighed the information needs they mentioned. I've found this approach more effective as managers don't usually know exactly what information they need. I then wrote up the results of the interviews and asked them to verify whether my perception of what they said was accurate. These interviews provided the weighted information needs for the new cases I documented.

Analysts were the primary source of the second and third types of data: the organizational conditions that affect the TFPM application and the quantities, prices and/or values that were used for the initial TFPM application. Of course, the data were disguised, whenever necessary to preserve their confidentiality. They also provided the documents and explanation of systems that interface with TFPM.

After determining the information needs, conditions that affected the TFPM application, and data available, alternative TFPM applications were designed, developed, and evaluated. Evaluations were done as described in the previous section using PRFORM. The weighted information needs were used as the criteria, TFPM model/version features that provided the information needs were the attributes, organizational conditions considered were the sub-attributes. Transformation curves represent how the features and organizational conditions relate to providing the needed information. Table 2.2 lists the information needs, TFPM features, and organizational conditions used for the pilot TFPM application. The first information need is "assessing overall impact of improvement efforts." This information need was addressed by "how the TFPM model is formulated and how information is portrayed." The TFPM model can be formulated to portray productivity alone (coded as 1), productivity and profitability (coded as 2), or productivity, profitability, and price recovery (coded as 3). Figure 2.4 shows a transformation curve that maps 0, 1, 2, and 3 to 0, 5, 8.5, and 10,respectively, i.e., the TFPM application is acceptable if it portrays productivity only, better with productivity and profitability, and best if it portrays all three performance criteria.

Table 2.2 also shows that for the first information need, SCORBORD has satisfied it with a score of 7.2 while REALST scored a perfect 10. For this TFPM application, SCORBORD scored 5.1 and REALST scored 8.5 in the overall satisfaction of information needs. The next question is how valid are these scores? First, the weights of each criterion or information need is determined by the user. I determine the weights of the attributes and sub-attributes and the transformation curves. However, I can logically justify those weights and the construction of the curves and they will remain constant within each case and across all cases, thereby establishing internal validity. Furthermore, data accuracy was confirmed by submitting the case study documentation to the managers who provided the data for their review, thus establishing face and content validity.

Table 2.2: PRFORM Will Be Used to Evaluate How Each TFPM Model/Version Satisfies Information Needs

Memory: 339K °SCORBORD 5.1°REALST 8.5

Description	Weight	Raw	Adjust	Raw	Adjust
Overall Impact	25		7.2		10.0
Model Formulation	53		8.0		10.0
Prod/Prof/PrRec	40	3.00	10.0	3.00	10.0
Static/Dynamic	20	2.00	10.0	2.00	10.0
Relative/Absolute	20	1.00	5.0	2.00	10.0
Fog Index	20	1.00	5.0	2.00	10.0
Portrayal	47		6.4		10.0
Graphics	29	2.00	10.0	2.00	10.0
Level of Detail	25	3.00	5.0	2.00	10.0
Choice of Reports	23	0.00	0.0	1.00	10.0
Deflation	23	1.00	10.0	1.00	10.0
Measure Dep'ts./WIP	22		4.3		9.4
Aggregation	36	0.00	0.0	1.00	10.0
Level of Detail	33		8.3		8.3
Input/Output Matching	36	2.00	10.0	2.00	10.0
Base Period Choice	33	1.00	5.0	1.00	5.0
Period Length	31	3.00	10.0	3.00	10.0
Portrayal	31		5.1		10.0
Graphics	51	2.00	10.0	2.00	10.0
Choice of Reports	49	0.00	0.0	1.00	10.0
Partial Measures	21		5.7		10.0
Resource Variability	34	0.00	0.0	1.00	10.0
Level of Detail	33	2.00	10.0	2.00	10.0
Portrayal	33		7.4		10.0
Relative/Absolute	51	1.00	5.0	2.00	10.0
Graphics	49	2.00	10.0	2.00	10.0
Use for Planning	19		2.5		2.5
Simulation	50	1.00	5.0	1.00	5.0
Challenge Budget Proc	50	0.00	0.0	0.00	0.0
Analysis by Product	13		4.8		10.0
Aggregation	51	0.00	0.0	1.00	10.0
Level of Detail	49	2.00	10.0	2.00	10.0

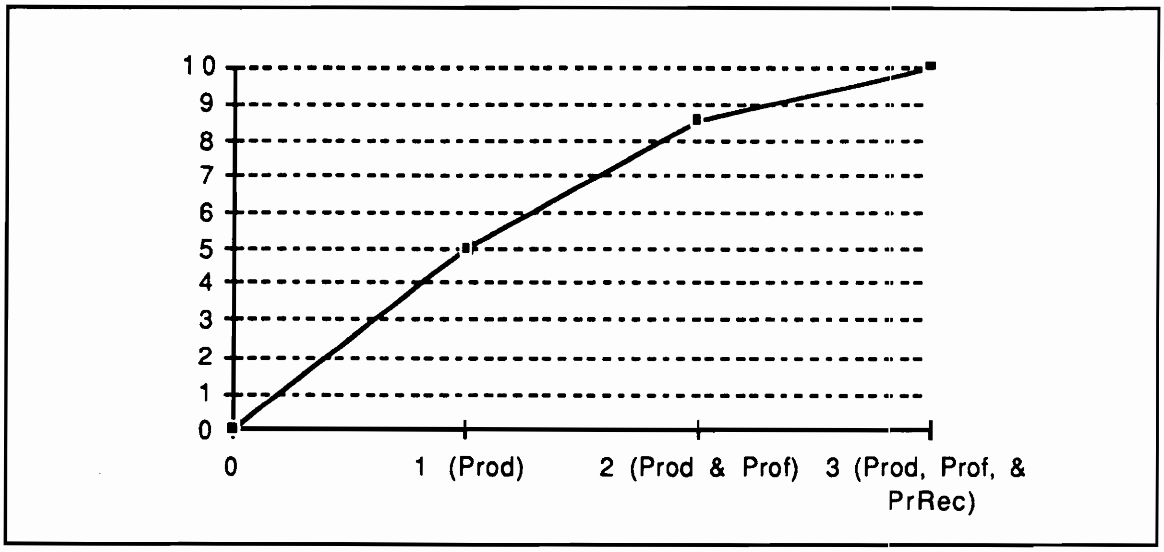


Figure 2.4: Transformation Curve for Measure Portrayed

3. For each case study, user requirements, methodological issues, and appropriate methods were collected (see Figure 2.5). The common information needs were identified as previously discussed. Each case dealt with evaluating which of the different features were most appropriate or designing new ones to satisfy user requirements. The resolution of methodological issues and the resulting applicable features were also compiled.

After compiling user information needs from the case studies, I previously thought the next step should be to verify these user information needs using a survey of what users and possible users expect from TFPM. However, after looking at a few cases, I realized I could not get the depth and richness of data I'm getting from cases from a survey of users, and much less from possible users who expectedly will not have an in-depth understanding of TFPM concepts. This realization was supported by Mintzberg (1979) when he said, "For while systematic data create the foundation for our theories, it is anecdotal data that enable us to do the building. Theory building seems to require rich description, the richness that comes from anecdote. We uncover all kinds of relationships in our hard data, but it is only through the use of this soft data that we are able to explain them." After all, data from past surveys done by APQC/UCCEL (Thor, 1985) and one other survey referenced by Steedle (1988) were compared and contrasted against the data I had collected from the cases.

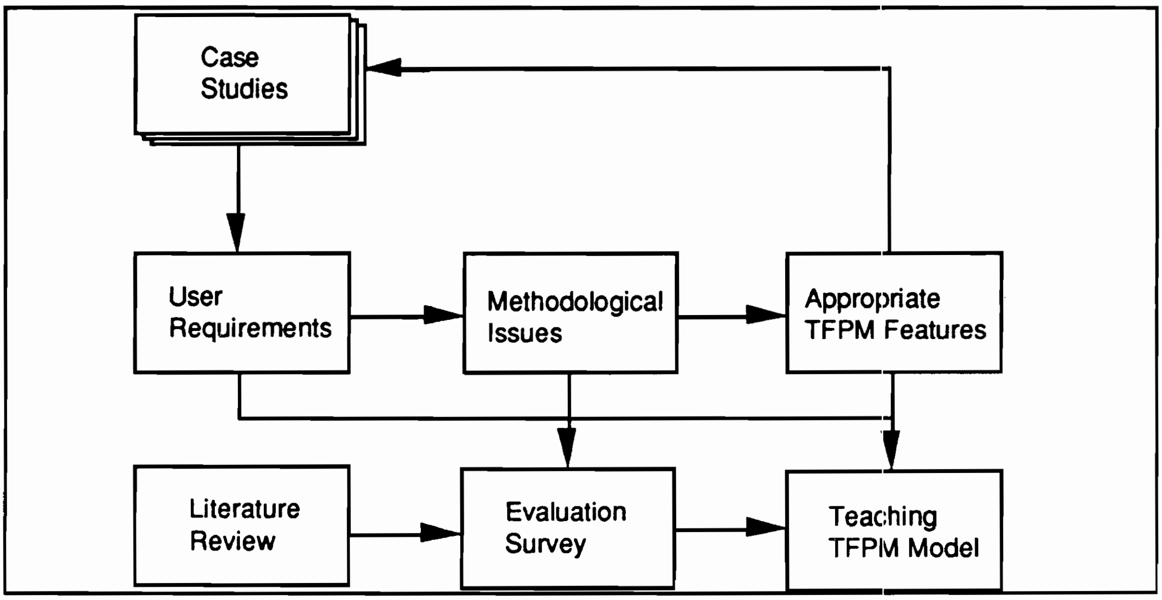


Figure 2.5: Case Study Process for My Research

4. The list of common user information needs was then used to describe, compare, and evaluate the present models, versions and features. Chapter 3 is an evaluation survey of models. This evaluation survey also includes an evaluation of whether accounting systems provide the same information as TFPM.

5. The results of activities 2 to 4 gave me the common user information needs, the distinctions between the available TFPM models, versions, and features, and the features that were applicable to the common user requirements based on the results of the case studies. Step 4 also provided the explanation about why the features appropriately provide

the needed information. This step (5) puts together the applicable features from the case studies into a teaching TFPM model that would respond to the common user requirements.

Steps 2 - 4 will be an iterative process. Again, saturation is the key consideration. Iterations stop when incremental data and/or information added is minimal.

6. The teaching TFPM model was evaluated in two ways: using it on the case examples and showing that it provides the needed information (using the same PRFORM evaluation process discussed earlier); and, comparing it with related literature.

While this dissertation is primarily intended to be a rigorous research and development document (based on Yin, 1987; please see Table 2.3: Parallelism Between Eisenhardt's (1989) "Process for Building Theory from Case Study" and My Research Methodology), anyone reading it should be able to develop an application using the teaching TFPM model, distinguish and understand the differences between the available models and versions of TFPM, feel confident to decide what features to use to enhance the initial application, and be able to use them successfully. However, the research has been subject to the following limitations.

Limitations of the Research Methodology

While case study research methods have been generally accepted to explain the existence of certain phenomenon, it cannot be used to make categorical conclusions with some statistical significance. I cannot claim with say, a 95% probability, that all organizations interested in developing a TFPM application will have the same common information needs that I compiled from my case studies. I used case study research because I wanted to experience and learn how TFPM applications should be developed to respond to management information needs. I believe I achieved this end and I can also be confident that when I discuss information needs, I really understand the details of those information needs, not just in broad terms or categories, but I am not confident to make

Table 2.3: My Research Parallels Eisenhardt's (1989) Case Study Process

Eisenhardt's Steps	Activity	Reason	*My Steps*
Getting Started	• Definition of research question • Possibly a priori constructs • Neither theory nor hypotheses	• Focuses efforts • Provides better grounding of construct measures • Retains theoretical flexibility	• *Problem Definition* • *Conceptual model of research phenomenon*
Selecting Cases	• Specified population • Theoretical, not random, sampling	• Constrains extraneous variation and sharpens external validity • Focuses efforts on theoretically useful cases, i.e. those replicate or extend theory by filling conceptual categories	• *Selecting cases* • *Theoretical sampling considerations*
Crafting Instruments and Protocols	• Multiple data collection methods • Qualitative and quantitative data combined • Multiple Investigators	• Strengthens grounding of theory by triangulation of evidence • Synergistic view of evidence • Fosters divergent perspectives and strengthens grounding	• *Initial design sessions, interview meetings, documents, data bases, literature, cases, and previous surveys* • *Participation of other colleagues in data collection*
Entering the Field Analyzing Data	• Overlap data collection and analysis, including field notes • Flexible and opportunistic data collection methods • Within-case analysis • Cross-case pattern using divergent techniques	• Speeds analyses and reveals helpful adjustments to data collection • Allows investigators to take advantage of emergent themes and unique case features • Gains familiarity with data and preliminary theory generation • Forces investigators to look beyond initial impressions and see evidence thru multiple lenses	• *Case study reports* • *Sequential analysis of cases* • *Use of Archer's process* • *In-depth literature review and mathematical derivations*
Shaping Hypotheses	• Iterative tabulation of evidence for each construct • Replication, not sampling, logic across cases • Search evidence for "why" behind relationships	• Sharpens construct definition, validity, and measurability • Confirms, extends, and sharpens theory • Builds internal validity	• *Compiling user requirements and appropriate methods* • *Evaluation survey of available versions* • *Development and evaluation of a teachingTFPM model*
Enfolding Literature	• Comparison with conflicting literature • Comparison with similar literature	• Builds internal validity, raises theoretical level, and sharpens construct definitions • Sharpens generalizability, improves construct definition, and raises theoretical level	• *Contrasting with conflicting literature* • *Comparing with similar literature*
Reaching Closure	• Theoretical saturation when possible	• Ends process when marginal improvement becomes small	• *Conclusions and lessons learned*

generalizations about most applications. I believe I achieved "theoretical saturation" with four cases, and my results matched the results of two previous surveys, but other researchers who might try to replicate what I've done may not come to the same conclusion. There was so much variability in my cases, four uniquely different organizations crossing national and cultural boundaries, functional, lateral and vertical variability in my interviewees, and there was not much I could do to control that. The only consolation I got was I did not find any evidence of significant differences in their management information needs. I suspect this may have been biased by my interviewees knowing I was helping their organization develop a TFPM application.

Other limitations deal with how I developed the attributes, sub-attributes, and transformation curves for evaluating the TFPM versions and applications. I rationalized and used my best judgment in developing the attributes and curves, but some other researcher may use other attributes, sub-attributes, and transformation curves, for different reasons and come up with different conclusions. The evaluation procedure assumes the attributes and sub-attributes are all additive, independent, mutually exclusive, and comprehensive. To minimize my biasing the results, the same attributes, sub-attributes, and transformation curves were used across all cases, except when some weren't applicable, however, I still can't defend that the attributes are definitely additive and comprehensive. Some of them are not independent and not mutually exclusive. The evaluation procedure I used could not adequately model those situations.

Finally, while I tried my best to follow the literature in developing and conducting case study research, I still cannot claim to be an expert in case study methods and I'm not sure I documented everything I did well enough for someone else to thoroughly replicate my research.

Chapter 3: State-of-the-Art of TFPM

This chapter presents the different TFPM models and versions based on my review of the literature, literature review, and experiences with some applications. To clearly portray the features of each model/version, I provided examples for some versions; I used another example to compare the features and information provided by each version and show how each version applies to this example. I conclude this chapter by presenting a summary of the main features and differences of the models and versions.

Prior to World War II, all productivity estimates were of the simple output-per-worker or per-hour variety. This was true of the first estimates prepared by Carrol Wright of the Bureau of Labor in the nineteenth century, the work of the National Research Project of the Works Progress Administration in the 1930's, the subsequent program of the Bureau of Labor Statistics, and the various industry studies of the National Bureau of Economic Research - to mention only the major productivity measurement initiatives (Kendrick and Vaccara, 1980; Davis, 1978; Gollop, 1982).

The first estimates of total-factor productivity prepared in the United States were those of Jan Tinbergen in 1942 (National Research Council, 1979), referred to as multi-factor productivity as it only considered labor and capital, and also did not include intangibles such as inputs resulting from research and development, education, and training); George Stigler, presented in a 1947 volume of the National Bureau of Economic Research (NBER, Kendrick and Vaccara, 1980) for manufacturing; and by Barton and Cooper (National Research Council, 1979) in 1948 for agriculture.

Davis (1955) Pioneered Total-Factor Productivity Measurement Using the Productivity Indices Model

At about the same time, Hiram Davis had been an active participant in national conferences on productivity, and by 1954, he wrote a book, *Productivity Accounting*, which earned him the recognition of being the pioneer in "total-factor productivity" (reprinted 1978; Sink, 1985; National Center for Productivity and Quality of Working Life, 1976; Miller and Rao, 1984). The primary measure he used was total-factor productivity, i.e., total dollar value of all outputs over the total dollar value of all inputs. To remove the effects of inflation in his calculations, he used price change indices or repricing inputs and outputs using base year prices. This way he obtained productivity indices for at least two periods. Being an accountant, he emphasized the need to match costs and quantities of inputs to costs and quantities of outputs for specific production periods. Table 3.1 shows an example of how Davis portrayed his TFP results.

Table 3.1: Productivity Indices Model - Davis' Version

PRODUCTIVITY STATEMENT
The X Manufacturing Company
1947

	Thousands of Dollars: 1939 In 1939 Prices	1947 In 1939 Prices	1947 In 1947 Prices	1947 Implicit Price Indexes (1939 = 100)
OUTPUT				
Class M (medium unit cost)	3,384	3,893	12,157	312
Class N (high unit cost)	3,120	5,535	14,433	261
Class O (high unit cost)	1,303	345	974	282
Class P (low unit cost)	162	309	982	318
Total	7,969	10,082	28,551	283
INPUT				
Labor and management	2,108	2,092	6,660	318
Materials	2,947	3,284	12,566	383
Supplies and business services	2,295	2,463	4,110	167
Capital goods (Depreciation)	246[1]	300	560[1]	187
Investor				
Gross	373	400	4,655	1164
Taxes	157	168[2]	2,078	1237
Net	216	232	2,577	1111
Total	7,969	8,539	28,551	334
PRODUCTIVITY CHANGE				
Output per $ of input	1.00	1.18		
Increase in output per $ of input		.18		
Savings over base year (Dollar increase for input of $8,539)		1,540[3]		

[1]Reported depreciation after adjustment to the replacement prices of the year indicated and for year rate of operation.

[2]Taxes at their base-year ratio to gross investor input.

[3]In this example, the savings do not equal the difference between 1947 output and input totals revalu to 1939 prices because of rounding of the productivity increase to 18 cents.

In 1965, Kendrick and Creamer published *Measuring Company Productivity: A Handbook with Case Studies* and in 1973, Craig and Harris wrote the paper, "Total Productivity at the Firm Level." I don't see any significant methodological developments contributed by these publications - they basically followed Davis' formulations. They, however, introduced the term "total productivity" instead of Davis' "total-factor productivity." Both terms mean total output over total input. The term total productivity was coined to differentiate it from the economists' definition of "total-factor productivity (TFP)." Economists use the concept of value-added, i.e. total value of outputs less interfirm purchases. They define TFP as value added over labor and capital because their unit of analysis is usually an industry or a nation's economy. Hence, intermediate inputs and outputs or interfirm purchases (materials and energy) are taken out to prevent double counting. The other contribution of these two versions were on ways to determine capital input. Kendrick and Creamer advocated the use of book value while Craig and Harris advocated the use of lease value. The main consideration is to use whatever an organization deems best to approximate their capital costs which should be what they are presently using in their accounting system..

In 1976, Hines introduced the concept of productivity by product and in 1983, Mundel published a paper detailing how to compute input and output values. All the preceding versions use static productivity measures compared against each other by productivity indices, as originally done by Davis.

Sumanth (1979)

In 1979, Sumanth published his dissertation, *Productivity Measurement and Evaluation Models for Manufacturing Companies*. He developed another version computing the total productivity of a firm as the weighted average of the total productivities of each product. The total productivity of a product is the ratio of the constant dollar value of total output over the total constant dollar value of all inputs for the particular product. The total productivity of a firm is related to the total productivity of each product and the partial productivities so management can pinpoint causes of growth or decline. He also relates profit breakeven in terms of the total productivity of the firm. Since Sumanth's model uses static productivity measures, he recommends the use of productivity indices like all the previous versions. While the model may be very powerful in analyzing problems and opportunities for productivity improvement, it also demands very detailed, accurate, and precise data. Due to the enormous number of raw data needed for this version, I will show only one example later.

Econometric Model (Gollop, 1982)

Econometric models use logarithmic derivatives of production functions of both the macro economy and its subsectors (Kendrick and Vaccara, 1980; National Research Council, 1979). TFP is defined as the growth rate of physical output (or deflated value of output) less the weighted average of the growth rates of physical inputs (or deflated value of inputs) so as to avoid confounding price and productivity effects and insure the TFP measure is not sensitive to the choice of the base period. Gollop's model can aggregate the industry measures into the macro economy level.

While most of the econometric developments deal with the macro economic levels such as industry or national levels, Gollop argues that there is a need to be able to analyze and relate each level. Hence, he formulated an example of how to aggregate and analyze data and portray the resulting information for 2 levels of aggregation. As a corollary, he has extended the traditional econometric definition of TFP from total output over labor and capital to include intermediate inputs such as materials and energy. Now, the Bureau of Labor Statistics uses "multifactor productivity" instead of "total-factor productivity." (BLS, 1988; Dean and Kunze, 1988; Mark and Waldorf, 1983)

An important assumption underlying the econometric model is the treatment of time as a continuous variable rather than a discrete period. In using derivatives with respect to time, the variable is considered continuous; in the example, however, it is considered a discrete period. When I interviewed Gollop, he said that in Economics, most of the theoretical modelling is done using continuous functions. When they are applied, discrete approximating functions are used. These approximating functions have the property that when their limits are taken as the variable/interval approaches 0, they equal the original function. Another basic assumption is the validity of using particular production functions for firms. According to Gollop, economists use very general forms of production functions such that simpler forms that may more appropriately characterize production functions of firms can be considered as simplified versions of the general form.

Tables 3.2 and 3.3 show an example of how Gollop's model is implemented at the firm level. This example has 2 plants in a division and shows how measures for one unit of analysis are aggregated to get to a higher level or unit of analysis. Following is the explanation of Table 3.2.

The output of plant 1 is the material input of plant 2 - columns 1 and 2. Hence, the total output of the division is just the output of plant 2 and the total material input of the division is the input of plant 1 - column 3. Same comments hold for columns 4-6. Columns 7-9 are growth rates from year 1 to year 2, i.e. (year 1 - year 2) / year 1. Columns 10-12 are production costs which are actually taken from the base period - year 1. Columns 13-15 are input cost shares which are the corresponding costs in columns 10-12 over the column total. Using the growth rates and cost shares, TFP is computed using the formula given in the table.

Table 3.2 TFPMM Model - Gollop
Aggregating Over Plants

	Quantities (stated in constant prices)									Production Costs (stated in current prices)			Input Cost Shares		
	Year 1			Year 2			Growth Rates			Year 1			Year 1		
	(1) Plant 1	(2) Plant 2	(3) Division	(4) Plant 1	(5) Plant 2	(6) Division	(7) Plant 1 [(4)-(1)]/(1)	(8) Plant 2 [(5)-(2)]/(2)	(9) Division [(6)-(3)]/(3)	(10) Plant 1	(11) Plant 2	(12) Division	(13) Plant 1 (10)/Col (10) Total	(14) Plant 2 (11)/Col (11) Total	(15) Division (12)/Col (12) Total
Sales	105	158	158	111	172	172	.057	.089	.089						
Inputs:															
Labor	12	13	25	11	9	20	-.083	-.308	-.200	$12.00	$13.00	$25.00	.114	.093	.179
Plant & Equip.	15	16	31	17	17	34	.133	.063	.097	$15.00	$16.00	$31.00	.143	.114	.221
Raw & Pk. Mat.	75	105	75	84	111	84	.120	.057	.120	$75.00	$105.00	$75.00	.714	.750	.536
Energy	3	6	9	4	6	10	.333	0	.111	$3.00	$6.00	$9.00	.029	.043	.064
Total										$105.00	$140.00	$140.00	1.000	1.000	1.000

Productivity Growth:

(Growth rate of TFP) = (Growth rate of Sales) - (Cost share of labor Input) x (Growth rate of labor Input) - (Cost share of plant & Equip Input) x (Growth rate of Plant & Equip Input) - (Cost share of material input) x (Growth rate of material input) - (Cost share of energy input) x (Growth rate of energy input)

Plant 1: (-.048) = (.057) - (.114) x (-.083) - (.143) x (.133) - (.714) x (.120) - (.029) x (.333)

Plant 2: (.062) = (.089) - (.093) x (-.308) - (.114) x (.063) - (.750) x (.057) - (.043) x (0)

Division: (.031) = (.089) - (.179) x (-.200) - (.221) x (.097) - (.536) x (.120) - (.064) x (.111)

<u>Summing over Plants:</u>

(Growth rate of division TFP) = (<u>Plant 1 costs</u> Division costs) x (Growth rate of Plant 1 TFP) + (<u>Plant 2 costs</u> Division costs) x (Growth rate of Plant 2 TFP)

(.031) = (105/140) x (-.048) + (140/140) x (.067)

Table 3.3 shows the analysis of profitability broken down into productivity and price recovery. Note that operating income is not equal to $24 as you can compute from Table 3.1 since columns 4-6 of Table 3.1 are in constant dollars. $26.40 is in current (year 2) dollars. Hence, the total change in profits is $8.40. Productivity contribution can either be computed directly for the division or the total of the 2 plants' contributions. Unit growth sales contribution comes purely from the change (increase) in sales. The change in profits is the sum of contributions due to changes in productivity, sales, and prices.

Table 3.3: Gollop's TFPM Model - Corporate Income and Productivity Analysis

Change in Division Operating Income

	=	(O.I.: Year 2)	-	(O.I.: Year 1)			=	
	=	($26.40)	-	($18.00)			=	$8.40

Productivity Contribution

=	(Total production costs: year 1)		(Growth rate of TFP)				
Division:	($140.00)	x	(.0315)			=	$4.41
Plant 1:	($105.00)	x	(-.0476)	=	-$5.00		
Plant 2:	($140.00)	x	(.0672)	=	$9.41		

Unit Sales Growth Contribution

=	(Unit profit: Year 1)	x	(Period to period change in sales)		
=	($158 - $140) /158	x	(172-158)	=	$1.59

Contributions of Price Changes

= (Period to period change in price) x (Quantity: Year 2)

Sales	(+):	(1.10-1.00)	x	(172)	=	$17.20		
Labor	(-):	(1.05-1.00)	x	(20)	=	-$1.00		
Plant & Equipment	(-):	(1.09-1.00)	x	(34)	=	-$3.06		
Raw & Package Material	(-):	(1.11-1.00)	x	(84)	=	-$9.24		
Energy	(-):	(1.15-1.00)	x	(10)	=	-$1.50		
Net effect:							=	$2.40

American Productivity and Quality Center (APQC, formerly APC, 1978)

In 1977, the American Productivity Center (APC, 1978, 1988; Sink, 1985), building on the Davis, Kendrick and Creamer, and Craig and Harris works and with the help of Kendrick and Loggerenberg, developed a new model based on the relationships: Profitability ratio = Productivity ratio x Price recovery ratio and Profitability ($) = Productivity ($) + Price Recovery ($). Price recovery is the ratio of output prices to input costs or the extent input cost changes are passed on to the customers in terms of output prices. Different outputs (and inputs) are aggregated using base period unit prices (and costs) as weights. This produces Laspeyres index numbers or pure quantity change ratios used to compute productivity ratios. Output prices are weighted using current period quantities to produce Paasche index numbers or pure price change ratios used to compute price recovery ratios. (See Figure 3.1). The report format also shows dollar effects of all these changes to productivity, price recovery, and profitability. APC's version differs from its predecessors and has contributed in the development of TFPM in the following ways:

1. Productivity is directly related to profitability and price recovery.
2. In order to distinguish productivity and price recovery effects on profitability, pure quantity change ratios and price change ratios are computed. This necessitates the use of base price weighted quantity change ratios (Laspeyres index numbers) and current quantity weighted price change ratios (Paasche index numbers). Instead of just adjusting for the effects of inflation as Davis does, the concept of price recovery is introduced.
3. Aside from calculating productivity indices, dollar effects of productivity, price recovery, and profitability changes are portrayed.

4. Partial productivities, price recoveries, and possible trade-offs of inputs are also portrayed.

$$\text{Profitability ratio} = \text{Productivity ratio} \times \text{Price Recovery ratio}$$

$$\frac{\dfrac{\sum o_2p_2}{\sum o_1p_1}}{\dfrac{\sum i_2c_2}{\sum i_1c_1}} = \left\{ \frac{\dfrac{\sum o_2p_1}{\sum o_1p_1}}{\dfrac{\sum i_2c_1}{\sum i_1c_1}} \right\} \times \left\{ \frac{\dfrac{\sum o_2p_2}{\sum o_2p_1}}{\dfrac{\sum i_2c_2}{\sum i_2c_1}} \right\}$$

base price or cost-weighted quantities *(Laspeyres index numbers)*

current quantity-weighted prices and costs *(Paasche index numbers)*

o_j = output quantity, period j
i_j = input quantity, period j
p_j = output unit price, period j
c_j = input unit cost, period j
$\sum$ over all outputs or inputs

Figure 3.1: Profitability = Productivity x Price Recovery

Miller (1984)

In 1984, Miller developed a modification of the APC model. This version uses a cumulative deflation method to restate current figures to a base period, instead of APC's period to period deflation. APC deflates current dollars direct to its base period equivalent disregarding any intermediate periods. This version deflates current dollars to each preceding period up to the base period. Hence, it considers all dollar value fluctuations between the base and the current periods. While this modification may address the concern that APC's deflation method is too sensitive to the choice of the base period, it requires more complex data collection, storage, retrieval, processing, and information portrayal. A simplification was introduced in the data processing and information portrayal - indices are not considered; only dollar figures are portrayed. According to Miller, while many organizations including GM, have called him about using his version, Ethyl Corporation is the only known user.

VPC (1985)

In 1985, the VPC introduced another version of the model. This was initially developed at the Oklahoma Productivity Center. It was then called Multi-Factor Productivity Measurement Methodology. Sink (1985) argues that capital input may be removed as one of the inputs because (1) financial analysts, comptrollers, accountants, and engineers should already be doing a good job managing capital productivity. (2) Another major problem he cites is the determination of capital expense as a function of the appropriate planning horizon and the appropriate cost of capital which may have significant effects on capital productivity. The variability in determining planning horizons and cost of capital may distort not only capital productivity, but also total-factor productivity, price recovery, and profitability. Other developments of this version include the portrayal of cost drivers, inclusion of a simulation routine, and isolation of dollar effects due purely to price recovery. What the APC version calls dollar effect due to price recovery actually includes the combined effect of price recovery and productivity. This version is supported by a software now called SCORBORD which is being developed to include graphic capabilities. Past and future developments all aim to improve information portrayal, facilitate understanding, simplify and develop TFPM as an effective and efficient management support tool.

LTV/VAPD (1986)

At about the same time VPC's version was being developed, LTV/Vought Aero Products, (as it was called then) was also developing its own application (VPC, 1986). LTV uses APC's basic model with slight modifications to compute challenge budgets (i.e. input quantities and costs) and product price. Table 3.4 shows an example of how calculations are done. Sales volume and inflation are forecasted and competitive pricing is established to arrive at a total sales value in base-year dollars. A target productivity improvement is set from which cost to sales percentage, costs in base-year dollars, and current costs are computed, using a forecasted inflation rate.

The model is run with annual budgets and updated quarterly with actual figures. The model is also run for divisions and functions within the firm. Instead of using TFPM only for measurement, they also use TFPM for planning and budgeting. The paper test done by VPC and LTV has produced a list of advantages and disadvantages, data requirements and difficulties of using the model.

Table 3.4: Budget Calculation with Inflation and 4% Productivity Target (VPC, 1986)

	Base	Current	Logic
OUTPUT(SALES):			
• Sales (Current $)	111	222	Sales Forecast
• Sales Price Inflation %	Base	8%	DRI Forecast
• Sales (Constant $)	111	205.56	205.56 = 222 ÷ (1+8%)
PRODUCTIVITY IMPROVEMENT:			
• Target Improvement	Base	4%	
INPUT (RESOURCE COSTS):			
• Cost to Sales %	90.09%	86.5%	86.5 = 90.09 * (1 - 4%)
• Costs (Constant $)	100	177.8	177.8 = 205.56 * 86.5%
• Cost Inflation	Base	10%	DRI Forecast
• Costs (Current $)	100	195.56	195.5 = 177.8 * (1+10%)

National Productivity Institute (NPI, South Africa, 1982)

In 1982, Loggerenberg and Cucchiaro came up with another version. While this version is not basically different, the article that introduced it, "Productivity Measurement and the Bottom Line," included a very good portrayal of the TFPM concept (see Figure 3.2).

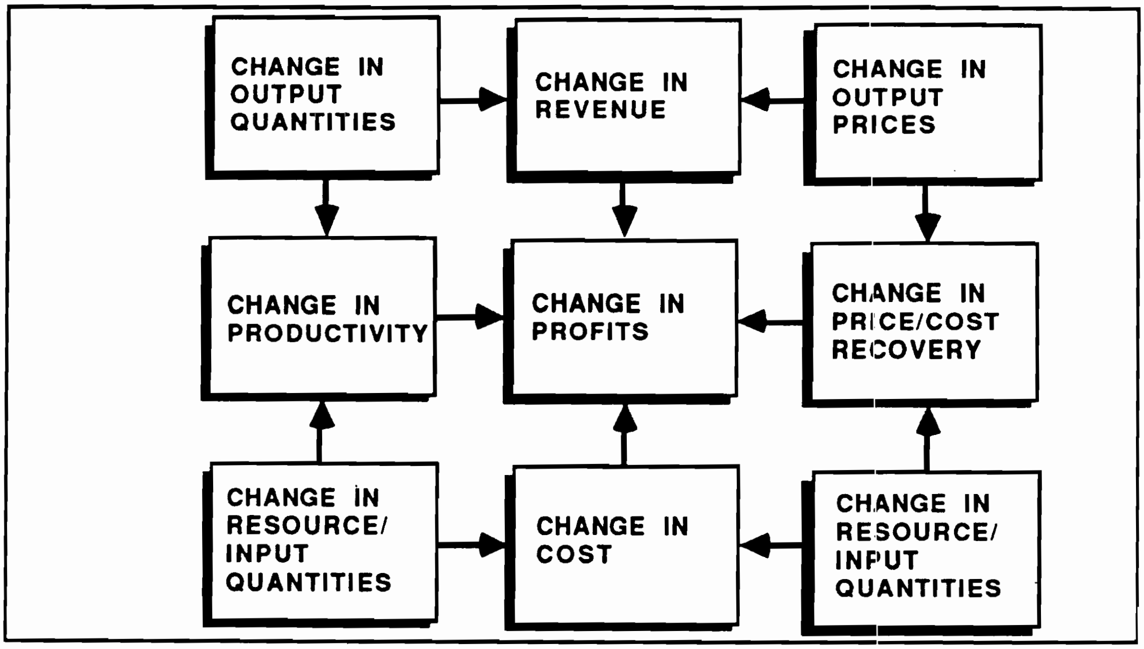


Figure 3.2: Conceptual Model of TFPM

This model differs from previous versions in that it breaks down productivity into capacity utilization and efficiency, and analyzes strategic options. Capacity utilization considers fixed inputs such as equipment and facilities, while efficiency considers variable inputs such as materials. Productivity is broken down into capacity utilization and efficiency using a resource variability ratio with a value from 0 to 1 and decided by the user. This resource variability ratio tells the model the relative percentages of fixed and variable resources consumed. Analysis of cost changes, choice of the level of detail of reports, import and export of data with other software, and budget generation, like LTV's, are standard features of the latest version of the software REALST 3.0. Strategic options are suggested depending on the productivity, price recovery, and profitability figures obtained. Figure 3.3 shows the Strategic Grids.

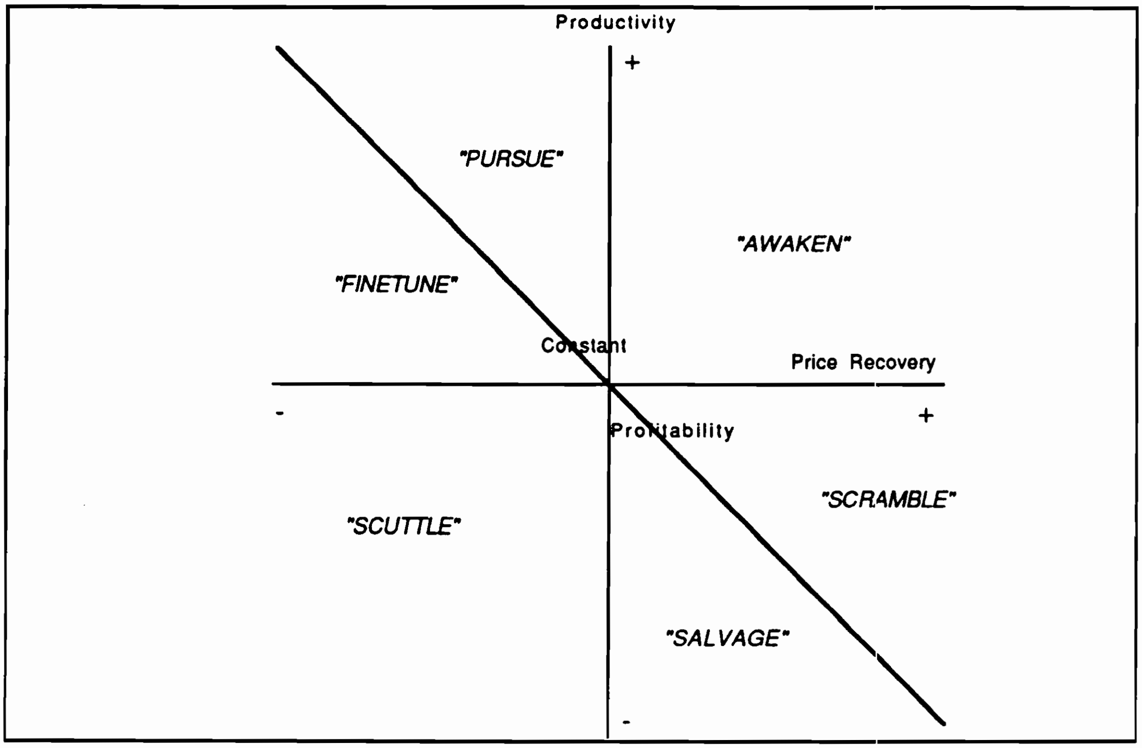
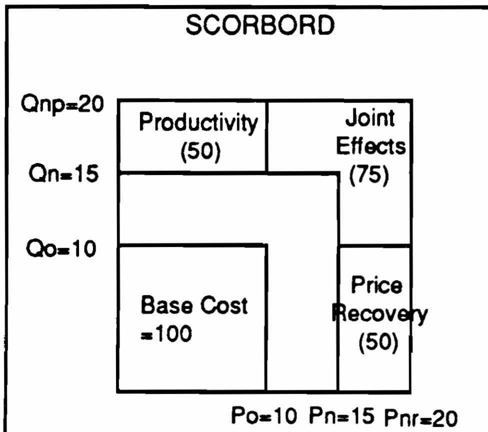
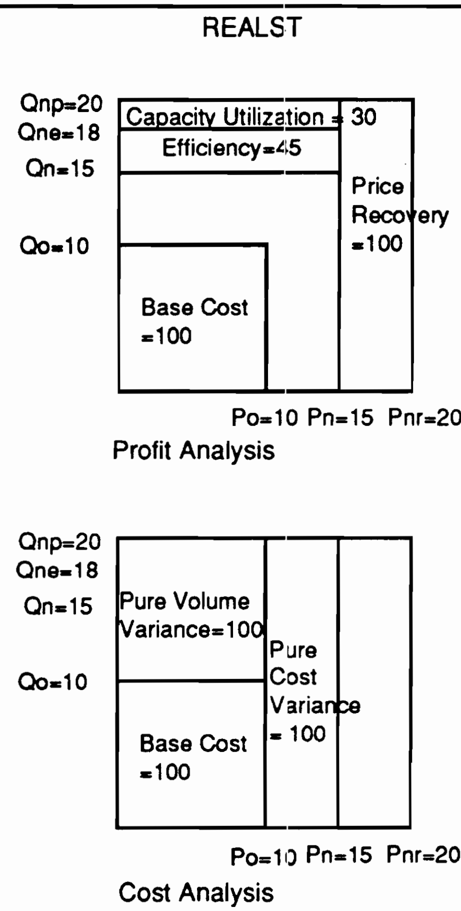


Figure 3.3: Strategic Grids

Figure 3.4 shows how REALST differs from APQC's and VPC's versions in terms of computing dollar effects of changes in profitability, productivity and price recovery. APQC and VPC's versions both use the base period cost to calculate the dollar effects due to productivity and assigns the remainder of the profitability change to price recovery, although VPC's latest version of SCORBORD isolates the pure price recovery dollar effect from the joint effects of changes in productivity and price recovery. In the example in Figure 3.4, profitability change is $175, the sum of the $50 productivity change, the $50 pure price recovery change and $75 joint effects. REALST uses the current period cost to calculate dollar effects of productivity change ($75); splits productivity into capacity utilization ($30) and efficiency ($45) using the concept of resource variability (REVA=.8); and also portrays product cost changes. Product cost change from \$100 to \$225 = -\$125 is explained as the sum of pure cost variance (-\$100), pure volume variance (-\$100), and productivity change (\$75). Note that productivity change is positive since actual resource consumption, Qn, was only 15, instead of what it should have been (Qne=20) had productivity remained constant from period 1 to period 2. The output quantity increased from 10 to 20; therefore, if productivity were to remain constant in both periods, the resource consumption in period 2 (Qne) should be 20.





	Base Period			Current Period		
	Vo	Qo	Po	Vo	Qo	Po
Product	100	10	10	400	20	20
Resource	100	10	10	225	15	15

Figure 3.4: Differences Between APQC/VPC's Version and REALST

While the econometric models use differential calculus, this model uses difference calculus: that branch of calculus that deals with functions with discrete, finite intervals (Loggerenberg, 1986). In differential calculus, the derivative of a function is its slope at a point on the function; in difference calculus, instead of derivatives, we have differences of functions between discrete intervals. This mathematical model intuitively seems more appropriate as we deal with periods of performance in TFPM rather than with continuous variables.

This version is supported by a software called REsource ALlocation STrategist (REALST). This seems to be the most widely-used model and software (REALST, National Productivity Institute, South Africa, 1988) and is further gaining popularity with international marketing efforts now underway. There are at least 20 industry, government, and business users in South Africa.

Other developments include: GM's Advanced Engineering Staff and the Corporate Productivity Research Group in Toronto are jointly developing a new process and software called FACTFINDER. This uses TFPM concepts but is now only available for their internal use. Another version developed by Loggerenberg and Hayzen is called Financial Productivity Management (FPM). It introduces productivity, quantity and price grids and uses a software that can import and export data from and to other software. This version does not significantly differ from REALST.

General Observations

The evolution of TFPM seems to have taken off at different levels, terminologies, and model development. The economists have applied TFPM to the national, industry, and company levels. Most of the other TFPM models have focused on the firm or plant level.

There have also been some differences in terminologies used. Davis first used the term "total-factor productivity" to mean all outputs over all inputs. This has also been used by Mali (1978), Miller and Rao (1984), and Sink (1988).

The economists, on the other hand, use the same term "total-factor productivity" to mean all final outputs of the macro economy over labor and capital - the factors of production. They also use the term "value-added index," synonymously, i.e. output value less interfirm purchases over labor and capital. Cost of purchased goods and services are taken out of both the numerator and the denominator. In referring to industry or firm level measures where all intermediate inputs such as materials, energy, and data are considered, the term "total productivity" is used. This set of meanings is used by Kendrick and Creamer (1965), Craig and Harris(1973), APC (1978), Sumanth (1979), Dogramaci (1981), and Silver (1984).

To avoid any further confusion by having consistent definitions, particularly for firm or plant level measurement, I strongly urge the productivity measurement field to define "total-factor productivity" and "total productivity" synonymously, as differentiated from "value-added ratio," i.e.,

total-factor productivity = total productivity = all outputs / all inputs

value-added ratio = (total output - purchased goods and services) / (labor + capital)

These two definitions will avoid hair-splitting distinctions and are more descriptive of the concepts they represent.

Summary of TFPM Models, Versions, and Features

Table 3.5 presents a summary of the features and main differences of each model and version of TFPM.

There are two basic models of TFPM: the Productivity Indices (PI) Model and the Profitability = Productivity + Price Recovery (PPPR) Model. Gollop's Model, which I originally thought was a different model because of how it was developed, proved to be operationally equivalent to the PPPR model. The PI model uses base period price or price index-weighted quantity (Laspeyres) indices to remove the effects of price changes thereby obtaining Productivity Indices. The PPPR model isolates but does not completely remove the effects of price changes. These price changes of outputs and inputs are measured as price recovery and used to relate productivity to profitability. By using a combination of base period price or price index-weighted quantity (Laspeyres) indices and current period quantity-weighted price (Paasche) indices (except for Miller's version which uses cumulative deflation), the following relationships are obtained:

ΔOutput Value or Revenue = ΔOutput Quantity X ΔOutput Price, and (3.1)

ΔInput Value or Costs = ΔInput Quantity X ΔInput Cost (3.2)

Dividing the first equation (3.1) by the second (3.2), the following equation is obtained:

Profitability Index = Productivity Index X Price Recovery Index.

The PPPR model also computes the dollar effects of changes in productivity, price recovery, and profitability. These dollar effects are related in the following manner:

ΔProfitability (\$) = ΔProductivity (\$) + ΔPrice Recovery (\$)

REALST goes further to relate the dollar effects of changes in profitability to the absolute or arithmetic difference between profits in the base period and profits in the current period, i.e., ΔProfits = ΔProfitability (\$) + Δ Level of Activity or Production (\$).

What I've just described constitutes the first set of features of TFPM versions.

The second set of features deal with partial productivity measures. All the models and versions calculate partial productivity measures and relate them or show their contribution to the total-factor productivity measure. The difference in the versions is how they treat capital input. Davis, Kendrick and Creamer, and REALST advocate the use of book value for capital assets. Craig and Harris, Sumanth, and APQC recommend the use of lease value. Sink (1985) argues that capital input may be removed as one of the inputs because (1) financial analysts, comptrollers, accountants, and engineers should already be doing a good job managing capital productivity. (2) Another major problem he cites is the determination of capital expense as a function of the appropriate planning horizon and the appropriate cost of capital which may have significant effects on capital productivity. The variability in determining planning horizons and cost of capital may distort not only capital productivity, but also total-factor productivity, price recovery, and profitability. I believe that for initial implementation of TFPM, whatever method is used by the accountants of a firm to treat capital expense should be used for TFPM. The understanding and acceptance of TFPM by finance and accounting people in a firm is critical to the successful implementation of TFPM. Therefore, it is very important to first ensure that TFPM is integrated with existing systems, particularly accounting. This helps gain understanding and acceptance for TFPM.

The third set of features deals with measuring performance of departments, plants, or product lines and relating or aggregating those measures to the division or firm level. Sumanth computes productivity by product; total firm productivity is the weighted average of the product productivities. He also computes what productivity level will correspond to profit breakeven point. Gollop's model and REALST both have a way of aggregating dependent organizational units, i.e., outputs of one unit become inputs of another. REALST also aggregates measures for independent units of analysis, i.e, organizational units do not depend on each other for inputs and outputs.

The fourth set of features deals with how TFPM may be used for planning. All versions may be used to evaluate plans by using budget data for the current or review period and using past actual performance as base period data. LTV and REALST both added a feature that computes a "macro challenge budget" given sales forecasts and prices, productivity improvement targets, and resource cost inflation. The slight difference between the two methods is that LTV uses cost to sales ratio as a substitute for productivity improvement target since LTV people are more used to the concept of cost to sales ratio rather than productivity change.

Other features include REALST's concept of resource variability. Some resources, called variable resources, vary with production volume or level of activity while others are fixed resources. The concept of resource variability enables REALST to attribute productivity changes to changes in efficiency or utilization of variable resources, capacity utilization, and use of fixed resources. REALST is also software supported along with VPC's version and Financial Productivity Management (FPM; Hayzen, 1989) of Gauss Computing in South Africa. Both REALST and FPM softwares feature choices in the level of detail in reports. They also both use Strategic, Productivity, and Price Recovery Grids to portray TFPM information. Other information portrayal techniques that could be used to portray data from the reports of any version are trend charts, pie or area charts, and bar or column charts.

These features and differences are what I'll use in evaluating the appropriateness of each version in responding to the information needs of each of the case studies.

Table 3.5: Summary of the Features of TFPM Models/Versions

TFPM Version Features \ TFPM Models/ Versions	Davis	Kendrick and Creamer	Craig and Harris	Mundel	Hines	Sumanth	Gollop	APQC/APCOMP	Miller	VPC/SCORBORD	LTV/APD	NPI/REALST	FPM
Performance Measure													
Deflation													
•Base Period Price-Weighted	√	√	√	√	√	√	√	√	√	√	√	√	√
Quantity (Laspeyres) Indices													
•Current Period Quantity-Weighted								√	√	√	√	√	√
(Paasche) Indices													
•Price Recovery Indices								√		√	√		
•Cumulative Deflation									√				
Dollar Effects of Changes							√	√	√	√	√	√	√
•Profit Reconciliation							√					√	√
•Cost Analysis and Reconciliation												√	√
Measure Departments/WIP													
Productivity by Product					√	√							
•Total Firm Related to Product Productivity						√							
•Profit Breakeven Related to Productivity						√							
Aggregation of Independent Centres						√						√	√
Aggregation of Dependent Centres							√					√	√
Partial Measures													
Partial Productivity Ratios	√	√	√	√	√	√	√	√	√	√	√	√	√
Cost-to-Revenue Ratios (Pie Charts)										√	√		
Treatment of Capital													
•Book Value for Capital Input	√	√											
•Lease Value for Capital Input			√					√					
•May Not Have Capital Input / Multi-Factor										√			
•ROI-based Capital Expense												√	√
Use for Planning													
•Challenge Budget Process											√		
- Cost-to-Sales Ratio (LTV)													
•Challenge Budget Process													
- Productivity Improvement Ratio												√	√
Other Desirable Features													
Portrayal Formats/Graphics													
•Trend Charts	√	√	√	√	√	√	√	√	√	√	√	√	√
•Bar Charts							√	√	√	√	√	√	√
•Strategic Grids												√	√
Software Supported						√				√		√	√
•Choice of Level of Detail in Reports												√	√
Resource Variability												√	√

Comparing All the Available Models and Versions: An Example

Table 3.6 shows data from a hypothetical example - Firm A composed of two plants, each producing one output. This example will be used to compare features of each of the available models and versions.

Table 3.6: Firm A Data

	Period 1							Period 2						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Unit Price	Plant X		Plant Y		Firm A		Unit Price	Plant X		Plant Y		Firm A	
	and Cost	Quantity	Value	Quantity	Value	Quantity	Value	and Cost	Quantity	Value	Quantity	Value	Quantity	Value
O1	5.00	200	1000			200	1000	4.00	250	1000			250	1000
O2	10.00			200	2000	200	2000	13.00		0	215	2795	215	2795
Total Output			1000		2000		3000			1000		2795		3795
Inputs														
Labor	10.00	40	400	40	400	80	800	12.00	38	456	42	504	80	960
Materials														
•Raw	4.00	80	320			80	320	4.00	100	400			100	400
•O1	5.00			200	1000	200	1000	4.00			250	1000	250	1000
Capital	1.00	250	250	250	250	500	500	1.00	250	250	250	250	500	500
Energy	0.05	600	30	600	30	1200	60	0.05	650	33	650	33	1300	65
Total Inputs			1000		1680		2680			1139		1787		2925

Productivity Indices Model

From Table 3.6, the productivity index is obtained by first computing the constant dollar values for period 2. This is done by multiplying quantity columns 9, 11, 13 by column 1, resulting into columns shown on Table 3.7. By dividing the constant dollar total output values by the total input values, the productivity change indices are obtained, i.e, Plant X is 17% more productive, Plant Y's productivity has declined from 1.1905 to 1.10115, and the whole firm's productivity improved from 1.1194 to 1.12769.

Table 3.7: Productivity Indices Model

	(1) Unit Price and Cost	(2) Plant X Quantity	(3) Value	(4) Plant Y Quantity	(5) Value	(6) Firm A Quantity	(7) Value	Plant X	Plant Y	Firm A
			Period 1							
O1	5.00	200	1000			200	1000	1250		1250
O2	10.00			200	2000	200	2000		2150	2150
Total Output			1000		2000		3000	1250	2150	3400
Inputs										
Labor	10.00	40	400	40	400	80	800	380	420	800
Materials									0	0
•Raw	4.00	80	320			80	320	400	0	400
•O1	5.00			200	1000	200	1000		1250	1250
Capital	1.00	250	250	250	250	500	500	250	250	500
Energy	0.05	600	30	600	30	1200	60	33	33	65
Total Inputs			1000		1680		2680	1063	1953	3015
Productivity Change: (Total Output/Total Inputs)			1		1.1905		1.1194	1.17647	1.10115	1.12769

This model provides a productivity measure by taking out the effects of price changes. Except for Sumanth's version which computes a profit breakeven based on the productivity figure, none of the other versions relate productivity to financial measures. The concern with Sumanth's version is that while it can give very detailed information regarding products, it assumes that all data on product costs are available, accurate, and reliable. There is reasonable doubt about this assumption as evidenced by the cost accounting literature's concern for more accurate product costing and Activity-Based Cost (ABC) Accounting (discussed in Chapter 5). And even with accurate data, imagine how involved this measurement system could be if a firm had hundreds of products and/or thousands of inputs. Of course, as with any reporting system, summaries and portrayal formats with varying levels of detail need to be situationally generated.

Note that as proven by Sumanth (1978), the firm's total productivity could have been obtained by computing the weighted average of the two products' productivities, i.e., [(1063 / 3015) x 1.176] + [(1953 / 3015) x 1.101 = 1.128. This does not hold true, however, when the products or plants are not independent, say, when the output of one is used as an input for the other. Table 3.8 is very similar to Table 3.6 except that the output of Plant X is the material input of Plant Y.

Table 3.8: Firm Raw Data, Plant X Output = Plant Y Input

	Period 1							Period 2						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Unit Price	Plant X		Plant Y		Firm A		Unit Price	Plant X		Plant Y		Firm A	
	and Cost	Quantity	Value	Quantity	Value	Quantity	Value	and Cost	Quantity	Value	Quantity	Value	Quantity	Value
O1	5.00	***200***	1000				0	4.00	***250***	1000		0		0
O2	10.00			200	2000	200	2000	13.00		0	215	2795	215	2795
Total Output			1000		2000		2000			1000		2795		2795
Inputs														
Labor	10.00	40	400	40	400	80	800	12.00	38	456	42	504	80	960
Materials														
•Raw	4.00	80	320			80	320	4.00	100	400			100	400
•O1	5.00			***200***	1000			4.00			***250***	1000		
Capital	1.00	250	250	250	250	500	500	1.00	250	250	250	250	500	500
Energy	0.05	600	30	600	30	1200	60	0.05	650	33	650	33	1300	65
Total Inputs			1000		1680		1680			1139		1787		1925

Table 3.9 is the result of applying Sumanth's model to the data given in Table 3.8. Note that the weighted average of the productivities of the two products (1.926) does not equal the total productivity of the firm (1.218).

Table 3.9: Sumanth's Model Applied to Table 3.8 Data

	(1) Unit Price and Cost	(2) Period 1 Plant X Quantity	(3) Period 1 Plant X Value	(4) Period 1 Plant Y Quantity	(5) Period 1 Plant Y Value	(6) Period 1 Firm A Quantity	(7) Period 1 Firm A Value	Plant X	Plant Y	Firm A
O1	5.00	200	1000				0	1250		
O2	10.00			200	2000	200	2000		2150	2150
Total Output			1000		2000		2000	1250	2150	2150
Inputs										
Labor	10.00	40	400	40	400	80	800	380	420	800
Materials									0	0
•Raw	4.00	80	320			80	320	400	0	400
•O1	5.00			200	1000				1250	0
Capital	1.00	250	250	250	250	500	500	250	250	500
Energy	0.05	600	30	600	30	1200	60	33	33	65
Total Inputs			1000		1680		1680	1063	1953	1765
										1.218
Productivity Index:			1		1.1905		1.1905	1.17647	1.10115	1.926

Gollop's Model

Gollop's Model, on the other hand, applies perfectly to this situation. Table 3.10 shows the computations for Gollop's Model based on data from Table 3.8. TFP for Plant X has improved by 18.75%, decreased by 8.72% for Plant Y, and improved by 2.44% for the whole of Firm A. TFP in Gollop's Model is defined as the weighted average growth rate of the outputs less the weighted average growth rate of the inputs, i.e.,

Σ Output Price Share x Output Growth Rate - Σ Input Cost Share x Input Growth Rate.

The firm's change in TFP could be obtained directly by using the above formula or it can be obtained by getting the weighted average TFP of each Plant, i.e., (1000/1690)x(0.1875) + (1690/1690)x(-.0872) = .0244.

As mentioned earlier, Gollop's Model shows the dollar effects of changes in productivity and prices to changes in profits as shown in Table 3.11.

Table 3.10: Gollop's Model

	------- Growth Rates --------			Output Price or Input Cost Shares		
	(15)	(16)	(17)	(18)	(19)	(20)
	Plant X	Plant Y	Firm A	Plant X	Plant Y	Firm A
	(9-3)/3	(11-4)/4	(13-6)/6	3/3 Total	5/5 Total	7/ 7 Total
O1	0.250			1.000		0.000
O2		0.075	0.075	0.000	1.000	1.000
Total Output	0.250	0.075	0.075	1.000	1.000	1.000
Inputs						
Labor	-0.050	0.050		0.400	0.238	0.476
Materials						
•Raw	0.250		0.250	0.320		0.190
•O1		0.250			0.595	
Capital				0.250	0.149	0.298
Energy	0.083	0.083	0.083	0.030	0.018	0.036
Total Inputs	0.0625	0.1622	0.0506	1.000	1.000	1.000
			0.0244			
Productivity Growth:	0.1875	-0.0872	0.0244			

Table 3.11: Gollop's TFPM Model - Corporate Income and Productivity Analysis

Change in Firm Operating Income								
=	(O.I.: Period 2)	-	(O.I.: Period 1)					
=	($870)	-	($320)				=	$550
Productivity Contribution								
=	(Total production costs: period 1)		(Growth rate of TFP)					
Firm:	($1,680)	x	(.0244)				=	$41
Plant X:	($1,000)	x	(.1875)		=	$187.5		
Plant Y:	($1,680)	x	(.-.0872)		=	-$146.5		
Unit Sales Growth Contribution								
=	(Unit profit: Period 1)	x	(Period to period change in sales)					
=	(2,000 - 1,680) /2000)	x	(2,150-2,000)				=	$24
Contributions of Price Changes								
=		(Period to period change in price)	x	(Quantity: Period 2)				
Sales	(+):	(13-10)	x	(215)	=	$645		
Labor	(-):	(12-10)	x	(80)	=	-$160		
Capital	(-):	(1.00-1.00)	x	(500)	=	-$0		
Raw & Package Material	(-):	(4-4)	x	(100)	=	-$0		
Energy	(-):	(.05-.05)	x	(1300)	=	-$0		
Net effect:							=	$485

Gollop's Model, however, does not apply to data with independent inputs and outputs such as the one on Table 3.6. Table 3.12 shows the results of using Gollop's computations on Table 3.6 data. Note that the TFP of the firm (.0083) does not equal the weighted average of the TFP's of the plants (.0153).

Table 3.12: Gollop's Model Does Not Apply to Independent Plants

	------ Growth Rates -------			-Output Price or Input Cost Shares-		
	(15)	(16)	(17)	(18)	(19)	(20)
	Plant X	Plant Y	Firm A	Plant X	Plant Y	Firm A
	(9-3)/3	(11-4)/4	(13-6)/6	3/3 Total	5/5 Total	7/ 7 Total
O1	0.250		0.250	1.000		0.333
O2		0.075	0.075	0.000	1.000	0.667
Total Output	0.250	0.075	0.133	1.000	1.000	1.000
Inputs						
Labor	-0.050	0.050	0.000	0.400	0.238	0.299
Materials						0.000
•Raw	0.250		0.250	0.320		0.119
•O1		0.250	0.250		0.595	0.373
Capital	0.000		0.000	0.250	0.149	0.187
Energy	0.083	0.083	0.083	0.030	0.018	0.022
Total Inputs	0.0625	0.1622024	0.125	1.000	1.000	1.000
	0.1875	-0.0872	**0.0083**			
Productivity Growth:			**0.0153**			

Profitability ($) = Productivity ($) + Price Recovery ($) Model

Since APQC's and VPC's versions use exactly the same computations with slight differences in report formats, I used VPC's SCORBORD software on the common example in Table 3.8. Table 3.13.1 shows data used from Table 3.8 consolidated Firm A data. Table 3.13.2 shows intermediate computations of weighted change ratios, cost/revenue ratios, and productivity ratios. Table 3.13.3 shows weighted performance indexes, and the dollar effects on profits of changes in profitability, productivity, and price recovery. Note that the dollar effect on profits due to change in productivity ($41) is equal to Gollop's productivity contribution in Table 3.11. I proved in Appendix A: Mathematical Models and Derivations, that Gollop's model computes the dollar effects of changes in TFP on profits in exactly the same manner as APQC and VPC model/versions. Hence, one of the main insights I learned from this literature review is that the seemingly different models

(APQC/VPC versions and Gollop's model) with different theoretical foundations are operationally equivalent.

Table 3.13.1: SCORBORD Data from Table 3.8

	PERIOD 1 (1) QUANTITY	PERIOD 1 (2) PRICE	PERIOD 1 (3) VALUE	PERIOD 2 (4) QUANTITY	PERIOD 2 (5) PRICE	PERIOD 2 (6) VALUE
O2	200.0	10.00	2000.00	215.0	13.00	2795.00
Total Output			2000.00			2795.00
Labor	80.0	10.00	800.00	80.0	12.00	960.00
Raw Materials	80.0	4.00	320.00	100.0	4.00	400.00
Capital	500.0	1.00	500.00	500.0	1.00	500.00
Energy	1200.0	0.05	60.00	1300.0	0.05	65.00
Total Inputs			1680.00			1925.00

Table 3.13.2: SCORBORD Weighted Change, Cost/Revenue, and Productivity Ratios

	WEIGHTED CHANGE RATIOS (7) QUANTITY	WEIGHTED CHANGE RATIOS (8) PRICE	WEIGHTED CHANGE RATIOS (9) VALUE	COST/REVENUE RATIOS (10) PERIOD 1	COST/REVENUE RATIOS (11) PERIOD 2	PRODUCTIVITY RATIOS (12) PERIOD 1	PRODUCTIVITY RATIOS (13) PERIOD 2
O2	1.0750	1.3000	1.398				
Total Output	1.0750	1.3000	1.398				
Labor	1.0000	1.2000	1.200	0.4000	0.3435	2.50	2.69
Raw Materials	1.2500	1.0000	1.250	0.1600	0.1431	6.25	5.38
Capital	1.0000	1.0000	1.000	0.2500	0.1789	4.00	4.30
Energy	1.0833	1.0000	1.083	0.0300	0.0233	33.33	33.08
Total Inputs	1.0506	1.0907	1.146	0.8400	0.6887	1.19	1.22

Table 3.13.3: SCORBORD Weighted Performance Indexes and Their Dollar Effects

	WEIGHTED PERFORMANCE INDEXES (14) CHANGE IN PRODUC-TIVITY	(15) CHANGE IN PRICE RECVRY	(16) CHANGE IN PROFIT-ABILITY	DOLLAR EFFECTS ON PROFITS (17) CHANGE IN PRODUC-TIVITY	(18) CHANGE IN PRICE RECOVERY	(19) CHANGE IN PROFIT-ABILITY
O2						
Total Output						
Labor	1.075	1.083	1.165	60.00	98.00	158.00
Raw Materials	0.860	1.300	1.118	-56.00	103.20	47.20
Capital	1.075	1.300	1.398	37.50	161.25	198.75
Energy	0.992	1.300	1.290	-0.50	19.35	18.85
Total Inputs	1.023	1.192	1.220	41.00	381.80	422.80

REALST

So far, we've seen some of the strengths, limitations, and similarities of the earlier TFPM versions. The latest version of REsource ALlocation STrategist (REALST) addresses most of the limitations of the earlier TFPM versions. It handles aggregation of multiple units of analysis, called centres in REALST terminology, regardless of whether they are independent or dependent. Using the same example as in Table 3.8, the following tables and discussions show REALST's features.

Tables 3.14.1 , 3.14.2, and 3.14.3 are the raw data reports from REALST for Plant X, Plant Y, and Firm A consolidated from the two plants, respectively. Consolidation is done by summing up all inputs and outputs across all centres. Another feature of REALST is the recognition of resource variability. In Accounting, some costs are considered fixed and some are considered variable. REALST captures this data by using the constant, REVA - resource variability. When REVA is assigned a value of 0, this means the resource has a fixed cost. When REVA is assigned a value greater than 0 to less than 1, the resource cost varies proportionately with the product quantity as the REVA.

The other feature that can be observed from Tables 3.14.1, 3.14.2, and 3.14.3 is the way REALST treats capital. To input capital into the REALST software, instead of inputting the actual expense for capital for the value, the investment value of the assets considered should be inputted. The software then computes the expense to be charged for the use of the assets based on either the actual rate of return for the base or reference period or a preset rate of return. For example, in Table 3.14.1, the actual rate of return was 10% and the investment value of the assets employed was $2,500; the capital expense charged was, therefore, $250.

Table 3.14.1: REALST Raw Data Report for Plant X

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
01		1000.0	200.0	5.00	1000.0	250.0	4.00	0.00000	0.25000	0.20000-
GRAND TOTAL Outputs		1000.0			1000.0			0.00000	0.25000	0.20000-
Labor	0.50	400.0	40.0	10.00	456.0	38.0	12.00	0.14000	0.05000-	0.20000
Raw Material	1.00	320.0	80.0	4.00	400.0	100.0	4.00	0.25000	0.25000	0.00000
Energy	1.00	30.0	600.0	0.05	32.5	650.0	0.05	0.08333	0.08333	0.00000
Capital	0.00	250.0	250.0	1.00	250.0	250.0	1.00	0.00000	0.00000	0.00000
AGGREGATE		1000.0			1138.5			0.13850	0.05417	0.08000
Capital	0.00	2500.0	250.0	10.00	2500.0	250.0	10.00	0.00000	0.00000	0.00000
TOTAL ASSETS		2500.0			2500.0					
PROFIT		250.0			111.5					
RATE of RETURN (%)		10.00			4.46					

Table 3.14.2: REALST Raw Data Report for Plant Y

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
02		2000.0	200.0	10.00	2795.0	215.0	13.00	0.39750	0.07500	0.30000
GRAND TOTAL Outputs		2000.0			2795.0			0.39750	0.07500	0.30000
Labor	0.50	400.0	40.0	10.00	504.0	42.0	12.00	0.26000	0.05000	0.20000
Energy	1.00	30.0	600.0	0.05	32.5	650.0	0.05	0.08333	0.08333	0.00000
Capital	0.00	1570.0	250.0	6.28	1570.0	250.0	6.28	0.00000	0.00000	0.00000
AGGREGATE		2000.0			2106.5			0.05325	0.01274	0.04000
Capital	0.00	2500.0	250.0	10.00	2500.0	250.0	10.00	0.00000	0.00000	0.00000
TOTAL ASSETS		2500.0			2500.0					
PROFIT		1570.0			2258.5					
RATE of RETURN (%)		62.80			90.34					

Table 3.14.3: REALST Consolidated Data Report for Firm A

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
01		1000.0	200.0	5.00	1000.0	250.0	4.00	0.00000	0.25000	0.20000-
02		2000.0	200.0	10.00	2795.0	215.0	13.00	0.39750	0.07500	0.30000
GRAND TOTAL Outputs		3000.0			3795.0			0.26500	0.13333	0.11618
Labor	0.50	800.0	80.0	10.00	960.0	80.0	12.00	0.20000	0.00000	0.20000
Raw Material	1.00	320.0	80.0	4.00	400.0	100.0	4.00	0.25000	0.25000	0.00000
Energy	1.00	60.0	1200.0	0.05	65.0	1300.0	0.05	0.08333	0.08333	0.00000
Capital	0.00	1820.0	500.0	3.64	1820.0	500.0	3.64	0.00000	0.00000	0.00000
AGGREGATE		3000.0			3245.0			0.08167	0.02690	0.05333
TOTAL ASSETS		5000.0			5000.0					
PROFIT		1620.0			2370.0					
RATE of RETURN (%)		32.40			47.40					

Tables 3.15.1, 3.15.2, 3.15.3, and 3.15.4 show the profit reports in different levels of detail from the center detailed analysis to the firm's consolidated profit reconciliation report. As mentioned earlier, REALST further breaks down productivity into resource allocation (efficiency) and product volume (capacity utilization) components using the concept of resource variability (REVA). The first three tables explain the difference in profitability (REALST Profit Variance). Note that the REALST Profit Variance is not the arithmetic difference between the values in the reference period and the review period. It merely explains the change in profitability due to changes in productivity and price recovery. If productivity and price recovery remained constant from the reference period to the review period, the REALST Profit Variance would be zero but that does not mean that the profits in both periods are equal because the product volume or the level of activity may have changed. Table 3.15.4 explains the arithmetic difference ("profit change") between the profits in the reference period and the review period using the REALST Profit Variance and "change in turnover." The table also shows how REALST adjusts the analysis of the profit change by taking out the prof om Plant X since Plant X's output is an intermediate output that was used as an input to Plant Y. With this feature, REALST can then be used for both dependent and independent centers and products.

Table 3.15.1: REALST Detailed Analysis Profit Report for Plant X

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	EFFECT OF: PRODUCT VOLUME	EFFECT OF: RESOURCE ALLOCATION	EFFECT OF: PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+	F
TOTAL PRODUCTS	1000.0	1000.0						
Labor	400.0	456.0	56.0-	31.58	144.0	60.0	84.0	200.0-
Raw Material	320.0	400.0	80.0-	0.00	0.0	0.0	0.0	80.0-
Energy	30.0	32.5	2.5-	15.38	5.0	0.0	5.0	7.5-

Table 3.15.2: REALST Detailed Analysis Profit Report for Plant Y

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	EFFECT OF: PRODUCT VOLUME	EFFECT OF: RESOURCE ALLOCATION	EFFECT OF: PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+	F
TOTAL PRODUCTS	2000.0	2795.0						
Labor	400.0	504.0	55.0	2.38	12.0	18.0	6.0-	43.0
Energy	30.0	32.5	9.4	0.77-	0.3-	0.0	0.3-	9.7
AGGREGATE	430.0	536.5	64.4	2.19	11.8	18.0	6.2-	52.7

Table 3.15.3: REALST Consolidated Detailed Analysis Profit Report for Firm A

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	EFFECT OF: PRODUCT VOLUME	EFFECT OF: RESOURCE ALLOCATION	EFFECT OF: PRICE RECOVERY VARIANCE
	A	B	C =		D +			G
					D =	E +	F	
TOTAL PRODUCTS	3000.0	3795.0						
Labor	800.0	960.0	1.0-	16.25	156.0	78.0	78.0	157.0-
Raw Material	320.0	400.0	80.0-	0.00	0.0	0.0	0.0	80.0-
Energy	60.0	65.0	6.9	7.31	4.8	0.0	4.8	2.2
AGGREGATE	1180.0	1425.0	74.1-	11.28	160.8	78.0	82.8	234.8-

Table 3.15.4: REALST Executive Report for Profit Reconciliation

CENTRES	REFERENCE PERIOD PROFIT	REVIEW PERIOD PROFIT	PROFIT CHANGE		CHANGE IN TURNOVER		REALST PROFIT VARIANCE
	A	B	C	=	G	+	F
*Common Example - Plant X	250.0	111.5	138.5-		0.0		138.5-
Common Example - Plant Y	1570.0	2258.5	688.5		624.1		64.4
CONSOLIDATION	1820.0	2370.0	550.0		624.1		74.1-
*Common Example - Plant X	250.0	111.5	138.5-		0.0		138.5-
LESS INTERMEDIATE	250.0	111.5	138.5-		0.0		138.5-
ADJUSTED CONSOLIDATION	1570.0	2258.5	688.5		624.1		64.4

The REALST software also generates cost analysis reports. Tables 3.16.1, 3.16.2., and 3.16.3 are sample cost analysis reports with varying levels of detail and in the same logical fashion as the profit reports.

Table 3.16.1: Consolidated Firm A Detailed Analysis of Cost Changes

06-24-1990 15:30:12 CONSOLIDATION COST C1

Detailed Analysis

COMMON.LAB

Base or Reference vs. Current or Review Period

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PRODUCT COST	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	%	RESOURCE PRICE
	A	B	C	=	D		+		6
					D	= E	+ F		
Labor	800.0	960.0	30.0-	16.25	156.0	78.0	78.0	20.00	186.0-
Raw Material	320.0	400.0	0.0	0.00	0.0	0.0	0.0	0.00	0.0
Energy	60.0	65.0	4.8	7.31	4.8	0.0	4.8	0.00	0.0

Table 3.16.2: Consolidated Firm A Executive Report of Cost Performance

VALUES are in DOLLARS

	REFERENCE PERIOD COST	REVIEW PERIOD COST	REALST PRODUCT COST	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	%	RESOURCE PRICE
	A	B	C	=	D		+		6
					D	= E	+ F		
*Common Example - Plant X	750.0	888.5	49.0	16.77	149.0	60.0	89.0	10.67	100.0-
Common Example - Plant Y	430.0	536.5	74.3-	2.19	11.8	18.0	6.2-	18.60	86.0-
CONSOLIDATION	1180.0	1425.0	25.3-	11.28	160.8	78.0	82.8	13.56	186.0-
*Common Example - Plant X	750.0	888.5	49.0						49.0
LESS INTERMEDIATE	750.0	888.5	49.0						49.0
ADJUSTED CONSOLIDATION	430.0	536.5	74.3-	11.28	160.8	78.0	82.8	50.84	235.0-

Table 3.16.3: Consolidated Firm A Cost Reconciliation Executive Report

VALUES are in DOLLARS

	REFERENCE PERIOD COST	REVIEW PERIOD COST	CHANGE IN COST		CONTRIBUTION FROM PRODUCT VOLUME		REALST PRODUCT COST
	A	B	C	=	G	+	F
*Common Example - Plant X	750.0	888.5	138.5-		187.5-		49.0
Common Example - Plant Y	430.0	536.5	106.5-		32.3-		74.3-
CONSOLIDATION	1180.0	1425.0	245.0-		219.8-		25.3-
*Common Example - Plant X	750.0	888.5	138.5-		187.5-		49.0
LESS INTERMEDIATE	750.0	888.5	138.5-		187.5-		49.0
ADJUSTED CONSOLIDATION	430.0	536.5	106.5-		32.3-		74.3-

Finally, REALST also generates "challenge budgets." Table 3.17.1 is the REALST software screen for generating challenge budgets. Given a particular centre and a reference period data, the software asks for targetted percentage changes in productivity, budgeted sales volume, budgeted selling price, and a budgeted cost resource price.

Table 3.17.1: REALST Challenge Budget Screen

```
Centre number                          : 1
Reference period number                : 1
Budget period number                   : 3


             Percentage change in
Productivity required                  : 5
Budgeted sales volume                  : 8
Budgeted selling price                 : 3
Budgeted cost resource price           : 10
```

Based on Table 3.17.1, REALST computes and generates a budget (Review period data) as shown in Table 3.17.2.

Table 3.17.2: REALST Challenge Budget

CONSOLIDATION INPUT C1

Base or Reference vs. Challenge Budget

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
01		1000.0	200.0	5.00	1112.4	216.0	5.15	0.11240	0.08000	0.03000
02		2000.0	200.0	10.00	2224.8	216.0	10.30	0.11240	0.08000	0.03000
GRAND TOTAL Outputs		[illegible]			3337.2			0.11240	0.08000	0.03000
Labor	0.50	800.0	80.0	10.00	905.1	82.3	11.00	0.13143	0.02857	0.10000
Raw Material	1.00	320.0	80.0	4.00	362.1	82.3	4.40	0.13143	0.02857	0.10000
Energy	1.00	[illegible]	1200.0	0.05	67.9	1234.3	0.06	0.13143	0.02857	0.10000
Capital	0.00	1820.0	500.0	3.64	1872.0	514.3	3.64	0.02857	0.02857	0.00000-
AGGREGATE		[illegible]			3207.1			[illegible]	0.02857	0.03933
TOTAL ASSETS		[illegible]			5142.9					
PROFIT		[illegible]			2002.1					
RATE of RETURN (%)		[illegible]			38.93					

LTV Challenge Budgets

Table 3.18 shows how LTV develops a challenge budget using the same data in Table 3.18.2. The difference in the challenge budgets generated by the two versions are due to the following factors: (1) the way REALST computes the capital expense as explained earlier, and more significantly, (2) because of the way LTV defines productivity. LTV operationally defines productivity as cost to sales ratio, instead of total output value over total input value. Note that in Table 3.18, the targetted productivity is deducted from the cost to sales ratio of the base period to obtain the cost to sales ratio of the current period. Had LTV used sales to cost ratio and increased the ratio by the productivity target (as shown in Table 3.19.1) and REALST applied the same rates of change on capital expense (as shown in Table 3.19.2), the challenge budget generated using the two versions would be the same.

Table 3.18: Budget Calculation with Inflation and 5% Cost to Sales Target Reduction

	Base	Current	Logic
OUTPUT(SALES):			
• Sales (Current $)	3,000	3,337.20	Sales Forecast (+8%)
• Sales Price Inflation %	Base	3%	Forecast
• Sales (Constant $)	3,000	3,240	= 3,337.2 + (1+3%)
PRODUCTIVITY IMPROVEMENT:			
• Target Improvement	Base	5%	
INPUT (RESOURCE COSTS):			
• Cost to Sales %	100%	95%	= 100 * (1-5%)
• Costs (Constant $)	3000	3078	= 3,240 * 95%
• Cost Inflation	Base	10%	Forecast
• Costs (Current $)	3000	3385.80	= 3,078 * (1+10%)

Table 3.19.1: Budget Calculation with Inflation and 5% Productivity Target

	Base	Current	Logic
OUTPUT(SALES):			
• Sales (Current $)	3,000	3,337.20	Sales Forecast (+8%)
• Sales Price Inflation %	Base	3%	Forecast
• Sales (Constant $)	3,000	3,240	= 3,337.2 ÷ (1+3%)
PRODUCTIVITY IMPROVEMENT:			
• Target Improvement	Base	5%	
INPUT (RESOURCE COSTS):			
• Sales to Cost %	100%	105%	= 100 * (1+5%)
• Costs (Constant $)	3000	3085.71	= 3,240 / 105%
• Cost Inflation	Base	10%	Forecast
• Costs (Current $)	3000	3394.29	= 3,085.71 * (1+10%)

Table 3.19.2: REALST Challenge Budget with Capital Expense Changing Just Like Other Resources

CONSOLIDATION INPUT C1

Base or Reference vs. Challenge Budget

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
01		1000.0	200.0	5.00	1112.4	216.0	5.15	0.11240	0.08000	0.03000
02		2000.0	200.0	10.00	2224.8	216.0	10.30	0.11240	0.08000	0.03000
GRAND TOTAL Outputs		3000.0			3337.2			0.11240	0.08000	0.03000
Labor	0.50	800.0	80.0	10.00	905.1	82.3	11.00	0.13143	0.02857	0.10000
Raw Material	1.00	320.0	80.0	4.00	362.1	82.3	4.40	0.13143	0.02857	0.10000
Energy	1.00	60.0	1200.0	0.05	67.9	1234.3	0.06	0.13143	0.02857	0.10000
Capital	0.00	1820.0	500.0	3.64	2059.2	514.3	4.00	0.13143	0.02857	0.10000
AGGREGATE		3000.0			3394.3			0.13143	0.02857	0.10000
PROFIT		0.0			57.1-					

I have presented in this chapter the features and differences of the available TFPM versions. Based on these features, TFPM applications for the case studies in the following chapters were developed.

Chapter 4 - Pilot Case Study: Plant A Wants to Measure Overall Plant Performance

This pilot case (1) illustrates user information needs, methodological requirements and issues involved; (2) describes the process of developing a TFPM application and how data are collected; (3) looks at alternative ways of analyzing and resolving methodological issues; (4) illustrates the differences between available TFPM versions; and, (5) helped in defining my research methodology.

Plant A is owned and managed by one of the fastest growing pharmaceutical companies in the U.S. with a present annual revenue of about $1.5B. They would like to be able to sustain growth and excellence by continuously improving their operations. They have instituted various programs and innovations, each with its own estimated benefits, and would like to be able to measure the overall effect of all their improvement efforts, show period-to-period changes and trends, and relate the changes to present financial measures. This is how they got interested in using TFPM.

Major Findings, Conclusions, and Lessons Learned (Summary)

After identifying the user requirements through a series of meetings and looking at the available data, I looked at alternative ways of providing for their information needs. After matching the user requirements (including organizational conditions and data availability) with the available TFPM versions, I concluded that only Gollop's model, SCORBORD and REALST could come close to responding to their needs. I will discuss how I came to this conclusion and how both the SCORBORD and REALST applications were developed in detail. Gollop's model produced inconsistent results. REALST could actually address all the user needs except that after running REALST, a report portraying the major findings and conclusions needs to be manually prepared by an analyst for managers' use. None of the presently-available TFPM versions offer a comprehensive information portrayal feature.

The main issue in this case is modelling the plant operation with two main operations and considering work in progress (WIP). Only REALST and Gollop's model have the capability to aggregate data from multiple units of analysis to a higher level unit of analysis such as aggregating data from departments to the plant level.

VPC Is Helping Plant A Implement TFPM

VPC got involved with Plant A when their Sr. IE contacted Paul Rossler, an associate at the Center, asking for VPC's assistance in implementing TFPM in their plant. This call led to a one-day visit by this Sr. IE to VPC. During the visit, Paul Rossler and I briefed him on general measurement and TFPM concepts and methodology. We also started drafting Plant A's Input/Output Analysis (See Figure 4.1). The I/O Analysis was developed by first explaining what it is and why it is necessary for designing a TFPM application. Based on our explanation and guidance, Plant A's Sr. IE drafted their plant's I/O Analysis.

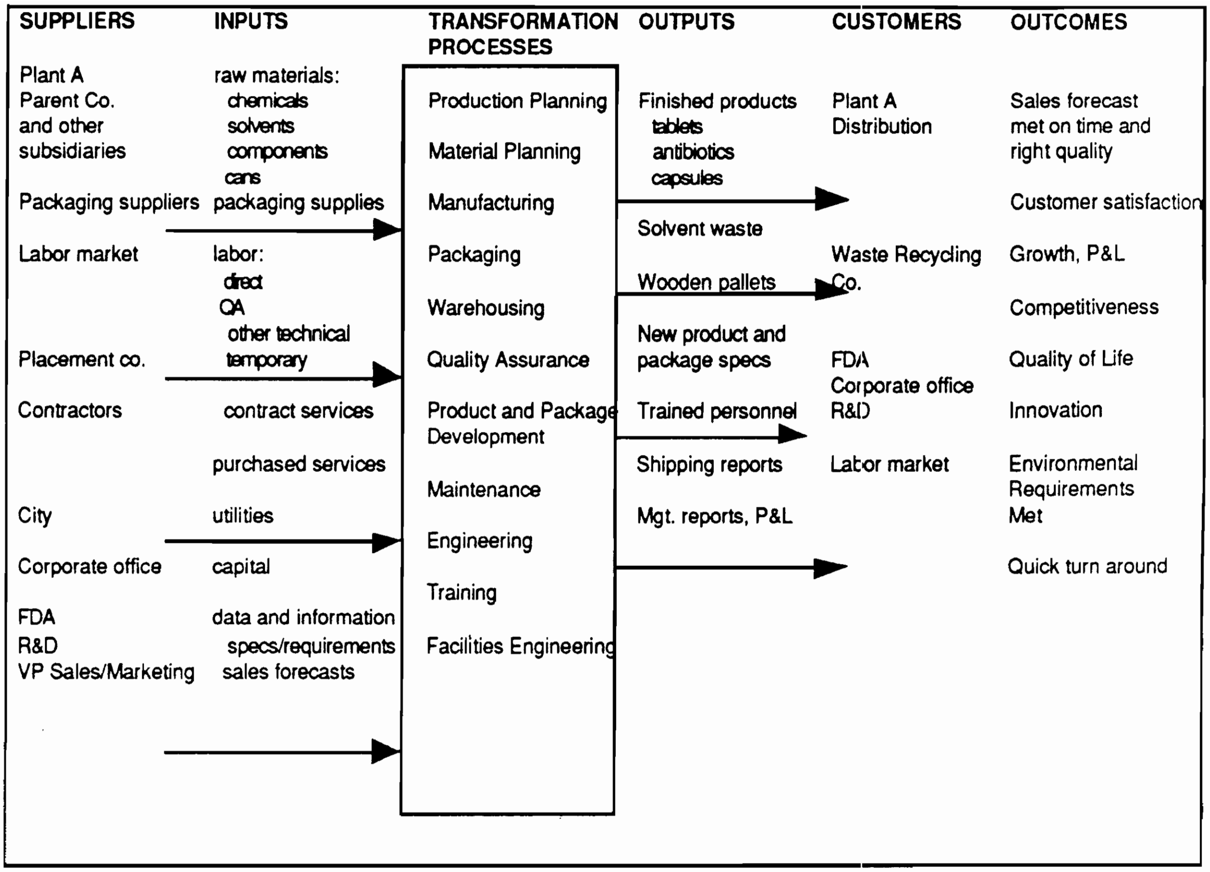


Figure 4.1: Plant A's Plant Input/Output Analysis

Based on our inputs, Sink's (1985) *Productivity Management*, and using SCORBORD (VPC's TFPM software; I also refer to VPC's TFPM version as SCORBORD), Plant A's IE group started developing a TFPM application on their own.

After about a year, Plant A's Sr. IE called again asking us to help them determine their data requirements to be able to apply TFPM using SCORBORD. In response to this request, Joy Davis, VPC's Software Manager, and I visited their plant. Note that the original intention was to use SCORBORD. This is the reason why some discussions focused on SCORBORD. However, I also considered alternative ways to approach this case.

The following sections document what we discussed during our two-day visit and some afterthoughts. These include the agenda for the two-day visit, user requirements, research issues, resolution of methodological/implementation/data collection issues, software design considerations, action items, findings, conclusions, and future directions.

Agenda of Two-Day Visit to Plant A

Day 1	a.m.	Plant tour to familiarize ourselves with their operations and concerns
		Briefing on available data and problems encountered
	p.m.	Discussion of possible resolution of issues
Day 2	a.m.	Visited Accounting and Production Planning to investigate data sources
		Finalized resolution of issues to be discussed with IE manager
	p.m.	Meeting with IE manager on resolution of implementation issues

While we went to Plant A as expert, solution provider, we also played roles of other professional modes such as active listener, challenger, and/or data gatherer (Morris, 1979). Many of their problems deal with data stored somewhere but not readily retrievable in a few reports or computer screens for use as TFPM data.

Our main client is Plant A's IE Department. They are looking for tools to better present information to their decision makers regarding overall performance. The IE Department is in-charge of performance improvement efforts for the plant and would, therefore, want to measure the results of their improvement efforts and pinpoint areas for further improvement. The IE Department has regular meetings with Plant A's management to present and discuss progress on the improvement efforts. Hence, the IE's have a good feel for what information the managers need.

Plant A has two main operations: Manufacturing and Packaging as shown in Figure 4.2. Manufacturing produces bulk materials for Packaging. Before bulk materials are packaged, they are stored in the warehouse for at least 8 days to await quality control results until they are packaged. Packaged products are then sent to the distribution warehouse as finished products -- Plant output.

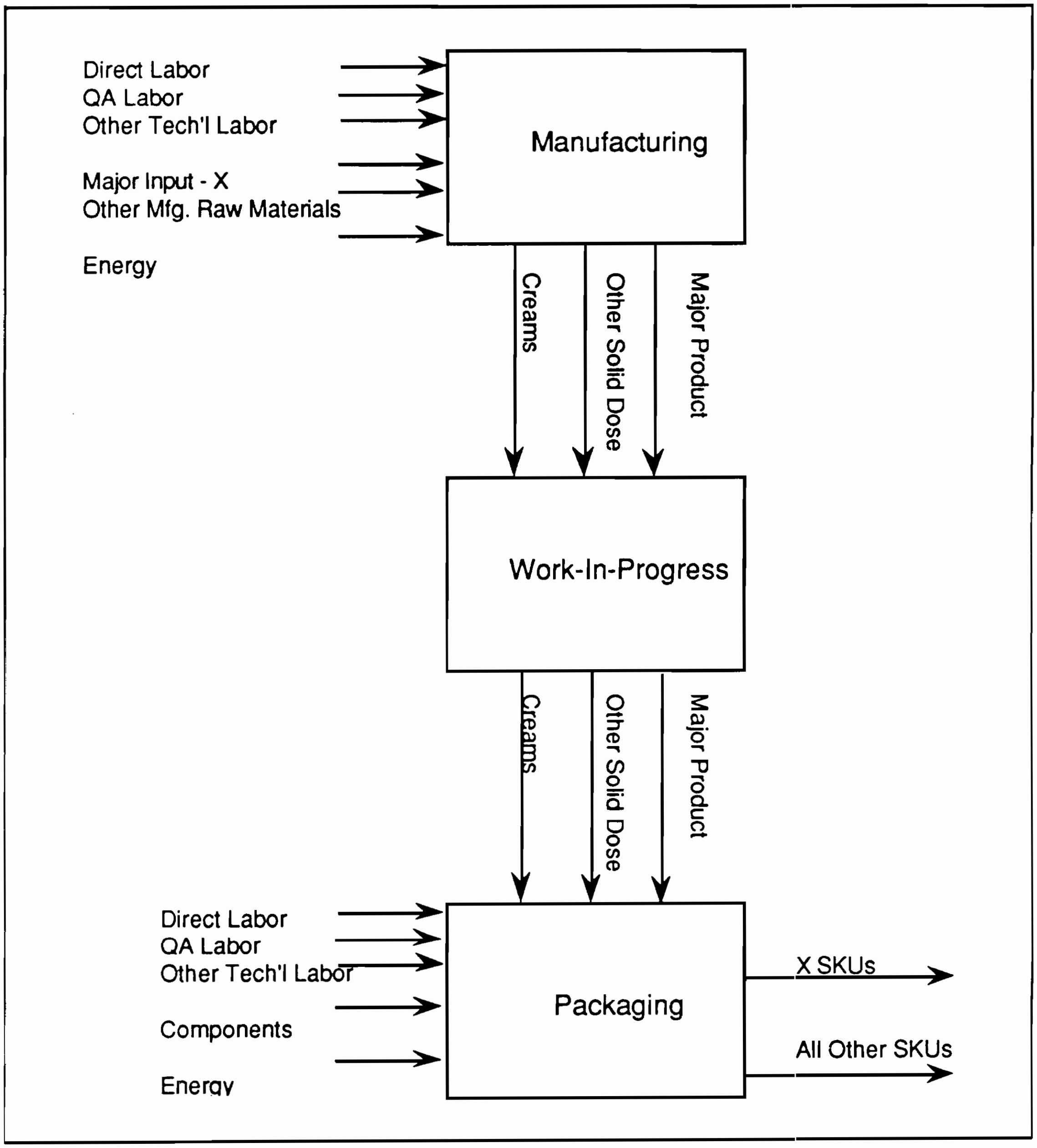


Figure 4.2: Plant A's Plant Workflow

Plant A's Managers and IEs Are Concerned About the Following Information, Decisions, and Actions

The following information needs and organizational conditions are what we compiled from the meetings with Plant A's IEs. These are what they need to present and discuss with their managers to better manage their Plant performance.

1. Plant A has implemented productivity improvement efforts, each with estimated dollar savings. However, they want TFPM to show the overall impact of all improvement efforts on plant performance that can be related to profitability. This is clearly an information need of both the IEs and Plant A's management.
2. Plant A has two main operations: Manufacturing and Packaging. They want to see the effects of work-in-process (WIP) on overall performance. They believe this is a significant cost that can be minimized by better production planning and coordination. This points out a significant problem in matching inputs and outputs. Within a particular period, the inputs used will not actually be the same inputs used to produce the outputs of that period, because of WIP. The two problems here would be how to match outputs with their corresponding inputs and how to determine period lengths to consider and/or minimize discrepancies associated with output/input matching. This is an organizational condition that a TFPM application must consider. The information need here is to ascertain the effect of WIP to see if any decisions and actions need to be made on improving production planning and control.
3. They want to simulate what input and output changes are needed to attain improvement objectives and analyze where the opportunities are for productivity improvement. They want to be able to play "what if" games to evaluate strategies for improving performance. The information needed is how to allocate resources so as to maximize productivity and profitability.

4. They want to measure partial productivity of indirect labor and show that material input is more significant than labor - to focus on reducing scrap during good times in order to gear up for possible bad times. This is clearly another information need.

5. Some data are not in the form for directly feeding into TFPM. Material costs are all recorded in standard costs, not in actual unit costs as purchased. This is clearly an organizational condition that a TFPM application needs to consider.

6. Plant A has various products that use different inputs, i.e., some products use only a few of the inputs. How will TFPM consider and model this situation? The information need here is measuring productivity by product.

Resolution of Implementation and Data Collection Issues

1 & 4. SCORBORD can provide the first two information requirements. Total-Factor Productivity Measurement (TFPM) was conceived mainly to answer Number 1. However, SCORBORD has been designed to also show partial productivities such as indirect labor and materials productivities. All indirect labor, including accounting and other plant support services, will be included in indirect labor input. Research people not directly supporting the plant will be excluded.

2. The inital thinking was to use one month for the period length. However, a significant quantity of bulk inputs to packaging comes from WIP not manufactured during the same months. Hence, inputs within a month are not necessarily the same inputs used to produce the outputs for that month. On the other hand, tracing back all the actual inputs used to produce the outputs of the month will not only be a tedious process, but a significant portion of the inputs were actually used during previous months.

   Taking all the outputs in a three-month period and all the inputs within the same three-month period will provide a more representative picture of actual inputs used to produce the outputs within the same three-month period. This was verified by checking production plans versus actual production reports for three-month periods. Over three-month periods, both production plans and actual production looked constant. Even if there were a lot of month-to-month variations in production mix, they leveled off in three months. One of Plant A's IEs verified this observation with people who have been working with this information and they confirmed our observation. Hence, even if the inputs used for SCORBORD are the inputs used for the quarter and not exactly what was actually used to produce the outputs for that quarter, they'll be reasonably close and will be a good indicator of actual plant performance.

Budgets will be used for the base period until Plant A's management is confident they have enough data that is representative of a typical three-month period which they can use for the base period.

3. The present version of SCORBORD directly addresses information need number 3 to a limited extent; it uses a triangular distribution on quantities and prices of inputs and outputs. However, information need number 3 can still be addressed even without the simulation routine by doing SCORBORD (or any TFPM version) runs plugging in alternative inputs and outputs. Another approach for getting information on optimum resource allocations is to use other optimization methods such as mathematical programming.

5. Price variances from standard costs will be obtained from Purchasing to get the actual cost of inputs.

   The output of the plant goes to the distribution warehouses and not directly to sales. Hence, cost of goods produced based on standard costs will be used as output prices. This implies that the plant will only be profitable if production costs stay lower than standard costs.

6. Plant A manufactures and packages many different products; each product is made from different raw materials and components. A TFPM application can be designed to show this level of detail. This entails breaking down all inputs, labor, material, and energy into their individual contributions per product. Sumanth's version was designed to measure productivity of each product and then aggregate the measure to the plant or firm level. Gollop's model and REALST can also do this. We didn't think Plant A will want to go into this level of detail at this point, nor did we recommend they do so until they have "perfected" the plant level, macro productivity measurement. What we recommended was to break up their outputs and inputs into the following major categories to balance their detailed requirements against simplicity of the initial application:

Outputs

- Major Product, called X SKUs (their measure of output)
- All other solid dose SKUs
- Cream SKUs
- Capsule SKUs

Inputs

- Labor
  - direct
  - QA
  - other technical
- Materials

- Major Product raw material
- All other manufacturing materials
- Components

- Energy

Since there were no significant changes in capital resources, Plant A was not interested in including capital as an input. This may be done as an enhancement in the future.

Table 4.1.1 is a simplified but representative sample of an initial TFPM application data for Plant A, i.e., they have been disguised to maintain confidentiality. Note that this table shows WIP through the figures in italics. For example, in Quarter 1, Manufacturing produced 1,100 units of Bulk materials; Packaging used 1,000 ; so overall, the Plant had a new WIP of 100. The 100 units of bulk are considered as inputs for the whole plant to penalize the plant for not balancing the production between Manufacturing and Packaging, and producing more WIP. The 1,100 units of bulk produced by Manufacturing are not considered as plant outputs; these are inputs to Packaging. Also, the 1,000 units of bulk used by packaging are not considered as plant inputs as they actually came from Manufacturing. On the other hand, the second quarter shows the Plant using -100 units of bulk. This is a way of rewarding the Plant for balancing production and getting rid of WIP.

Table 4.1.: Sample Inputs and Outputs

	Quarter 1							Quarter 2						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Unit Price and Cost	Manufacturing Quantity	Manufacturing Value	Packaging Quantity	Packaging Value	Plant Quantity	Plant Value	Unit Price and Cost	Manufacturing Quantity	Manufacturing Value	Packaging Quantity	Packaging Value	Plant Quantity	Plant Value
Bulk	4.00	***1100***	4400	0			0	4.00	***1300***	5200		0		0
X SKUs	25.00			150	3750	150	3750	23.00		0	160	3680	160	3680
Other SKUs	15.00			300	4500	300	4500	18.00		0	280	5040	280	5040
Total Output			4400		8250		8250			5200		8720		8720
Inputs														
Direct Labor	10.00	40	400	40	400	80	800	12.00	38	456	42	504	80	960
Indirect	15.00	30	450	30	450	60	900	16.00	33	528	28	448	61	976
Total Labor			850		850		1700			984		952		1936
Major Input	2.00	1200	2400	0		1200	2400	2.30	1300	2990		0	1300	2990
Mfg. Mtls.	1.00	1000	1000	0		1000	1000	1.00	800	800		0	800	800
Bulk	4.00		0	***1000***	4000	100	400	4.00		0	***1400***	5600	-100	-400
Components	1.00		0	2000	2000	2000	2000	0.80		0	2200	1760	2200	1760
Total Mtls.			3400		6000		5800			3790		7360		5150
Energy	0.05	3000	150	3000	150	6000	300	0.05	3000	150	3000	150	6000	300
Total Inputs			4400		7000		7800			4924		8462		7386

An important lesson I learned while setting up this application was the need to carefully model the situation. I wasted so much time trying to directly set up the applications using three different models/versions just to end up concluding that the application did not adequately fit the situation. I had trouble modelling the two main operations of Plant A with WIP in between. The main issue here is consistent data aggregation. I almost jumped to the conclusion that TFPM would not really be able to model the situation. It was only after carefully reviewing the operations process flow that I realized I could consider another operation -- Warehousing, even if it was not value adding, just so I could portray WIP. In the broad sense, what I realized was the need to first go back to basics, analyzing process flow diagrams, to be able to advance to more sophisticated methods.

Alternative Models/Versions To Use for this Application

The first user information need required productivity to be tied up with profitability; hence, the Productivity Indices TFPM model (Davis', Craig and Harris', LTV's, etc.) cannot be used for this case as it does not relate productivity to profitability. The choices therefore are the Profitability = Productivity + Price Recovery (PPPR) model or Gollop's model. I used Gollop's model but it gave inconsistent results when the base period total revenue did not equal the total cost and when I used negative quantities to represent WIP. The PPPR versions I tried are VPC's SCORBORD and REALST. APQC's is basically the same as VPC's and FPM is basically the same as REALST. Miller's version is not applicable since there really is no need for cumulative deflation. Following are the results from the SCORBORD and REALST applications.

SCORBORD Can Provide Most of the User Requirements

The SCORBORD application was set up with three separate SCORBORD runs: overall Plant level, Manufacturing, and Packaging. The SCORBORD tableaus, Tables 4.2 - 4.4, show data and information on change ratios, cost drivers, productivity ratios, performance indices, and dollar effects of performance changes. They show the period-to-period changes in profitability, price recovery, and profitability and their corresponding dollar effects. In particular, SCORBORD provides most of the user information requirements as discussed in the following:

Table 4.2.1: SCORBORD Data for Plant A

	PERIOD 1			PERIOD 2		
	(1) QUANTITY	(2) PRICE	(3) VALUE	(4) QUANTITY	(5) PRICE	(6) VALUE
X SKUs	150.0	25.00	3750.00	160.0	23.00	3680.00
Other SKUs	300.0	15.00	4500.00	280.0	18.00	5040.00
Total Output			8250.00			8720.00
Direct Labor	80.0	10.00	800.00	80.0	12.00	960.00
Indirect Labor	60.0	15.00	900.00	61.0	16.00	976.00
Total Labor			1700.00			1936.00
Major Input	1200.0	2.00	2400.00	1300.0	2.30	2990.00
Mfg. Mtls.	1000.0	1.00	1000.00	800.0	1.00	800.00
Bulk Mtls.	100.0	4.00	400.00	-100.0	4.00	-400.00
Components	2000.0	1.00	2000.00	2200.0	0.80	1760.00
Total Matls.			5800.00			5150.00
Energy	6000.0	0.05	300.00	6000.0	0.05	300.00
Total Inputs			7800.00			7386.00

Table 4.2.2: SCORBORD Change, Cost/Revenue, and Productivity Ratios

	WEIGHTED CHANGE RATIOS			COST/REVENUE RATIOS		PRODUCTIVITY RATIOS	
	(7) QUANTITY	(8) PRICE	(9) VALUE	(10) PERIOD 1	(11) PERIOD 2	(12) PERIOD 1	(13) PERIOD 2
X SKUs	1.0667	0.9200	0.981				
Other SKUs	0.9333	1.2000	1.120				
Total Output	0.9939	1.0634	1.057				
Direct Labor	1.0000	1.2000	1.200	0.0970	0.1101	10.31	10.25
Indirect Labor	1.0167	1.0667	1.084	0.1091	0.1119	9.17	8.96
Total Labor	1.0088	1.1289	1.139	0.2061	0.2220	4.85	4.78
Major Input	1.0833	1.1500	1.246	0.2909	0.3429	3.44	3.15
Mfg. Mtls.	0.8000	1.0000	0.800	0.1212	0.0917	8.25	10.25
Bulk Mtls.	-1.0000	1.0000	-1.000	0.0485	-0.0459	20.63	-20.50
Components	1.1000	0.8000	0.880	0.2424	0.2018	4.13	3.73
Total Matls.	0.8966	0.9904	0.888	0.7030	0.5906	1.42	1.58
Energy	1.0000	1.0000	1.000	0.0364	0.0344	27.50	27.33
Total Inputs	0.9250	1.0237	0.947	0.9455	0.8470	1.06	1.14

1. SCORBORD gives an indication of overall plant performance. Table 4.2.3 shows plant productivity improved by 7.5% and price recovery improved by 3.9%, producing an 11.6% increase in profitability for the whole plant. Dollar effects of these improvements are also shown. Tables 4.3 and 4.4 show details on the performance of Manufacturing and Packaging. They show that while overall plant performance looked good, there are problems with Packaging's productivity. Manufacturing has been very productive that even if its price recovery has decreased, its profitability still increased.

A question that may arise is that when we look at the dollar effects of Packaging's decrease in productivity, it may look too high to be offset by the increase in price recovery of Packaging and the increase in productivity of Manufacturing. The explanation here is since SCORBORD was used separately on Manufacturing, Packaging, and the Plant as a whole, there is really no direct mathematical relationship between the figures obtained. Intuitively, the difference in magnitudes of the dollar effects could be explained by the fact that Packaging's total cost was artificially higher than the Plant's total cost for the second quarter as it used up more bulk materials than the Plant had in its warehouse; while the Plant was "rewarded" with using -100 units of bulk. This will be discussed further when I discuss WIP in the next paragraph.

Table 4.2.3: SCORBORD Performance Indexes and Dollar Effects on Profits

	WEIGHTED PERFORMANCE INDEXES (14) PRODUC-TIVITY	(15) CHANGE IN PRICE RECVRY	(16) PROFIT-ABILITY	DOLLAR EFFECTS ON PROFITS (17) CHANGE IN PRODUC-TIVITY	(18) CHANGE IN PRICE RECOVERY	(19) CHANGE IN PROFIT-ABILITY
X SKUs						
Other SKUs						
Total Output						
Direct Labor	0.994	0.886	0.881	-4.85	-109.58	-114.42
Indirect Labor	0.978	0.997	0.975	-20.45	-4.27	-24.73
Total Labor	0.985	0.942	0.928	-25.30	-113.85	-139.15
Major Input	0.917	0.925	0.848	-214.55	-238.73	-453.27
Mfg. Mtls.	1.242	1.063	1.321	193.94	63.03	256.97
Bulk Mtls.	-0.994	1.063	-1.057	797.58	25.21	822.79
Components	0.904	1.329	1.201	-212.12	566.06	353.94
Total Matls.	1.109	1.074	1.190	564.85	415.58	980.42
Energy	0.994	1.063	1.057	-1.82	18.91	17.09
Total Inputs	1.075	1.039	1.116	537.73	320.64	858.36

Table 4.3.1: SCORBORD Data for Manufacturing

	PERIOD 1 (1) QUANTITY	(2) PRICE	(3) VALUE	PERIOD 2 (4) QUANTITY	(5) PRICE	(6) VALUE
Bulk	1100.0	4.00	4400.00	1300.0	4.00	5200.00
Total Output			4400.00			5200.00
Direct Labor	40.0	10.00	400.00	38.0	12.00	456.00
Indirect Labor	30.0	15.00	450.00	33.0	16.00	528.00
Total Labor			850.00			984.00
Major Input	1200.0	2.00	2400.00	1300.0	2.30	2990.00
Mfg. Mtls.	1000.0	1.00	1000.00	800.0	1.00	800.00
Total Mtls.			3400.00			3790.00
Energy	3000.0	0.05	150.00	3000.0	0.05	150.00
Total Inputs			4400.00			4924.00

Table 4.3.2: SCORBORD Change, Cost/Revenue, and Productivity Ratios

	WEIGHTED CHANGE RATIOS (7) QUANTITY	(8) PRICE	(9) VALUE	COST/REVENUE RATIOS (10) PERIOD 1	(11) PERIOD 2	PRODUCTIVITY RATIOS (12) PERIOD 1	(13) PERIOD 2
Bulk	1.1818	1.0000	1.182				
Total Output	1.1818	1.0000	1.182				
Direct Labor	0.9500	1.2000	1.140	0.0909	0.0877	11.00	13.68
Indirect Labor	1.1000	1.0667	1.173	0.1023	0.1015	9.78	10.51
Total Labor	1.0294	1.1246	1.158	0.1932	0.1892	5.18	5.94
Major Input	1.0833	1.1500	1.246	0.5455	0.5750	1.83	2.00
Mfg. Mtls.	0.8000	1.0000	0.800	0.2273	0.1538	4.40	6.50
Total Mtls.	1.0000	1.1147	1.115	0.7727	0.7288	1.29	1.53
Energy	1.0000	1.0000	1.000	0.0341	0.0288	29.33	34.67
Total Inputs	1.0057	1.1128	1.119	1.0000	0.9469	1.00	1.18

Table 4.3.3: SCORBORD Performance Indices and Dollar Effects on Profits

	WEIGHTED PERFORMANCE INDEXES (14) CHANGE IN PRODUC-TIVITY	(15) PRICE RECVRY	(16) PROFIT-ABILITY	DOLLAR EFFECTS ON PROFITS (17) CHANGE IN PRODUC-TIVITY	(18) CHANGE IN PRICE RECOVERY	(19) CHANGE IN PROFIT-ABILITY
Bulk						
Total Output						
Direct Labor	1.244	0.833	1.037	92.73	-76.00	16.73
Indirect Labor	1.074	0.937	1.007	36.82	-33.00	3.82
Total Labor	1.148	0.889	1.021	129.55	-109.00	20.55
Major Input	1.091	0.870	0.949	236.36	-390.00	-153.64
Mfg. Mtls.	1.477	1.000	1.477	381.82	0.00	381.82
Total Mtls.	1.182	0.897	1.060	618.18	-390.00	228.18
Energy	1.182	1.000	1.182	27.27	0.00	27.27
Total Inputs	1.175	0.899	1.056	775.00	-499.00	276.00

Table 4.4.1: SCORBORD Data for Packaging

	PERIOD 1 (1) QUANTITY	PERIOD 1 (2) PRICE	PERIOD 1 (3) VALUE	PERIOD 2 (4) QUANTITY	PERIOD 2 (5) PRICE	PERIOD 2 (6) VALUE
X SKUs	150.0	25.00	3750.00	160.0	23.00	3680.00
Other SKUs	300.0	15.00	4500.00	280.0	18.00	5040.00
Total Output			8250.00			8720.00
Direct Labor	40.0	10.00	400.00	42.0	12.00	504.00
Indirect Labor	30.0	15.00	450.00	28.0	16.00	448.00
Total Labor			850.00			952.00
Bulk Mtls.	1000.0	4.00	4000.00	1400.0	4.00	5600.00
Components	2000.0	1.00	2000.00	2200.0	0.80	1760.00
Total Mtls.			6000.00			7360.00
Energy	3000.0	0.05	150.00	3000.0	0.05	150.00
Total Inputs			7000.00			8462.00

Table 4.4.2: SCORBORD Change, Cost/Revenue, and Productivity Ratios

	WEIGHTED CHANGE RATIOS			COST/REVENUE RATIOS		PRODUCTIVITY RATIOS	
	(7) QUANTITY	(8) PRICE	(9) VALUE	(10) PERIOD 1	(11) PERIOD 2	(12) PERIOD 1	(13) PERIOD 2
X SKUs	1.0667	0.9200	0.981				
Other SKUs	0.9333	1.2000	1.120				
Total Output	0.9939	1.0634	1.057				
Direct Labor	1.0500	1.2000	1.260	0.0485	0.0578	20.63	19.52
Indirect Labor	0.9333	1.0667	0.996	0.0545	0.0514	18.33	19.52
Total Labor	0.9882	1.1333	1.120	0.1030	0.1092	9.71	9.76
Bulk Mtls.	1.4000	1.0000	1.400	0.4848	0.6422	2.06	1.46
Components	1.1000	0.8000	0.880	0.2424	0.2018	4.13	3.73
Total Mtls.	1.3000	0.9436	1.227	0.7273	0.8440	1.38	1.05
Energy	1.0000	1.0000	1.000	0.0182	0.0172	55.00	54.67
Total Inputs	1.2557	0.9627	1.209	0.8485	0.9704	1.18	0.93

Table 4.4.3: SCORBORD Performance Indices and Dollar Effects on Profits

	PERFORMANCE INDEXES			DOLLAR EFFECTS ON PROFITS		
	(14)	(15)	(16)	(17)	(18)	(19)
		CHANGE IN		CHANGE	CHANGE	CHANGE
	PRODUC-	PRICE	PROFIT-	IN PRODUC-	IN PRICE	IN PROFIT-
	TIVITY	RECVRY	ABILITY	TIVITY	RECOVERY	ABILITY
X SKUs						
Other SKUs						
Total Output						
Direct Labor	0.947	0.886	0.839	-22.42	-58.79	-81.21
Indirect Labor	1.065	0.997	1.062	27.27	0.36	27.64
Total Labor	1.006	0.938	0.944	4.85	-58.42	-53.58
Bulk Mtls.	0.710	1.063	0.755	-1624.24	252.12	-1372.12
Components	0.904	1.329	1.201	-212.12	566.06	353.94
Total Mtls.	0.765	1.127	0.862	-1836.36	818.18	-1018.18
Energy	0.994	1.063	1.057	-0.91	9.45	8.55
Total Inputs	0.792	1.105	0.874	-1832.42	769.21	-1063.21

2. The biggest challenge in this case study has been how to effectively model two main operations and WIP in between. My recommendation is to portray the data as in Table 4.1, which was discussed earlier. Both Manufacturing and Packaging operations will be portrayed based on what inputs and outputs they actually have while WIP will be portrayed at the Plant level. SCORBORD has effectively portrayed WIP as shown in Table 4.2.3. Bulk materials productivity was shown to have increased significantly from Quarter 1 to Quarter 2. Recall from Table 4.1 that in Quarter 1, the Plant was penalized with an additional input of 100 units of bulk for adding that much to WIP while it was rewarded with a -100 units of bulk for the second quarter for reducing WIP.

While this information portrayal may sound reasonable to an intuitive manager, it may not be good enough for a sensing (see Myers, 1980) manager who may be looking for hard data and proven mathematical relationships. This will be addressed by the REALST application.

3. To use SCORBORD for playing "what if" games, the user can plug-in different sets of data, run the program, and interpret results as in usual simulation routines.

4. While SCORBORD is primarily for calculating total-factor productivity, partial productivities are also calculated. Performance indices and their corresponding dollar effects are shown. Table 4.2.3 shows that labor productivity has decreased primarily due to a big decrease in indirect labor productivity while labor price recovery has also decreased this time primarily due to a big decrease in direct labor price recovery. It also shows materials productivity, price recovery, and profitability have all increased mainly due to improved productivity for bulk and better price recovery for components.

REALST Can Provide All the User Requirements

Unlike in SCORBORD where 3 separate runs needed to be made for Manufacturing, Packaging and the Plant as a whole, REALST has a way of aggregating Manufacturing and Packaging into the whole Plant. This is simply done by adding outputs and inputs of the units of analysis being aggregated. However, to take care of the WIP, I added a third attribute or centre (this is what the REALST literature calls a unit of analysis), Warehouse. Tables 4.5.1 -4.5.4 show REALST data.

Table 4.5.1 shows the data for Manufacturing. Note that this table contains almost exactly the same data as Table 4.3.1 and part of Table 4.3.2. of SCORBORD except that the change ratios are portrayed with a slight difference. SCORBORD uses 1.1818 while REALST uses .1818 for change in bulk quantity and value. SCORBORD uses .95 while REALST uses -.05 to both mean a decrease in the quantity of direct labor.

The more significant difference is the use of resource variability (REVA) in REALST. Use of resources can be fixed or variable. Indirect labor and capital equipment may be fixed resources; their cost does not change with the quantity of output. Some other resources like materials and direct labor may vary directly with the quantity of output.

Others such as energy may be semi-variable; a part of it varies with output while a part is fixed. REALST considers this variation in the use of resources by requiring users to define whether a resource is fixed or variable. A zero in the REVA column means the resource is fixed while a nonzero number estimates how the resource varies with the output. A one means the resource quantity should change one unit for every unit of change in the output quantity.

Table 4.5.2 represents the data for Warehousing - WIP. This is actually a dummy attribute I'm using to represent and adjust for WIP. Recall that the outputs of Manufacturing are used as inputs to Packaging and therefore, only the outputs from Packaging should be considered as Plant output. In SCORBORD, the consolidation or aggregation of Manufacturing and Packaging data to Plant level was done manually. REALST does the consolidation by adding inputs and outputs across all attributes that have to be aggregated. Hence, if I didn't use a dummy attribute (Warehouse), outputs from Manufacturing will be added as part of Plant output. What I've done is to use output quantities for the Warehouse with the negative output quantity of Manufacturing so that bulk will not show up as a Plant output in the consolidation. I have also used negative numbers in the input rows to be able to get the actual usage of bulk in the consolidation. I have to resort to adjusting data so I can get the desired portrayal of the situation in the consolidation at the Plant level.

Table 4.5.1: REALST Data and Change Ratios for Manufacturing

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE Period VALUE	QUANTITY	PRICE	REVIEW Period VALUE	QUANTITY	PRICE	CHANGE in RATIO VALUE	QUANTITY	PRICE
Bulk		4400.0	1100.0	4.00	5200.0	1300.0	4.00	0.1818	0.1818	0.0000
Total Outputs		4400.0			5200.0			0.1818	0.1818	0.0000
Labor										
Direct	1.00	400.0	40.0	10.00	456.0	38.0	12.00	0.1400	0.0500-	0.2000
Indirect	0.00	450.0	30.0	15.00	528.0	33.0	16.00	0.1733	0.1000	0.0667
Total Labor		850.0			984.0			0.1576	0.0294	0.1246
Materials										
Major Input	1.00	2400.0	1200.0	2.00	2990.0	1300.0	2.30	0.2458	0.0833	0.1500
Manufacturing Materials	1.00	1000.0	1000.0	1.00	800.0	800.0	1.00	0.2000-	0.2000-	0.0000
Total Materials		3400.0			3790.0			0.1147	0.0000	0.1147
Energy	0.50	150.0	3000.0	0.05	150.0	3000.0	0.05	0.0000	0.0000	0.0000
Total Inputs		4400.0			4924.0			0.1191	0.0057	0.1128

Table 4.5.2: REALST Data and Change Ratios for Warehousing

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE Period VALUE	QUANTITY	PRICE	REVIEW Period VALUE	QUANTITY	PRICE	CHANGE in RATIO VALUE	QUANTITY	PRICE
Bulk		4400.0-	1100.0-	4.00	5200.0-	1300.0-	4.00	0.1818	0.1818	0.0000
Total Outputs		4400.0-			5200.0-			0.1818	0.1818	0.0000
Materials										
Bulk	1.00	3600.0-	900.0-	4.00	6000.0-	1500.0-	4.00	0.6667	0.6667	0.0000
Total Materials		3600.0-			6000.0-			0.6667	0.6667	0.0000
Total Inputs		3600.0-			6000.0-			0.6667	0.6667	0.0000

Table 4.5.3 is the data for Packaging while Table 4.5.4 is the consolidation of Manufacturing, Warehousing, and Packaging -- the aggregated Plant data. Note that REALST does this aggregation by summing up all outputs and inputs of units of analysis that have to be aggregated. Table 4.5.4 has actually duplicated the data that was manually entered in Table 4.2.1 of SCORBORD.

<u>Table 4.5.3: REALST Data and Change Ratios for Packaging</u>

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE Period			REVIEW Period			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
X SKUs		3750.0	150.0	25.00	3680.0	160.0	23.00	0.0187-	0.0667	0.0800-
Other SKUs		4500.0	300.0	15.00	5040.0	280.0	18.00	0.1200	0.0667-	0.2000
Total Outputs		8250.0			8720.0			0.0570	0.0061-	0.0634
Labor										
Direct	1.00	400.0	40.0	10.00	504.0	42.0	12.00	0.2600	0.0500	0.2000
Indirect	0.00	450.0	30.0	15.00	448.0	28.0	16.00	0.0044-	0.0667-	0.0667
Total Labor		850.0			952.0			0.1200	0.0118-	0.1333
Materials										
Bulk	1.00	4000.0	1000.0	4.00	5600.0	1400.0	4.00	0.4000	0.4000	0.0000
Components	1.00	2000.0	2000.0	1.00	1760.0	2200.0	0.80	0.1200-	0.1000	0.2000-
Total Materials		6000.0			7360.0			0.2267	0.3000	0.0564-
Energy	0.50	150.0	3000.0	0.05	150.0	3000.0	0.05	0.0000	0.0000	0.0000
Total Inputs		7000.0			8462.0			0.2089	0.2557	0.0373-

Table 4.5.4: REALST Consolidated Data and Change Ratios for the Plant

DESCRIPTION	REVA	REFERENCE Period			REVIEW Period			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
X SKUs		3750.0	150.0	25.00	3680.0	160.0	23.00	0.0187-	0.0667	0.0800-
Other SKUs		4500.0	300.0	15.00	5040.0	280.0	18.00	0.1200	0.0667-	0.2000
Total Outputs		8250.0			8720.0			0.0570	0.0061-	0.0634
Labor										
Direct	1.00	800.0	80.0	10.00	960.0	80.0	12.00	0.2000	0.0000	0.2000
Indirect	0.00	900.0	60.0	15.00	976.0	61.0	16.00	0.0844	0.0167	0.0667
Total Labor		1700.0			1936.0			0.1388	0.0088	0.1289
Materials										
Major Input	1.00	2400.0	1200.0	2.00	2990.0	1300.0	2.30	0.2458	0.0833	0.1500
Manufacturing Materials	1.00	1000.0	1000.0	1.00	800.0	800.0	1.00	0.2000-	0.2000-	0.0000
Bulk	1.00	400.0	100.0	4.00	400.0-	100.0-	4.00	2.0000-	2.0000-	0.0000
Components	1.00	2000.0	2000.0	1.00	1760.0	2200.0	0.80	0.1200-	0.1000	0.2000-
Total Materials		5800.0			5150.0			0.1121-	0.1034-	0.0096-
Energy	0.50	300.0	6000.0	0.05	300.0	6000.0	0.05	0.0000	0.0000	0.0000
Total Inputs		7800.0			7386.0			0.0531-	0.0750-	0.0237

Table 4.6.1 is the REALST report that details dollar effects of changes in productivity and price recovery to profitability. This is similar to SCORBORD's Table 4.3.3 except that it only shows the percentage change in productivity but not in price recovery and profitability. The other difference is that dollar effects of changes in productivity are further broken down into capacity utilization and efficiency. This is where the REVA data is used. Capacity utilization refers to changes in the usage of fixed resources while efficiency refers to changes in the usage of variable resources. Note that contributions from capacity utilization for direct labor, major input, and manufacturing materials are all zero; these are the resources which were identified as varying directly with output (given a REVA of one in Table 4.5.1). Energy which had a REVA of .5 split the dollar effects of productivity changes evenly into capacity utilization and efficiency.

Table 4.6.1: REALST Dollar Effects for Manufacturing

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE	PRODUCTIVITY	CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C =		D +			G
					D =	E +	F	
TOTAL PRODUCTS	4400.0	5200.0						
Labor								
Direct	400.0	456.0	16.7	24.40	111.3	0.0	111.3	94.5-
Indirect	450.0	528.0	3.8	7.44	39.3	87.3	48.0-	35.5-
Total Labor	850.0	984.0	20.5	14.81	150.5	87.3	63.3	130.0-
Materials								
Major Input	2400.0	2990.0	153.6-	9.09	271.8	0.0	271.8	425.5-
Manufacturing Materials	1000.0	800.0	381.8	47.73	381.8	0.0	381.8	0.0
Total Materials	3400.0	3790.0	228.2	18.18	653.6	0.0	653.6	425.5-
Energy	150.0	150.0	27.3	18.18	27.3	13.6	13.6	0.0
Total Inputs	4400.0	4924.0	276.0	17.51	831.5	100.9	730.5	555.5-

Tables 4.6.2 and 4.6.3 portray dollar effects of changes in productivity and price recovery on profitability for Warehousing and Packaging, respectively, and are similar to Table 4.6.1.

Table 4.6.2: REALST Dollar Effects for Warehousing

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	4400.0-	5200.0-						
Materials								
Bulk	3600.0-	6000.0-	1745.5	29.09-	1745.5	0.0	1745.5	0.0
Total Materials	3600.0-	6000.0-	1745.5	29.09-	1745.5	0.0	1745.5	0.0
Total Inputs	3600.0-	6000.0-	1745.5	29.09-	1745.5	0.0	1745.5	0.0

Table 4.6.3: REALST Dollar Effects for Packaging

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	8250.0	8720.0						
Labor								
Direct	400.0	504.0	81.2-	5.34-	26.9-	0.0	26.9-	54.3-
Indirect	450.0	448.0	27.6	6.49	29.1	2.9-	32.0	1.5-
Total Labor	850.0	952.0	53.6-	0.58	2.2	2.9-	5.1	55.8-
Materials								
Bulk	4000.0	5600.0	1372.1-	29.00-	1624.2-	0.0	1624.2-	252.1
Components	2000.0	1760.0	353.9	9.64-	169.7-	0.0	169.7-	523.6
Total Materials	6000.0	7360.0	1018.2-	23.54-	1793.9-	0.0	1793.9-	775.6
Energy	150.0	150.0	8.5	0.61-	0.9-	0.5-	0.5-	9.5
Total Inputs	7000.0	8462.0	1063.2-	20.85-	1792.7-	3.4-	1789.3-	729.5

Table 4.6.4 portrays the consolidated dollar effects of changes in productivity and price recovery on profitability for the aggregated Plant level. This table portrays similar data as in Table 4.2.3 except that the dollar figures are not equal. The difference is because SCORBORD computes the dollar effects using base (or reference) period costs while REALST uses current (or review) period costs. The choice of which costs to use as weights (base or current) is a portrayal issue.

The other main difference is due to the effect of Warehousing. In the SCORBORD application, manual adjustments were made to consider the effect of WIP. In REALST, WIP was considered by adding a dummy attribute: Warehouse. However, the effect of warehouse performance was also considered in the overall Plant performance. A comparison of Tables 4.2.3 and 4.6.4 will show that while the numbers may be different, the performance trend portrayed are the same. This will be shown further in the next section -- graphics.

Table 4.6.4: REALST Dollar Effects for the Whole Plant

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	8250.0	8720.0						
Labor								
Direct	800.0	960.0	64.5-	8.79	84.4	0.0	84.4	148.8-
Indirect	900.0	976.0	31.5	7.00	68.4	84.4	16.0-	36.9-
Total Labor	1700.0	1936.0	33.0-	7.84	152.7	84.4	68.4	185.8-
Materials								
Major Input - R	2400.0	2990.0	153.6-	9.09	271.8	0.0	271.8	425.5-
Manufacturing Materials	1000.0	800.0	381.8	47.73	381.8	0.0	381.8	0.0
Bulk	400.0	400.0-	373.3	30.30-	121.2	0.0	121.2	252.1
Components	2000.0	1760.0	353.9	9.64-	169.7-	0.0	169.7-	523.6
Total Materials	5800.0	5150.0	955.5	10.14	605.2	0.0	605.2	350.3
Energy	300.0	300.0	35.8	8.79	26.4	13.2	13.2	9.5
Total Inputs	7800.0	7386.0	958.2	9.54	784.2	97.5	686.7	174.0

Table 4.6.5 - Control Report and Table 4.6.6 - Management Report - are summaries of Table 4.6.4. The Control Report includes all sub-totals and totals while the management report includes only the totals. Since no sub-totals were used in this example, the two reports resulted in exactly the same entries.

Table 4.6.5: REALST Control Report

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM				
				PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C =		D		+	G
					D =	E	+ F	
TOTAL PRODUCTS	8250.0	8720.0						
Total Labor	1700.0	1936.0	33.0-	7.84	152.7	84.4	68.4	185.8-
Total Materials	5800.0	5150.0	955.5	10.14	605.2	0.0	605.2	350.3
Total Inputs	7800.0	7386.0	958.2	9.54	784.2	97.5	686.7	174.0

Table 4.6.6: REALST Management Report

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Management Report

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Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM				
				PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C =		D		+	G
					D =	E	+ F	
TOTAL PRODUCTS	8250.0	8720.0						
Total Labor	1700.0	1936.0	33.0-	7.84	152.7	84.4	68.4	185.8-
Total Materials	5800.0	5150.0	955.5	10.14	605.2	0.0	605.2	350.3
Total Inputs	7800.0	7386.0	958.2	9.54	784.2	97.5	686.7	174.0

Table 4.6.7 - Executive Report of Performance is a succinct way of summarizing Plant performance. With just one report, I can draw out the information from three tables (4.2.3, 4.3.3, and 4.4.3) in SCORBORD, i.e.overall Plant performance was good but there are problems with Manufacturing's price recovery and Packaging's productivity.

<u>Table 4.6.7: REALST Executive Report on Overall Plant Performance</u>

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Performance

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Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD REVENUE	REVIEW PERIOD REVENUE	REALST PROFIT VARIANCE	CONTRIBUTION FROM PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	PRICE RECOVERY
	A	B	C	=	D		+	G
					D	= E	+ F	
Manufacturing	4400.0	5200.0	276.0	17.51	831.5	100.9	730.5	555.5-
Warehousing	4400.0-	5200.0-	1745.5	29.09-	1745.5	0.0	1745.5	0.0
Packaging	8250.0	8720.0	1063.2-	20.85-	1792.7-	3.4-	1789.3-	729.5
CONSOLIDATION	8250.0	8720.0	958.2	9.54	784.2	97.5	686.7	174.0

Tables 4.6.1 - 4.6.7 are Profit Reports. They portray the changes in profitability as a result of changes in productivity and price recovery. Tables 4.7.1 - 4.7.3 are Cost Reports. They portray how product costs have changed as a result of productivity changes and resource price changes. Table 4.7.1 has a similar format to Table 4.6.4 except Table 4.7.1 does not portray total products' values but shows percentage changes in resource prices. Note that this is not the same as price recovery; it is the denominator of the price recovery ratio. Tables 4.6.7 and 4.7.2 also have similar formats except Table 4.7.2 shows

percentage changes in resource prices. These differences were explained in the survey of TFPM models/versions (Chapter 3).

Table 4.7.1: REALST Cost Report

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PRODUCT COST	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	RESOURCE PRICE % CHANGE	
	A	B	C	=	D		+		6
					D	= E	+ F		
Labor									
Direct	800.0	960.0	89.7-	8.79	84.4	0.0	84.4	20.00	174.1-
Indirect	900.0	976.0	3.1	7.00	68.4	84.4	16.0-	6.67	65.3-
Total Labor	1700.0	1936.0	86.6-	7.84	152.7	84.4	68.4	12.94	239.3-
Materials									
Major Inout	2400.0	2990.0	153.6-	9.09	271.8	0.0	271.8	15.00	425.5-
Manufacturing Materials	1000.0	800.0	381.8	47.73	381.8	0.0	381.8	0.00	0.0
Bulk	400.0	400.0-	121.2	30.30-	121.2	0.0	121.2	0.00	0.0
Components	2000.0	1760.0	227.9	9.64-	169.7-	0.0	169.7-	20.00-	397.6
Total Materials	5800.0	5150.0	577.3	10.14	605.2	0.0	605.2	0.69-	27.9-
Energy	300.0	300.0	26.4	8.79	26.4	13.2	13.2	0.00	0.0
Total Inouts	7800.0	7386.0	517.0	9.54	784.2	97.5	686.7	2.31	267.2-

Table 4.7.2: REALST Executive Report on Cost Performance

[illegible]-27-199[illegible] 21:46:49 EXECUTIVE REPORT COST Page# 1

Performance

SSIMPL.LAB

Base - Quarter 1 vs. Current - Quarter 2

VALUES are in DOLLARS

	REFERENCE PERIOD COST	REVIEW PERIOD COST	REALST PRODUCT COST	CONTRIBUTION FROM: PRODUCTIVITY % CHANGE		CAPACITY UTILIZATION	EFFICIENCY	RESOURCE PRICE % CHANGE	
	A	B	C	=	D		+		6
					D	= E	+ F		
Manufacturing	4400.0	4924.0	276.0	17.51	831.5	100.9	730.5	10.68	555.5-
Warehousing	3600.0-	6000.0-	1745.5	29.09-	1745.5	0.0	1745.5	0.00	0.0
Packaging	7000.0	8462.0	1504.4-	20.85-	1792.7-	3.4-	1789.3-	4.14-	288.2
CONSOLIDATION	7800.0	7386.0	517.0	9.54	784.2	97.5	686.7	2.31	267.2-

Table 4.7.3 is the REALST Cost Reconciliation Report. As the name implies, it reconciles and explains the arithmetic difference between the costs in the two periods. Note that the REALST product cost in Table 4.7.2 does not exactly explain the difference between the costs in the two periods. REALST product cost change is really the difference between the actual cost in the second period and what it should have been if productivity and prices remained constant from the base period to the review period. Table 4.7.3 shows another column: contribution from product volume, which is the difference in product costs mainly due to the change in output volume or level of activity. Contributions from the REALST product cost change and product volume make up the arithmetic difference between costs in the two periods. These were also explained in Chapter 3.

Table 4.7.3: REALST Cost Reconciliation Report

VALUES are in DOLLARS

	REFERENCE PERIOD COST	REVIEW PERIOD COST	CHANGE IN COST		CONTRIBUTION FROM PRODUCT VOLUME		CONTRIBUTION FROM REALST PRODUCT COST
	A	B	C	=	G	+	F
Manufacturing	4400.0	4924.0	524.0-		800.0-		276.0
Warehousing	3600.0-	6000.0-	2400.0		654.5		1745.5
Packaging	7000.0	8462.0	1462.0-		42.4		1504.4-
CONSOLIDATION	7800.0	7386.0	414.0		103.0-		517.0

The tables presented above show that REALST can provide all information requirements of this case. The only information requirement not shown is productivity by product. In the first place, I would not recommend going through the detailed data collection necessary to do a REALST application by product for an initial application. This process is not only tedious, but there is still some discussion in the Cost Accounting field regarding inadequacies in current practices on product costing (Gilligan, 1990; Kaplan, 1989). This is the motivation for the development of Activity-Based Cost Accounting (ABC). However, if and when Plant A is ready to do the detailed data collection, it will be a very simple process of developing such an application given the data aggregation feature of REALST. This was shown in a more macro level in this case using three departments within a plant. Instead of aggregating data by departments, it could be done by product. REALST can, therefore, do more than what Sumanth's version can do as it does not only portray productivity by product but immediately relates productivity with profitability using price recovery.

Instead of playing "what if" games, the latest version of REALST directly computes budgets backwards given productivity goals, price inflation, and sales forecasts, similar to LTV's model.

An Analyst Needs to Enhance Information Portrayal from SCORBORD or REALST with Graphics

While both SCORBORD and REALST may be able to provide the user information needs, they need to be portrayed in such a manner that managers perceive them as information and not data. Hence, in addition to an executive summary, a few tables with explanations on the main points and the following graphics may be used to portray the information from the TFPM application.

Figure 4.3 is the Strategic Grid which shows managers the current positioning of Plant A and its departments in terms of profitability, productivity and price recovery changes. The information shown in this figure could also be obtained from Table 4.6.7 which may portray the information more accurately and with more details while this figure is a more vivid portrayal. The portrayals should complement each other.

Figure 4.3 shows Manufacturing is in the best possible position on the grid: suggesting a "pursue" strategy, i.e. increasing productivity is good enough to offset a decreasing price recovery. While it may seem that Plant A is in the best position -- increasing productivity and price recovery, the "awaken" strategy is recommended. What this means is Plant A may consider lowering product prices to be more competitive and still be profitable. Packaging is in the "salvage" position because despite its increasing price recovery, it's still becoming less profitable due to its decreasing productivity. Given the information from the tables and figure, managers will have a good indicator of where they are presently headed and how they might improve performance.

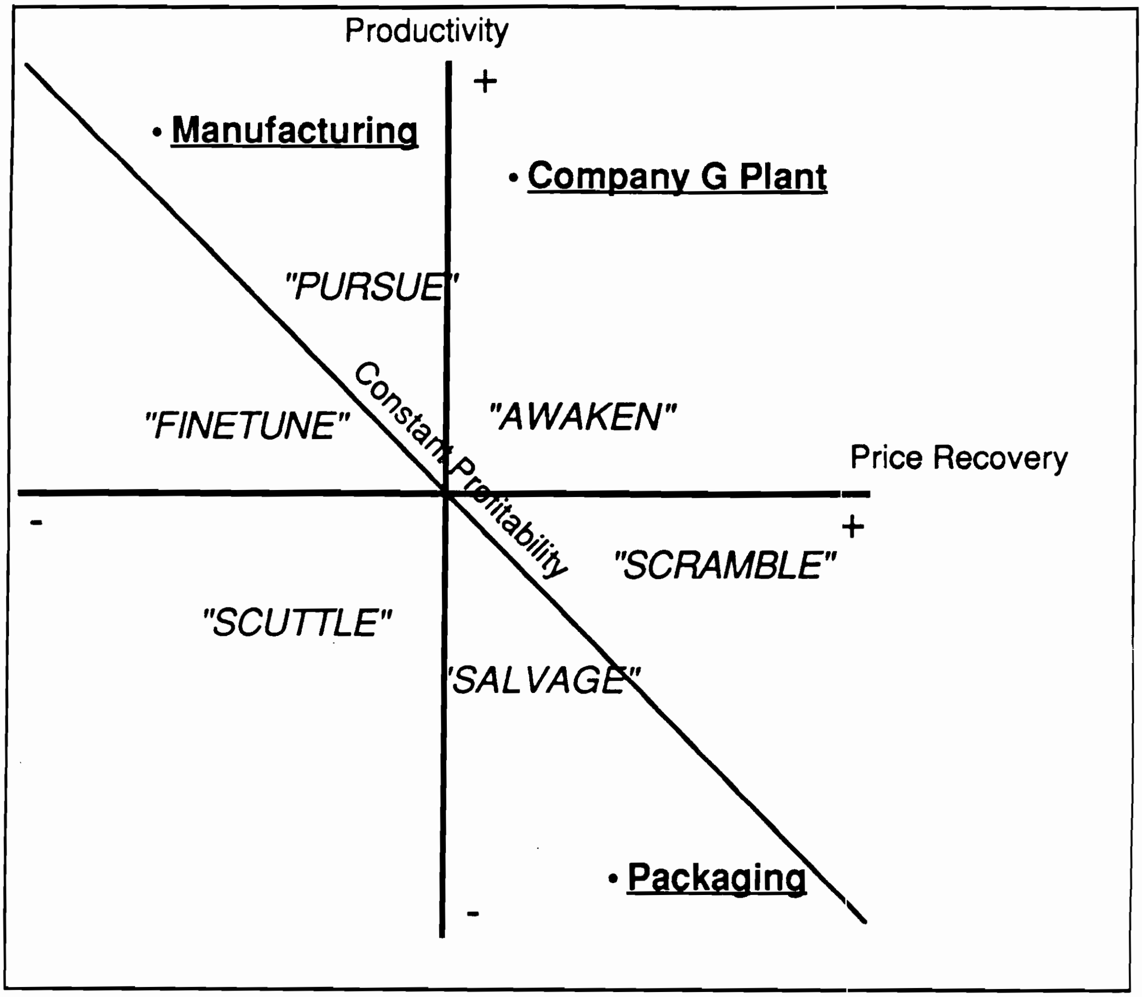

Figure 4.3: Plant A Strategic Grid

Based on Figure 4.3, Plant A's management would probably want to take a closer look at what's wrong with Packaging. Figure 4.4 shows which resources have contributed to the poor performance of Packaging. Obviously, efficiency in the use of bulk has declined significantly, causing the poor performance of the whole department.

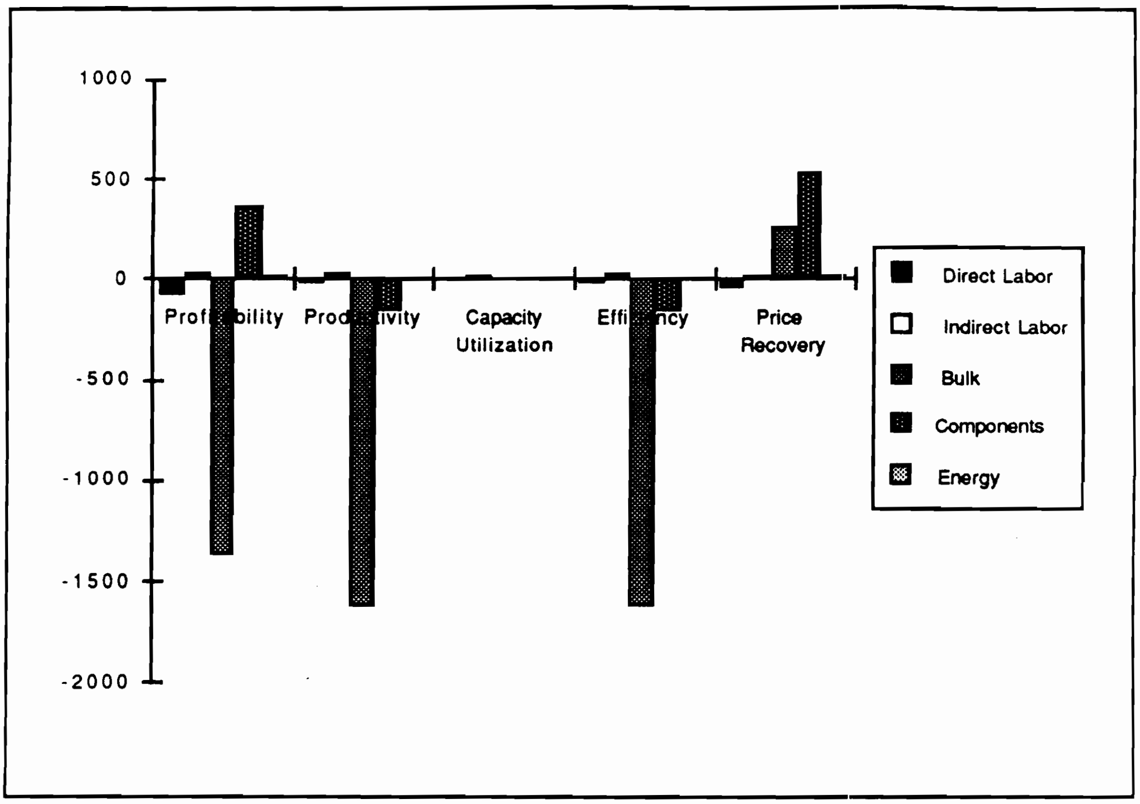

Figure 4.4: Dollar Effects of Changes in Productivity and Price Recovery on Profitability

Action Items and Future Directions

1. Get more data from Purchasing, Accounting, and/or Production Planning for:
   - Purchase Price Variances
   - Budgeted Raw Materials
2. Get programming support from MIS to facilitate data collection. Most if not all data needed are available. However, they are in different data bases and are not processed into reports in the form directly importable to SCORBORD.

3. Change base periods in the future once you're confident you have data that are representative of "typical" operations.
4. Consider including capital as an input in the future particularly when expanding or introducing new equipment.
5. Review data aggregation to either provide more details on inputs and/or outputs. More line items will enable you to look closer into the utilization of your resources.

Chapter 5 - Case #2: Division B Wants to Develop a Total-Factor Productivity Measurement (TFPM) Application for Planning and Measurement

Case Summary

This case study identifies the information needs of Division B and shows how TFPM provides these information . Information needs were obtained through meetings with managers, while data and systems available were identified by meeting staff analysts. The main information needs: providing feedback to department managers on their operations' performance and generating challenge budgets, are addressed using TFPM, particularly REALST. Other issues such as dealing with indirect costs, Activity-Based Costing (ABC) and long production cycles are also addressed.

Introduction

In June 1989, Division B requested VPC for assistance in developing a productivity measurement and evaluation system. VPC's response was to first clarify their specific expectations from such a productivity measurement and evaluation system and how they intend to integrate it with their other management systems. Division B is developing a performance improvement and measurement system. This system is composed of the following subsystems: a suggestion system, a cost-benefit analysis system, a Productivity Council approval system, a project management system, and a measurement system. In short, they want a measurement system that will help them plan for improvement and know whether they are actually improving or not.

In response to Division B's request, Greg Sedrick, a VPC Research Associate, and I, visited them for two days in November 1989 to become familar with Division B's operations, clarify expectations/desired outcomes of their measurement development team, collect data and brief them on measurement in general and TFPM in particular. This case study documents the information needs we collected and our recommendations on how TFPM should be developed to respond to their needs.

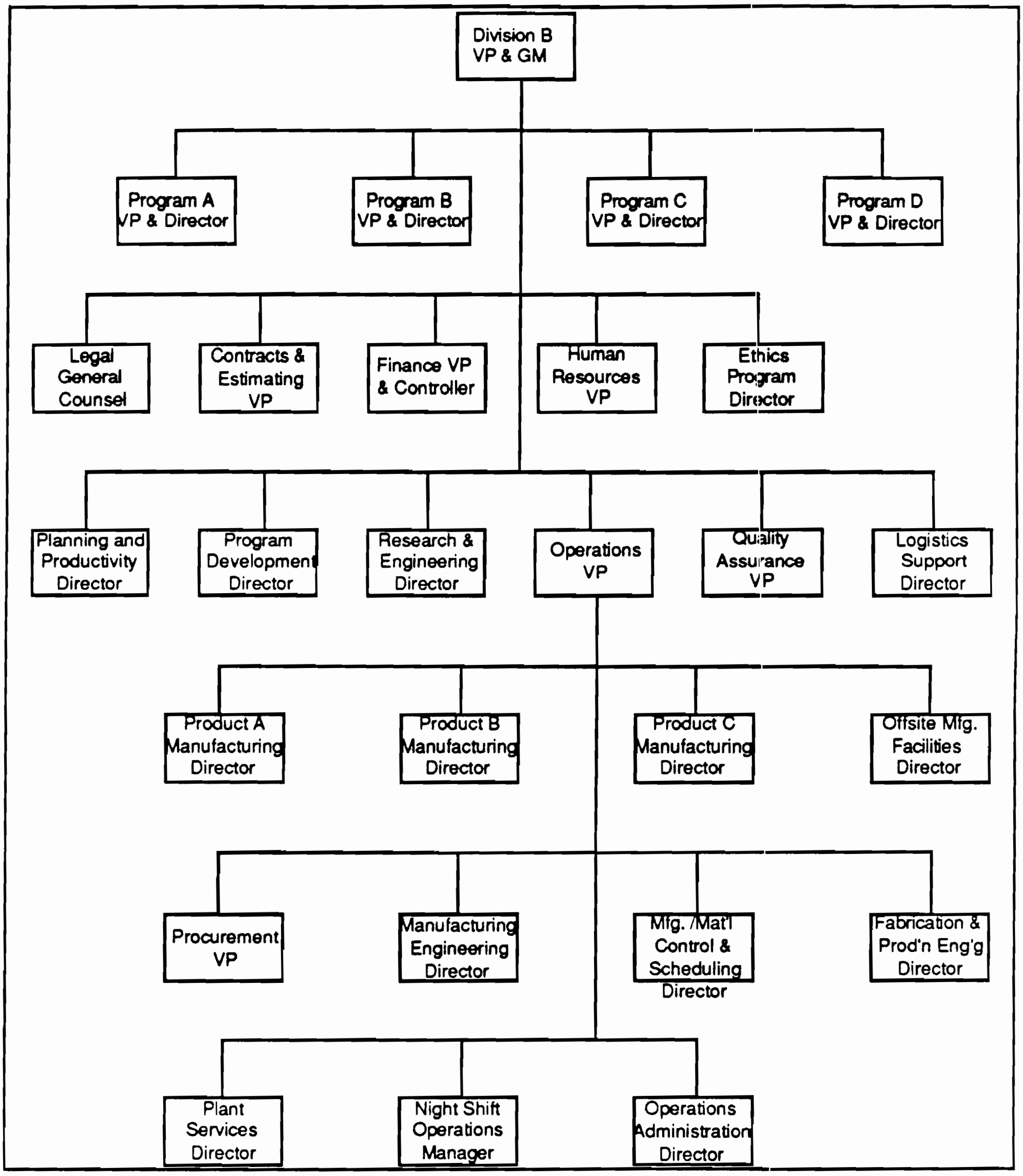

Figure 5.1: Division B's Organizational Structure

Division B is a defense contractor. They are in a high-technology environment and production cycles take about three years. While the inital focus of the measurement system development is on the Operations organization, there is a need to carefully consider other organizations within the division such as Program Management, Engineering, Research and Development, Quality Assurance, etc., that contribute to costs of Operations. Our point of contact, Operations Technology, is a unit within Operations' Manufacturing Engineering department. Figure 5.1 shows Division B's organizational chart.

Data Collection Strategy

Before we visited Division B, we advised our contact persons that there was a need to form a measurement system development team composed of representatives of managers/end-users, Finance and Accounting, Information Systems, and of course, Operations Technology who are tasked with developing the measurement system. Our strategy was to first brief the possible members of the measurement systems development team about measurement and TFPM so they would be in a better position to provide the data we needed on measurement systems development. We specified the need for the managers to be present when we discuss the overview of measurement and TFPM and ask the team to generate a list of their expectations from the measurement systems development effort. However, due to some urgent tasks for their strategic planning process, most of the managers could not be available for meetings during our visit. We had to change our strategy to obtain information needs data through short meetings with a few managers; and collected data on existing information systems and data sources from the staff/analyst members of the measurement system development team in a workshop setting rather than from one-on-one interviews. The following organizations were represented: Manufacturing Engineering (5 representatives), Finance, Financial Information Systems, Program Finance, Manufacturing Scheduling, and Accounting. This adjustment strategy, however, failed when some key attendees brought up the subject of the need for Activity-Based Cost (ABC) Accounting to improve the allocation of indirect and overhead costs. While we agree that ABC Accounting improves tracking of product costs, it will not provide the same information managers can obtain from TFPM (this will be discussed in detail later in this case study). There seems to a confusion between data and information. Information is biased data (Kurstedt, 1985). Data is what you get out of reports such as those from, say, ABC Accounting. The interpretation of the data for use in decision making is what comprises information. Hence, we believe it was inappropriate for some of the members of the measurement systems development team to evaluate TFPM at that point as frankly, there was still no clear understanding of what TFPM is; that is why VPC was asked for assistance in the first place. In hindsight, our mistake was to unintentionally and implicitly assume that an overview of measurement and TFPM would have them communicate in "our language" rather than our communicating in their language.

Day two began with a software demo of REsource ALlocation STrategist (REALST, a TFPM version) to give them an idea of how a TFPM software works. The remaining time was spent examining existing management systems and data sources/reports/forms. We specifically asked for current work standards, definitions of datafields that match resource inputs with outputs, and their definitions of outputs. In each case, the measurement systems development team could not reach a consensus on definitions. This led to an off-line discussion with our contact persons that we may have the wrong team members. Our recommendation was to pick one of their definitions and remain consistent with this definition when building the model. Once the structure was designed, the chosen definition could be changed if they wish to change the choice.

We believe Operations Technology attempted to assemble the most knowledgeable people of Division B's products and systems available. We also believe this group is composed of dedicated professionals with Division B's best interest in mind. However, as discussed with our contact persons before we left, we obviously did not have the right members for the measurement systems development team. An action item was to locate those who had access to necessary data and information, had authority to commit resources and make decisions on system changes, and who were open-minded to first understand new paradigms before evaluating them.

Another action item was to verify the information needs enumerated in the next section. These information needs are what we inferred from our brief meetings with a few managers from Manufacturing Engineering. The successful implementation of any system depends on the perceived need for it by the end-users.

Information Needs and Organizational Conditions

After this two-day visit, we went away with the following information needs and organizational conditions:

1. The present measures are either geared towards measuring the overall financial performance of the division. These are mainly for outside audiences such as the government, auditors, customers, etc. The Manager of Operations Technology wanted a measurement system for giving feedback to department managers on how they are performing. As mentioned earlier, Operations Technology is developing a performance improvement and measurement system. Hence, they need a measure that will tell departments how they are performing.

A critical concern is how to measure outputs of departments. Our impression is that the current financial information system will support the Input data requirements of TFPM. We are concerned that it will not support the Output data requirements. The largest roadblock we encountered was communicating and/or translating Division B's terms to ours and vice-versa. An educational intervention on Mundel's (1983) Hierarchy of Work

Unit Structure was extremely helpful in discussing how Work In Progress (WIP) could be handled and how to transfer accountability of the total product line and services to the departmental level. This will be discussed further in the next section.

Another concern is how to deal with indirects (and overhead). Some departments are composed entirely of this type of function. The concern is that the managers of these departments will not be able to use TFPM for improvement because of the difficulty and the unavailability of measures for their output. At present, TFPM could be applied only to the direct "touch labor" departments and it could consider indirect departments as inputs to the touch labor departments. This brought up the concern that ABC Accounting was the more immediate need to improve indirect cost allocation. We agree that ABC Accounting would refine the data for TFPM. Instead of allocating indirect costs traditionally based on factors such as direct labor and materials usage, activities and resource consumption are accounted for and directly charged to the particular product using the resource for which the activity is intended. Another approach would be to prototype a knowledge worker productivity or performance measurement system to supplement TFPM.

2. Being in the same industry as LTV, Division B is aware of LTV's integrated approach to planning and measurement using TFPM. Division B believes they will also benefit from such a system. The tricky part about LTV's system is that it assumes a management culture that has very open communications and that the "challenge budget process" will be supported by the financial and accounting systems, adapting where necessary while at Division B, one of the organizational conditions is that the measurement system should interface with the present systems. A challenge budget is generated from a reference period budget given targeted improvements in productivity, and forecasted sales, resource costs, and competitive selling prices. The process essentially computes desired levels of resource consumption.

How TFPM Can Provide Division B's Information Needs

1. As mentioned earlier, the primary concern for providing departments some feedback on their productivity performance is measuring outputs. The problem is that production cycles take about three years and different departments work on different components or at various stages in the production of the final product . Hence, there is a need to be able to approximate or measure output per department at least every three months, as feedback may be too late if it is received after more than a quarter, i.e., opportunities of improving performance or even correcting variances may be lost.

Based on our discussions with the Finance and Accounting representatives and some of the sample reports we examined, Division B's accounting system generates reports showing the Planned Value of Work Accomplished (PVWA) vs. the Planned Value of Work Scheduled (PVWS). The report is based on units completed or percentage of work accomplished on a project by each department. The units completed or percentage of work accomplished are used as the basis for billing customers periodically and can be used as the quantities for the TFPM application. The portion of the actual amount of the bill for the customer contributed by the work accomplished by each department can be used as the value of the output for the TFPM application. For example, Department A completed 15% of the work to be done on project X in period or quarter n, and the customer was billed $1.5M for the work accomplished. Then the data for the department's output in the TFPM application would be 15% for the quantity, $1.5M for the value, and the price can be computed using the formula V = Q x p or p = $1.5M / 15% = $10M.

Regarding the problem with the departments whose costs are mostly indirect, there is no way they can be measured directly at present using TFPM until their output is clearly defined for measurement. White collar measurement methods should help in measuring their output. Until an output measure can be defined for the indirect departments, their performance can be indirectly measured by considering them as inputs to the direct departments, i.e., their contribution to the performance of the direct departments can be measured. It is the allocation of indirect and overhead expenses that ABC Accounting aims to improve. To further clarify this notion, I reviewed what the literature says.

Some Notes on Activity-Based Cost (ABC) Accounting

Staubus (1988), in his book, *Activity Costing for Decisions*, says that prior to 1953, the [Accounting] profession had not embraced the objective of providing information useful for making decisions; in fact, it had not explicitly identified any objective of the practice of accounting except to report to external parties. Kaplan (1988) stated that most firm's cost systems are inadequate because they do not address three important functions: inventory valuation for financial and tax statements; operational control, including feedback on resources consumed to production and other department managers; and the costing of individual products. Consequently, important operating costs data are often late, inaccurate, and address, typically, only one element (labor), ignoring design, marketing, distribution, and servicing. Cooper and Kaplan (1990) elaborate further that traditional cost accounting systems distort cost information by weighting direct labor and materials more heavily than factory support operations, thus giving management inferior information on which to base decisions on pricing, product mix, and process technology. Activity Based Costing (ABC) takes into account that the majority of company activities support the production and delivery of goods and services. ABC offers a sophisticated approach to attributing factory and corporate overhead and other resources to activities and then to the products that consume indirect resources. ABC offers management accurate data by delineating support costs and tracing them to individual products and product lines.

Johnson and Kaplan (1987) emphasized the need to develop new and more flexible approaches to the design of effective cost accounting, management control, and performance measurement systems to face the challenge of today's competitive environment. They also stressed the importance of nonfinancial indicators of performance depending on what performance criteria managers need to measure. Kaplan (1990) says executives of manufacturing firms want a single cost accounting system, but multiple cost systems are an intermediate, practical stage through which progress is made towards implementing an effective integrated management information system. Multiple cost systems is a stage through which most companies must pass. These stages are characterized by: first, poor data quality; second, external reporting; third, innovation; and fourth, integration. Companies will progress through these four stages arriving at the integration of two managerial systems, one for customer profitability analysis and one for on-line feedback and performance measurement.

I believe Division B is now between stages two and three when external reporting is deemed inadequate for internal process control and performance improvement. Innovations are being sought and there is a need for multiple systems to be developed in parallel for integration in the future. Division B needs ABC to refine product cost data through a more rational allocation of indirect costs. Other performance indicators are needed to directly measure performance of these indirect departments. At the same time, productivity measures for direct departments need to be developed to start giving feedback for their control and improvement efforts. As VPC has found out in some of the organizations where we developed a TFPM application, the development of the TFPM application paved the way for collecting and storing more accurate and relevant data. ABC and TFPM are not redundant, they complement each other and can be components of an integrated performance measurement system in the future. At this point, TFPM can provide the necessary feedback needed by direct departments and how indirect departments are contributing to their performance even without ABC. With ABC, the TFPM application can be modified to analyze performance by products and indirect departments' contribution will be be more accurately measured and allocated. The following example based on sample data for a direct department of Division B shows the information that TFPM can provide to department managers even without ABC.

TFPM/REALST Generates Reports for Department Managers

In this example, the REALST software was used to process the sample data and generate reports. Tables 5.1.1 and 5.1.2 are the sample Data Reports showing a reference period, 1st Quarter 1989, and a review period, 2nd Quarter 1989. The reference period could have been the budget for the quarter being reviewed or some other comparable quarters. Table 5.1.1 first shows the products worked on by Department D then shows the resources used to work on those products (continued through Table 5.1.2). The resources include labor, materials, energy, money, and contributions from indirect Departments I, J, and K. These two tables show value (V) = quantity (Q) x price (p) for each product and resource and for each of the two periods. The tables also show the change ratios for values, quantities, and prices.

Table 5.1.1: Raw Sample Data Report for Department D

1ST QUARTER 1989 vs. 2ND QUARTER 1989

VALUES are in THOUSANDS of DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Proj M Work Completed										
A		2550.0	0.1	31875.00	2850.0	0.1	28500.00	0.11765	0.25000	0.10588-
B		1850.0	0.1	18500.00	2000.0	0.1	15384.62	0.08108	0.30000	0.16840-
C		1500.0	0.2	10000.00	1000.0	0.1	14285.71	0.33333-	0.53333-	0.42857
Proj. M - TOTAL		5900.0			5850.0			0.00847-	0.06653	0.07032-
Proj. N Work Completed										
X		1350.0	0.1	15882.35	1580.0	0.1	14363.64	0.17037	0.29412	0.09562-
Y		1040.0	0.1	9454.55	1000.0	0.1	11111.11	0.03846-	0.18182-	0.17521
Z		2105.0	0.3	8420.00	2000.0	0.1	20000.00	0.04988-	0.60000-	1.37530
Proj. N TOTAL		4495.0			4580.0			0.01891	0.23471-	0.33141
COMPONENTS										
A		[illegible]	30.0	5.17	180.0	35.0	5.14	[illegible]	[illegible]	[illegible]
B		[illegible]	25.0	9.22	235.0	28.0	8.39	[illegible]	[illegible]	[illegible]
C		[illegible]	3.0	227.83	780.0	4.0	195.00	[illegible]	[illegible]	[illegible]
COMPONENTS TOTAL		[illegible]			1195.0			[illegible]	[illegible]	[illegible]
GRAND TOTAL Department D		[illegible]			11625.0			[illegible]	0.03325-	[illegible]
LABOR										
DIRECT	1.00	2423.3	220849.0	0.01	2125.0	191713.0	0.01	0.12309-	0.13193-	0.01018
DIRECT DISTRIBUTED	0.00	261.4	23853.0	0.01	289.9	26085.0	0.01	0.10896	0.09357	0.01407
INDIRECT	0.00	27.2	2440.0	0.01	32.5	2934.0	0.01	0.19222	0.20246	0.00851-
TOTAL LABOR		2711.9			2447.4			0.09756-	0.10681-	0.01036
RAW										
HYDRAULIC	1.00	1500.0	15000.0	0.10	1800.0	17475.7	0.10	0.20000	0.16505	0.03000
ELECTRONIC	1.00	2500.0	25000.0	0.10	2400.0	28235.3	0.08	0.04000-	0.12941	0.15000-
MECHANICAL	1.00	800.0	8000.0	0.10	1000.0	9523.8	0.10	0.25000	0.19048	0.05000
SUB-TOTAL RAW MATERIALS		4800.0			5200.0			0.08333	0.15299	0.06042-
QUALITY	1.00	3000.0	30000.0	0.10	3000.0	30000.0	0.10	0.00000	0.00000	0.00000
SUB-TOT QUALITY MATERIAL		3000.0			3000.0			0.00000	0.00000	0.00000
MATERIALS TOTAL		7800.0			8200.0			0.05128	0.09188	0.03718-

Table 5.1.2: Raw Sample Data Report for Department D (cont'd)

8-1990 14:39:33 Division B - Department D INPUT 1.2
CENTRE - 1
1ST QUARTER 1989 vs. 2ND QUARTER 1989

VALUES are in THOUSANDS of DOLLARS

DESCRIPTION	REVAL	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
ENERGY										
ELECTRICITY	1.00	171.4	3146634.1	0.00	255.0	3282292.1	0.00	0.48830	0.04311	0.42679
NATURAL GAS	1.00	57.2	128778.8	0.00	20.2	41674.3	0.00	0.64667-	0.67639-	0.09183
WATER	1.00	25.1	11235.3	0.00	23.6	10680.9	0.00	0.06127-	0.04934-	0.01255-
FUEL OIL	1.00	9.5	10252.5	0.00	1.1	1307.0	0.00	0.88640-	0.87252-	0.10888-
COGENERATION	1.00	43.6	98169.7	0.00	34.1	96894.7	0.00	0.21811-	0.01299-	0.20782-
TOTAL ENERGY		306.8			334.0			0.08867	0.10880-	0.22158
OTHER COSTS										
DEPRECIATION	0.00	3.3	33.2	0.10	8.1	81.1	0.10	1.44646	1.44646	0.00000
TAXES	0.00	0.3	3.3	0.10	1.0	9.6	0.10	1.88855	1.88855	0.00000
INSURANCE	0.00	0.0	0.4	0.10	0.1	0.9	0.10	1.59331	1.59331	0.00000
TOTAL OTHER COSTS		3.7			9.2			1.48774	1.48774	[illegible]
INDIRECT COSTS										
DEPARTMENT I	0.00	53.2	3155.1	0.02	88.3	5052.6	0.02	0.66011	0.60140	[illegible]
DEPARTMENT C	0.00	3.1	190.0	0.02	7.1	437.0	0.02	1.27849	1.27604	0.00106
DEPARTMENT F	0.00	63.4	4965.5	0.01	55.[illegible]	4290.6	0.01	0.13295-	0.13471-	0.00204
TOTAL INDIRECT COSTS		119.7			150.2			0.25600	0.23452	0.01740
GRAND TOTAL DEPARTMENT D		10942.1			11140.9			0.01816	0.03633	0.01753-
AGGREGATE		10942.1			11140.9			0.01816	0.03633	0.01753-
PROFIT		521.9			484.1					

Table 5.2.1 is the Management Report summarizing the analysis of Department D's profit performance. It shows profitability declined (-$45,100) mainly caused by a decline in total-factor productivity (-6.71% or -$748,100) but cushioned by price over-recovery ($703,000). These results place Department D in the "Salvage" half-quadrant of the Strategic Grid (see Figure 5.2). This implies Department D needs to turnaround from its present strategy of relying more on price recovery rather than on productivity improvement to be profitable. In a highly competitive environment, a competitor who can be more productive can definitely offer much lower prices.

A quick glance at the resource totals shows the decline in overall performance is mainly caused by a profitability decline (-$290,500), further caused by a productivity decline (-11.46% or -$939,700) but cushioned by price over-recovery ($649,300) for materials. Contributions from indirect departments also declined in profitability (-$29,000) and productivity (-21.69% or -$32,600).

Table 5.2.1: Summary Management Report

1ST QUARTER 1989 vs. 2ND QUARTER 1989

VALUES are in THOUSANDS of DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF: %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	11464.0	11625.0						
LABOR	2711.9	2447.4	302.7	8.24	201.6	9.7-	211.3	101.1
MATERIALS TOTAL	7800.0	8200.0	290.5-	11.46-	939.7-	0.0	939.7-	649.3
ENERGY	306.8	334.0	22.9-	8.48	28.3	0.0	28.3	51.2-
OTHER COSTS	3.7	9.2	5.4-	61.14-	5.6-	0.1-	5.5-	0.2
INDIRECT COSTS	119.7	150.3	29.0-	21.69-	32.6-	4.0-	28.6-	3.6
GRAND TOTAL DEPARTMENT D	10942.1	11140.9	45.1-	6.71-	748.1-	13.9-	734.2-	703.0
AGGREGATE	10942.1	11140.9	45.1-	6.71-	748.1-	13.9-	734.2-	703.0

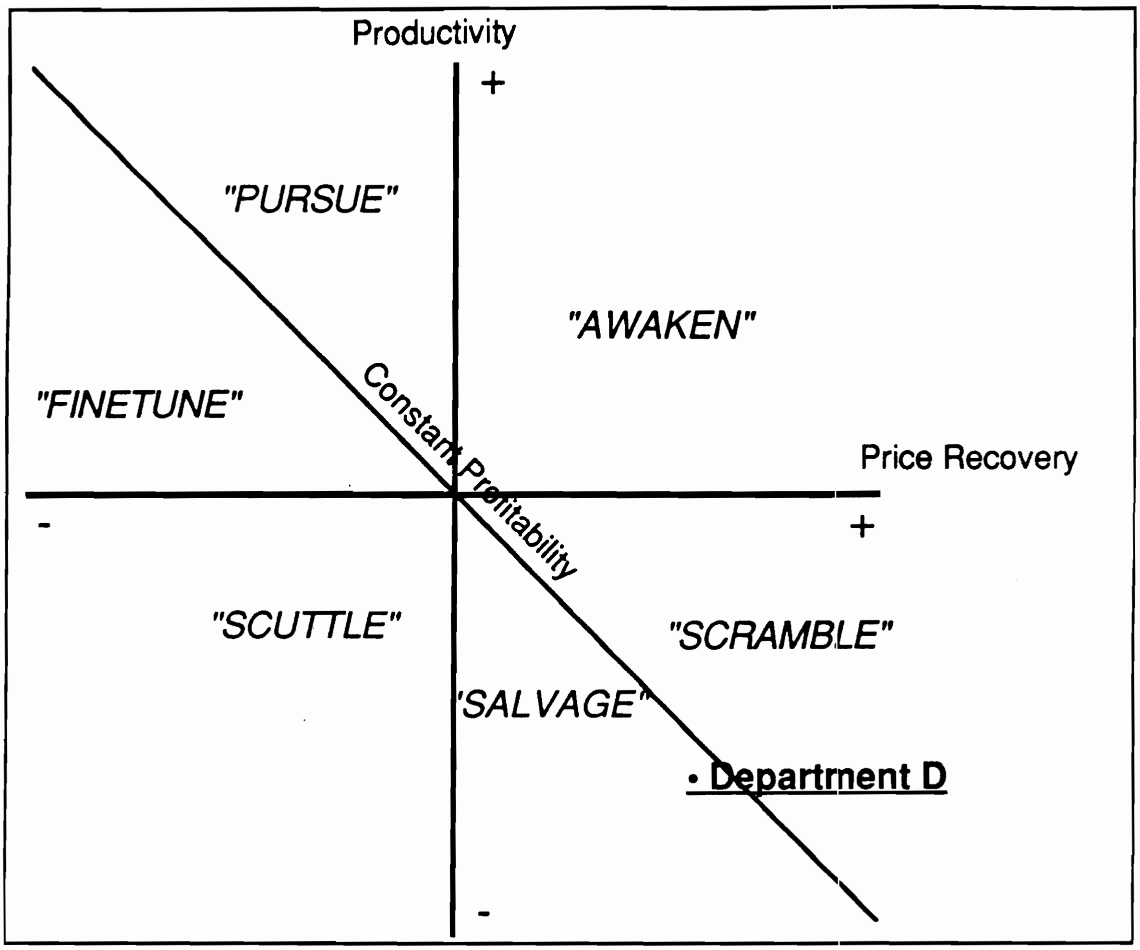

Figure 5.2: Department D Needs a "Salvage" Strategy

Tables 5.3.1 and 5.3.2 show the details needed to further analyze the changes between the two periods being compared. Table 5.3.1 shows the decline in materials profitability is caused by hydraulic (-$278,900) and mechanical (-$188,800) materials. Tables 5.3.1 and 5.3.2, show the profitability contribution to Department D of Departments I and J declined (-$34,400 and -$3,900, respectively).

The sample reports have shown that TFPM, in general, and REALST, in particular, provide the information needed by managers to monitor their department's performance.

They can see from the reports where they are doing well and what areas need improvement. All the data are related using dollar effects on profitability, productivity and price recovery.

Table 5.3.1: Analysis of Department D's Profitability, Productivity, and Price Recovery

06-19-1990 08:37:02 Division B - Department D PROFIT 1.1

Detailed Analysis

CENTRE - 1

1ST QUARTER 1989 vs. 2ND QUARTER 1989

VALUES are in THOUSANDS of DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D =	E	+	F
TOTAL PRODUCTS	11464.0	11625.0						
LABOR								
DIRECT	2423.3	2125.0	332.[illegible]	11.37	241.6	0.0	241.[illegible]	[illegible]
DIRECT DISTRIBUTED	261.4	289.9	24.8-	11.60-	33.6-	8.8-	24.8-	[illegible]
INDIRECT	27.2	32.5	4.9-	19.60-	6.4-	0.9-	5.5-	[illegible]
TOTAL LABOR	2711.9	2447.4	302.7	8.24	201.6	9.7-	211.3	[illegible]
RAW								
HYDRAULIC	1500.0	1800.0	278.9-	17.02-	306.4-	0.0	306.4-	27.4
ELECTRONIC	2500.0	2400.0	135.1	14.40-	345.7-	0.0	345.7-	480.8
MECHANICAL	800.0	1000.0	188.8-	18.79-	187.9-	0.0	187.9-	0.8-
SUB-TOTAL RAW MATERIALS	4800.0	5200.0	332.6-	16.15-	840.0-	0.0	840.0-	507.4
QUALITY	3000.0	3000.0	42.1	3.33-	99.8-	0.0	99.8-	141.9
SUB-TOT QUALITY MATERIAL	3000.0	3000.0	42.1	3.33-	99.8-	0.0	99.8-	141.9
MATERIALS TOTAL	7800.0	8200.0	290.5-	11.46-	939.7-	0.0	939.7-	649.3
ENERGY								
ELECTRICITY	171.4	255.0	81.3-	7.32-	18.7-	0.0	18.7-	62.6-
NATURAL GAS	57.2	20.2	37.8	198.74	40.2	0.0	40.2	2.4-
WATER	25.1	23.6	1.9	1.69	0.4	0.0	0.4	1.5
FUEL OIL	9.5	1.1	8.6	658.35	7.1	0.0	7.1	1.5
COGENERATION	43.6	34.1	10.1	2.05-	0.7-	0.0	0.7-	10.8
TOTAL ENERGY	306.8	334.0	22.9-	8.48	28.3	0.0	28.3	51.2-
OTHER COSTS								
DEPRECIATION	3.3	8.1	4.7-	60.48-	4.9-	0.1-	4.8-	0.2
TAXES	0.3	1.0	0.6-	66.53-	0.6-	0.0-	0.6-	0.0
INSURANCE	0.0	0.1	0.1-	62.72-	0.1-	0.0-	0.1-	0.0
TOTAL OTHER COSTS	3.7	9.2	5.4-	61.14-	5.6-	0.1-	5.5-	0.2
INDIRECT COSTS								
DEPARTMENT I	53.2	88.3	34.4-	39.63-	35.0-	1.8-	33.2-	0.6

Table 5.3.2: Analysis of Department D's Profitability, Productivity, and Price Recovery (continued)

Division B - Department D PROFIT 1.2
Detailed Analysis
CENTRE - 1
1ST QUARTER 1989 vs. 2ND QUARTER 1989

VALUES are in THOUSANDS of DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF PRODUCTIVITY VARIANCE	EFFECT OF PRODUCT VOLUME	EFFECT OF RESOURCE ALLOCATION	EFFECT OF PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
DEPARTMENT J	3.1	7.1	3.9-	57.53-	4.1-	0.1-	4.0-	0.1
DEPARTMENT K	63.4	55.0	9.3	11.73	6.4	2.1-	8.6	2.9
TOTAL INDIRECT COSTS	119.7	150.3	29.0-	21.69-	32.6-	4.0-	28.6-	3.6
GRAND TOTAL DEPARTMENT D	10942.1	11140.9	45.1-	6.71-	748.1-	13.9-	734.2-	703.0
AGGREGATE	10942.1	11140.9	45.1-	6.71-	748.1-	13.9-	734.2-	703.0

2. The second information need deals with generation of "challenge budgets." Only REALST and the LTV versions of TFPM have the capability of computing challenge budgets. Since the earlier example used REALST, the REALST version will be shown first.

REALST Can Generate "Challenge Budgets"

Table 5.4 1 shows how the challenge budget is set up. The software asks for productivity required, budgeted sales volume, selling price, and resource cost. Given these percentage changes, Tables 5.4.2 and 5.4.3 are generated. These two tables show the quantities of outputs/products needed to increase sales volume by 8% and inputs/resources needed to attain a 5% increase in productivity. They also show selling prices increasing by 3% and unit costs increasing by 10%. Table 5.5.1 is the summary Management Report showing productivity increasing by 5%. The table also shows that a 5% increase in productivity is not enough to maintain profitability. This means the selling prices will need to be increased, input costs decreased, and/or productivity needs to improve by >5%.

<u>Table 5.4.1: REALST Challenge Budget Set-Up</u>

```
                                  ;MMMMMMMMMMMMMMM:
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMM9 REALST BUDGET LMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM:
:                                 HMMMMMMMMMMMMMMM<                 08:51:20 :
:                                                                            :
:                                                                            :
:              Centre number                          : 1                    :
:              Reference period number                : 1                    :
:              Budget period number                   : 3                    :
:                                                                            :
:                                                                            :
:                                                                            :
:                                                                            :
:                      Percentage change in                                  :
:              Productivity required                  : 5                    :
:              Budgeted sales volume                  : 8                    :
:              Budgeted selling price                 : 3                    :
:              Budgeted cost resource price           : 10                   :
:                                                                            :
```

Table 5.4.2: Challenge Budget Generated by REALST

9-1990 08:53:42 Division B - Department D INPUT 1.1
CENTRE - 1
1ST QUARTER 1989 vs.

VALUES are in THOUSANDS of DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Proj M Work Completed										
A		2550.0	0.1	31875.00	2836.6	0.1	32831.25	0.11240	0.08000	0.03000
B		1850.0	0.1	18500.00	2057.9	0.1	19055.00	0.11240	0.08000	0.03000
C		1500.0	0.2	10000.00	1668.6	0.2	10300.00	0.11240	0.08000	0.03000
Proj. M - TOTAL		5900.0			6563.2			0.11240	0.08000	0.03000
Proj. N Work Completed										
X		1350.0	0.1	15882.35	1501.7	0.1	16358.82	0.11240	0.08000	0.03000
Y		1040.0	0.1	9454.55	1156.9	0.1	9738.18	0.11240	0.08000	0.03000
Z		2105.0	0.3	8420.00	2341.6	0.3	8672.60	0.11240	0.08000	0.03000
Proj. N TOTAL		4495.0			5000.2			0.11240	0.08000	0.03000
COMPONENTS										
A		155.0	30.0	5.17	172.4	32.4	5.32	0.11240	0.08000	0.03000
B		230.5	25.0	9.22	256.4	27.0	9.50	0.11240	0.08000	0.03000
C		683.5	3.0	227.83	760.3	3.2	234.67	0.11240	0.08000	0.03000
COMPONENTS TOTAL		1069.0			1189.2			0.11240	0.08000	0.03000
GRAND TOTAL Department D		11464.0			12752.6			0.11240	0.08000	0.03000
LABOR										
DIRECT	1.00	2423.3	220849.0	0.01	2741.8	227159.0	0.01	0.13143	0.02857	0.10000
DIRECT DISTRIBUTED	0.00	261.4	23853.0	0.01	295.8	24534.5	0.01	0.13143	0.02857	0.10000
INDIRECT	0.00	27.2	2440.0	0.01	30.8	2509.7	0.01	0.13143	0.02857	0.10000
TOTAL LABOR		2711.9			3068.4			0.13143	0.02857	0.10000
RAW										
HYDRAULIC	1.00	1500.0	15000.0	0.10	1697.1	15428.6	0.11	0.13143	0.02857	0.10000
ELECTRONIC	1.00	2500.0	25000.0	0.10	2828.6	25714.3	0.11	0.13143	0.02857	0.10000
MECHANICAL	1.00	800.0	8000.0	0.10	905.1	8228.6	0.11	0.13143	0.02857	0.10000
SUB-TOTAL RAW MATERIALS		4800.0			5430.9			0.13143	0.02857	0.10000
QUALITY	1.00	3000.0	30000.0	0.10	3394.3	30857.1	0.11	0.13143	0.02857	0.10000
SUB-TOT QUALITY MATERIAL		3000.0			3394.3			0.13143	0.02857	0.10000
MATERIALS TOTAL		7800.0			8825.1			0.13143	0.02857	0.10000

Table 5.4.3: Challenge Budget Generated by REALST (cont'd)

VALUES are in THOUSANDS of DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD VALUE	REFERENCE PERIOD QUANTITY	REFERENCE PERIOD PRICE	REVIEW PERIOD VALUE	REVIEW PERIOD QUANTITY	REVIEW PERIOD PRICE	CHANGE in RATIO VALUE	CHANGE in RATIO QUANTITY	CHANGE in RATIO PRICE
ENERGY										
ELECTRICITY	1.00	171.4	3146634.1	0.00	193.9	3236537.9	0.00	0.13143	0.02857	0.10000
NATURAL GAS	1.00	57.2	128778.8	0.00	64.7	132458.2	0.00	0.13143	0.02857	0.10000
WATER	1.00	25.1	11235.3	0.00	28.4	11556.3	0.00	0.13143	0.02857	0.10000
FUEL OIL	1.00	9.5	10252.5	0.00	10.8	10545.4	0.00	0.13143	0.02857	0.10000
COGENERATION	1.00	43.6	98169.7	0.00	49.3	100974.6	0.00	0.13143	0.02857	0.10000
TOTAL ENERGY		306.8			347.1			0.13143	0.02857	0.10000
OTHER COSTS										
DEPRECIATION	0.00	3.3	33.2	0.10	3.8	34.1	0.11	0.13143	0.02857	0.10000
TAXES	0.00	0.3	3.3	0.10	0.4	3.4	0.11	0.13143	0.02857	0.10000
INSURANCE	0.00	0.0	0.4	0.10	0.0	0.4	0.11	0.13143	0.02857	0.10000
TOTAL OTHER COSTS		3.7			4.2			0.13143	0.02857	0.10000
INDIRECT COSTS										
DEPARTMENT I	0.00	53.2	3155.1	0.02	60.2	3245.3	0.02	0.13143	0.02857	0.10000
DEPARTMENT J	0.00	3.1	192.0	0.02	3.5	197.5	0.02	0.13143	0.02857	0.10000
DEPARTMENT K	0.00	63.4	4965.5	0.01	71.7	5107.4	0.01	0.13143	0.02857	0.10000
TOTAL INDIRECT COSTS		119.7			135.4			0.13143	0.02857	0.10000
GRAND TOTAL DEPARTMENT D		10942.1			12380.2			0.13143	0.02857	0.10000
AGGREGATE		10942.1			12380.2			0.13143	0.02857	0.10000
PROFIT		521.9			372.3					

Table 5.5.1: Management Report Evaluating the Challenge Budget

06-19-1990 11:24:02 Division B - Department D PROFIT 1.1
Management Report
CENTRE - 1
1ST QUARTER 1989 vs. Challenge Budget

VALUES are in THOUSANDS of DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	EFFECT OF: PRODUCT VOLUME	EFFECT OF: RESOURCE ALLOCATION	EFFECT OF: PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	11464.0	12752.6						
LABOR	2711.9	3068.4	51.6-	5.00	153.4	25.4	128.0	205.0-
MATERIALS TOTAL	7800.0	8825.1	148.4-	5.00	441.3	0.0	441.3	589.7-
ENERGY	306.8	347.1	5.8-	5.00	17.4	0.0	17.4	23.2-
OTHER COSTS	3.7	4.2	0.1-	5.00	0.2	0.3	0.1-	0.3-
INDIRECT COSTS	119.7	135.4	2.3-	5.00	6.8	10.5	3.8-	9.0-
GRAND TOTAL DEPARTMENT D	10942.1	12380.2	208.2-	5.00	619.0	36.3	582.8	827.2-
AGGREGATE	10942.1	12380.2	208.2-	5.00	619.0	36.3	582.8	827.2-

The LTV Version Computes Challenge Budgets on the Macro Level

While REALST computes challenge budgets on the detailed level although choices on percentage changes are made across the board for all outputs and inputs' quantities and prices, LTV's version computes challenge budgets only on the macro level. This saves the receiver of the report from looking at so much details without really getting more information. After all across the board percentage changes merely represent average changes; detailed budget changes will still have to be worked out by those actually preparing the detailed budgets. Table 5.6.1 shows the actual computations done using LTV's challenge budget process. Note that the end result in terms of total input costs ($12,349.30) is comparable to the total input costs obtained in Table 5.4.3 ($12, 380.2).

The slight difference is caused by LTV's use of cost-to-sales ratio (input/output) rather than a productivity improvement target used by REALST.

Table 5.6.1: LTV Version Computes Challenge Budgets on the Macro Level

	Base	Current	Logic
OUTPUT			
• Current $s	$11,464.00	$12,752.60	Forecast
• Price Inflation %	Base	3%	Forecast
• Constant $s	$11,464.00	$12,381.17	= 12,752.60 / (1 + 3%)
PRODUCTIVITY IMPROVEMENT			
•Target Improvement	Base	5%	
INPUT (Resource Costs)			
• Cost to Sales %	95.45%	90.68%	= 95.45 (1 - 5%)
• Costs (Constant $s)	100	$11,226.64	= 12,381.165 * 90.68%
• Cost Inflation	Base	10%	Forecast
• Costs (Current $s)	100	$12,349.30	= 11226.64 (1 + 10%)

Conclusions

This case study has shown that TFPM and REALST in particular can provide the information needs of Division B even without waiting for ABC to be developed and implemented. TFPM and ABC need not be developed sequentially; they may be developed simultaneously with the thrust of integrating them in the future. Integration should be facilitated by the fact that those using and implementing the two systems will be very familiar with both when the time comes for integrating them. There would also be a need to supplement TFPM with a white collar measurement system particularly for indirect departments. For the moment, indirect departments could first be treated as inputs to the direct departments; once a measurement system is developed so that outputs of indirect departments could already be measured, then, a TFPM application could also be developed for them. Finally, I recommend using REALST as it is the only version that could provide both the information needs of Division B and even later provide an aggregated report for the whole division which will combine the performance measurement for all the departments. I have not discussed all the capabilities and choices of report REALST can generate as they are not needed at the moment. From this case study, however, it can be inferred that an analyst will have to make the choices as to the level of detail each manager will need and the portrayal reports and graphics they will appreciate.

Chapter 6 - Case #3: Company C Wants Physical Measures to Supplement Financial Measures

Case Summary

In this case study, I identified information needs of Company C managers and explored how TFPM provides such information. The information needs and data available were identified by interviewing operating managers and staff analysts and reviewing documents and forms. After identifying information needs, sample data from Company C's Plastics Department were used to explore how to provide for the information needs. I used REALST to process the data and address the information needs. I concluded that all the information needs can be obtained from REALST reports but an analyst will need to interpret the reports and portray the information in an executive summary including graphics.

Introduction

How VPC Got Involved

On July 14, 1989, Company C's Manager, Productivity Improvements, requested VPC for assistance in developing a "comprehensive productivity measurement system tied in with work standards and relatable to profitability." Company C's industrial engineers have used Craig and Harris' version of TFPM in the past which they found cumbersome and provided them with just a measure of physical productivity but did not directly relate to their financial measures. In response to Company C's request, we proposed a series of activities leading to the development of a pilot TFPM application at Company C. I first visited the company for three days in December 1989 to collect data on specific information needs, data available, existing systems and organizational conditions, brief them on TFPM, and recommend next steps for developing a TFPM application. What follows is a documentation of the data I collected during that visit and the alternative approaches to TFPM development at Company C.

Background Info on Company C

Company C is a highly diversified manufacturer of food, beverages and packaging materials. It employs more than 20,000 people in its operations. The organizational structure is shown in Figure 6.1. The organization is composed of several divisions which are further subdivided into business units and plants for the operating divisions, and into directorates and departments for the non-operating divisions.

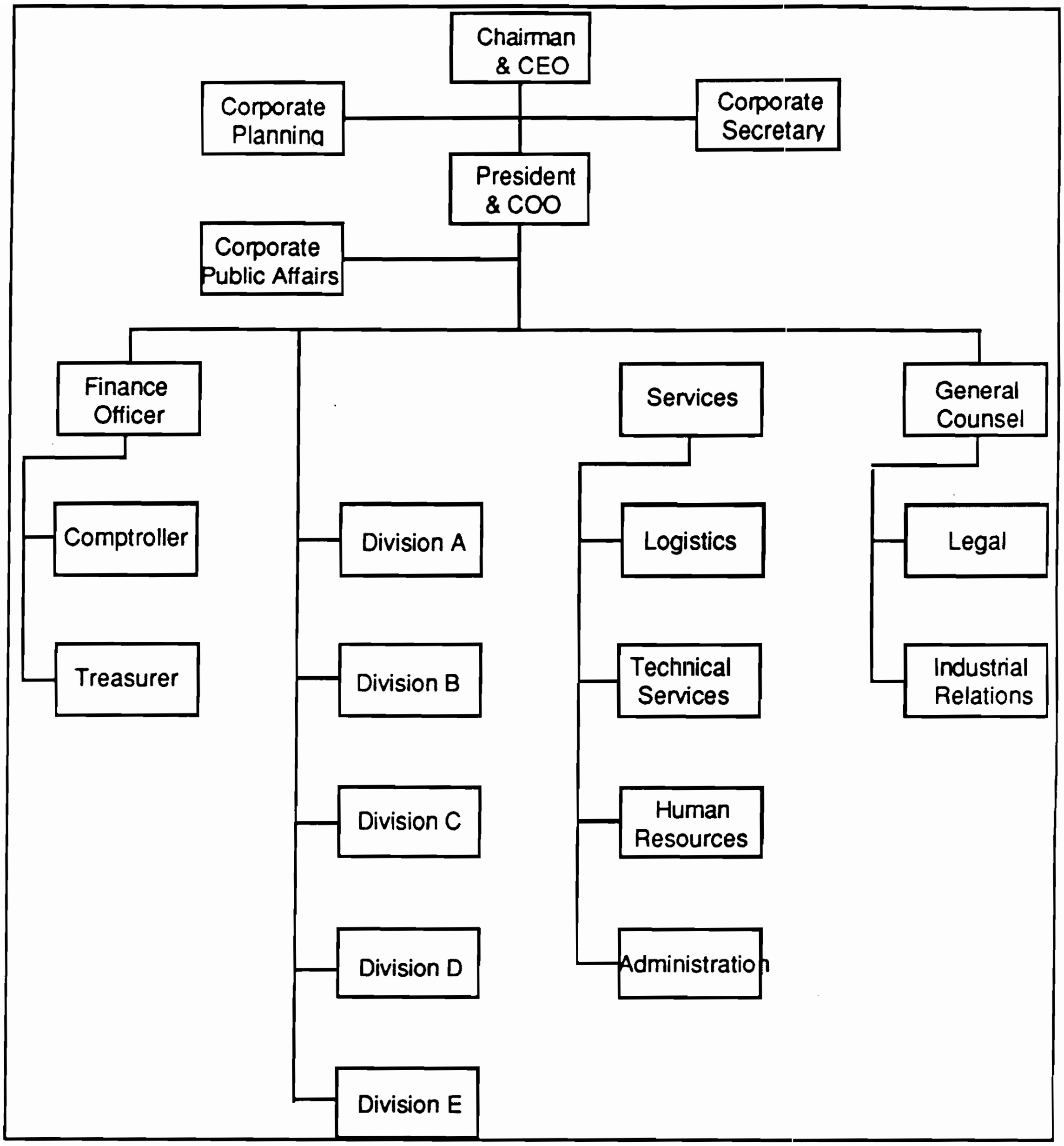

Figure 6.1: Company C Organizational Structure

Company C has evolved and institutionalized an integrated planning and control system that includes strategic direction setting (goal), strategic programming (path), budgeting (detailed plans for next year), and performance monitoring and reporting (assessment). Figure 6.2 is Company C's planning calendar mostly showing only the financial aspects of planning although these financial plans are backed up by the technical plans. Note that towards the end of May, five-year sales and production volumes are reviewed in preparation for developing capital and operating budgets. In performance monitoring and reporting, the focus has mostly been on financial measures that in the words of the Chief Operating Officer, "we need to provide operating managers some tools so they can have in their operating reports, physical measures to supplement financial measures." From what I gathered from the operating managers, they have detailed plant efficiency standards. What is lacking is the integration of the financial measures with their plant efficiency standards.

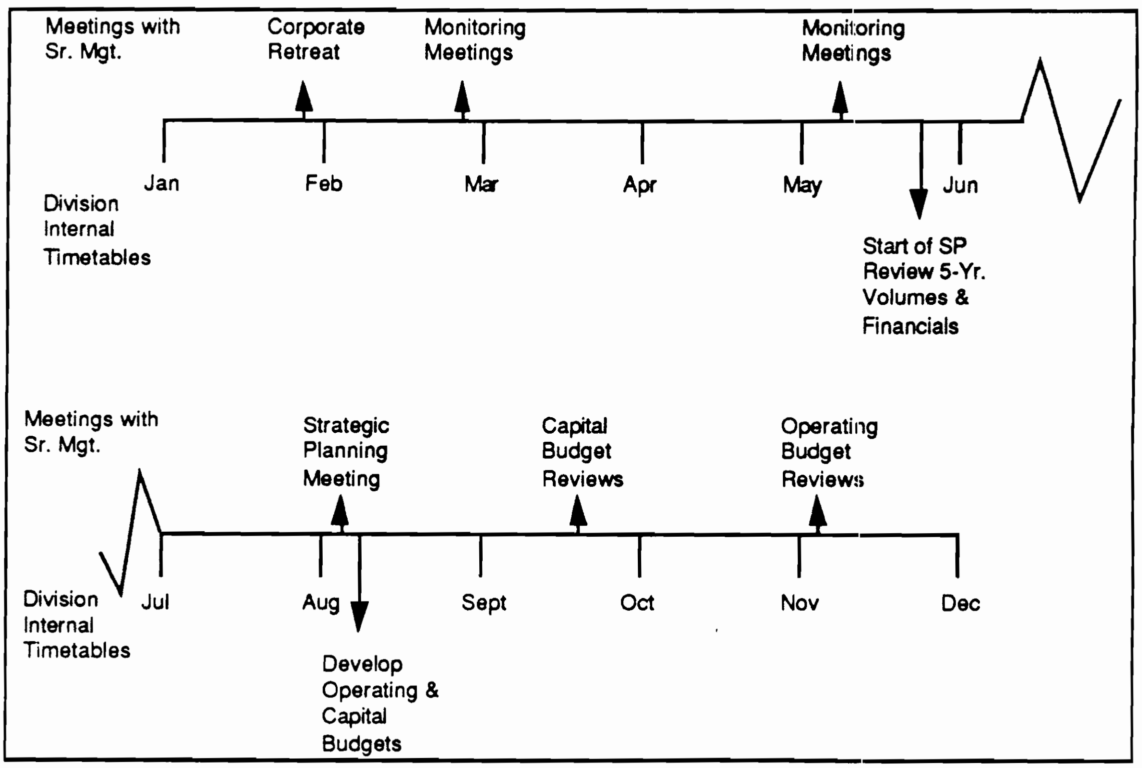

Figure 6.2: Company C Planning Calendar

Data Collection Strategy

Following is the agenda (briefings, interviews, document/forms reviews, and presentation) for the visit last December 1989:

Day 1	11:00 am	Met with Technical Services Division Manager/VP, Productivity Services Director/AVP, and their staff to finalize details of the next two days	
		<u>Topic</u>	<u>Resource Person</u>
Day 2	9:00 am	Company C Organization	Head, Human Resource Planning
	9:30 am	Quality Management System	Manager, Quality Management
	10:00 am	Coffee Break	
	10:15 am	Accounting Systems	Manager of Accounting
	11:15 am	Strategic Planning/ Capital Expenditure	Manager, Strategic Planning
	12:00 noon	Lunch	
	1:30 pm	Budgetary System	Sr. Budget Analyst
	3:00 pm	Coffee Break	
	3:15 pm	Computer Systems	AVP/Director, Information Systems
	4:15 pm	Review documentation and forms used for budgetary system	
Day 2	8:30 am	Division B	VP/General Manager
	10:00 am	Services	Sr. VP
	2:00 pm	Introduction to Performance Measurement, TFPM, and REALST	
Day 3	8:30 am	Division A	VP/General Manager and Sr. AVP
Day 4	8:30 am	Division D	VP/General Manager
	11:00 am	Division E	VP/General Manager

As can be gleaned from the above agenda, different ways of collecting data were used: briefings, interviews, documents/forms reviews, and a presentation/workshop. This ensures that data collection is done comprehensively and enables cross-validation of data (Yin, 1987).

Briefings

I was briefed on the company's:

- organizational structure so I could see the reporting relationships and how their responsibilities are divided;
- quality management system so I could see what their ongoing improvement efforts are and how they may relate to the measurement systems development;
- accounting systems, including the Capital Expenditure Planning and Control and budgetary systems, so I could see what accounting data and information are presently available
- computer/information systems to see the available data sources, storage, retrieval, processing, and reporting flow

Documents/Forms Review

Aside from the briefings, I collected documents describing the management systems and tools in place and the forms that are used: the organizational structure, the planning calendar, description of their strategic planning and capital expenditure planning and control system, the manual for their annual budgetary system, the product standard data sheet, statements of expenses, profit and loss, and operating summary report forms. These documents and forms gave me a clear picture of the level of detail and flow of data collection, storage, retrieval, processing, and information reporting/portrayal. While the data and information flow may not yet be very integrated, they are very well-interfaced, so that TFPM data sources can readily be available.

Interviews

Most of the people who gave me briefings were staff analyst types. They develop and maintain the information systems, but are not the end-users of the systems. Hence, I decided to interview operating managers to know what concerns they had, what decisions and actions they were making, and the information they needed to support their decisions and actions to improve performance.

Workshop

After getting a general idea of the information and data available, I made a presentation on performance measurement systems, the additional information they can get from TFPM and how they could integrate TFPM with their existing systems. The audience consisted of people who gave me briefings during the first day, other possible members of the measurement systems development team (staff personnel from the operating divisions) they will be forming, and a Senior Management Consultant. Based on my presentation, I gathered feedback from the audience on their concerns about how TFPM can be used at Company C.

After the briefings, interviews, documents/forms review, and my presentation, I was convinced that Company C is ready for and could benefit from the development of a TFPM application because of the following reasons. The operating managers are looking for other measures to supplement their financial measures and their plant efficiency measures to help them pinpoint areas for continued improvement. The planning and control system is well in place and the accounting and information systems have all the necessary data to support a TFPM application. The only hurdle left is that the accountants still believe their reports should be able to provide the same information TFPM provides. They believe standard cost, volume, and price variance analysis yield the same information TFPM provides. They were, however, open to and awaiting my explanation regarding the difference in TFPM information and standard cost accounting variance analysis information which is an integral part of this case study.

Information Needs and Organizational Conditions

Based on the above data collection activities, I compiled the following information needs and organizational conditions:

1. The Chief Operating Officer wants to provide the operating managers with physical productivity measures related to financial measures and plant efficiency measures for the divisions, business units, and plants, so they can use these types of information in their operating meetings.

Both the "Profitability = Productivity + Price Recovery (PPPR)" and Gollop's models can provide this information need. Both models consider partial productivity measures which can relate to plant efficiency measures and relate all measures to profitability using price recovery. The Productivity Indices model such as Craig and Harris's version cancels out the effect of price recovery thereby focusing mainly on productivity and not relating it to profitability.

2. Division B's VP/General Manager wants to provide the lowest cost and highest quality products in the domestic market and prepare to get into the international market. He believes Company C has world-class machinery and he wants to make sure labor productivity is also world class. This is why they are experimenting with an incentive system that rewards in kind (families are involved with the choice of reward) performance

beyond agreed group standards. He is interested in measures that support these thrusts and which are integrated with the planning and control system already in place.

There are three information requirements here: (2.1) Division B wants to provide the lowest cost and highest quality products. Hence, they need to know how low their prices can go, and still be profitable. Of course, this information can be obtained through the usual accounting methods; however, the relationship Profitability = Productivity + Price Recovery will facilitate this "sensitivity analysis." In fact, two versions of TFPM (LTV's and REALST) can directly compute challenge budgets given targeted productivity, sales forecast, and price changes. (2.2) The second information need is concerned with measuring labor contribution to overall performance in relation to other resources such as capital (equipment and facilities). I have not come across any other way this could be done directly except through TFPM. (2.3) The third information requirement is the need to integrate information needs 2.1 and 2.2 above with the planning and control system. Both the PPPR and Gollop's models are designed to be integrated to a firm's budgeting and accounting systems. The data is from the accounting system and the information is directly related to the firm's profitability, costs and selling prices.

3. Division A's VP/General Manager wants to change the format of operations reviews from a performance variance explanation focus to a performance improvement focus. He wants to see how detailed plant efficiency measures add up to the overall performance of his division to distinguish what critical factors affect the operations significantly. He believes that they get so involved with looking at the numbers that they lose the meaning of the data. He wants to see measures that will point out ways to improve performance in the next period; and he needs such information within the first 10 days of the month.

This information need emphasizes the inadequacy of present accounting reports in portraying and pinpointing areas for improvement. Managers see data, not information. By showing contributions to productivity, price recovery, and profitability of each of the resources used, managers can pinpoint areas for improvement. The choice of the level of detail of reports and other portrayal formats will also enable managers to "distinguish the trees from the forest." The requirement that the information be available within 10 days of the month can be done depending on the design of data collection and processing.

4. Division D's VP/General Manager felt that the information he was receiving was sufficient for his decision-making needs but he was interested in finding out what additional information TFPM might provide.

This case study shows the information TFPM can provide based on the information needs identified by the other managers.

5. Division E's VP/General Manager said he had excess production capacity mainly to respond to the volatile market demand. He is interested, though, in better ways of forecasting and responding to fluctuations in the market.

While TFPM is not designed for forecasting, it can help pinpoint the relevant/significant factors that contribute to the company's past performance given the fluctuations in market demand. LTV's and REALST's challenge budget process can also help in planning how to respond to different market conditions.

6. The accounting and finance people at Company C would like to see what additional information TFPM can provide which they cannot get from traditional standard cost accounting variance analysis. This case will pinpoint this additional information and show how it relates to cost accounting information.

How TFPM Can Provide Company C Operating Managers' Information Needs

To show how TFPM can provide Company C operating managers' information needs, the following sample data from Company C's Plastics Department were used.

Table 6.1.1: Company C Plastics Department 1987 First Quarter Operating Results

PLASTICS DEPARTMENT
1987 FIRST QUARTER OPERATING RESULTS

A. OUTPUT	JANUARY		FEBRUARY		MARCH		1978
	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	UNIT PRICE
1. REGULAR MOLDS							
A	285,390	15.65	375,227	16.79	460,396	18.70	4.45
B	165,150	15.40	217,775	18.23	243,780	19.50	4.46
C	32,696	15.80	47,346	18.63	53,772	19.96	4.38
D	226,106	351.95	257,824	367.98	286,825	372.03	122.36
E	6,587	313.16	9,249	355.86	7,893	369.97	83.70
F	5,982	346.14	5,837	368.40	7,714	386.52	95.43
G	1,227	425.28	223	501.68	1,327	495.48	129.16
H	2,308	310.04	3,302	366.07	671	366.07	76.09
I	155	764.78	2,857	954.19	3,517	1,042.67	288.90
J	3,806	1,112.50	4,663	1,289.92	5,938	1,394.11	239.50
K	872	1,208.87	1,245	1,260.93	1,045	1,559.82	290.02
L	3,416	1,038.88	5,004	1,131.31	2,662	1,119.47	240.75
M	3,805	1,878.79	4,656	2,131.94	1,893	2,313.77	484.03
N	958	1,942.55	1,319	2,184.41	911	2,354.88	507.16
O	1,432	1,247.47	744	1,726.25	890	1,611.80	377.74
Others	156,103		273,549		155,070		
Sub-total	895,993		1,210,820		1,234,304		
2. SCRAP							
A	2,898	1.65	3,716	2.02	4,888	2.82	
B	3,934	11.00	2,647	13.06	4,688	13.10	
C	647	1.83	591	2.27	406	2.32	
D	2,730	19.25	1,760	38.89	0	-	
Others	2,404		1,228		2,668		
Sub-total	12,613		9,942		12,650		
3. OTHER INCOME		INDEX*		INDEX*		INDEX*	
Sub-total	24,570	4.44	28,215	5.06	25,352	5.40	
TOTAL OUTPUT	933,176		1,248,977		1,272,306		

*Price Index = Current Unit Price / 1978 Unit Price (Base Year/NEDA)

Table 6.1.2: Company C Plastics Department 1987 First Quarter Operating Results (cont'd)

B. LABOR INPUT

	JANUARY		FEBRUARY		MARCH	
	AMOUNT	INDEX*	AMOUNT	INDEX*	AMOUNT	INDEX*
1. DIRECT LABOR	20,287	5.23	28,454	6.39	36,685	7.64
2. INDIRECT LABOR	47,348	4.83	62,163	6.37	66,275	7.49
3. OTHER LABOR INPUT						
• Hospitalization	570	7.97	862	10.96	1,197	14.03
• Seminar Fees	140	4.44	339	5.06	254	5.40
• Rice Ration	1,433	2.83	2,364	3.46	2,315	3.98
Total	69,778		94,182		106,726	

C. MATERIAL INPUT

	JANUARY		FEBRUARY		MARCH		1978
	AMOUNT	UNIT COST	AMOUNT	UNIT COST	AMOUNT	UNIT COST	UNIT COST
1. DIRECT MATERIALS							
A	225,32[illegible]	20.18	324,796	25.70	347,819	28.55	7.12
B	21,146	20.97	21,160	22.05	21,954	24.12	5.71
C	126,073	41.94	125,631	49.47	147,710	53.85	6.21
D	39,018	59.25	43,206	60.99	39,045	66.24	13.45
E	15,845	0.78	18,156	0.74	36,374	0.79	0.11
F	2,875	84.97	2,937	86.77	2,684	88.40	32.00
G	19,190	67.98	16,134	65.48	28,973	69.41	11.31
H	48,112	111.13	57,211	110.19	60,842	114.03	15.81
I	1,715	343.89	2,425	355.87	2,457	347.98	64.32
Others	46,635		100,247		18,032		
Sub-total	545,937		711,903		705,890		
2. MANUFACTURING SUPPLIES							
Sub-total	14,563		19,562		18,292		
TOTAL	560,500		731,465		72[illegible],182		

*Cost Index = Current Unit Cost / 1978 Unit Cost

Table 6.1.3: Company C Plastics Department 1987 First Quarter Operating Results (cont'd)

	JANUARY			FEBRUARY			MARCH		
D. CAPITAL INPUT*	VALUE	INDEX	COST OF MONEY	VALUE	INDEX	COST OF MONEY	VALUE	INDEX	COST OF MONEY
1. FIXED ASSET	38,410	1.00	14.32%	35,327	1.00	14.32%	36,586	1.00	22.20%
2. LIQUID ASSET									
o Invty & Receivables	273,130	4.44		427,049	5.06		409,770	5.40	
o Cash & Deferred Charges	97,888	4.44		85,875	5.06		2,664	5.40	
Total	371,018		14.32%	513 924		14.32%	412,434		22.20%
3. OTHER CAPITAL INPUT									
o Depreciation	9,065	4.44		10,235	5.06		11,762	5.40	
o Repairs & Maintenance	12,426	4.44		18,430	5.06		25,655	5.40	
o Rentals	285	4.44		511	5.06		1,739	5.40	
Total	21,776			29,176			39,156		
E. ENERGY INPUT									
1. Fuel	6,883	3.46		6,419	3.39		5,760	2.98	
2. Power & Electricity	9,636	6.50		9,271	5.34		8,783	4:66	
F. OTHERS INPUT									
1. Other Supplies	5,718	4.44		6,998	5.06		8,338	5.40	
2. Other Expenses	42,85[illegible]	4.44		58,791	5.06		55,550	5.40	

* Value X Index = Deflated Value(1978);
Deflated Value(1978) X Cost of Money = Asset Input (Craig [illegible] Harris Model)

REALST Summary Reports Portray Overall Performance

From the information requirements, my proposition is that among the available versions of TFPM, REALST can provide most if not all of the users' information needs. Hence, I'll start with a REALST application and then evaluate if there are inadequacies from this application that may need to be addressed using other models or versions.

Given the three-month sample data, January is used as the reference or base period; February and March data are used for two review periods. Unit prices are used whenever available; otherwise the applicable price index is used. Following are the results of the REALST application. I present the results from summaries to details depending on what details need further scrutiny.

Tables 6.2.1 and 6.2.2 are the Management Reports explaining changes in profits from major input categories. Both tables show an increase in profitability in February and March against January, mainly due to continued improvement in productivity (7.68% in February and 13.12% in March), large enough to offset the negative change in price recovery ($54,549.60 in February and $127,953.60 in March). However, March profit variance decreased ($9,531.30 against $23,377.20 in February).

Table 6.2.1: Management Report on Profit Changes from January to February

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Management Report
CENTRE - 1
January vs. February

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF: %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	933176.0	1248977.0						
- Labor	69778.0	94182.0	790.1-	15.36	14467.5	13562.3	905.1	15257.5-
- Materials/Suppls	560500.0	731465.0	18716.8	7.98	58394.7	0.0	58394.7	39677.9-
- Energy	16519.0	15690.0	6419.3	12.89	2022.4	0.0	2022.4	4396.9
- Other Inputs	48576.0	65789.0	774.1-	1.67	1096.1	11526.0	10429.9-	1870.2-
- Capital Expenses	21776.0	29176.0	30.7-	2.77	807.7	5166.9	4359.2-	838.4-
GRAND TOTAL - Resources	717149.0	936302.0	23541.2	8.20	76788.4	30255.3	46533.1	53247.2-
GRAND TOTAL - Assets	58630.1	78635.4	164.0-	1.45	1138.4	1145.2	6.7-	1302.4-
AGGREGATE	775779.1	1014937.4	23377.2	7.68	77926.8	31400.4	46526.4	54549.6-

Table 6.2.2: Management Report on Profit Changes from January to March

05-27-1990 17:31:56 — Plastics Dept. Management Report CENTRE - 1 January vs. March — PROFIT Page# 1

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	%	EFFECT OF: PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D / D	= E	+ / + F	G
TOTAL PRODUCTS	933176.0	1272306.0						
- Labor	69778.0	106726.0	11589.6-	15.03	16041.5	11911.8	4129.7	27631.2-
- Materials/Suppls	560500.0	724182.0	40012.0	13.73	99411.0	0.0	99411.0	59399.0-
- Energy	16519.0	14543.0	7979.2	1.99	289.2	0.0	289.2	7690.0
- Other Inputs	48576.0	63888.0	2341.2	6.85	4376.6	9185.6	4809.1-	2035.3-
- Capital Expenses	21776.0	39156.0	9466.3-	21.85-	8553.9-	4117.8	12671.7-	912.4-
GRAND TOTAL - Resources	717149.0	948495.0	29276.6	11.76	111564.4	25215.2	86349.2	82287.8-
GRAND TOTAL - Assets	58630.1	99682.4	19745.3-	26.00	25920.5	1325.8	24594.7	45665.8-
AGGREGATE	775779.1	1048177.4	9531.3	13.12	137484.9	26541.0	110943.9	127953.6-

These results place Company C's Plastics Department in the "Pursue" direction of REALST's Strategic Grids (see Figure 6.3), i.e., competitiveness is maintained or improved by not passing on the increases in costs of inputs to the customers; cost increases are absorbed by the firm through improved productivity. This strategic thrust also helps prevent inflation.

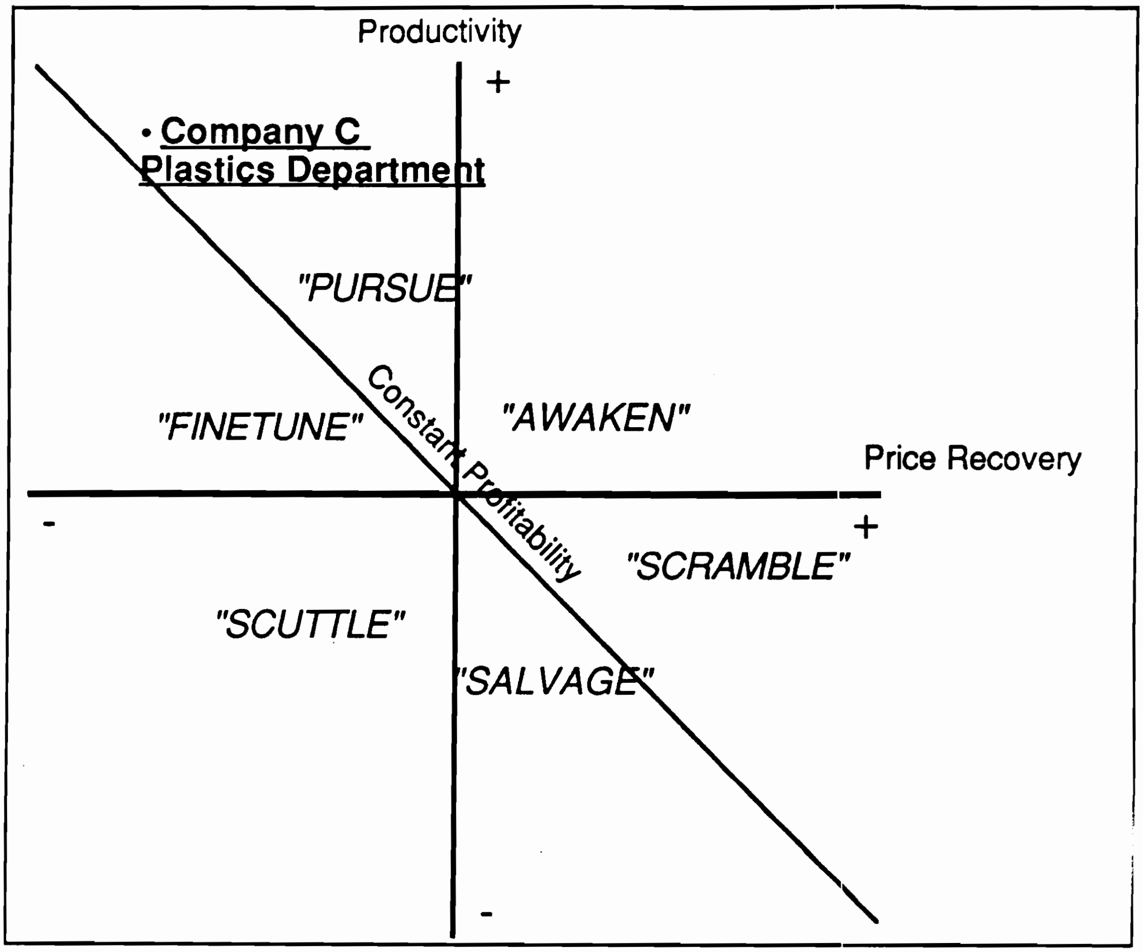

Figure 6.3: Company C Plastics Department Strategic Grid

The Strategic Grid shows the overall direction the firm needs to take; for Company C's Plastics Department, they should pursue or continue their current strategic thrust - continue to improve operations. Tables 6.2.1 and 6.2.2 show that the best contributor to the productivity increase is labor (15.36% in February and 15.03% in March). However, it is necessary to closely watch labor price recovery as it is continuing to increase (-$15,257.50 in February and -$27,631.20 in March) while labor productivity seems to have plateaued. Materials and supplies, the biggest cost driver and, therefore the biggest source of potential savings, show increasing trends in productivity (7.98% in February and 13.73% in March) although price recovery is worsening (-$39,677.90 in February and -$59,399.00 in March) This situation implies that Company C's Plastics Department needs to further increase materials and supplies productivity, influence suppliers to lower their prices, and/or increase their selling price.

The information presented in the preceding paragraphs, tables and figures are examples of information REALST provides. These address the information needs identified earlier: (1) Physical productivity measures related to plant efficiencies and financial measures; (2.1) The increase in profitability due to the increase in productivity despite the decrease in price recovery, implies selling prices can still be lowered, if necessary. Further decreases in selling price can be evaluated using REALST's budgeting method to be discussed later; (2.2) The two tables clearly show the contribution of labor to overall performance; (3) REALST indicates possible causes of variance and points out areas for improvement. More details can be obtained from other reports, depending on the need, as will be discussed later; (5) REALST shows how the firm has responded in the past to changes in market demand. It can also evaluate different plans for responding to market demand using the budgeting method to be discussed later.

REALST Detailed Reports Help Analyze Variances and Point Out Areas for Improvement

Since the trend of labor productivity is plateauing, while labor price recovery continues to worsen, there is a need to look more closely into labor performance. Materials and supplies also deserve further scrutiny as price recovery is worsening while productivity continues to improve. Capital assets also need to be analyzed; while productivity improved (1.45% or $1,138.40 in February and 26% or $25,920.50 in March), price recovery decreased by -$1,302.4 in February and -$45,665.8 in March. These are the more significant factors (see Figure 6.4) to consider based on Tables B.2.1 and B.2.2.

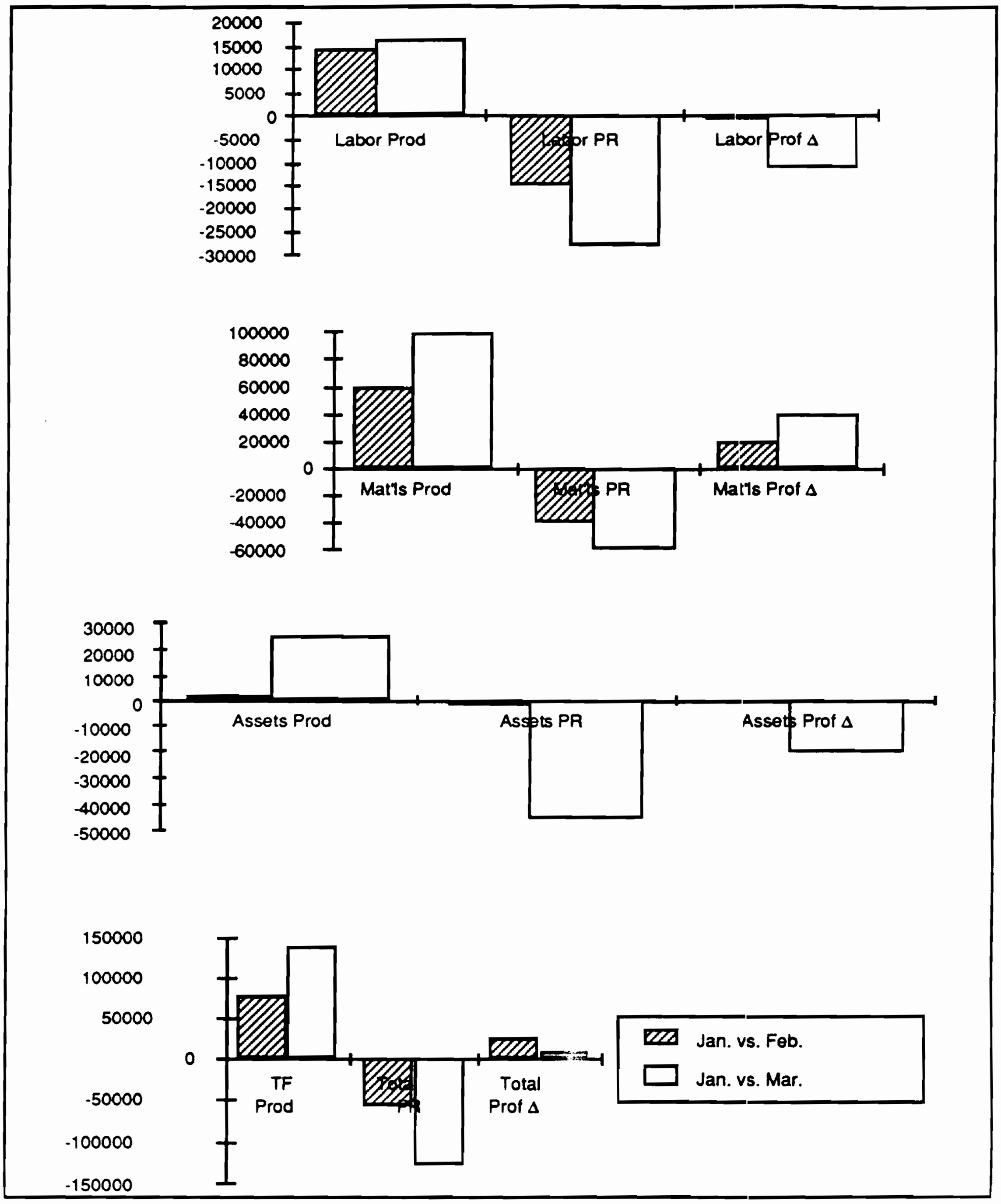

Figure 6.4: Dollar Effects of Changes in Labor, Materials, Assets, and Total-Factor Productivity, Price Recovery and Profitability

Tables 6.3.1, 6.3.2, 6.3.3, 6.3.4, 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5, and 6.4.6 show the necessary details needed to further analyze the more significant causes of the changes and the possible improvement opportunities. Tables 6.3.1 and 6.3.3 show that while indirect labor productivity has improved (21.37% or $13,282.60 in February and 28.01% or $18,564.70 in March), this is offset by the decrease in price recovery (-$12,074.30 in February and -$20,284.70 in March). Comparing these numbers with the labor totals shows an improvement in productivity (15.36% or $14,467.50 in February and 15.03% or $16,041.50 in March) but a decrease in price recovery (-$15,257.50 in February and -$27,631.20 in March).This indicates indirect labor clearly accounts for most of the changes in labor performance. Tables 6.4.1 and 6.4.4: Raw Data Reports for February and March, show that weighted average (or total) of product quantities increased by 20.82% in February and 15.55% in March; and prices increased by 10.78% in February and 18% in March. Indirect labor, on the other hand, decreased in quantity but increased significantly in cost (-.45% in February and -9.74% in March for quantities; and 31.88% in February and 55.07% in March for prices). Hence, the big increases in indirect labor costs caused the labor price recovery problem.

Tables 6.3.1 and 6.3.2 also show that the materials price recovery problem is mainly caused by Direct Material A. The dollar effect of total materials and supplies price recovery was -$39,677.90 in February and -$59,399 in March mainly caused by Direct Material A's price recovery dollar effect of -$45,128.30 in February and -$61,136.30 in March. Tables 6.4.2 and 6.4.5 show that Direct Material A's price recovery increase is mainly due to its cost increases of 27.35% in February and 41.48% against product price increases of only 10.78% in February and 18% in March, as pointed out earlier. Hence, there is a need to pay close attention to Direct Material A's cost such as directly confronting the problem by looking for alternative sources, suppliers, or even substitutes; continuously improving productivity (which is presently low in relation to the other direct materials); to prevent the last recourse action of eventually increasing selling prices.

Regarding capital assets, Tables 6.3.2 and 6.3.4 show that the main problem is Inventory and Receivables. Both productivity and price recovery decreased (-11.94% or -$7,299.20 in February and -6.33% or -$5,757.90 in March for productivity and -$1,505.90 in February and -$31,884.90 in March for price recovery). This problem is mainly caused by the increase in Inventory and Receivables from $273,130 in January to $427,049 in February and $409,770 in March (see Tables 6.4.3 and 6.4.6).

From the REALST summary, users can determine what level of detail and which particular report is needed to further analyze what causes the critical changes and pinpoint improvement opportunities.

Table 6.3.1: Profit Detailed Analysis

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Detailed Analysis
CENTRE - 1
January vs. February

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF: %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	E
					D	= E	+ F	
TOTAL PRODUCTS	933176.0	1248977.0						
LABOR								
Direct Labor	20287.0	28454.0	1301.6-	5.25	1493.3	0.0	1493.3	2794.8-
Indirect Labor	47348.0	62163.0	1208.3	21.37	13282.6	13001.2	281.5	12074.7-
SUB-TOTAL - Labor	67635.0	90617.0	93.3-	16.31	14775.9	13001.2	1774.7	14869.2-
OTHER LABOR COSTS								
Hospitalization	570.0	862.0	99.1-	9.87	85.0	163.2	78.2-	184.1-
Seminar Fees	140.0	339.0	151.6-	43.14-	146.2-	33.2	179.5-	5.4-
Rice Ration	1433.0	2364.0	446.1-	10.46-	247.2-	364.8	612.0-	198.8-
SUB-TOTAL - Other Costs	2143.0	3565.0	696.8-	8.65-	308.4-	561.2	869.6-	388.4-
TOTAL - Labor	69778.0	94182.0	790.1-	15.36	14467.5	13562.3	905.1	15257.5-
Direct Materials								
A	225328.0	324796.0	23213.6-	6.75	21914.7	0.0	21914.7	45128.3-
B	21146.0	21160.0	7142.1	26.96	5704.5	0.0	5704.5	1437.6
C	126073.0	125631.0	43107.0	43.01	54039.0	0.0	54039.0	10932.0-
D	39018.0	43206.0	9016.3	12.31	5320.1	0.0	5320.1	3696.2
E	15845.0	18156.0	3051.2	0.03	6.2	0.0	6.2	3044.9
F	2875.0	2937.0	910.9	20.78	610.2	0.0	610.2	300.8
G	19190.0	16134.0	9550.2	38.42	6198.8	0.0	6198.8	3351.4
H	48112.0	57211.0	7182.8	0.75	426.4	0.0	426.4	6756.4
I	1715.0	2425.0	129.6-	11.58-	280.7-	0.0	280.7-	151.1
Others	46635.0	100247.0	37830.0-	35.95-	36034.5-	0.0	36034.5-	1795.5-
SUB-TOTAL - Materials	545937.0	711903.0	18787.4	8.13	57904.7	0.0	57904.7	39117.2-
Manufacturing Supplies	14563.0	19562.0	70.7-	2.51	490.0	0.0	490.0	560.7-
SUB-TOTAL - Mfg. Suplies	14563.0	19562.0	70.7-	2.51	490.0	0.0	490.0	560.7-
TOTAL - Materials/Suppls	560500.0	731465.0	18716.8	7.98	58394.7	0.0	58394.7	39677.9-
ENERGY								
Fuel	6883.0	6419.0	2793.3	26.93	1728.8	0.0	1728.8	1064.5
Power	9636.0	9271.0	3626.0	3.17	293.6	0.0	293.6	3332.4

Table 6.3.2: Profit Detailed Analysis (cont'd)

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Detailed Analysis

CENTRE - 1

January vs. February

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D D	= E	+ + F	G
TOTAL - Energy	16519.0	15690.0	6419.3	12.89	2022.4	0.0	2022.4	4396.9
OTHER INPUTS								
Supplies	5718.0	6998.0	655.1	12.51	875.2	1356.7	481.5-	220.2-
Expenses	42858.0	58791.0	1429.2-	0.38	220.9	10169.2	9948.3-	1650.1-
TOTAL - Other Inputs	48576.0	65789.0	774.1-	1.67	1096.1	11526.0	10429.9-	1870.2-
CAPITAL EXPENSES								
Depreciation	9065.0	10235.0	1897.7	21.95	2246.7	2150.9	95.8	349.0-
Repairs and Maintenance	12426.0	18430.0	1798.9-	7.16-	1320.4-	2948.4	4268.8-	478.4-
Rentals	285.0	511.0	129.6-	23.21-	118.6-	67.6	186.2-	11.0-
TOTAL - Capital Expenses	21776.0	29176.0	30.7-	2.77	807.7	5166.9	4359.2-	838.4-
GRAND TOTAL - Resources	717149.0	936302.0	23541.2	8.20	76788.4	30255.3	46533.1	53247.2-
Fixed Assets	5500.3	5058.8	2302.9	31.36	1586.7	1145.2	441.5	716.2
Liquid Assets								
Inventory and Receivables	39112.2	61153.4	8805.0-	11.94-	7299.2-	0.0	7299.2-	1505.9-
Cash and Deferred Charges	14017.6	12423.1	6338.2	55.15	6850.9	0.0	6850.9	512.7-
GRAND TOTAL - Assets	58630.1	78635.4	164.0-	1.45	1138.4	1145.2	6.7-	1302.4-
AGGREGATE	775779.1	1014937.4	23377.2	7.68	77926.8	31400.4	46526.4	54549.6-

Table 6.3.3: Profit Detailed Analysis (cont'd)

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Detailed Analysis

CENTRE - 1

January vs. March

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	933176.0	1272306.0						
LABOR								
Direct Labor	20287.0	36685.0	9025.4-	6.66-	2442.0-	0.0	2442.0-	6583.4-
Indirect Labor	47348.0	66275.0	1720.0-	28.01	18564.7	11416.0	7148.7	20284.7-
SUB-TOTAL - Labor	67635.0	102960.0	10745.4-	15.66	16122.7	11416.0	4706.7	26868.2-
OTHER LABOR COSTS								
Hospitalization	570.0	1197.0	419.9-	3.14-	37.6-	156.0	193.6-	382.3-
Seminar Fees	140.0	254.0	63.1-	22.54-	57.3-	26.5	83.7-	5.9-
Rice Ration	1433.0	2315.0	361.2-	0.59	13.7	313.3	299.7-	374.9-
SUB-TOTAL - Other Costs	2143.0	3766.0	844.2-	2.16-	81.2-	495.8	577.0-	763.0-
TOTAL - Labor	69778.0	106726.0	11589.6-	15.03	16041.5	11911.8	4129.7	27631.2-
Direct Materials								
A	225328.0	347819.0	40603.5-	5.90	20532.8	0.0	20532.8	61136.3-
B	21146.0	21954.0	6876.8	28.01	6150.1	0.0	6150.1	726.7
C	126073.0	147710.0	24179.8	26.63	39333.3	0.0	39333.3	15153.5-
D	39018.0	39045.0	14152.7	29.09	11358.4	0.0	11358.4	2794.3
E	15845.0	36374.0	14770.7-	49.02-	17830.7-	0.0	17830.7-	3060.0
F	2875.0	2684.0	1235.8	28.77	772.1	0.0	772.1	463.7
G	19190.0	28973.0	2809.1-	21.86-	6332.9-	0.0	6332.9-	3523.8
H	48112.0	60842.0	4754.6	6.24-	3798.8-	0.0	3798.8-	8553.4
I	1715.0	2457.0	118.7-	18.39-	451.8-	0.0	451.8-	333.0
Others	46635.0	18032.0	45550.9	263.45	47504.8	0.0	47504.8	1954.0-
SUB-TOTAL - Materials	545937.0	705890.0	38448.6	13.78	97237.4	0.0	97237.4	58788.8-
Manufacturing Supplies	14563.0	18292.0	1563.4	11.88	2173.6	0.0	2173.6	610.2-
SUB-TOTAL - Mfg. Suplies	14563.0	18292.0	1563.4	11.88	2173.6	0.0	2173.6	610.2-
TOTAL - Materials/Suppls	560500.0	724182.0	40012.0	13.73	99411.0	0.0	99411.0	59399.0-
ENERGY								
Fuel	6883.0	5760.0	3624.4	18.92	1089.8	0.0	1089.8	2534.5
Power	9636.0	8783.0	4354.9	9.12-	800.6-	0.0	800.6-	5155.5

Table 6.3.4: Profit Detailed Analysis (cont'd)

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Detailed Analysis

CENTRE - 1

January vs. March

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D	= E	+ F	+ G
TOTAL - Energy	16519.0	14543.0	7979.2	1.99	289.2	0.0	289.2	7690.0
OTHER INPUTS								
Supplies	5718.0	8338.0	542.0-	3.63-	302.4-	1081.3	1383.7-	239.6-
Expenses	42858.0	55550.0	2883.2	8.42	4679.0	8104.4	3425.4-	1795.7-
TOTAL - Other Inputs	48576.0	63888.0	2341.2	6.85	4376.6	9185.6	4809.1-	2035.3-
CAPITAL EXPENSES								
Depreciation	9065.0	11762.0	597.4	8.31	977.2	1714.2	737.0-	379.8-
Repairs and Maintenance	12426.0	25655.0	8713.2-	31.93-	8192.6-	2349.7	10542.3-	520.6-
Rentals	285.0	1739.0	1350.4-	76.97-	1338.5-	53.9	1392.4-	11.9-
TOTAL - Capital Expenses	21776.0	39156.0	9466.3-	21.85-	8553.9-	4117.8	12671.7-	912.4-
GRAND TOTAL - Resources	717149.0	948495.0	29276.6	11.76	111564.4	25215.2	86349.2	82287.8-
Fixed Assets	5500.3	8122.1	622.9-	21.31	1730.7	1325.8	404.9	2353.6-
Liquid Assets								
Inventory and Receivables	39112.2	90968.9	37642.8-	6.33-	5757.9-	0.0	5757.9-	31884.9-
Cash and Deferred Charges	14017.6	591.4	18520.3	5063.79	29947.7	0.0	29947.7	11427.3-
GRAND TOTAL - Assets	58630.1	99682.4	19745.3-	26.00	25920.5	1325.8	24594.7	45665.8-
AGGREGATE	775779.1	1048177.4	9531.3	13.12	137484.9	26541.0	110943.9	127953.6-

Table 6.4.1: Raw Data Report

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CENTRE - 1

January vs. February

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
REGULAR MOLDS										
A		285390.0	18235.8	15.65	375227.0	22348.2	16.79	0.31479	0.22552	0.07284
B		165150.0	10724.0	15.40	217775.0	11946.0	18.23	0.31865	0.11394	0.18377
C		32696.0	2069.4	15.80	47346.0	2541.4	18.63	0.44807	0.22810	0.17911
D		226106.0	642.4	351.95	257824.0	700.6	367.98	0.14028	0.09061	0.04555
E		6587.0	21.0	313.16	9249.0	26.0	355.86	0.40413	0.23565	0.13635
F		5982.0	17.3	346.14	5837.0	15.8	368.40	0.02424-	0.08320-	0.06431
G		1227.0	2.9	425.28	223.0	0.4	501.68	0.81826-	0.84593-	0.17965
H		2308.0	7.4	310.04	3302.0	9.0	366.07	0.43068	0.21170	0.18072
I		155.0	0.2	764.78	2857.0	3.0	954.19	17.43226	13.77339	0.24767
J		3806.0	3.4	1112.50	4663.0	3.6	1289.92	0.22517	0.05666	0.15948
K		872.0	0.7	1208.87	1245.0	1.0	1260.93	0.42775	0.36880	0.04307
L		3416.0	3.3	1038.88	5004.0	4.4	1131.31	0.46487	0.34519	0.08897
M		3805.0	2.0	1878.79	4656.0	2.2	2131.94	0.22365	0.07835	0.13474
N		958.0	0.5	1942.55	1319.0	0.6	2184.41	0.37683	0.22438	0.12451
O		1432.0	1.1	1247.47	744.0	0.4	1726.25	0.48045-	0.62455-	0.38380
Others		156103.0	35158.3	4.44	273549.0	54061.1	5.06	0.75236	0.53765	0.13964
Total		895993.0			1210820.0			0.35137	0.22213	0.10575
SCRAP										
A		2898.0	1756.4	1.65	3716.0	1839.6	2.02	0.28226	0.04739	0.22424
B		3934.0	357.6	11.00	2647.0	202.7	13.06	0.32715-	0.43328-	0.18727
C		647.0	353.6	1.83	591.0	260.4	2.27	0.08655-	0.26361-	0.24044
D		2730.0	141.8	19.25	1760.0	45.3	38.89	0.35531-	0.68089-	1.02026
Others		2404.0	541.4	4.44	1228.0	242.7	5.06	0.48918-	0.55177-	0.13964
Total		12613.0			9942.0			0.21177-	0.39031-	0.29285
OTHER INCOME		24570.0	5533.8	4.44	28215.0	5576.1	5.06	0.14835	0.00764	0.13964
Total		24570.0			28215.0			0.14835	0.00764	0.13964
Grand Total		933176.0			1248977.0			0.33842	0.20820	0.10777
LABOR										
Direct Labor	1.00	20287.0	3879.0	5.23	28454.0	4452.9	6.39	0.40257	0.14796	0.22180
Indirect Labor	0.00	47348.0	9802.9	4.83	62163.0	9758.7	6.37	0.31290	0.00451-	0.31884
Sub-total		67635.0			90617.0			0.33979	0.03882	0.28973
Other Labor Costs										
Hospitalization	0.00	570.0	71.5	7.97	862.0	78.6	10.96	0.51228	0.09972	0.37516
Seminar Fees	0.00	140.0	31.5	4.44	339.0	67.0	5.06	1.42143	1.12473	0.13964

<u>Table 6.4.2: Raw Data Report (cont'd)</u>

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CENTRE - 1

January vs. February

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Rice Ration	0.00	1433.0	506.4	2.83	2364.0	683.2	3.46	0.64969	0.34931	0.22261
Sub-total		2143.0			3565.0			0.66356	0.32263	0.25777
Total		69778.0			94182.0			0.34974	0.04732	0.28875
Direct Materials										
A	1.00	225328.0	11165.9	20.18	324796.0	12638.0	25.70	0.44144	0.13184	0.27354
B	1.00	21146.0	1008.4	20.97	21160.0	959.6	22.05	0.00066	0.04835-	0.05150
C	1.00	126073.0	3006.0	41.94	125631.0	2539.5	49.47	0.00351-	0.15519-	0.17954
D	1.00	39018.0	658.5	59.25	43206.0	708.4	60.99	0.10734	0.07574	0.02937
E	1.00	15845.0	20314.1	0.78	18156.0	24535.1	0.74	0.14585	0.20779	0.05128-
F	1.00	2875.0	33.8	84.97	2937.0	33.8	86.77	0.02157	0.00037	0.02118
G	1.00	19190.0	282.3	67.98	16134.0	246.4	65.48	0.15925-	0.12715-	0.03678-
H	1.00	48112.0	432.9	111.13	57211.0	519.2	110.19	0.18912	0.19927	0.00846-
I	1.00	1715.0	5.0	343.89	2425.0	6.8	355.87	0.41399	0.36639	0.03484
Others	1.00	46635.0	10503.4	4.44	100247.0	19811.7	5.06	1.14961	0.88622	0.13964
Sub-total		545937.0			711903.0			0.30400	0.11732	0.16708
Manufacturing Supplies	1.00	14563.0	3280.0	4.44	19562.0	3866.0	5.06	0.34327	0.17868	0.13964
Sub-total		14563.0			19562.0			0.34327	0.17868	0.13964
Total		560500.0			731465.0			0.30502	0.11888	0.16636
Energy										
Fuel	1.00	6883.0	1989.3	3.46	6419.0	1893.5	3.39	0.06741-	0.04816-	0.02023-
Power	1.00	9636.0	1482.5	6.50	9271.0	1736.1	5.34	0.03788-	0.17112	0.17846-
Total		16519.0			15690.0			0.05018-	0.07025	0.11253-
Other Inputs										
Supplies	0.00	5718.0	1287.8	4.44	6998.0	1383.0	5.06	0.22385	0.07390	0.13964
Expenses	0.00	42858.0	9652.7	4.44	58791.0	11618.8	5.06	0.37176	0.20368	0.13964
TOTAL		48576.0			65789.0			0.35435	0.18840	0.13964
Capital Expenses										
Depreciation	0.00	9065.0	2041.7	4.44	10235.0	2022.7	5.06	0.12907	0.00928-	0.13964
Repairs and Maintenance	0.00	12426.0	2798.6	4.44	18430.0	3642.3	5.06	0.48318	0.30145	0.13964
Rentals	0.00	285.0	64.2	4.44	511.0	101.0	5.06	0.79298	0.57329	0.13964
Total		21776.0			29176.0			0.33982	0.17566	0.13964

Table 6.4.3: Raw Data Report (cont'd)

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CENTRE - 1

January vs. February

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Grand Total		717149.0			936302.0			0.30559	0.11663	0.16923
Fixed Assets	0.00	5500.3	38410.0	0.14	5058.8	35327.0	0.14	0.08027-	0.08027-	0.00000
Liquid Assets										
Inventory and Receivables	1.00	39112.2	61515.8	0.64	61153.4	84397.0	0.72	0.56354	0.37196	0.13964
Cash and Deferred Charges	1.00	14017.6	22046.8	0.64	12423.1	17169.0	0.72	0.11375-	0.22125-	0.13805
Grand Total		58630.1			78635.4			0.34121	0.19096	0.12616
AGGREGATE		775779.1			1014937.4			0.30828	0.12205	0.16597
Fixed Assets	0.00	38410.0	38410.0	1.00	35327.0	35327.0	1.00	0.08027-	0.08027-	0.00000
Liquid Assets										
Inventory and Receivables	1.00	273130.0	61515.8	4.44	427049.0	84397.0	5.06	0.56354	0.37196	0.13964
Cash and Deferred Charges	1.00	97888.0	22046.8	4.44	86875.0	17169.0	5.06	0.11251-	0.22125-	0.13964
Grand Total		409428.0			549251.0			0.34151	0.19082	0.12654
TOTAL ASSETS		409428.0			549251.0					
RATE of RETURN (%)		52.76			56.93					

Table 6.4.4: Raw Data Report (cont'd)

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CENTRE - 1

January vs. March

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD VALUE	REFERENCE PERIOD QUANTITY	REFERENCE PERIOD PRICE	REVIEW PERIOD VALUE	REVIEW PERIOD QUANTITY	REVIEW PERIOD PRICE	CHANGE in RATIO VALUE	CHANGE in RATIO QUANTITY	CHANGE in RATIO PRICE
REGULAR MOLDS										
A		285390.0	16235.8	15.65	460396.0	24620.1	18.70	0.61322	0.35010	0.19489
B		165150.0	10724.0	15.40	243780.0	12501.5	19.50	0.47611	0.16575	0.26623
C		32696.0	2069.4	15.80	53772.0	2694.0	19.96	0.64460	0.30184	0.26329
D		226106.0	642.4	351.95	286825.0	771.0	372.03	0.26854	0.20007	0.05705
E		6587.0	21.0	313.16	7993.0	21.3	369.97	0.19827	0.01427	0.18141
F		5982.0	17.3	346.14	7714.0	20.0	386.52	0.28954	0.15482	0.11662
G		1227.0	2.9	425.28	1327.0	2.7	495.48	0.08150	0.07173-	0.16507
H		2308.0	7.4	310.04	671.0	1.8	366.07	0.70927-	0.75377-	0.18072
I		155.0	0.2	764.78	3517.0	3.4	1042.67	21.69032	15.64295	0.36336
J		3806.0	3.4	1112.50	5938.0	4.3	1394.11	0.56017	0.24501	0.25313
K		872.0	0.7	1208.87	1045.0	0.7	1559.82	0.19839	0.07124-	0.29031
L		3416.0	3.3	1038.88	2662.0	2.4	1119.47	0.22073-	0.27683-	0.07757
M		3805.0	2.0	1878.79	1893.0	0.8	2313.77	0.50250-	0.59603-	0.23152
N		958.0	0.5	1942.55	911.0	0.4	2354.88	0.04906-	0.21557-	0.21226
O		1432.0	1.1	1247.47	890.0	0.6	1611.80	0.37849-	0.51898-	0.29206
Others		156103.0	35158.3	4.44	155070.0	28716.7	5.40	0.00662-	0.18322-	0.21622
Total		895993.0			1234304.0			0.37758	0.16978	0.17765
SCRAP										
A		2898.0	1756.4	1.65	4888.0	1733.3	2.82	0.68668	0.01311-	0.70909
B		3934.0	357.6	11.00	4688.0	357.9	13.10	0.19166	0.00063	0.19091
C		647.0	353.6	1.83	406.0	175.0	2.32	0.37249-	0.50502-	0.26776
D		2730.0	141.8	19.25	0.0	0.0	5.40	1.00000-	1.00000-	0.71948-
Others		2404.0	541.4	4.44	2668.0	494.1	5.40	0.10982	0.08748-	0.21622
Total		12613.0			12650.0			0.00293	0.26184-	0.35869
OTHER INCOME		24570.0	5533.8	4.44	25352.0	4694.8	5.40	0.03183	0.15161-	0.21622
Total		24570.0			25352.0			0.03183	0.15161-	0.21622
Grand Total		933176.0			1272306.0			0.36341	0.15548	0.17995
LABOR										
Direct Labor	1.00	20287.0	3879.0	5.23	36685.0	4801.7	7.64	0.80830	0.23788	0.46080
Indirect Labor	0.00	47348.0	9802.9	4.83	66275.0	8848.5	7.49	0.39974	0.09736-	0.55072
Sub-total		67635.0			102960.0			0.52229	0.00096-	0.52375
Other Labor Costs										
Hospitalization	0.00	570.0	71.5	7.97	1197.0	85.3	14.03	1.10000	0.19294	0.76035
Seminar Fees	0.00	140.0	31.5	4.44	254.0	47.0	5.40	0.81429	0.49175	0.21622

Table 6.4.5: Raw Data Report (cont'd)

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CENTRE - 1

January vs. March

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Rice Ration	0.00	1433.0	506.4	2.83	2315.0	581.7	3.98	0.61549	0.14876	0.40626
Sub-total		2143.0			3766.0			0.75735	0.18094	0.48809
Total		69778.0			106726.0			0.52951	0.00450	0.52266
Direct Materials										
A	1.00	225328.0	11165.9	20.18	347819.0	12182.8	28.55	0.54361	0.09107	0.41477
B	1.00	21146.0	1008.4	20.97	21954.0	910.2	24.12	0.03821	0.09738-	0.15021
C	1.00	126073.0	3006.0	41.94	147710.0	2743.0	53.85	0.17162	0.08750-	0.28399
D	1.00	39018.0	658.5	59.25	39045.0	589.4	66.24	0.00069	0.10491-	0.11797
E	1.00	15845.0	20314.1	0.78	36374.0	46043.0	0.79	1.29561	1.26656	0.01282
F	1.00	2875.0	33.8	84.97	2684.0	30.4	88.40	0.06643-	0.10266-	0.04037
G	1.00	19190.0	282.3	67.98	28973.0	417.4	69.41	0.50980	0.47869	0.02104
H	1.00	48112.0	432.9	111.13	60842.0	533.6	114.03	0.26459	0.23243	0.02610
I	1.00	1715.0	5.0	343.89	2457.0	7.1	347.98	0.43265	0.41581	0.01189
Others	1.00	46635.0	10503.4	4.44	18032.0	3339.3	5.40	0.61334-	0.68208-	0.21622
Sub-total		545937.0			705890.0			0.29299	0.01558	0.27315
Manufacturing Supplies	1.00	14563.0	3280.0	4.44	18292.0	3387.4	5.40	0.25606	0.03276	0.21622
Sub-total		14563.0			18292.0			0.25606	0.03276	0.21622
Total		560500.0			724182.0			0.29203	0.01601	0.27167
Energy										
Fuel	1.00	6883.0	1989.3	3.46	5760.0	1932.9	2.98	0.16316-	0.02836-	0.13873-
Power	1.00	9636.0	1482.5	6.50	8783.0	1884.8	4.66	0.08852-	0.27137	0.28308-
Total		16519.0			14543.0			0.11962-	0.13295	0.22293-
Other Inputs										
Supplies	0.00	5718.0	1287.8	4.44	8338.0	1544.1	5.40	0.45820	0.19897	0.21622
Expenses	0.00	42858.0	9652.7	4.44	55550.0	10287.0	5.40	0.29614	0.06572	0.21622
TOTAL		48576.0			63888.0			0.31522	0.08140	0.21622
Capital Expenses										
Depreciation	0.00	9065.0	2041.7	4.44	11762.0	2178.1	5.40	0.29752	0.06685	0.21622
Repairs and Maintenance	0.00	12426.0	2798.6	4.44	25655.0	4750.9	5.40	1.06462	0.69758	0.21622
Rentals	0.00	285.0	64.2	4.44	1739.0	322.0	5.40	5.10175	4.01700	0.21622
Total		21776.0			39156.0			0.79813	0.47846	0.21622

Table 6.4.6: Raw Data Report (cont'd)

5-1990 15:26:40 Plastics Dept. INPUT Page# 3

CENTRE - 1

January vs. March

VALUES are in DOLLARS

DESCRIPTION	REVA	REFERENCE PERIOD			REVIEW PERIOD			CHANGE in RATIO		
		VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE	VALUE	QUANTITY	PRICE
Grand Total		717149.0			948495.0			0.32259	0.03387	0.27926
Fixed Assets	0.00	5500.3	38410.0	0.14	8122.1	36586.0	0.22	0.47666	0.04749-	0.55028
Liquid Assets										
Inventory and Receivables	1.00	39112.2	61515.8	0.64	90968.9	75883.3	1.20	1.32584	0.23356	0.88547
Cash and Deferred Charges	1.00	14017.6	22046.8	0.64	591.4	493.3	1.20	0.95781-	0.97762-	0.88547
Grand Total		58630.1			99682.4			0.70019	0.08297-	0.85403
AGGREGATE		775779.1			1048177.4			0.35113	0.02150	0.32270
Fixed Assets	0.00	38410.0	38410.0	1.00	36586.0	36586.0	1.00	0.04749-	0.04749-	0.00000
Liquid Assets										
Inventory and Receivables	1.00	273130.0	61515.8	4.44	409770.0	75883.3	5.40	0.50027	0.23356	0.21622
Cash and Deferred Charges	1.00	97888.0	22046.8	4.44	2664.0	493.3	5.40	0.97279-	0.97762-	0.21622
Grand Total		409428.0			449020.0			0.09670	0.08297-	0.19593
TOTAL ASSETS		409428.0			449020.0					
RATE of RETURN (%)		52.76			72.12					

REALST Can Generate "Challenge Budgets"

Two information needs identified were: how low the selling price could go without sacrificing profitability and how the firm could respond to changes in market conditions. REALST has a method for generating a budget based on targeted or required productivity, budgeted sales volume, budgeted selling price, and budgeted cost resource price. Table

6.5.1 shows how REALST generates a budget based on percentage changes from a reference period data (called a challenge budget): 12% average improvement in productivity over January data which has been shown to be attainable in February and March, 15% increase in sales, no selling price increase, and 20% increase in resource costs. Given these data, a challenge budget is generated and when compared against the reference period actual data, Table 6.5.2 shows profitability will still increase by $7,804.80! The increase in sales and the improvement in productivity was able to offset the increase in costs without having to increase selling prices. These reports directly address the two information needs regarding selling prices and responding to market changes. A number of challenge budgets could be generated and evaluated to determine the most desirable target - Tables B.5.1 and B.5.2 comprise an example.

Table 6.5.1: Challenge Budget Parameters

```
                              REALST BUDGET
                                                              10:24:06

                 Centre number                       : 1
                 Reference period number             : 1
                 Budget period number                : 5




                         Percentage change in
                 Productivity required               : 12
                 Budgeted sales volume               : 15
                 Budgeted selling price              : 0
                 Budgeted cost resource price        : 20

          Do you want to change the specifications (Y/N)? N

                                                   Press Esc to CANCEL
```

Table 6.5.2: Management Report for Challenge Budget

06-02-1990 10:25:43 Plastics Dept. PROFIT Page# 1

Management Report

CENTRE - 1

January vs. Challenge Budget

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PROFIT VARIANCE	EFFECT OF				
				%	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	PRICE RECOVERY VARIANCE
	A	B	C	=	D		+	G
					D	= E	+ F	
TOTAL PRODUCTS	933176.0	1073152.4						
- Labor	69778.0	85976.5	5731.8-	12.00	10317.2	8908.4	1408.8	16048.9-
- Materials/Suppls	560500.0	690616.1	46041.1-	12.00	82873.9	0.0	82873.9	128915.0-
- Energy	16519.0	20353.8	1356.9-	12.00	2442.5	0.0	2442.5	3799.4-
- Other Inputs	48576.0	59852.6	3990.2-	12.00	7182.3	8743.7	1561.4-	11172.5-
- Capital Expenses	21776.0	26831.1	1788.7-	12.00	3219.7	3919.7	699.9-	5008.5-
GRAND TOTAL - Resources	717149.0	883630.0	58908.7-	12.00	106035.6	21571.7	84463.9	164944.3-
GRAND TOTAL - Assets	58630.1	711.1	66713.5	12.00	85.3	8.3	77.1	66628.2
AGGREGATE	775779.1	884341.1	7804.8	12.00	106120.9	21580.0	84540.9	98316.1-

REALST's Cost Reports Provide Information Similar to Standard Cost Accounting

In this section, I present the similarities and distinctions between information provided by REALST and Standard Cost Accounting. Standard Cost Accounting information can be obtained from one of the optional reports REALST can generate, i.e., REALST Cost Reports, if the budget using standard costs and quantities are used for the base or reference period. Table 6.6.1 is the summary Management Cost Report. This is similar to a profit report except that instead of analyzing profitability, productivity and price recovery, it only analyzes changes in costs as affected by changes in input and output quantities (productivity) and input costs.

Figure 6.4 shows the similarity and difference between Standard Cost Accounting and REALST Cost Variance analysis. Consider Q_o as the budgeted or standard resource quantity; Q_n as the actual resource quantity used; Q_{np} as the resource quantity that should have been used had the planned productivity ratio been achieved or had resource consumption changed in direct proportion to the change in the quantity of output produced; P_o as the budgeted or standard resource unit cost ; and, P_n as the actual resource unit cost. The area representing QoPo is the budgeted/standard resource total cost; while the area representing QnPn is the actual resource total cost. The difference between the budgeted total cost and the actual total cost can be explained by the differences in three factors: the product quantity, the resource quantity, and the resource unit cost. To simplify the analysis, the product quantity is first held constant using actual quantity produced. Based on the actual product quantity, the corresponding resource quantity is computed maintaining the same product quantity/resource quantity ratio (productivity) as in the budget. The resulting quantity is Qnp. For example, if the budget calls for a resource quantity, Qo = 100 to produce 50 widgets and only 40 widgets were actually produced, then Qnp = 80. The variance can now be explained based on changes in resource quantity and resource cost. This variance is what is called the "Total Flexible Budget Variance" in Standard Cost Accounting (Smith, Keith, and Stephens, 1986) or the REALST Product Cost (refer to Table 6.6.1), represented by the shaded areas in Figure 6.4. Note that while the components of the shaded areas are different, their total areas are equal. Hence, if standard cost accounting analysis is done on the Company C Plastics Department, the total flexible budget variance for each cost category will be equal to the REALST Product Cost Column entries of Table 6.6.1. Note also that there is an unexplained difference between the budgeted cost and the actual cost in both Figure 6.4 ({Qnp-Qo} x Po) and Table 6.6.1 (i.e., the difference between the values in the two periods is not equal to the REALST

Product Cost Variance). This unexplained difference is due to the difference between budgeted product quantity and the actual quantity produced. Table 6.7.1: Executive Report - Cost Reconciliation portrays this difference as the contribution from change in product volume.

Table 6.6.1: Management Report on Operating Costs

05-25-1990 15:53:26 Plastics Dept. COST Page# 1

Management Report
CENTRE - 1
January vs. February

VALUES are in DOLLARS

	REFERENCE PERIOD VALUE	REVIEW PERIOD VALUE	REALST PRODUCT COST	EFFECT OF %	PRODUCTIVITY VARIANCE	PRODUCT VOLUME	RESOURCE ALLOCATION	%	RESOURCE PRICE
	A	B	C	=	D		+		G
					D	= E	+ F		
- Labor	69778.0	94182.0	9876.0-	15.36	14467.5	13562.3	905.1	28.88	24343.4-
- Materials/Suppls	560500.0	731465.0	54266.9-	7.98	58394.7	0.0	58394.7	16.64	112661.6-
- Energy	16519.0	15690.0	4268.3	12.89	2022.4	0.0	2022.4	11.25-	2245.9
- Other Inputs	48576.0	65789.0	7099.3-	1.67	1096.1	11526.0	10429.9-	13.96	8195.4-
- Capital Expenses	21776.0	29176.0	2866.2-	2.77	807.7	5166.9	4359.2-	13.96	3673.9-
GRAND TOTAL - Resources	717149.0	936302.0	69840.0-	8.20	76788.4	30255.3	46533.1	16.92	146628.4-

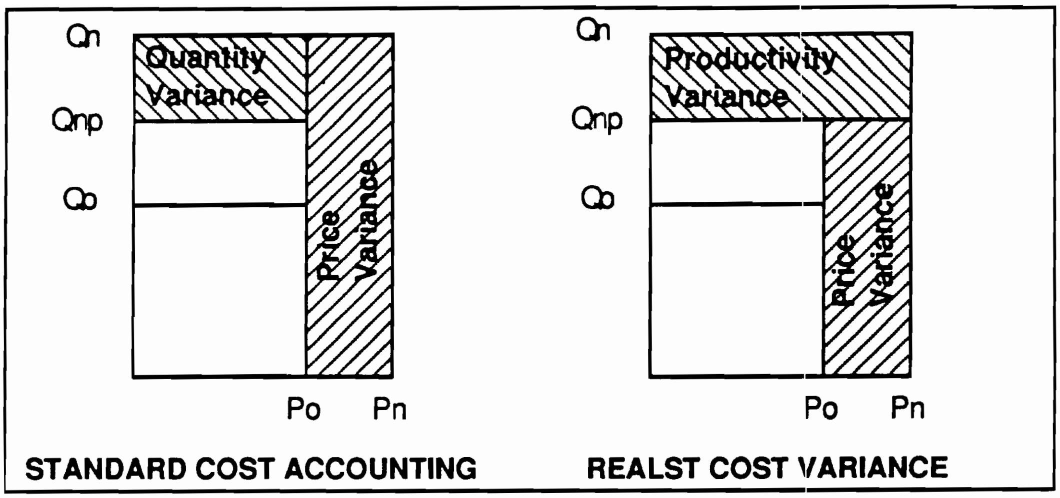

Figure 6.4: Similarity and Difference Between Standard Cost Accounting and REALST Cost Variance Analysis

Table 6.7.1: Cost Reconciliation Executive Report

05-25-1990 15:53:27 EXECUTIVE REPORT COST Page# 1

Cost Reconciliation

January vs. February

VALUES are in DOLLARS

	REFERENCE PERIOD COST	REVIEW PERIOD COST	CHANGE IN COST		CONTRIBUTION FROM PRODUCT VOLUME		CONTRIBUTION FROM REALST PRODUCT COST
	A	B	C	=	G	+	F
Plastics Dept.	717149.0	936302.0	219153.0-		149313.0-		69840.0-

Conclusion: An Analyst Can Draw Out and Portray All the Information Needed by Company C Managers from REALST Reports

The preceding section shows that REALST reports contain all the processed data needed to draw out information needed by Company C managers. I have also shown that while REALST provides some data similar to Standard Cost Accounting data, the latter does not provide all the data REALST provides. REALST by itself does not provide information which I define as biased data - something a manager can use to make decisions. An analyst will need to closely look at the reports, interpret the data, and summarize the information including graphically portraying the most important information, just like what I did in the preceding section. He will need to decide which detailed reports to show and that decision will be based on how he interprets the data from the summary REALST reports.

Since all the information needed by Company C managers could be obtained from REALST reports, I did not see the need to try other versions. After all, only REALST and LTV's versions compute challenge budgets - one of the needed information; and while the LTV version computes challenge budgets, it does not provide the choice of the level of detail in the reports like REALST does.

Chapter 7: Center D Is Developing a TFPM Application to Track and Analyze Performance, Evaluate Plans and Budgets, and Develop a Basis for Gainsharing

Case Summary

This case uses a different approach from the three previous cases discussed. Instead of starting with determining the information needs before developing the appropriate TFPM application, the application was first developed and then the analysts portrayed and presented all the information obtained from the application to Center D's top management team. The top managers then prioritized what they considered the most relevant information as the basis for making decisions and initiating action. The resulting list of information needs will be compared against the common information needs of the first three cases to check the internal validity of measuring information needs.

The information portrayed deals with the analysis of the past year's month by month performance against the average monthly performance two years ago, an evaluation of plans and budgets for the coming fiscal year, and the implications on gainsharing for the planned performance.

Introduction

Center D is a non-profit university-based quality and productivity center with performance measurement as one of its main research areas. Center D tries to practise what it preaches and hence, it automatically becomes a research site for most of its areas of research. This situation has facilitated the development of a TFPM application for Center D.

Center D tried to develop a TFPM application about two to three years ago, but did not have the necessary data. Fortunately, Center D's management support system which focused mainly on financial and accounting information was also being developed. This turned out to be a pleasant surprise when we looked at the data currently available; they were already in the form that could easily be processed to develop a TFPM application. I believe that while the development of the management support system did not aim to provide data for a TFPM application, the previous awareness of the lack of TFPM data may have influenced the collection, retrieval, and storage of TFPM data. This also shows evidence that a good accounting/financial information system should be able to provide the necessary data needed to develop a TFPM application even if the accounting system was not necessarily designed to provide TFPM data.

Data Collection, Retrieval, Processing, and Reporting

Data collection, retrieval, processing, and reporting were done mainly by one of Center D's more senior associates, with my assistance. The Finance and Administration Director provided and verified the data used for the TFPM application. Having three of us involved in the development of this TFPM application helped maintain data integrity.

Outputs were classified into projects/programs, products, and contributions from associates and the department where Center D is affiliated. The quantity used for projects/programs is the number of projects and programs for which there was activity during the month. We assumed that activity leads to either a tangible or intangible output bringing the project or program closer to final completion. The project/programs revenue is the accrued service revenue found on the Monthly Income Statement. Dividing project/programs revenue by the quantity yields the average price.

The products revenue is the accrued sales revenue found on the Monthly Income Statement. An index similar to the Consumer Price Index is used for the product price. A figure of 100 was assigned as the base year price index and indices for subsequent periods are based on percentage price changes from the base period. The product quantity is obtained by dividing the revenue by the price index. Hence, product quantity has no meaning in the absolute sense; it only has meaning in a relative sense, when compared with a quantity in another period.

The third output category consists of contributions from associates in terms of unpaid overtime and other revenues from the department where Center D is affiliated in terms of salaries of some principal investigators and provision of facilities. This category is not strictly an output but had to be included to offset the effects of overtime, salaries of some principal investigators, and facilities costs which were all included as inputs to match the Center's accounting reports.

Inputs were classified into labor; materials and facilities; computers, furniture, and equipment; and travel. Total Labor Cost was obtained from the Monthly Income Statement. Labor quantity was computed from the Monthly Level of Effort Tracking Sheets. Average labor cost was calculated by dividing the total cost by the quantity. Materials and Facilities Total Cost was obtained by subtracting depreciation costs for computers, furniture, and equipment from the total operating expenses. Materials and Facilities average cost was obtained using the Producers Price Index for Paper and Commercial Printing which represents the bulk of this input. Materials and Facilities quantity was calculated by dividing the total cost by the average cost. Computers, Furniture, and Equipment Depreciation Total Cost was obtained from the Monthly Budget Detail Report. An assumed rate of return had the depreciation cost been invested in a money market fund was used for the Computers, Furniture, and Equipment depreciation average cost. The quantity for this input category was calculated by dividing the total cost by the depreciation average cost. Total Travel Cost was obtained from the Monthly Detail Budget Report. The Consumer Price Index for Airfare, Lodging Out-of-Town, and Food Out Cost was used for the average travel cost and the travel quantity was computed by dividing the total cost by the average cost. Like the product quantity, the Materials and

Facilities quantity, Computers, Furniture, and Equipment quantity, and the Travel quantity have meaning only in relation to the corresponding numbers in other periods; they have no meaning in absolute terms.

After collecting and verifying the data, parallel runs were made on SCORBORD and REALST. Results of the two runs were compared and found to have no conflicts nor significant differences except for the difference in dollar effects due to the inherent difference in the formulas. SCORBORD uses base period costs while REALST uses review period costs to compute the dollar effects of changes in productivity, price recovery, and profitability. If dollar effects are used as indicators of the magnitude of the impact of the changes rather than the absolute basis for say, how much gains to share, then it will not matter whether SCORBORD or REALST dollar effects are used. If the dollar effects are used as the absolute basis for other purposes such as determining how much gains to share or for determining optimal production levels, the REALST dollar effects (using review period costs) will be a better number to use as it represents the current value of money for the review period.

Monthly average data for fiscal year 88-89 were first used as base period against monthly data for July, 1989 - April, 1990. Then, worst and best case monthly average budgets for fiscal year 90-91 were run against fiscal year 88-89 and fiscal year 89-90 monthly averages. The results are presented in the next section.

Information Obtained

Past Performance

Figure 7.1 clearly shows that profit performance was driven by price recovery, not productivity. Without doing a correlation analysis, and just by looking at the chart, it is obvious that this was the case as the profitability line closely followed the price recovery line, almost unaffected by the productivity line. The question raised by Center D's Business Development Director was why price recovery was so high in October 1989 while productivity just slightly increased when this month was the peak of activities and deliverables for one of the major clients. We agreed this had to do with how the outputs were counted. Since most of the activities were for just one major client, they were counted as only one unit of output quantity when it could have been equivalent to as much as 20 small projects. This brought the need to further refine the definition of project/program output quantity to say, use the concept of client engagements. This concept though is still not well defined. The idea is to be able to break down project/program outputs into sets of deliverables that have less variance in terms of levels of activities and number of deliverables. Nevertheless, once the data are refined, the directors confirmed that the information portrayed in this figure would be valuable to them. The Business Development Director further explained that the high price recovery in the later months of 1989 was caused by a few high revenue-generating projects that could actually be broken down and counted as smaller client engagements; while in the early months of 1990, the trend reversed as people scrambled on a number of smaller low to no revenue-generating projects that increased productivity but decreased price recovery. Had the few high-revenue generating projects been broken down and counted as smaller client engagements, the productivity and price recovery lines may have switched trends depending on the actual number of client engagements counted.

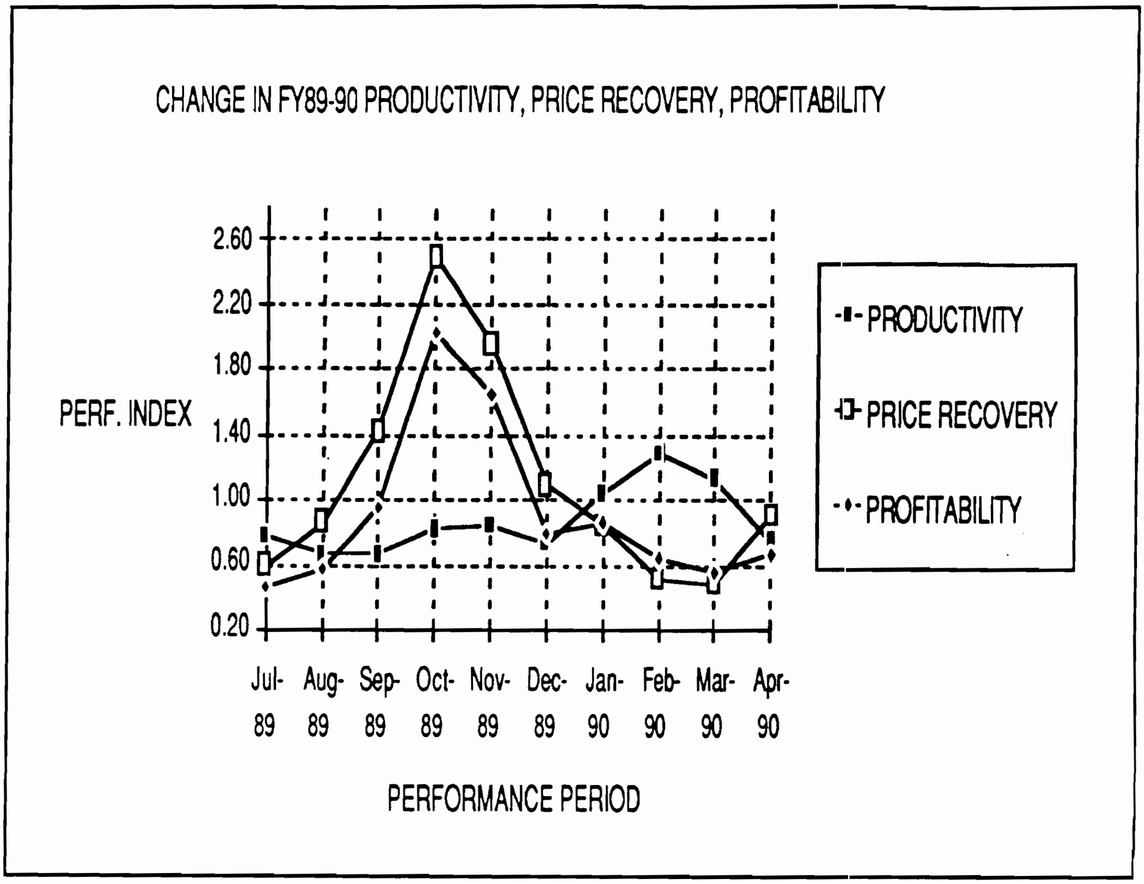

Figure 7.1: Profitability is Driven By Price Recovery

Figure 7.2 shows that labor profitability together with materials and facilities drive overall profitability. The chart may look too crowded and confusing at first glance but a careful look will show that total profitability follows labor and materials profitability. Color coding the lines helped us see this information.

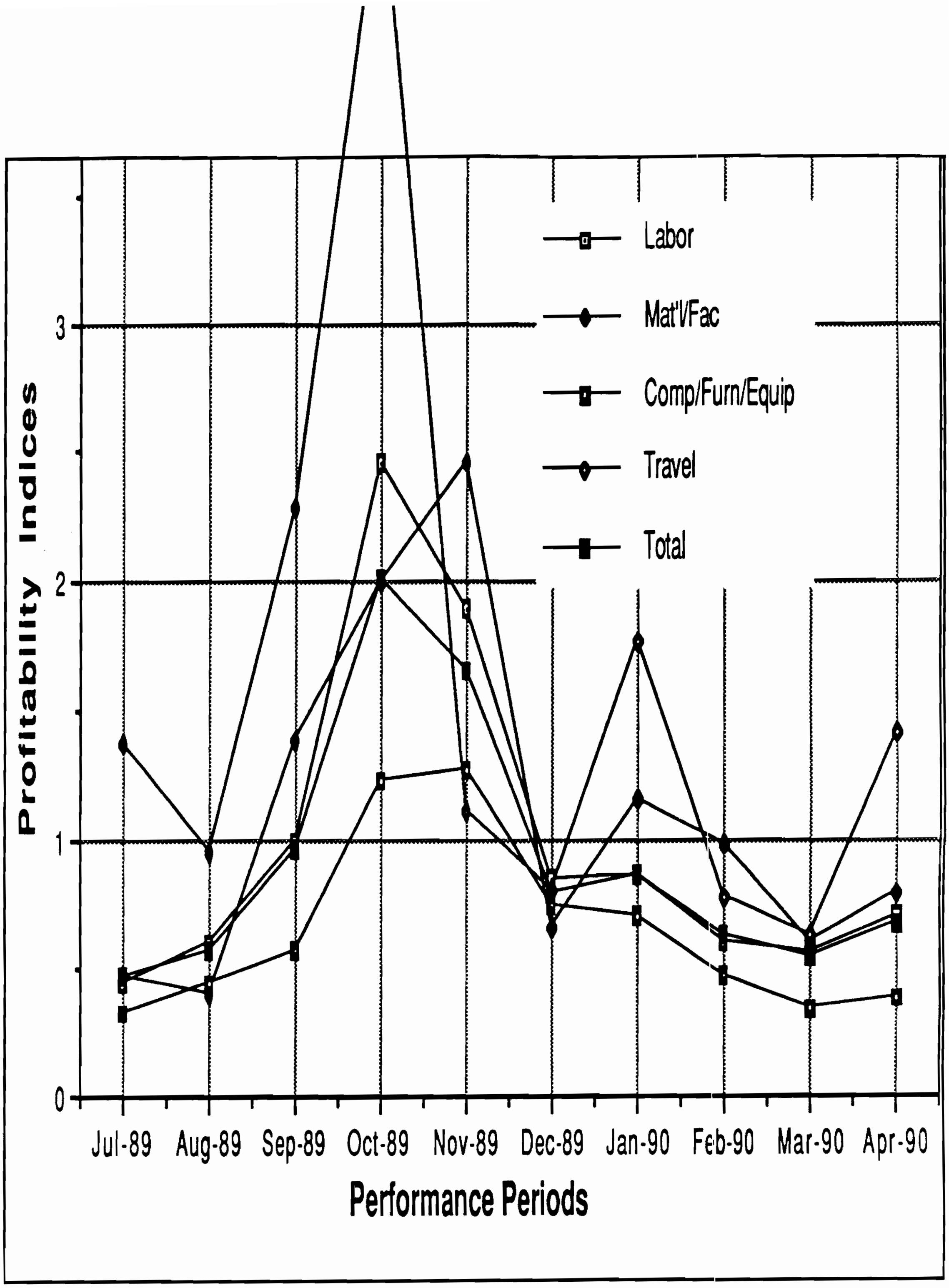

Figure 7.2: Labor Profitability Together With Materials and Facilities Drive Overall Profitability

Figure 7.3 shows that labor productivity continuously dragged down total productivity. While other partial productivities fluctuated mostly over the total productivity line, total productivity just stayed over the labor productivity line which mostly remained low (below 1). The directors felt that this was mainly caused by the fact that in fiscal year 88-89, Center D employed less total manpower but with higher average base pay, while in fiscal year 89-90, the total manpower was higher with lower average base pay. This explanation is supported by Figure 7.4 which shows labor price recovery pulling up total price recovery while in Figure 7.3, labor productivity dragged down total productivity.

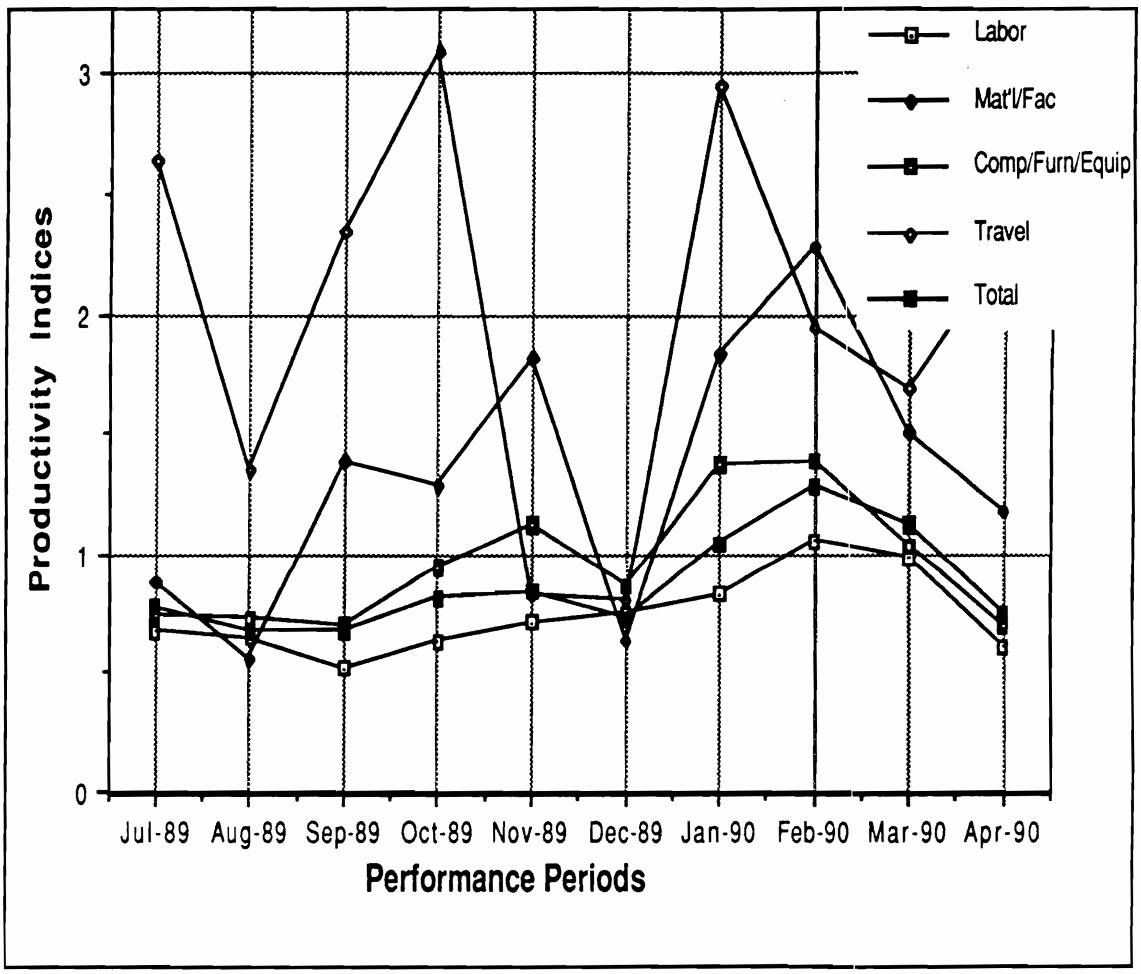

Figure 7.3: Labor Productivity Drives Total Productivity

Note also in Figure 7.4 that the behavior of the price recovery trend lines was not as erratic as the productivity trend lines in Figure 7.3. This could be attributed to more consistent budgeting/costing/pricing guidelines as compared with the more frequent changes in resource allocation and the diversity of the project and program resource requirements.

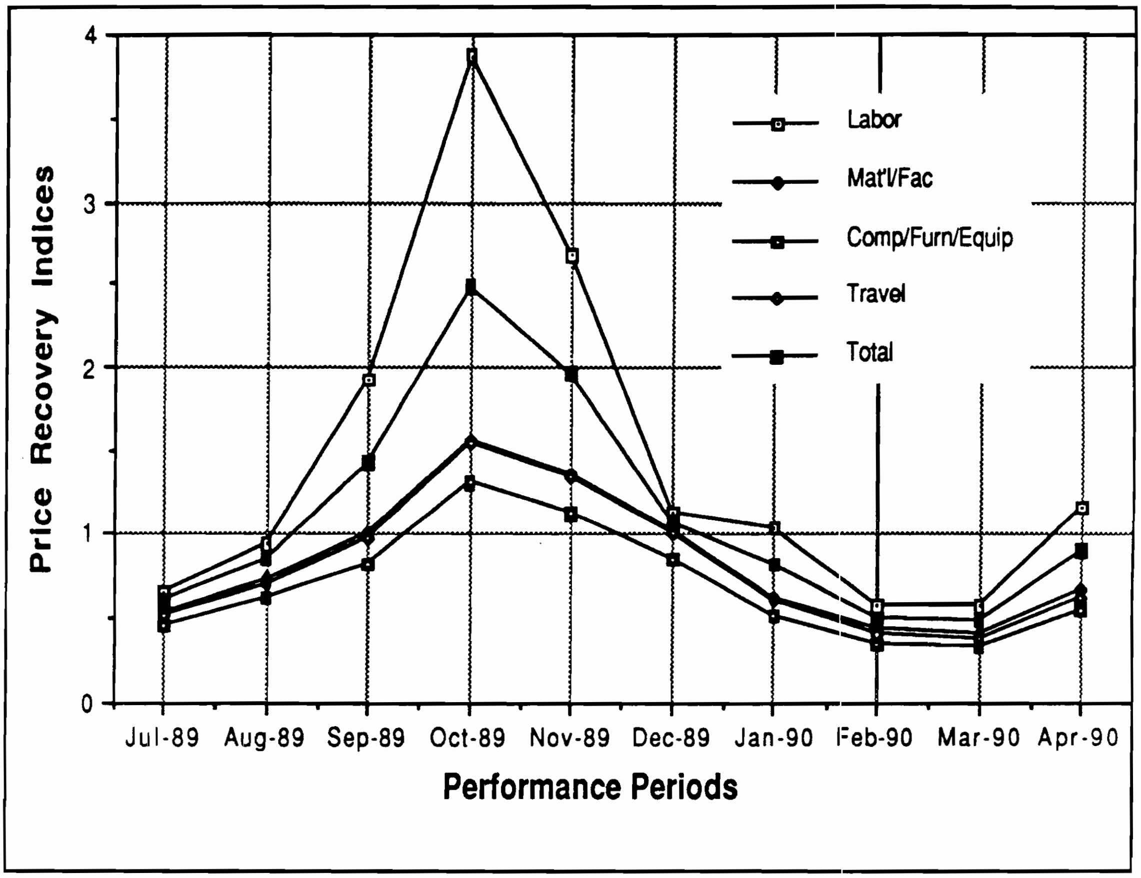

Figure 7.4: Labor Price Recovery Drives Total Price Recovery

These charts indicate how Center D performed in terms of profitability, productivity, and price recovery. Discussions of these results with the directors of Center D have focused on what caused the data to be such, how to better improve performance, and how to better improve the measures. After discussing past performance, plans and budgets were also evaluated.

Evaluation of Plans and Budgets

The evaluation of plans and budgets was done by applying TFPM to the worst and best case budgets for fiscal year 90-91 using actual data from fiscal years 88-89 and 89-90 as base periods. Table 7.1 shows the summary of results from the REALST evaluations of the budgets.

Table 7.1 shows that Center D will have difficulty surviving in the worst case scenario budget for fiscal year 90-91. Even in the best case scenario, Center D will just be able to match the profitability performance in fiscal year 88-89, and improve profitability compared to fiscal year 89-90 by 20% or $27,444. However, profitability change will be driven by increasing price recovery thereby offsetting decreasing productivity. Because of the productivity trend, Center D cannot justify additional resources, particularly for labor, unless the strategy is really to hire more people with less base pay and less expected average output in relation to those in the base period.

Table 7.1: Summary of Results of REALST Evaluation Runs for Monthly Average Budgets Vs. Past Performance

		Budget Period	
		FY 90-91 Worst Case	FY 90-91 Best Case
Base Period	FY 88-89	• Total-Factor Productivity will decrease by 57% or ($63,579). Productivity of all resources will decrease with labor productivity decreasing by 60% or ($40,139) and materials and facilities productivity decreasing by 61% or ($20, 806). • Total price recovery will increase by 69% or $32,326 mainly due to labor price recovery increasing by 95% or $25,643. • Total profitability will decrease by 28% or ($31,253).	• Total-Factor Productivity will decrease by 41% or ($55,858) driven by labor productivity decreasing by 40% or ($29,327) and materials and facilities productivity decreasing by 54% or ($25,804). • Total price recovery will increase by 67% or $54,499 mainly due to labor price recovery increasing by 98% or $42,959. • Minimal change in total profitability.
	FY 89-90	• Total-Factor Productivity will decrease by 32% or ($36,609) driven by labor productivity decreasing by 32% or ($21,857) and materials and facilities productivity decreasing by 30% or ($10,388). • Total price recovery will increase by 32% or $24,920 mainly due to labor price recovery increasing by 36% or $16,244. • Total profitability will decrease by 10% or ($16,688).	• Total-Factor Productivity will decrease by 10% or ($36,609) driven by travel productivity decreasing by 27% or ($3,458) and materials and facilities productivity decreasing by 20% or ($9,680). • Total price recovery will increase by 34% or $42,145 mainly due to labor price recovery increasing by 38% or $27,356. • Total profitability will increase by 20% or $27,444.

Gainsharing Implications

Gainsharing best case is 7.4% ($5,201 net income, $33,753 participating payroll, 50% sharing ratio). Bonuses, however, will be earned through price recovery, not productivity. To attain 10% gainsharing, net income will have to be $6,750. For gainsharing to be earned through productivity, the dollar effects from changes in productivity, particularly from labor productivity, must be at least $6,750. Given the best and worst case budgets, this seems to be very difficult to attain for Center D. Some strategic shifts in allocation of resources need to be made to attain such a productivity gain.

Conclusions and Lessons Learned

At the end of our meeting, the directors of Center D agreed that the information that would be useful for them from the TFPM reports were: (1) tracking and analyzing what drives performance, (2) evaluating plans and budgets, (3) developing a basis for gainsharing, and (4) having an overall performance measure that relates financial measures (profitability) to countable outputs and inputs (productivity) and changes in prices and costs (price recovery). The first two were deemed most important as the directors felt they could really use the information immediately; while the last two were less important. Developing a basis for gainsharing is not a must but a desired outcome for the future and the fourth information need was subordinated to the first one. These prioritized information needs will be further discussed and compared with information needs of other case studies in the next chapter.

When the results of the TFPM runs were first presented to the directors of Center D, a summary sheet of the most relevant data was used as a cover sheet for the detailed reports and figures. The directors commented that what were presented to them were still data. What they considered information were the meaning and interpretation they perceived from the data presented. For them, the information consisted of the explanations in their operational terms (i.e., the users' day-to-day language) on why the numbers turned out to be what they were (what caused them to be such) and this gives them an idea about what could be done to attain the desired changes. This implies that to interpret the meaning of the TFPM processed data, the analysts and managers who intimately know the operations of the organization have to work closely together to draw out information from TFPM and state them in operational terms.

This case study also shows evidence that a good accounting/financial information system should provide the necessary TFPM data. Center D's accounting/financial information system was not necessarily designed to provide TFPM data but we were able to retrieve the necessary data with minimal additional data processing. Center D's Finance and Administration Director further commented that TFPM reinforces the accounting/financial information system by helping give meaning to the numbers presented in the reports. This does not mean that the application was a "perfect" TFPM application as developed. As discussed earlier, the directors agreed there was a need to further refine the definition of outputs in terms of client engagements. This refinement will not only help in developing better measures but also in planning resource allocations, budgeting, and scheduling.

Finally, this case study has convinced me that the alternative approach to developing TFPM applications I used in this case study could prove to be more effective. I had difficulty identifying the information needs from interactions with managers in the previous cases. Many of them couldn't explicitly verbalize information needs. I had to continuously probe into their concerns, issues, and or problems to identify information needs. Then, I had to write down these needs and have managers verify the accuracy of my perception of their needs. In fact, Center D has also made attempts at identifying information needs before designing a more general measurement system, and has faltered in the development and implementation phases. In this case, I found it more effective to develop the TFPM application first, present all the information obtained from the application, and ask the managers which information are most useful to them. It has helped them look at accounting data and relate them to their operational performance. Particularly, in situations where the managers are not quite familiar with TFPM or even accounting and financial data, this approach would be effective in introducing TFPM. It could serve to prime managers into thinking about what information they need to better manage and improve their organization's performance.

Chapter 8: Data Processing and the Results of the Research

In this chapter, I compiled the user information needs from the four cases in the previous chapters and compared them with the results of two previous surveys to determine the common information needs the teaching TFPM model should address. Before developing the teaching TFPM model, I reviewed and evaluated how the available TFPM versions addressed the information needs in each of the cases to decide what features should be included in the teaching TFPM model and what features need to be designed. This is my way of proposing resolutions to the methodological issues and differences of the available TFPM versions. Then I developed the teaching TFPM model and evaluated it using the same procedure for evaluating the appropriateness of the available versions to the cases. I also compared the teaching model with prescriptions from related literature on what TFPM should do.

Common User Information Needs

Table 8.1 summarizes the information needs collected from the four cases discussed in the previous chapters. The managers were asked to assign weights to the information needs they identified on a scale of 1-100 according to their importance in decision making. I summed up the weights and those with the highest weights were selected as the common information needs. Actually, without looking at the weights, it was quite obvious that there were four common information needs. I did the computations as planned to determine the magnitude of differences in the average weights. The differences in magnitude were minimal for the common information needs but highly significant if we compare the percentages of the common against the information needs specific to two cases (21%-25% vs.2% and 6%). The common information needs are:

1. Use for Planning - to be able to use TFPM reports to evaluate plans and budgets against past performance, responding to fluctuations in the environment, evaluating and maximizing resource allocation options, and generating challenge budgets.
2. Measurement and evaluation of past performance to assess the overall impact of improvement efforts and relate physical measures to profitability.
3. Measurement of units within a firm and aggregating those measures to the firm level measures to ascertain the units' contribution to firm performance.
4. Measurement and relationship of partial factors to total-factor productivity, price recovery and profitability to determine which factors drive overall performance.

Table 8.1: Summary of Weighted Information Needs from the Case Studies

Info Needs/ Relative Importance	Plant A	Division B	Company C	Center D	Total	%
Measure Overall Past Performance	•Impact of Improvement Efforts	•Physical/ Financial Measures	•Physical/ Financial Measures	•Physical/ Financial Measures		
	100	50	100	50	300	24
Measure Departments/ WIP	WIP		•Roll up of Plant Measures			
	88	100	80		268	21
Partial Measures	•Labor vs. Material Cost		•Labor Contribution	•What Drives Performance		
	82		80	100	262	21
Use for Planning	• Maximize Resource Allocation	• Challenge Budgets	•Pricing/ Fluctuations in Market	• Evaluating Plans/ Budgets		
	38	100	80	100	318	25
Analysis by Product	26				26	2
Gainsharing				75	75	6
					1249	99

The two other information needs identified could actually be addressed by providing the related common information. Analysis by product could be treated as a special case of measuring units within a firm and aggregating these measures into the plant level measure. A product line could be considered as an organizational unit. Gainsharing information could be obtained from the measure of overall past performance as related to the partial measures.

Other organizational concerns identified were integration of TFPM with existing systems particularly regarding the availability of data, allocation of indirect and overhead costs, Activity-Based Cost Accounting, and Standard Cost Accounting. While these are not information needs, they are concerns that have to be addressed in developing a TFPM application. These concerns were addressed in the case studies and will again be discussed in the development of the teaching TFPM model.

I compared the four common information needs with the results of two related surveys. The first survey was done by the American Productivity (and Quality) Center and UCCEL Corporation (APC, 1985) on those firms who have sent representatives to APQC's productivity measurement seminars. Out of 183 respondents, 38% use TFPM. Figure 8.1 shows the reasons cited by the respondents for using TFPM. Another more recent survey (Steedle, 1988) of 1000 U.S. controllers cited basically the same reasons for using TFPM as the first survey. While the populations for these two surveys may have been different, they can both be subsets of the bigger population of TFPM users or possible users.

The reasons with the highest frequencies in the first survey, strategic planning of options, validity of budgets or forecasts, screening report of current performance, and diagnosis of past performance all correspond with three of the four common information needs identified from the case studies. Only the need for measures of performance of units within a firm and aggregating those measures to firm level measures was not cited in both the APQC/UCCEL and Steedle surveys. This was also the only information need not identified in all the four case studies. John Parsons, Director for Economics and Finance of the National Productivity Institute of South Africa, who has been teaching and developing REALST applications worldwide, warns against developing TFPM applications for multiple organizational units until users have become quite familiar with the concepts and implementation of TFPM. Given all these considerations, initial TFPM applications should, therefore, not be developed with multiple units of analysis aggregated to the firm level measure until users have become quite familiar with TFPM concepts and implementation. But while a first-time user should not develop a TFPM application with multiple organizational units, he should be able to modify/upgrade his application later with multiple units aggregated to the firm level, using the teaching TFPM model.

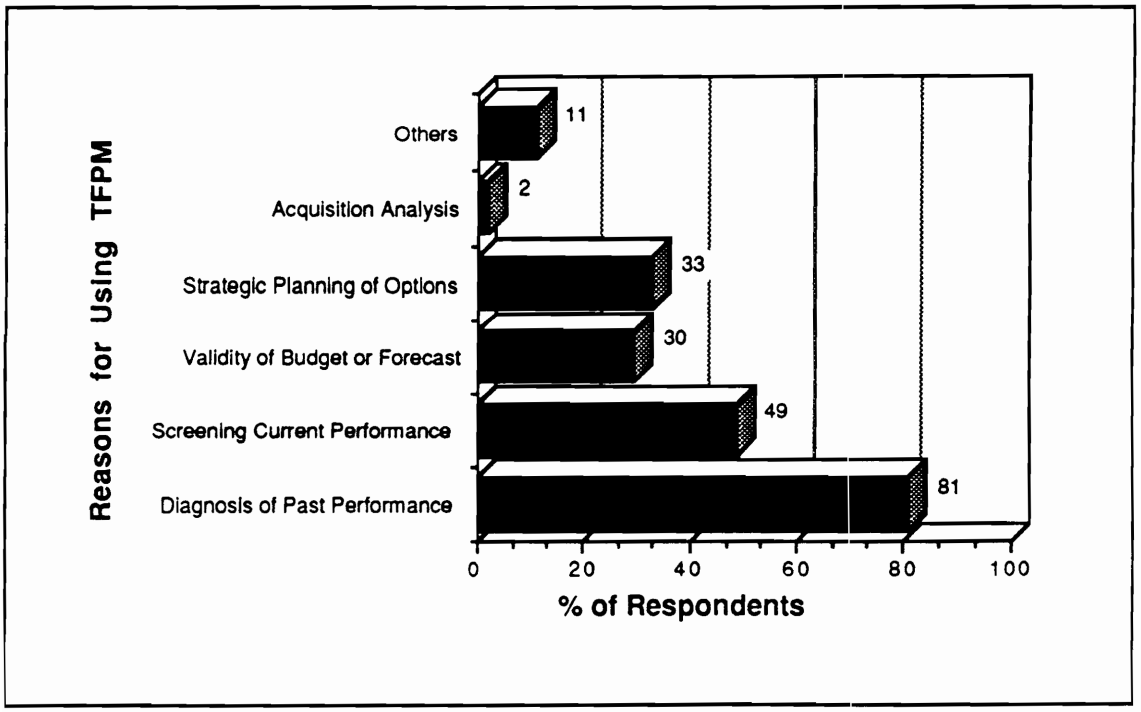

Figure 8.1: APQC/UCCEL Survey Results on Reasons for Using TFPM

Evaluation of Available Versions as Applied to the Case Studies

This section presents my evaluation of the available versions as applied to the case studies to determine what features should be incorporated into the teaching TFPM model and what features need to be designed, if any.

As explained in Chapter 2, the main evaluation criteria will be the identified information needs for each case. The criteria will be addressed by the features of the versions being evaluated and the organizational conditions affecting the criteria. For example, the first information need identified in Chapter 4 - Plant A Case Study was the need to assess the impact of improvement efforts on overall performance, particularly on profitability. The first set of TFPM features addresses this need but as discussed in Chapter 3, different models and versions provide different data. The Productivity Indices Model portrays only productivity indices while the PPPR Model also relates productivity to profitability using price recovery and provides dollar effects of performance changes. Hence, the criterion "assessing impact on overall performance" could be addressed by two attributes: "performance indices portrayal" and "dollar effects portrayal." Figure 8.2 shows the transformation curve on how a TFPM version/application is rated on the attribute "dollar effects portrayal." If dollar effects are not portrayed, the version/application receives a rating of zero for this attribute; 5 for portraying only the dollar effects, 8.5 for reconciling (relative) dollar effects with changes in (absolute) profits, and 10 for analyzing and reconciling the (relative) dollar effects to changes in (absolute) costs.

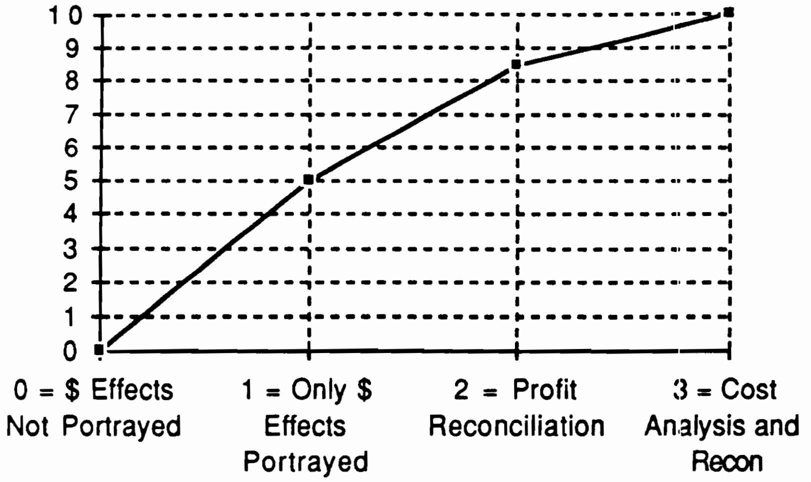

Figure 8.2: Portrayal of Dollar Effects Transformation Curve

Other attributes may not be how a feature provides for the information need but how the TFPM application is developed for the case conditions. For example, period length is not dependent on any TFPM model or version feature but dictated by organizational needs and/or conditions. For the case in Chapter 4, there will be too much variation in operations if the period length used is just one month. The best period length agreed upon by the analysts and managers is one quarter for period performance to be comparable with each other. This condition is portrayed in the transformation curve shown in Figure 8.3.

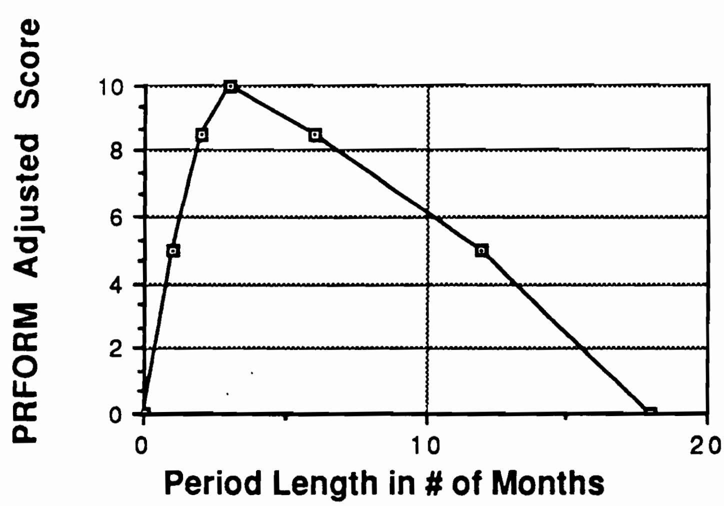

Figure 8.3: Portrayal of Dollar Effects Transformation Curve

Since some attributes are dependent on a particular case, their transformation curves may vary from case to case. However, attributes that are dependent on how features of TFPM versions respond to common information needs will have the same transformation curves across all cases.

Criteria and attributes are all weighted and a weighted average rating could be obtained for each TFPM version/application. This is how the PRFORM software was used in this research to obtain an evaluation rating for each TFPM version/application for each of the case studies. Table 8.2 shows the evaluations of SCORBORD and REALST applications to the case in Chapter 4. The first five criteria and their weights were taken from the information needs identified by the users. I added two other criteria (unused data/features and software supported) to further evaluate each version. Some versions have features or report data that are not used in the application. These features or extra data, aside from not adding value to the application, may confuse first-time users. Hence, the more unused data or features a version has, the lower its rating. Table 8.2 shows the SCORBORD application for Plant A obtained an average rating of 8.5 while the REALST application averaged 9.5 on a scale from 0 to 10.

Table 8.2: PRFORM Evaluation of the SCORBORD and REALST Applications to Plant A

Memory: 342K		SCORBORD	8.5	REALST	9.5
Description	Weight	Raw	Adjust	Raw	Adjust
Performance Measure	20		7.5		10.0
Performance Indices	50	2.00	10.0	2.00	10.0
$ Effects Portrayal	50	1.00	5.0	3.00	10.0
Measure Dep'ts./WIP	18		6.5		9.2
Aggregation	54	1.00	5.0	2.00	10.0
Level of Detail	46		8.4		8.4
Input/Output Matching	36	2.00	10.0	2.00	10.0
Base Period Choice	33	1.00	5.0	1.00	5.0
Period Length	31	3.00	10.0	3.00	10.0
Partial Measures	17		10.0		10.0
Level of Detail	50	2.00	10.0	2.00	10.0
Treatment of Capital	50		10.0		10.0
Include Capital Input	50	1.00	10.0	1.00	10.0
No Capital Input	50	0.00	10.0	0.00	10.0
Use for Planning	15	1.00	10.0	1.00	10.0
Analysis by Product	10	1.00	10.0	1.00	10.0
Unused Data/Features	10	2.00	6.7	2.00	6.7
Software Supported	10	1.00	10.0	1.00	10.0

Only those versions which I considered the two most appropriate ones based on the information requirements were evaluated for each case. There was no need to try all the versions for each case as it was apparent that some would not be able to provide the information required. The PRFORM evaluations and the transformation curves used to evaluate each of the versions applied to each of the cases are shown in the Chapter Appendix. Table 8.3 summarizes the results of those evaluations.

Table 8.3: Summary of PRFORM Evaluations of Each of the Versions Applied to Each of the Cases

Versions	Plant A	Division B	Company C	Center D
REALST	9.5	9.4	9.2	8.8
SCORBORD	8.5			8.5
Craig & Harris			5.0	
LTV		7.6		

It is obvious from Table 8.3 that REALST is the most flexible version as it has outscored all the other versions. This is because it has more features than other versions and can, therefore, provide most of the information needed in each of the cases. The task of developing the teaching TFPM model then becomes simplifying REALST to make it easier to understand, incorporating other features from other versions that best address common information needs, and proposing report and portrayal formats to facilitate information portrayal.

Teaching TFPM Model Development

In order to simplify REALST, I looked at its features that were not used in the case studies especially those that did not address any of the common information needs.

The REALST feature that takes some attention away from the basic analysis of profitability using productivity and price recovery is the concept of resource variability.

This concept enables REALST to allocate the effects of productivity changes into capacity utilization of fixed resources and efficiency of using variable resources as discussed in Chapter 3. While this concept may be a powerful analytical tool, its validity depends on the accuracy of the estimate of how variable or fixed a particular resource is. The other REALST feature that does not address any common information need is the way REALST especially treats capital input in terms of return on investment. These features further complicate matters particularly for first-time users. I believe these are advanced features for more advanced users. Hence, these two REALST features will not be included in the teaching TFPM model.

Table 8.4 is the spreadsheet portrayal of the teaching TFPM model I developed. Columns A through G are fairly standard PPPR Model columns following the relationship V = Q x P for both the base and review periods. The change ratios (Columns H, I, and J) are also standard PPPR Model columns with some slight variations. The individual output or input rows are obtained by simply dividing review period value, quantity, or price by their corresponding data in the base period. The variations deal with how average changes in quantity and price are computed for all outputs and all inputs. Most PPPR Model versions use base period price-weighted (Laspeyres) average quantity change ratio and review period quantity-weighted (Paasche) average price change ratio for both outputs and inputs. The latest REALST version (3.0) follows the same convention for outputs but uses review period price-weighted (Paasche) quantity change average ratio and base period quantity-weighted (Laspeyres) average price change ratio for inputs. This is done to avoid the possibility of having conflicting signals from performance change ratios and the dollar effects of the performance changes. I shall show an example of this issue later in this chapter and also show the mathematical derivations in the Appendix.

Columns K, L, and M are performance indices portrayed in the APQC and VPC versions. The Productivity Indices Model shows only column L as it is not concerned with portraying profitability or price recovery. Gollop's version and REALST also portray only the productivity indices while Miller does not show any indices although all three portray the dollar effects of profitability, productivity, and price recovery changes. The indices are simply obtained by dividing the average change ratios of the output value, quantity, and price by each corresponding input change ratio including the average input change ratio for all inputs.

Columns N, O, and P have not been portrayed in any previous versions. I decided to portray these columns to facilitate understanding of the meaning of Columns Q, R, and S, and reconcile the change in absolute profits from the base period to the review period with the dollar effects of the performance changes. Columns N, O, and P represent what should have been the values or total costs, quantities, and unit costs of the inputs had they changed in direct proportion to the change in overall average revenues, quantities, and prices of outputs, respectively. This is similar to the concept of a flexible budget in standard cost accounting. The only difference is that standard cost accounting uses standard unit costs (as in base period unit costs) instead of projecting what the unit costs should be in direct proportion to the average change in output price. For example, total average quantity of output increased by 13%; therefore, input quantities are also expected to increase by 13% of their quantities in the base period. The implied assumption is that productivity remains constant from the base period to the review period. The same assumption is made for price recovery. Therefore, the change in profit from the base period to this hypothetical period (which is $37.86 for the example in Table 8.4) represents the change in profit due to the change in operating level or production volume.

Table 8.4: The Teaching TFPM Model in Spreadsheet Format

	Base Period Data			*Review Period Data*			*Change Ratios*		
A	B	C	D	E	F	G	H=E/B	I=F/C	J=G/D
	Vo ($)	**Qo**	**Po ($)**	**Vn ($)**	**Qn**	**Pn ($)**	**Δ V**	**Δ Q**	**Δ P**
Output1	1,000	200	5.00	1,000	250	4.00	1.000	1.250	0.800
Output2	2,200	200	11.00	2,805.75	215	13.05	1.275	1.075	1.186
Total	3,200			3,805.75			1.189	1.130	1.05277
Labor	800	80	10.00	960.00	80	12.00	1.200	1.000	1.200
Mat'ls	320	80	4.00	400.00	100	4.00	1.250	1.250	1.000
Energy	60	1200	0.05	65.00	1300	0.05	1.083	1.083	1.000
Capital	1,820	500	3.64	1,820	500	3.64	1.000	1.000	1.000
Total	3,000			3,245			1.082	1.027	1.053
Profit	200			560.75			360.75		

	Performance Indices			*Constant Performance Data*			*Dollar Effects of Changes*		
	K =ΣHo/Hi	L =ΣIo/Ii	M =ΣJo/Ji	N =O*P	O =C*ΣIo	P =D*ΣJo	Q =R+S	R = (O-F)G	S =O(P-G)
	ΔProf	**ΔProd**	**ΔPR**	**$Vnpr**	**Qnp**	**Pnr ($)**	**ΔProf**	**ΔProd**	**ΔPR**
Labor	0.991	1.130	0.877	951.44	90.38	10.53	-8.56	124.50	-133.06
Mat'ls	0.951	0.904	1.053	380.58	90.38	4.21	-19.42	-38.50	19.08
Energy	1.098	1.043	1.053	71.36	1,355.63	0.05	6.36	2.78	3.58
Capital	1.189	1.130	1.053	2,164.52	564.84	3.83	344.52	236.03	108.49
Total	1.100	1.100	0.99946	3,567.89			322.89	324.81	-1.92
Profit				237.86			37.8594		

Change in Profit From Base Period to Review Period Due to Changes in Performance + Changes in Operating Level or Production Volume 360.75

The variances between the corresponding data of this "flexible budget" (Columns N, O, and P) and the actual data for the review period represent the changes in performance and are used in computing the dollar effects shown in Columns Q, R, and S. Column R: the dollar effects due to changes in productivity, is the difference between what input quantity should have been used had productivity remained constant (Column O) and the actual quantity used (Column F), multiplied by the actual unit cost of that input during the review period (Column G). The APQC, VPC, and Gollop's versions of TFPM use the base period unit costs to compute the dollar effects of productivity changes while REALST uses the current or review period unit costs. Since users need to know what the performance changes are costing them now and not what it would have cost them in the base period, I used the current period unit costs.

The dollar effects of price recovery changes are computed by multiplying the difference between what the unit costs should have been had price recovery remained constant from the base period to the review period (Column P), and the actual unit cost in the review period (Column G), by the input quantity that should have been used had productivity remained constant (Column O).

Column Q: the dollar effects of changes in profitability is the sum of the dollar effects of changes in productivity (Column R) and changes in price recovery (Column S). The total of the dollar effects of changes in profitability over all the factors represent the total dollar effects of all changes, which is also the difference in profits of the flexible budget and the actual profit of the review period. The sum of the total dollar effects of all changes, and the difference between profits of the flexible budget and the profit from the base period equal the difference in profits of the review period and the base period. Using the data in Table 8.4, Change in profit from the base to the flexible budget = 237.86 - 200 = \$37.86

<u>+ Total dollar effects of changes in performance = \$322.89</u>

= Change in profits from the base period to the

review period = 560.75 - 200 = \$360.75

This report format makes it easier for first-time users to understand that the dollar effects of changes in performance do not fully explain the difference between profits in the base and the review periods. This was a question I asked when I first came across TFPM and this is a question I always hear from first-time users. REALST and Gollop's versions both portray these data but not as succinctly as they are portrayed in the teaching TFPM model spreadsheet.

The next point I'll discuss is how indices and dollar effects may be portrayed in graphic form to facilitate interpretation of the results. Since indices represent relative change, trend charts would most appropriately portray them. This is especially powerful when several periods are charted as in Chapter 7. Sometimes, the relationships between profitability, productivity and price recovery, and/or between the partial-factor indices and the total-factor indices are so clear, the reader will see what is really driving profitability without any formal correlation analysis. For dollar effects, I recommend using bar charts. They portray magnitudes and signs (+ or -) of the dollar effects and even what REALST's Strategic Grids portray, i.e., where profitability changes come from: productivity or price recovery changes. They also show the contributions of partial factors to total-factor profitability, productivity, and price recovery.

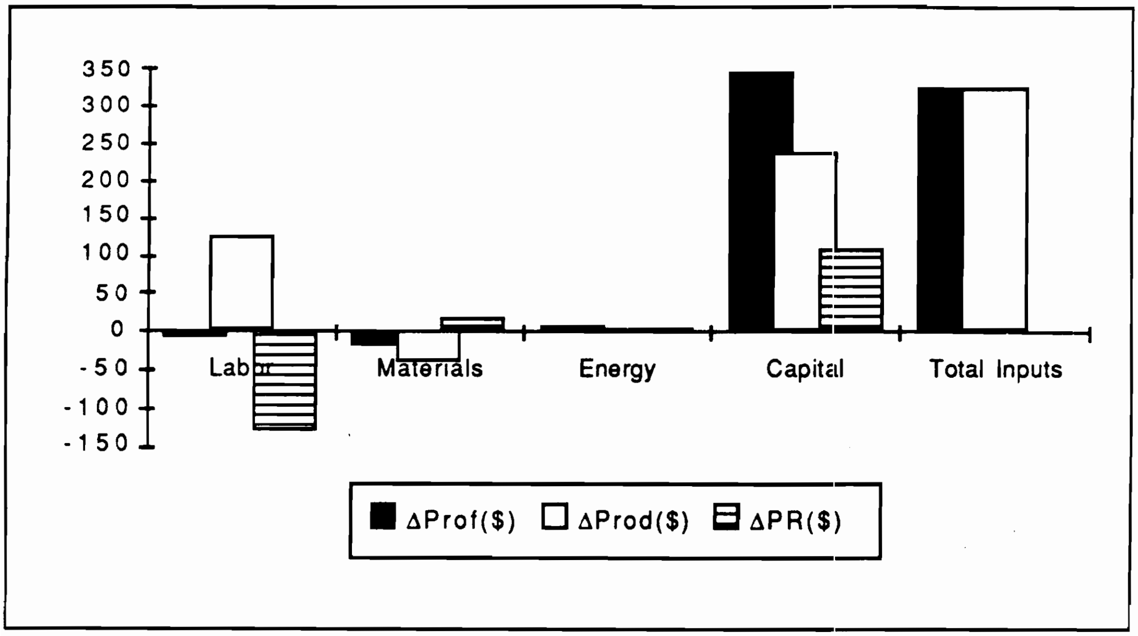

Figure 8.5: Bar Charts Show Dollar Effects of Changes in Profitability, Productivity, and Price Recovery for Partial and Total-Factors

Before evaluating the teaching TFPM model, I'd like to first explain why I decided to use REALST's combination of Laspeyres and Paasche ratios. As mentioned earlier, most PPPR Model versions use base period price-weighted (Laspeyres) average quantity change ratio and review period quantity-weighted (Paasche) average price change ratio for both outputs and inputs. The latest REALST version (3.0) follows the same convention for outputs but uses review period price-weighted (Paasche) quantity change average ratio and base period quantity-weighted (Laspeyres) average price change ratio for inputs. This is done to avoid the possibility of getting conflicting signals from performance change ratios and the dollar effects of the performance changes. Table 8.5 uses exactly the same data as in Table 8.4 but the change ratios are obtained by the usual combination of Laspeyres and Paasche ratios as in APQC's or VPC's versions. Table 8.5 shows how the total-factor price recovery index (1.001) could show an increase in price recovery but have negative dollar effects (-1.92) if the usual combination of Laspeyres and Paasche change ratios are used! This is caused by the joint or interactive effects of changes in productivity and price recovery of the partial factors.

Table 8.5: REALST and the Teaching TFPM Model Avoid the Mixed Signals Problem

	Base Period Data			*Review Period Data*			*Change Ratios*		
A	B	C	D	E	F	G	H=E/B	I=F/C	J=G/D
	Vo ($)	Qo	Po ($)	Vn ($)	Qn	Pn ($)	ΔV	ΔQ	ΔP
Output1	1,000.00	200	5.00	1,000.00	250	4.00	1.000	1.250	0.800
Output2	2,200.00	200	11.00	2,805.75	215	13.05	1.275	1.075	1.186
Total	3,200.00			3,805.75			1.189	1.130	1.05277
Labor	800.00	80	10.00	960.00	80	12.00	1.200	1.000	1.200
Mat'ls	320.00	80	4.00	400.00	100	4.00	1.250	1.250	1.000
Energy	60.00	1200	0.05	65.00	1300	0.05	1.083	1.083	1.000
Capital	1,820.00	500	3.64	1,820.00	500	3.64	1.000	1.000	1.000
Total	3,000.00			3,245.00			1.082	1.028	1.05186
Profit	200.00			560.75			360.75		

	Performance Indices			*Constant Performance Data*			*Dollar Effects of Changes*		
	K=ΣHo/Hi	L=ΣIo/Ii	M=ΣJo/Ji	N=O*P	O=C*ΣIo	P=D*ΣJo	Q=R+S	R=(O-F)G	S=O(P-G)
	ΔProf	ΔProd	ΔPR	Vnpr ($)	Qnp	Pnr ($)	ΔProf($)	ΔProd($)	ΔPR($)
Labor	0.991	1.130	0.877	951.44	90.38	10.53	-8.56	124.50	-133.06
Mat'ls	0.951	0.904	1.053	380.58	90.38	4.21	-19.42	-38.50	19.08
Energy	1.098	1.043	1.053	71.36	1,355.63	0.05	6.36	2.78	3.58
Capital	1.189	1.130	1.053	2,164.52	564.84	3.83	344.52	236.03	108.49
Total	1.100	1.099	1.001	3,567.89			322.89	324.81	-1.92
Profit				237.86			37.8594		

Change in Profit From Base Period to Review Period Due to Changes in Performance + Changes in Operating Level or Production Volume 360.75

Evaluation of Teaching TFPM Model

I evaluated the teaching TFPM Model in two ways. First, I used the same procedure for evaluating the TFPM applications to the case studies. I extended the PRFORM evaluations to include the teaching TFPM Model as one of the versions. Secondly, I compared the features and data provided by the teaching TFPM model against related literature.

PRFORM Evaluations of the Teaching Model as Applied to the Case Studies

Table 8.6 is the same as Table 8.3 except that the teaching TFPM model was added to the versions evaluated. The detailed evaluation results are shown in the Chapter Appendix.

REALST scored higher than the teaching TFPM model because of the criteria, "software supported." Otherwise, the teaching model would have scored as high if not higher than REALST. Therefore, as far as applications to the cases are concerned, the teaching TFPM model can match if not do better than REALST or any other TFPM versions.

Table 8.6: Summary of PRFORM Evaluations of Each of the Versions Applied to Each of the Cases Including the Teaching TFPM Model

Versions	Plant A	Division B	Company C	Center D
REALST	9.5	9.4	9.2	8.8
SCORBORD	8.5			8.5
Craig & Harris			5.0	
LTV		7.6		
Teaching Model	9.4	9.2	9.0	8.6

Comparison of the Teaching Model Features Against Related Literature

I shall compare the features and data provided by the teaching TFPM model against what developers of other TFPM models have prescribed as characteristics of sound productivity measurement. First, Visser and Loggerenberg (1986) have listed the following characteristics:

- provide simple and unambiguous signals to improve profit
- break down change in profit into the underlying contributions from each resource used in production
- break down the contribution to profit change from each resource into a productivity term and a price recovery term to isolate the effect of disparate change in product price vis-a-vis resource price
- break down the productivity term into a capacity utilization and an efficiency term
- use the price recovery term to evaluate whether productivity loss or productivity gain for a given resource is appropriate
- transform the above measures for change in profit into corresponding measures for change in profitability, change in cost per unit of output, and change in performance index numbers
- provide consistent signals for profit improvement regardless of the units in which the measure is expressed

Except for breaking down productivity into capacity utilization and efficiency, and measuring change in cost per unit of output, the teaching TFPM model has all these characteristics. As explained earlier, I believe the breakdown of productivity into capacity utilization and efficiency should be an advanced feature for advanced users so it does not cloud the analysis of profitability into productivity and price recovery; while change in cost per unit of output is usually provided by accounting systems.

The American Productivity and Quality Center (APQC, 1989) in their workshop entitled, "How To Measure Productivity in Your Organization," discusses the following characteristics of a good Total Productivity Measurement System:

- provide productivity trends
- express productivity ratios in dollar terms with care to adjust for inflation
- different items do not inflate at the same rate, thus separate adjustment is required
- complex dollar-based productivity ratios are best used for diagnosis and long-range planning purposes at higher levels of the organization
- there is a middle ground screening and reporting motive with still different characteristics
- use of total productivity for long-range planning emphasizes the distinction between productivity and profitability
- the core productive process is expressed in physical quantities of controllable inputs and outputs (productivity)
- financial analysis is expressed in dollar values of revenue and expense (profitability)
- price recovery puts prices on quantities or removes price effects from values

The teaching TFPM model conforms with all these characteristics of a good total productivity measurement system.

Miller (1988) suggests that understanding and explaining the basic processes of productivity measurement should be one of the major thrusts of productivity measurement research. I believe my research and its output - teaching TFPM model - is right in line with what Miller suggests and that the teaching model will in fact help in the understanding of the basic processes in Total-Factor Productivity Measurement. I have not come across any literature that prescribed anything contrary to what the teaching TFPM model does.

Chapter Appendix

This Chapter Appendix presents all the details of the PRFORM evaluations.

PRFORM Evaluations

Table 8.7 presents the weighted information needs of the first case study on Plant A as the evaluation criteria. Each criterion is addressed by attributes and sub-attributes which are either TFPM version features or organizational requirements that need to be fulfilled by the TFPM application. The first criterion is to provide an overall measure of performance to show the impact of all improvement efforts. This criterion is addressed by TFPM features providing performance indices and dollar effects of the changes in performance. How well the features provide the information needed is discussed in the next section on transformation curves.

The second criterion/information need is to provide measures for units within the firm and ascertaining their contributions to overall firm performance, as well as the effects of work-in-progress (WIP). This information need can be addressed by the TFPM capability for aggregating measures of units within a firm to the firm level measures. Some organizational conditions that affect an application's appropriateness deal with the level of detail in matching outputs with the corresponding inputs which are affected by WIP, the period length, and the choice of the base period. This issue was discussed in detail in Chapter 4.

The third information need is to provide partial measures which are addressed by the level of detail in measuring inputs and outputs and the treatment of capital. By level of detail in outputs and inputs, I mean the number of levels inputs and outputs are aggregated. For example, if inputs are classified and aggregated as labor, materials, energy, and capital, there is only one level of detail. A second level is added if say, labor is broken down into management, direct, and indirect labor. Treatment of capital is subdivided into two attributes, inclusion of capital input and if capital is not included, the attribute asks the question, were there any changes in capital resources between the base and review periods? This will be made clearer in the explanation of the corresponding transformation curve.

The fourth information need is use for planning. The basic question here is, to what extent can the TFPM version being evaluated be used for planning purposes? The fifth information need deals with analysis of performance by product or product lines. The question here is, can the TFPM version be used to analyze performance by product? The sixth criterion deals with the number of features or data generated by the version that is not used in the application to address information needs. Finally, the last criterion deals mainly with the availability of software support for the TFPM version.

The number to the right of the TFPM version is the weighted average score. Raw scores are adjusted using the transformation curves which will be discussed later in this Chapter Appendix.

Table 8.7: PRFORM Evaluation of the TFPM Versions/Applications for Plant A

Memory: 342K		SCORBORD	8.5	REALST	9.5	Teaching Model	9.4
Description	Weight	Raw	Adjust	Raw	Adjust	Raw	Adjust
Performance Measure	20		7.5		10.0		10.0
Performance Indices	50	2.00	10.0	2.00	10.0	2.00	10.0
$ Effects Portrayal	50	1.00	5.0	3.00	10.0	3.00	10.0
Measure Dep'ts./WIP	18		6.5		9.2		9.2
Aggregation	54	1.00	5.0	2.00	10.0	2.00	10.0
Level of Detail	46		8.4		8.4		8.4
Input/Output Matching	36	2.00	10.0	2.00	10.0	2.00	10.0
Base Period Choice	33	1.00	5.0	1.00	5.0	1.00	5.0
Period Length	31	3.00	10.0	3.00	10.0	3.00	10.0
Partial Measures	17		10.0		10.0		10.0
Level of Detail	50	2.00	10.0	2.00	10.0	2.00	10.0
Treatment of Capital	50		10.0		10.0		10.0
Include Capital Input	50	1.00	10.0	1.00	10.0	1.00	10.0
No Capital Input	50	0.00	10.0	0.00	10.0	0.00	10.0
Use for Planning	15	1.00	10.0	1.00	10.0	1.00	10.0
Analysis by Product	10	1.00	10.0	1.00	10.0	1.00	10.0
Unused Data/Features	10	2.00	6.7	2.00	6.7	0.00	10.0
Software Supported	10	1.00	10.0	1.00	10.0	0.00	5.0

Table 8.8 is the PRFORM Evaluation for Division B TFPM version/applications. Except for the change in the weights of the criteria which is determined by the users and the addition of the sub-attribute dealing with how indirect costs are allocated, the attributes in each criterion are the same as in Table 8.7.

Table 8.8: PRFORM Evaluation of the TFPM Versions/Applications for Division B

Memory: 342K		REALST	9.6	LTV	7.6	Teaching Model	9.2
Description	Weight	Raw	Adjust	Raw	Adjust	Raw	Adjust
Measure Dep'ts./WIP	25		9.2		5.5		9.2
Level of Detail	63		8.7		8.7		8.7
Indirect Costs Alloc	27	0.50	5.0	0.50	5.0	0.50	5.0
Input/Output Matching	27	2.00	10.0	2.00	10.0	2.00	10.0
Base Period Choice	24	2.00	10.0	2.00	10.0	2.00	10.0
Period Length	23	3.00	10.0	3.00	10.0	3.00	10.0
Aggregation	37	2.00	10.0	0.00	0.0	2.00	10.0
Use for Planning	25	1.00	10.0	0.50	5.0	1.00	10.0
Performance Measure	13		10.0		10.0		10.0
$ Effects Portrayal	50	3.00	10.0	3.00	10.0	3.00	10.0
Performance Indices	50	2.00	10.0	2.00	10.0	2.00	10.0
Unused Data/Features	13	1.00	8.3	0.00	10.0	0.00	10.0
Partial Measures	13		10.0		10.0		10.0
Level of Detail	50	2.00	10.0	2.00	10.0	2.00	10.0
Treatment of Capital	50		10.0		10.0		10.0
Include Capital Input	50	1.00	10.0	1.00	10.0	1.00	10.0
No Capital Input	50	0.00	10.0	0.00	10.0	0.00	10.0
Software Supported	13	1.00	10.0	1.00	10.0	0.00	5.0

Table 8.9 is very similar to Table 8.7 except for the weights of the criteria.

Table 8.9: PRFORM Evaluation of the TFPM Versions/Applications for Company C

Memory: 343K		REALST	9.2	Craig & Harris	5.0	Teaching Model	9.0
Description	Weight	Raw	Adjust	Raw	Adjust	Raw	Adjust
Performance Measure	23		10.0		2.5		10.0
$ Effects Portrayal	50	3.00	10.0	0.00	0.0	3.00	10.0
Performance Indices	50	2.00	10.0	1.00	5.0	2.00	10.0
Measure Dep'ts./WIP	18		10.0		7.1		10.0
Level of Detail	71		10.0		10.0		10.0
Base Period Choice	43	2.00	10.0	2.00	10.0	2.00	10.0
Period Length	40	1.00	10.0	1.00	10.0	1.00	10.0
Input/Output Matching	17	2.00	10.0	2.00	10.0	2.00	10.0
Aggregation	29	2.00	10.0	0.00	0.0	2.00	10.0
Partial Measures	18		7.5		7.5		7.5
Level of Detail	50	3.00	5.0	3.00	5.0	3.00	5.0
Treatment of Capital	50		10.0		10.0		10.0
Include Capital Input	50	1.00	10.0	1.00	10.0	1.00	10.0
No Capital Input	50	0.00	10.0	0.00	10.0	0.00	10.0
Use for Planning	17	1.00	10.0	0.00	0.0	1.00	10.0
Unused Data/Features	11	2.00	6.7	0.00	10.0	0.00	10.0
Software Supported	11	1.00	10.0	0.00	5.0	0.00	5.0

Table 8.10 is also very similar to Table 8.7 except for the number of criteria and the weights of the criteria.

Table 8.10: PRFORM Evaluation of the TFPM Versions/Applications for Center D

Memory: 344K		SCORBORD	8.5	REALST	8.8	Teaching Model	8.6
Description	Weight	Raw	Adjust	Raw	Adjust	Raw	Adjust
Partial Measures	29		7.6		7.6		7.6
Level of Detail	49	1.00	5.0	1.00	5.0	1.00	5.0
Include Capital Input	26	1.00	10.0	1.00	10.0	1.00	10.0
No Capital Input	26	0.00	10.0	0.00	10.0	0.00	10.0
Use for Planning	29	1.00	10.0	1.00	10.0	1.00	10.0
Performance Measure	14		7.5		10.0		10.0
$ Effects Portrayal	50	1.00	5.0	3.00	10.0	3.00	10.0
Performance Indices	50	2.00	10.0	2.00	10.0	2.00	10.0
Unused Data/Features	14	2.00	6.7	2.00	6.7	0.00	10.0
Software Supported	14	1.00	10.0	1.00	10.0	0.00	5.0

Transformation Curves Used in the PRFORM Evaluations

Two transformation curves were shown and described earlier in Figures 8.2 and 8.3. The rest of the transformation curves are shown and described in the following paragraphs. In all the transformation curves, the worst possible condition is given a PRFORM equivalent or adjusted score of 0, the acceptable level is given an equivalent of 5, and the best possible condition is given an equivalent of 10. Some other points may also be given PRFORM equivalent scores.

Figure 8.6 shows that an application not portraying any performance indices is unacceptable and thus receives an equivalent rating of zero. The minimum acceptable level (with an equivalent rating of 5) should at least portray productivity indices while the best application should portray both productivity and price recovery indices (an equivalent rating of 10). This transformation curve evaluates how a TFPM version satisfies the user information need for physical measures related to financial measures.

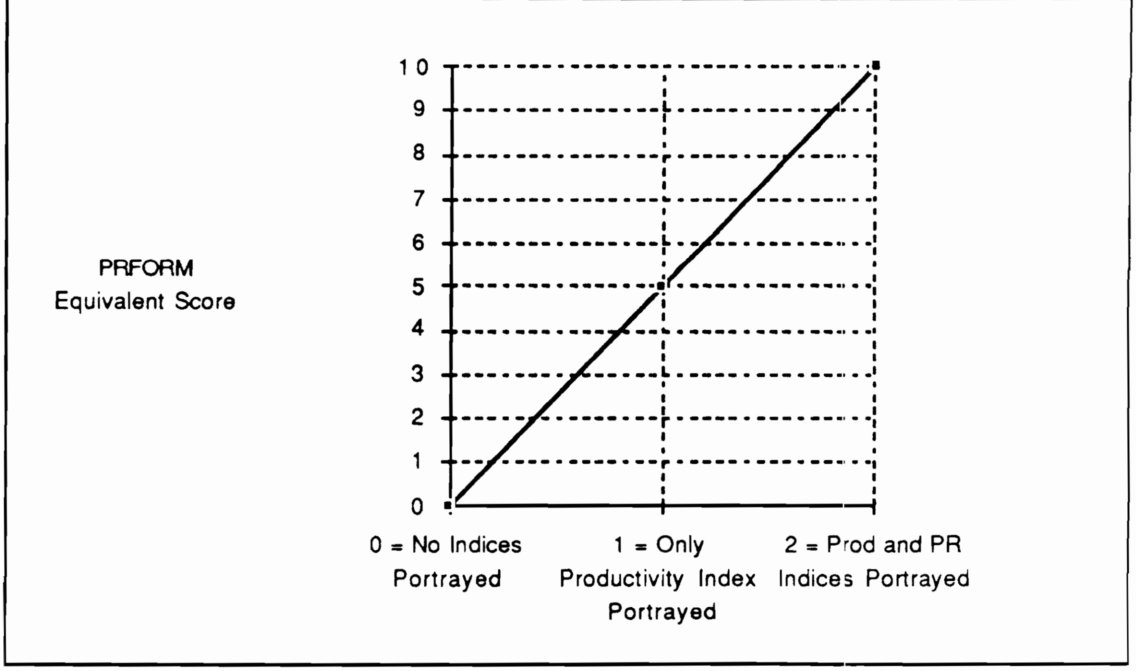

Figure 8.6: Performance Indices Transformation Curve

Figure 8.7 rates an application's capability to aggregate measures for dependent and independent units within a firm to the firm level measures. Dependent units use the output of one unit as an input for the other; independent units don't. The acceptable level is for a TFPM version to be able to aggregate independent units and best if it can aggregate both independent and dependent units. This transformation curve evaluates a TFPM version's capability to provide information regarding units within a firm in relation to the firm's overall performance.

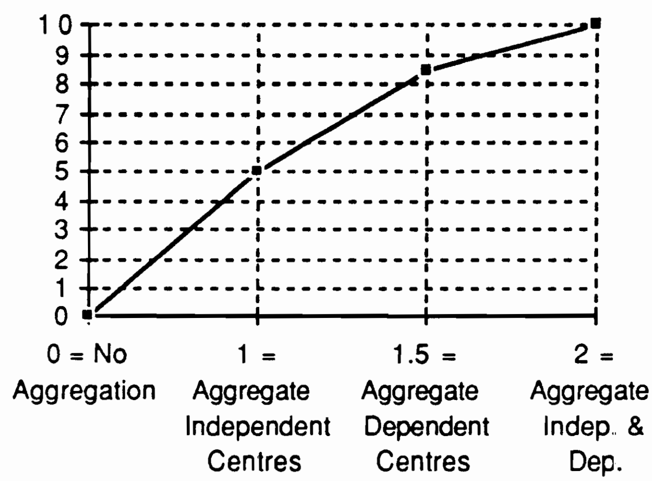

Figure 8.7: Aggregation Feature Transformation Curve

Figure 8.8 rates an application's being able to represent operational conditions when production cycle time is long. If the period length used is short, the outputs for the period being reviewed may not have been produced from the inputs used in that period. Hence, to match outputs with their corresponding inputs, there may be a need to trace back what inputs were actually used to produce the outputs for the period in review. However, as explained in Chapter 4, this is a very tedious process, and then again, the inputs used to produce the outputs of the review period may not have been actually consumed in that period. Hence, the desired alternative is to be able to use period lengths so that it will be possible to just take snapshots of all outputs and inputs within that period and still safely assume that those inputs and outputs represent a fairly accurate matching.

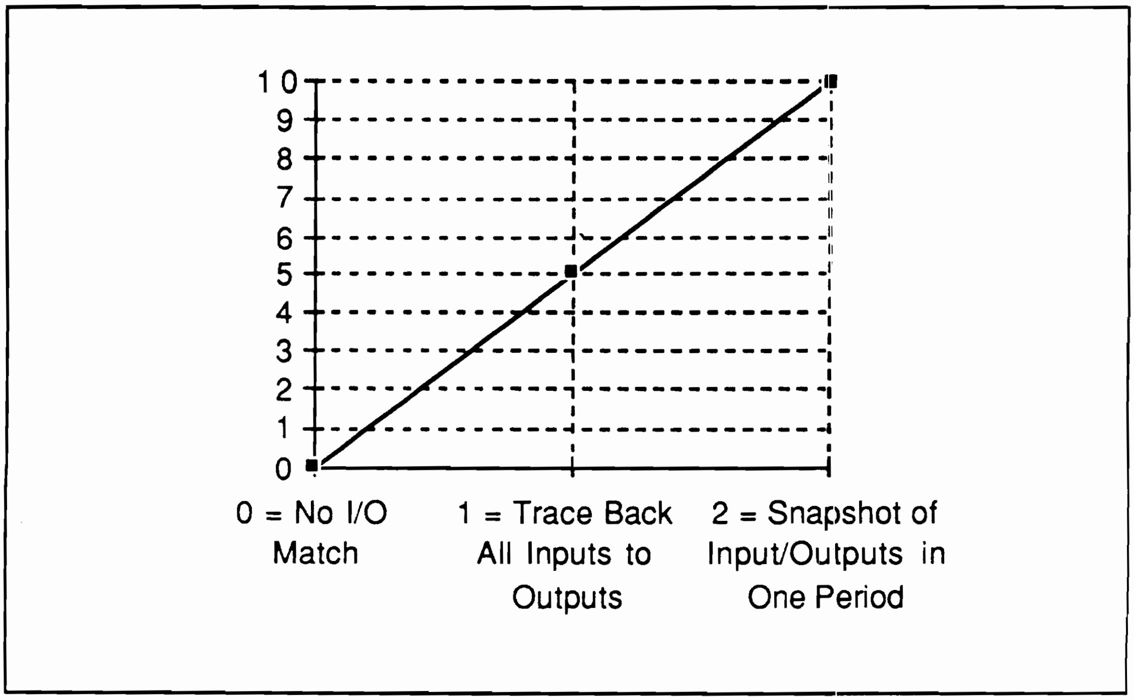

Figure 8.8: Input / Output Matching Transformation Curve

Figure 8.9 rates the application's choice of base period. The acceptable base period is the budget for the period being reviewed. The better base period is a period representing the typical performance of the firm so as to assess whether the firm is improving or not. This transformation curve is based on what the literature prescribes as the better choice for base periods assuming the main purpose of measurement is to support improvement efforts.

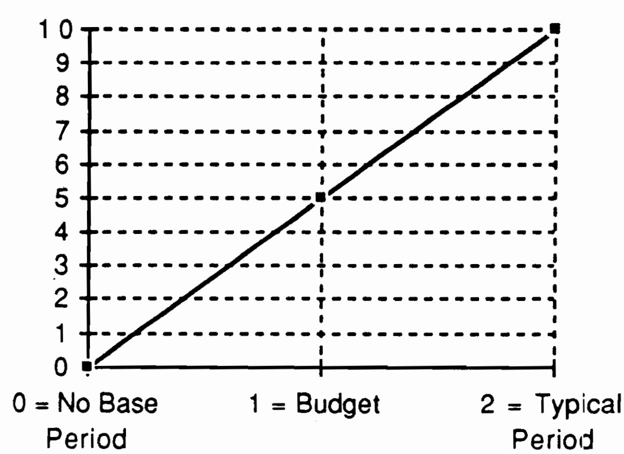

Figure 8.9: Choice of Base Period Transformation Curve

Figure 8.10 rates the level of detail of a TFPM application. According to the literature and my interviews with experts in the field who have had experiences in developing TFPM applications such as Thor, Dhir, and Parsons, TFPM should stay macro but also provide enough details to be able to pinpoint improvement opportunities; hence, the following transformation curve strikes a balance between being too aggregated and being too detailed as to count nuts and bolts or pennies and nickels.

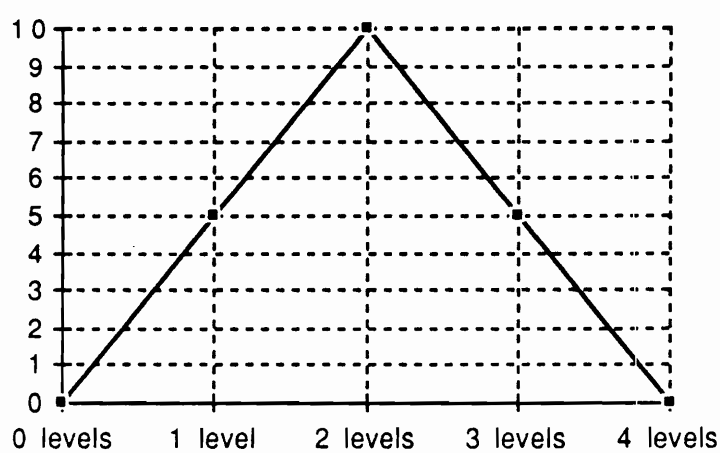

Figure 8.10: Level of Detail Transformation Curve

The next two figures rate the inclusion of capital and how it may affect the information from the TFPM application. Figure 8.11 shows it is best to include capital input; however, Figure 8.12 assumes that if there are no changes in capital input from the base period to the review period, there may be no problem excluding capital as an input. Figure 8.12 penalizes an application if capital input is not included and there is a significant change in capitalization from the base period to the review period.

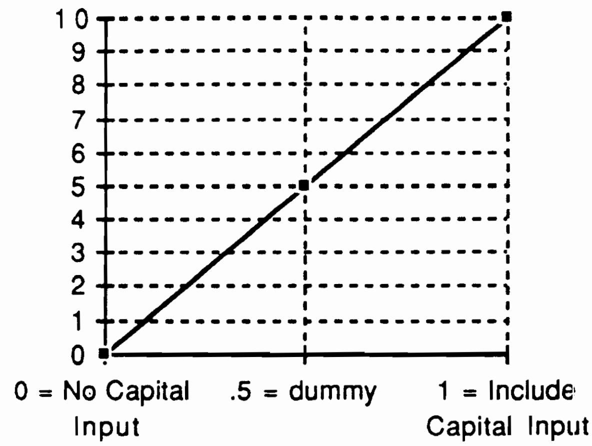

Figure 8.11: Inclusion of Capital Input Transformation Curve

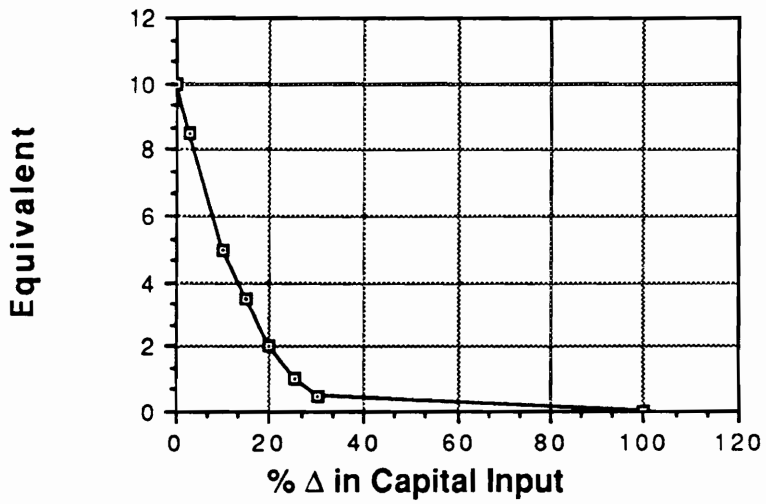

Figure 8.12: Capital Investment Change Transformation Curve

Figure 8.13 assumes that for consistency in definition of productivity, output/input ratio should be used for computing for challenge budgets instead of what LTV uses: cost to sales ratio.

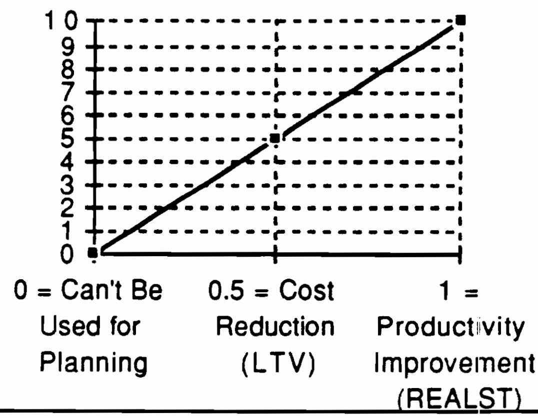

Figure 8.13: Use for Planning Transformation Curve

The transformation curve on Figure 8.14 rates a TFPM version's capability of analyzing by product. A TFPM version can either do it or not, hence, a 0 or 10 equivalent score.

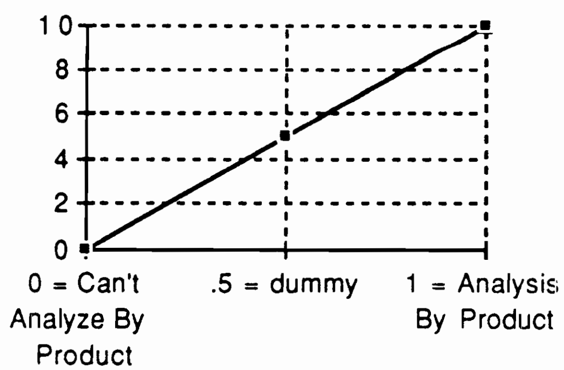

Figure 8.14: Analysis By Product Transformation Curve

The following transformation curve rates the "fog index" of a TFPM version, i.e. the more unused data or features a version has, the lower its PRFORM equivalent score. Features or data that are presented but not needed by users only confuse or complicate matters.

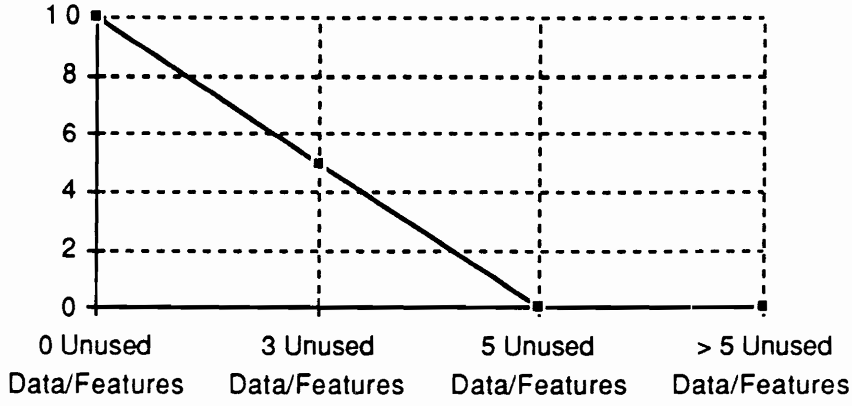

Figure 8.15: Unused Data / Features Transformation Curve

The next transformation curve shows it is acceptable for a TFPM version not to have software support although it is best if software is available.

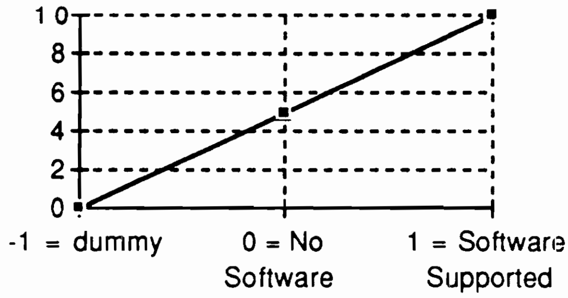

Figure 8.16: Software Support Transformation Curve

The next transformation curve shows it is best for Company C for the period length to be one month instead of 3 months. Company C wants to use TFPM for making adjustments to correct and/or improve operations. They feel one month is long enough for their type of business to assess performance and take appropriate actions. Up to one year period length is still acceptable but beyond that, the data/information is useless to them. This transformation curve is based on organizational conditions.

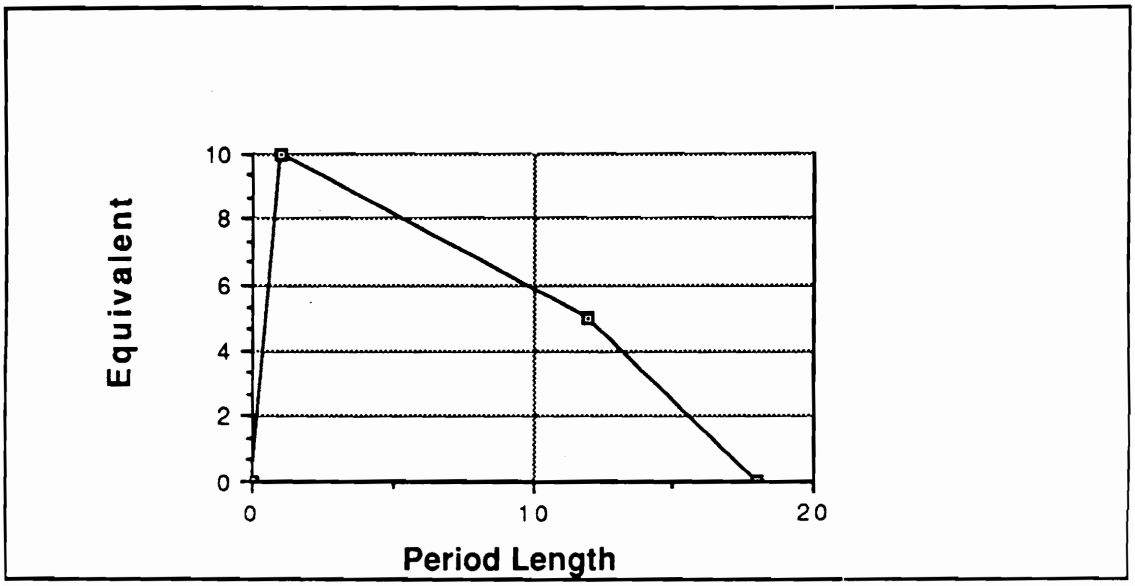

Figure 8.17: Company C Period Length Transformation Curve

The last transformation curve evaluates the method of allocating indirect and overhead costs. It is deemed unacceptable for indirect costs to just be allocated evenly into the various organizational uinits. It is acceptable allocated indirect costs based on output levels and/or direct resource consumption, and best if allocation is activity based as defined in Chapter 5.

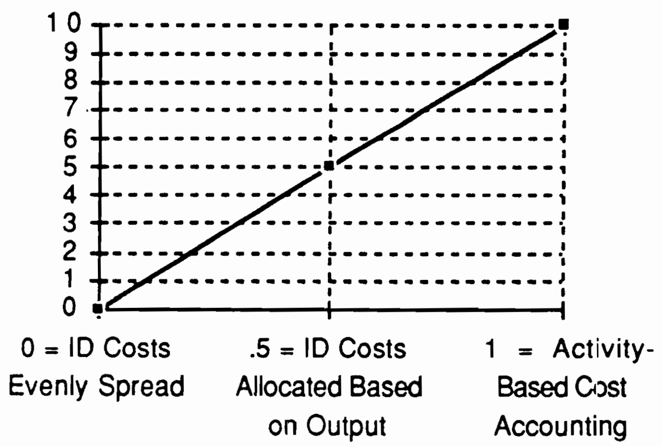

Figure 8.18: Indirect Costs Allocation Transformation Curve

As mentioned in Chapter 2, I defined all these transformation curves based on prescriptions from the literature, user information needs, and/or organizational conditions that TFPM applications have to satisfy. The same transformation curves were used across all cases whenever they were applicable.

This chapter presents the results of my research and describes how those results were obtained. These results are summarized in the following chapter.

Chapter 9: Conclusions, Lessons Learned, and Further Research Directions

One of the major concerns in the world today is the ever increasing, spiralling prices of goods and services - inflation. This is brought about by the traditional way of doing business by simply passing on the costs of production/operations, plus a profit margin (usually determined by what the market can bear), to customers. We call this business strategy - price recovery. With the business environment becoming increasingly competitive on a global scale, this business strategy has been challenged. World-class competitiveness has usually been characterized by better and yet relatively lower priced goods and services. World-class competitors are able to produce more and better goods and services with relatively less resources, i.e., they use productivity improvement rather than price recovery as a business strategy. Hence, it has become a necessity for firms to be more productive to survive and compete rather than rely on price recovery.

The scenario I just described implies that firms also need to modify the way they measure their performance. Instead of just measuring profitability, which may be driven mostly by price recovery, there is a need to know whether a firm is able to produce more and/or better products and services with relatively less resources (improving productivity) to be competitive. And yet, productivity measurement methods, such as Total-Factor Productivity Measurement (TFPM), are still underutilized.

As early as the 40's and 50's, accountants, economists, statisticians, and engineers realized the need to measure productivity. This resulted in the development of the earlier Productivity Indices Model. I believe this model did not gain wide acceptance because it failed to relate productivity directly with profitability. Managers found themselves with two independent measures that they could not easily integrate to fully explain changes in their performance. This situation was later remedied in the late 70's with the introduction of the Profitability = Productivity + Price Recovery (PPPR) Model by the American Productivity (and Quality) Center. Since then, at least five other versions have been developed to respond to particular needs from different applications. My observation is that most of the later versions have become too complex for managers and finance executives to easily understand and use as a management tool for decision making. Hence, my research focused on understanding and explaining the different versions presently available, determining the common information needs of managers regarding performance improvement, and developing a simple teaching TFPM model for first-time users.

The research combined various research methods. To understand and explain the features and differences of the various TFPM versions, I reviewed the literature, interviewed experts, and worked on hypothetical examples. These are described in detail in Chapter 3 and will be summarized in this chapter as alternative ways of responding to the information needs identified in the case studies I documented (Chapters 4-7). I used the case studies to identify common user information needs and evaluate alternative ways of providing the needed information. Evaluations of the applicability, usefulness, and/or appropriateness of the different versions to the cases were done using Archer's (1978) Design Process as implemented using VPC's Multi-Criteria Performance Measurement Technique software (PRFORM, 1990). An evaluation function, represented by a transformation curve, evaluates to what extent each feature of a version helps provide the information needs of the user. This evaluation process has been described in detail in Chapters 2 and 8.

Then, I developed a simple teaching TFPM model to provide the common information needs identified in Chapter 8, incorporating the features from the available versions that best provided for particular information needs. This teaching TFPM model was also evaluated using the same process used to evaluate the presently available versions as applied to the cases. It was also evaluated against prescriptions from related literature.

Common Information Needs

Information needs identified in each of the cases were given weights by the managers who identified them according to their importance in decision making. The weights were tabulated across all cases and the information needs with the highest total weights were taken as the common information needs. The result was that four categories of information needs were weighted heavily in all four cases, and only two others received lower weights as they were identified as information needs in only one or two cases. The four common information needs were compared with information needs identified in two previous surveys.

The first information need identified was use for planning, either in terms of evaluating budgets or strategic options, generating challenge budgets, improving resource allocation, or responding to fluctuations in the environment. This information need was also identified in all four cases and received 25% of the total weights. Strategic planning for future options and budget testing were cited by 33% and 30% of the APC/UCCEL survey respondents, respectively, while Steedle's survey also cited this information as a reason for productivity measurement. The second common information need was a measure of past overall performance to know if the firm is improving and to assess the impact of improvement efforts to profitability. This information need was identified in all four case studies and received 24% of the total weights. It was also identified as the main purpose for productivity measurement in two recent surveys: APC/UCCEL (81% of all respondents, 1985) and a survey of 1000 controllers (Steedle, 1988). The third information need identified in three of the four cases was measuring the performance of units within a firm and ascertaining their contribution to the overall performance of the firm. This received 21% of the total weights but unlike the first two information needs, it was not cited in the two previous surveys. The fourth and last common information need identified in the cases (21% of total weights) was determining the contribution of partial factors (labor, material, energy, capital, data and information) to total-factor productivity. This information need is related to what 46% of the respondents to the APC/UCCEL survey cited as screening current performance and what Steedle's survey cites as the problem analysis purpose of productivity measurement.

Other information needs identified in the cases were productivity analysis by product (2%) and basis for gainsharing (6%). Analysis by product can be considered a special case of measuring units within a firm and ascertaining their contribution to total firm performance. Measuring past productivity performance, relating productivity to profitability, and measuring the contribution of partial factors to total-factor productivity could provide a basis for gainsharing.

An important concern I observed in all the case studies was the need to integrate TFPM with the existing systems in the organizations. This concern serves many purposes. First, it deals with initially designing the TFPM application using data stored in existing data bases. Since TFPM is suited mainly for plant and firm levels, this concern was not a problem with the four cases I worked on. Most of the data were available in some form or another and with minor processing could be used for TFPM. This facilitated TFPM development as people did not feel burdened by a new system. Secondly, I saw evidence of Loggerenberg's (1989) claim that productivity tracking is facilitated when measures of productivity change are directly related to an operationally familiar measure such as profitability.

There is a need though to guard against the perception that TFPM duplicates existing systems without adding new data or information. Some accountants think TFPM duplicates Activity-Based Cost (ABC) Accounting or Standard Cost Accounting information. I explained in one case study (Chapter 5) that ABC Accounting improves the allocation of indirect and overhead costs. By identifying what activities indirect and overhead costs should be charged to, instead of the usual allocation of indirect and overhead costs proportional to direct labor and material costs, better product or activity costing is achieved. ABC Accounting will, therefore, make TFPM data more accurate, but will still not be able to measure productivity and price recovery and relate them to profitability. Standard Cost Accounting, on the other hand, explains variances of actual costs against a flexible budget based on standard costs. It is an efficiency measure in the sense that it portrays the difference between actual resources consumed against the expected resource consumption. It stops at explaining changes in costs. As shown in Chapter 6, it is similar to one of the optional reports generated by the REALST software, analyzing and reconciling changes in costs.

These common information needs and issues are what I used to develop and evaluate the teaching TFPM model. But first, I'll discuss the main features and differences of the available versions as related to the common information needs.

Main Features and Differences of Each TFPM Version

There are two basic models of TFPM: the Productivity Indices (PI) Model and the Profitability = Productivity + Price Recovery (PPPR) Model. Gollop's Model, which I originally thought was a different model because of how it was developed, proved to be operationally equivalent to the PPPR model. The PI model uses base period price or price index-weighted quantity (Laspeyres) indices to remove the effects of price changes thereby obtaining Productivity Indices. The PPPR model isolates but does not completely remove the effects of price changes. These price changes of outputs and inputs are measured as price recovery and used to relate productivity to profitability. By using a combination of base period price or price index-weighted quantity (Laspeyres) indices and current period quantity-weighted price (Paasche) indices (except for Miller's version which uses cumulative deflation), the following relationships are obtained:

ΔOutput Value or Revenue = ΔOutput Quantity X ΔOutput Price, and (9.1)

ΔInput Value or Costs = ΔInput Quantity X ΔInput Cost (9.2)

Dividing the first equation (9.1) by the second (9.2), the following equation is obtained:

Profitability Index = Productivity Index X Price Recovery Index.

The PPPR model also computes the dollar effects of changes in productivity, price recovery, and profitability. These dollar effects are related in the following manner:

ΔProfitability ($) = ΔProductivity ($) + ΔPrice Recovery ($)

REALST goes further to relate the dollar effects of changes in profitability to the absolute or arithmetic difference between profits in the base period and profits in the current period, i.e., ΔProfits = ΔProfitability ($) + Δ Level of Activity or Production ($).

What I've just described constitute the first set of features of TFPM versions. These features address the second common information need for a measure of overall past performance to know if the firm is improving by computing profitability, productivity, and price recovery indices; and to assess the impact of improvement efforts to profitability by computing the dollar effects of the changes in performance.

The second set of features deals with how TFPM may be used for planning, either in terms of evaluating budgets or strategic options, generating challenge budgets, improving resource allocation, or responding to fluctuations in the environment.. All versions may be used to evaluate plans by using budget data for the current or review period and using past actual performance as base period data. LTV and REALST both have a feature that computes a "macro challenge budget" given sales forecasts and prices, productivity improvement targets, and projected changes in resource costs. The difference between the two methods is that LTV uses cost to sales ratio as a substitute for productivity improvement target since LTV managers are more used to the concept of cost to sales ratio rather than productivity change. Of course, this challenge budget feature is something that can be added on to any of the versions.

The third set of features deals with measuring performance of departments, plants, or product lines and relating or aggregating those measures to the division or firm level measures. Gollop's model and REALST both have a way of aggregating dependent organizational units, i.e., outputs of one unit become inputs of another. REALST also aggregates measures for independent units of analysis. John Parsons, Director of Finance and Economics of the National Productivity Institute in South Africa, who has been teaching and developing REALST applications worldwide warns that applications dealing with aggregation of multiple units should not be attempted until users are very familiar with TFPM concepts and operational use. Aggregation of multiple units deal with relating measures of one organizational level with the next higher of lower level. Before attempting to do this, users should first become familiar with the TFPM application and data interpretation to information for one level.

Sumanth computes productivity by product; total firm productivity is the weighted average of the product productivities. He also computes what productivity level will correspond to profit breakeven point. This model is very powerful when product cost data are very accurate. However, cost accounting literature admits that most cost accounting systems have not yet been developed to the point of accurately allocating indirect and overhead costs. This is the reason why ABC Accounting is gaining popularity as it seeks to remedy this situation. Berliner and Brimson (1988) also advocate better product costing. This is why I believe Sumanth's version may be more useful when cost accounting systems are better developed to reflect more accurate product costs. When an organization reaches that stage though, any of the PPPR model versions may be used to measure productivity, price recovery, and profitability by product. Firm measures can be developed as an aggregate measure of product measures.

The fourth set of features deals with partial productivity measures. All the models and versions calculate partial productivity measures and relate them or show their contribution to the total-factor productivity measure. The difference in the versions is how they treat capital input. Davis and Kendrick and Creamer advocate the use of book value for capital assets. Craig and Harris, Sumanth, and APQC recommend the use of lease value. REALST uses the return on investment (ROI) as the capital input. Sink (1985) argues that capital input need not always be one of the inputs. I believe that for initial implementation of TFPM, whatever method is used by the accountants of a firm to treat capital expense should be used for TFPM. Treatment of capital expense or the availability of capital expense data did not really become a major issue in any of the case studies. The more critical issue is the understanding and acceptance of TFPM by finance and accounting people in a firm as they are critical to the successful implementation of TFPM. Therefore, it is very important to first ensure that TFPM is integrated with existing systems, particularly accounting. This also helps gain face validity for TFPM when the data from TFPM are consistent with the accounting reports.

Other features include REALST's and the Financial Productivity Measurement's (FPM) concept of resource variability. Some resources, called variable resources, vary with production volume or level of activity while others are fixed resources. The concept of resource variability enables REALST to attribute productivity changes to changes in efficiency or utilization of variable resources, capacity utilization, and use of fixed resources. REALST is also software supported along with VPC's version and FPM. Both

REALST and FPM softwares feature choices in the level of detail in reports. They also both use Strategic, Productivity, and Price Recovery Grids to portray TFPM information. Other information portrayal techniques that could be used to portray data from the reports of any version are trend charts, pie or area charts, and bar or column charts.

These features and differences are what I used in evaluating the appropriateness of each version, including the teaching TFPM model, in responding to the information needs of each of the case studies.

The Teaching TFPM Model I'm Proposing Provides for the Common Information Needs

Based on the evaluations of possible TFPM versions appropriate for each application, REALST has stood out as the most advanced and flexible version. However, these strengths are also weaknesses in the sense that they have become too complicated for first-time users and like all the other versions, REALST does not offer enough information portrayal features, except for the strategic grids and the choice of level of detail of reports. An example of an important feature of REALST is the concept of resource variability. While the concept may be critical in explaining changes contributed by fixed and variable resources, the concept muddles the basic analysis of profitability changes caused by productivity and price recovery changes. I believe simplicity is a critical factor in getting managers to understand and use TFPM. Carl Thor, President of the American Productivity and Quality Center and Shoni Dhir, a high-ranking manager at LTV, who have both extensively championed the use of TFPM in American organizations, agree that managers are still generally not too keen on even using financial and accounting data and information. Hence, the teaching TFPM model I have developed is a simplified version of REALST that incorporates some features of the other versions to facilitate understanding, usefulness, and information portrayal. It has been designed to respond to the common information needs of users.

The teaching TFPM model is actually a version of the PPPR model. It computes and portrays change ratios and performance indices in the same manner as the APQC, VPC, and REALST versions. It differs from other PPPR versions in portraying the dollar effects of performance changes. First, the teaching TFPM model presents a flexible budget, i.e., the quantities, costs, and total costs or values of inputs for the review period assuming productivity and price recovery remained constant as in the base period. This flexible budget is very similar to the Standard Cost Accounting flexible budget except that instead of using the actual unit costs in the review period, normalized unit costs directly proportional to the change in unit selling prices are used (i.e., for constant price recovery). Finance and Accounting people should easily understand this. The variance between the profits of this flexible budget and the profits from the base period can be explained by the change in level of activity or production volume. The variances between the flexible budget and the actual costs in the review period are the dollar effects of changes in profitability, productivity, and price recovery. These dollar effects are portrayed as the last three columns of the teaching TFPM model spreadsheet and are computed in the same manner as REALST, i.e., dollar effects of changes in productivity are valued at the review period unit costs, and the dollar effects of changes in price recovery are valued at the normalized review period unit costs; the dollar effects of changes in profitability is the sum of the dollar effects of changes in productivity and the dollar effects of changes in price recovery.

The teaching TFPM model, just like all the versions of the PPPR model , provides a measure of the overall past performance in terms of indices and dollar effects of changes in performance (the second common information need). The dollar effects are in terms of the value of money during the review period, so they are more indicative of the actual value of money at the time the review is done and can, therefore, be more useful for purposes such as gainsharing and planning for budgets of succeeding periods, rather than valuing the dollar effects based on the base period value of money. The teaching TFPM model provides for the first common information need as follows: it can be used to evaluate budgets by using budget data as the review period data compared with some past actual period data. If needed, a computation similar to LTV's could be done to generate challenge budgets using a productivity improvement target rather than a desired cost to sales ratio. As shown in Chapter 8, the teaching TFPM model can be used to measure units within a firm and to ascertain their contribution to the overall performance of the firm (the third common information need). It also provides for the fourth common information need by showing contributions of partial factors to total-factor productivity, price recovery, and profitability.

The PRFORM evaluations in Chapter 8 show that the teaching TFPM model has been rated as high if not higher than the other available versions of TFPM using the common information needs as the main criteria and just below REALST using the information needs from the cases, mainly because REALST rated higher in the criteria, "software supported." Hence, the teaching TFPM model can provide user information needs as well as, if not better, than the other TFPM versions. The other significant advantage is that it will be easier for first-time users to understand and implement.

The introduction of the flexible budget into the spreadsheet of the teaching TFPM model helps in understanding how the model works. The first time I saw a version of TFPM, I had difficulty reconciling and understanding why the total dollar effects of change in profitability did not equal the change in profits from the base period to the review period. It was not immediately clear why the dollar effect of profitability change could be negative and yet have a positive review period profit. The flexible budget clearly portrays that the change in profits from the base period to the review period is caused by two factors: change in level of activity or sales volume and changes in productivity and price recovery. REALST portrays these concepts in its profit and cost reconciliation reports but not explicitly as showing the flexible budget and its variances against the base period and the review period.

Based on the reasons just presented, I believe the teaching TFPM model will facilitate understanding and acceptance of TFPM as a basic management tool for managers who are seriously concerned about performance improvement. It may indeed be very timely to introduce TFPM to managers who according to Dixon, Nanni, and Vollmann (1990) are beginning to tinker with cost accounting systems in search for better operational measures at the firm level. They observe that there is a growing dissatisfaction with cost accounting systems and there is a need for better firm level measures that support performance improvement efforts.

Once users are more familiar with the basic TFPM concepts, they can look into more detailed analysis using REALST's resource variability concept. This will enable them to further analyze productivity in terms of capacity utilization of fixed resources and efficiency of variable resources. If the business is quite sensitive to fluctuations in prices and costs, the TFPM application could be modified using Miller's cumulative deflation.

An important concern regardless of what version is used is information portrayal. Portrayal formats can increase the probability that the information portrayed is what is actually perceived. Some people like tables and can extract information from them; others may think tables only present data. REALST uses Strategic Grids to show the present position of a firm with respect to its productivity, price recovery, and profitability performance. A criticism leveled on grids is they tend to be value-laden and critical rather than just being descriptive and analytical. Of all the portrayal formats I've seen and designed, I prefer trend charts based on indices and bar charts representing dollar effects of performance changes. Trend charts are very descriptive; they show trends rather than just present positions, and can even show relationships of the factors being portrayed. In some charts in Chapter 7, it was obvious by just looking at the trends (without correlation analysis) that price recovery drove profitability, while productivity had a minimal effect. I tried various types of charts to present dollar effects including combinations of bars and lines, areas, pie charts, and the best one I've tried so far is a simple bar chart as shown in Chapter 8. Bar charts can show negative numbers, and portray profitability as the sum of productivity and price recovery. They also dramatically portray the magnitudes of dollar effects of changes in performance.

Lessons Learned

The first lesson I learned in this research is that just like any management tool, TFPM provides biased[†] data (1985) but there's still a need for analysts and managers to be able to perceive the information and translate it to operational terms. According to Kurstedt (1989), "Given that we have the data in an MIS, we have to figure out how to organize and present information made from the data in the information-portrayal side of the information-portrayal-to-information-perception interface. In the information-perception side of the interface, we have to regularly and frequently review between supervisor and subordinate what came out of the management tools." (See Figure 9.1) What TFPM provides are indicators for analysts and managers to begin to search for information. As I concluded in one of the case studies, information consists of the explanations using the users' operational terms on why the TFPM numbers turned out to be such, which gives them an

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[†] Kurstedt's definition of information. "Biased" is not used in a negative sense. It is used as data that has been given a meaning, an interpretation, or compared with a standard.

idea about what could be done to attain the desired changes. This implies that to interpret the meaning of TFPM processed data, the analysts and managers who intimately know the operations of the firm have to work closely together to draw out the information from TFPM and state them in operational terms. They need to work together to define the information requirements, design the application, interpret the meaning of the processed data, ensure that the information provided was what was really needed in the first place, and find ways of improving the application. It is important as Derning (1989) says to have masters in the organization who have profound knowledge about theory and how they apply to particular situations. The analysts should be these masters. But while these masters may provide the knowledge and skills about management tools, they are not as familiar with the operations of a firm as those who actually manage resources. The managers can usually express their concerns in operational terms: problems, issues, decisions, actions, variances, crisis situations, but not in terms of management tools, problem solving techniques, measurement, information needs, or information portrayal. It is therefore imperative that these two groups of people work closely together in a firm, put together their strengths (to cover up for each other's weaknesses), to be able to use management tools operationally. I found that in the cases I worked on or reviewed, I became more confident of the quality of information needs and the TFPM application itself when I dealt with both the managers and analysts of the firm who were closely working together in developing and implementing management tools.

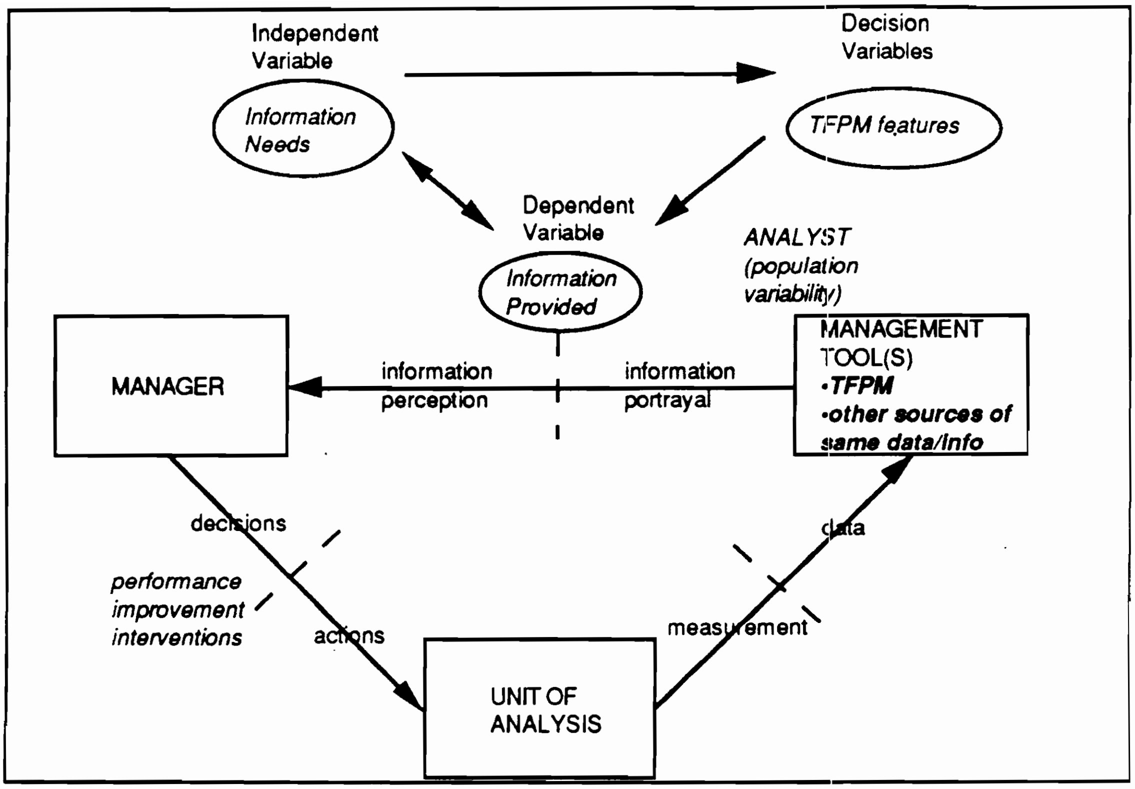

Figure 9.1: Analysts and Managers Need to Regularly Review the Interpretation of the Data and/or Information from the Management Tools

Start Simple; Modify Later

There is usually a tendency for analysts to try to develop a perfect application on the first attempt - to do it right the first time. While I believe the inital application should be a fairly accurate modelling of the actual situation, it need not be perfect or as sophisticated as applications which have been used for years. Some simplifying assumptions need to be made. As mentioned earlier, an application with multiple units within a firm should not even be attempted by first time users. I had great difficulty when I tried to do it for my pilot case. I learned a lot but I may have confused the users. The important guideline is to start with an application that will portray the basic information from TFPM - the analysis of profits using productivity and price recovery. Once this is understood and accepted, the application can be modified to model more complex conditions in the organization and do more detailed analysis.

Archer's Design Process Could Be Implemented Using PRFORM and Could Be a Standard Process for Designing, Developing, and Evaluating the Appropriateness of TFPM Applications.

As analysts develop a TFPM application, they can use Archer's (1978) Design Process for determining their goals and continually evaluating their application on how they score against the goals they have set. This process could be done in the same way I described in Chapter 8. First, they can use the process for evaluating the appropriateness of alternative TFPM versions; and secondly, they can use the process to continually evaluate how they are able to improve the application over time.

Future Research Directions

Other research directions I'd like to pursue or suggest that other researchers pursue in relation to this research are the following:

Develop more case studies to verify the usefulness of the teaching TFPM model and replicate, verify, and extend the list of common information needs when necessary.

I believe that case studies are an effective bridge between theory and practice. They are able to document both quantitative and qualitative data. They appeal to both academicians and practitioners. They not only extend and document new knowledge but also help in disseminating new methods for practitioners who may be able to use it and again add new experiences.

Use of production functions to define resource variability

REALST's resource variability allows the user to define the rate input consumption varies with output production levels. This concept still assumes a linear relationship between outputs and inputs. This relationship need not be necessarily linear. When the operations management field becomes more sophisticated to be able to define or at least have a good estimate of the actual relationship between input and output change rates, then there will be a need to modify productivity measurement to take into account these known relationships. It may need a more detailed definition of productivity other than the simple output over input ratio.

Relationships with other performance measures

When I was defining my research topic, I was tempted to pursue a topic on relationships of different performance criteria. However, I decided that the more basic need was for improving understanding and utilization of productivity measurement. While my research has not exhausted the research possibilities in the pure productivity measurement field, I believe I have laid the groundwork for better understanding and utilization of Total-Factor Productivity Measurement and am now in a better position to look into the bigger picture of performance. There are a number of other performance criteria which will be discussed in the next section. Another area that may be explored is the relationship of performance measures to a grounding criterion such as stock prices.

A Final Note

I have been using the word performance without having defined it. I use performance generically to mean the gestalt or overall result of a firm's activities. Sink (1985) defines performance as a function of seven interrelated criteria: effectiveness, efficiency, quality, productivity, quality of work life, innovation, and profitability. Note that profitability and productivity are just two of these criteria and price recovery is not one of them. Price recovery is clearly an attribute of profitability, although it can be affected by some aspects of quality (in terms of suppliers and costs of inputs, and customers and prices of outputs) and in the beginning of this chapter, price recovery was operationally equated by some firms to profitability. Figure 9.2 shows the logical relationships of the seven performance criteria. Note that productivity is right at the middle of the figure, capturing the effects of effectiveness, efficiency, and quality, with innovation and quality of work life as moderating variables, all affecting profitability. This figure shows what TFPM does. It measures what Thor (1989) calls physical and what Sumanth (1979) calls tangible things in terms of effectiveness (outputs and outcomes), efficiency (inputs), and quality (suppliers, inputs, processes, outputs, customers), all rolled up into productivity, and relates all these to the bottom line. This is why I consider TFPM, not just a productivity or profitability measure, but an overall performance measure.

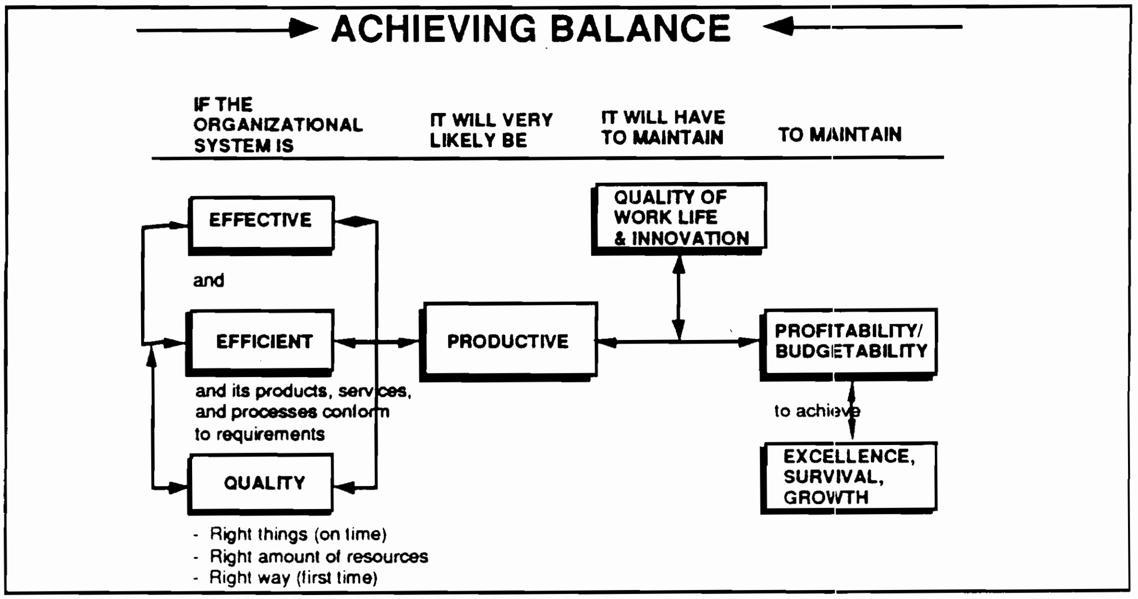

Figure 9.2: By Measuring Productivity, Price Recovery, and Profitability,TFPM Measures the Balance of Overall Performance

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Appendix A - Mathematical Models

Productivity Indices Model

Following is my portrayal of the three TFPM models in consistent symbols. This will facilitate comparisons of the models and the versions within each model. This will be one of the ways I'm investigating the model and version differences and similarities.

$\mathbf{R}_{kl}$ ≡ total revenue or value of output k in period l

$\mathbf{C}_{jl}$ ≡ total cost or value of input j in period l

$\mathbf{p}_{kl}$ ≡ price index of output k in period l

$\mathbf{c}_{jl}$ ≡ cost index of input j in period l

M ≡ number of outputs

N ≡ number of inputs

$$\textbf{Productivity Index } (\mathbf{PI}_l) = \frac{\sum_{k=1}^{M} \frac{\mathbf{R}_{kl}}{\mathbf{p}_{kl}}}{\sum_{j=1}^{N} \frac{\mathbf{C}_{jl}}{\mathbf{c}_{jl}}}$$

Profitability = Productivity + Price Recovery Model

O_{kl} ≡ quantity of output k in period l

I_{jl} ≡ quantity of input j in period l

p_{kl} ≡ unit price or price index of output k in period l

c_{jl} ≡ unit cost or cost index of input j in period l

l ≡ old, base, or reference period (=o), or
new, current or review period (=n)

$R_{kl} = O_{kl}\,p_{kl}$ ≡ total revenue from output k in period l

$C_{jl} = I_{jl}\,c_{jl}$ ≡ total cost of input j in period l

Profitability Index = Productivity Index x Price Recovery Index

$$\frac{\dfrac{\sum_{k=1}^{M} O_{kn}\,p_{kn}}{\sum_{k=1}^{M} O_{ko}\,p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jn}\,c_{jn}}{\sum_{j=1}^{N} I_{jo}\,c_{jo}}} = \frac{\dfrac{\sum_{k=1}^{M} O_{kn}\,p_{ko}}{\sum_{k=1}^{M} O_{ko}\,p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jn}\,c_{jo}}{\sum_{j=1}^{N} I_{jo}\,c_{jo}}} \times \frac{\dfrac{\sum_{k=1}^{M} O_{kn}\,p_{kn}}{\sum_{k=1}^{M} O_{kn}\,p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jn}\,c_{jn}}{\sum_{j=1}^{N} I_{jn}\,c_{jo}}}$$

Note that the numerator and the denominator of the Productivity Index are Laspeyres indices, i.e., they use base period price weighted quantities, while the numerator and the denominator of the Price Recovery Index are Paasche indices, i.e., they use current period quantity weighted prices.

With REALST, the denominator of the productivity index is a Paasche index while the denominator of the price recovery index is a Laspeyres index.

REALST Performance Indices

Profitability Index = Productivity Index x Price Recovery Index

$$\frac{\dfrac{\sum_{k=1}^{M} O_{kn} p_{kn}}{\sum_{k=1}^{M} O_{ko} p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jn} c_{jn}}{\sum_{j=1}^{N} I_{jo} c_{jo}}} = \frac{\dfrac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jn} c_{jn}}{\sum_{j=1}^{N} I_{jo} c_{jn}}} \times \frac{\dfrac{\sum_{k=1}^{M} O_{kn} p_{kn}}{\sum_{k=1}^{M} O_{kn} p_{ko}}}{\dfrac{\sum_{j=1}^{N} I_{jo} c_{jn}}{\sum_{j=1}^{N} I_{jo} c_{jo}}}$$

APQC Dollar Effects Computation

$$\text{Profitability } (\Delta\$) = \left[\frac{\sum_{k=1}^{M} O_{kn} p_{kn}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{\sum_{j=1}^{N} I_{jn} c_{jn}}{\sum_{j=1}^{N} I_{jo} c_{jo}} \right] \sum_{j=1}^{N} I_{jo} c_{jo}$$

$$\text{Productivity } (\Delta\$) = \sum_{j=1}^{N} \left[\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{I_{jn} c_{jo}}{I_{jo} c_{jo}} \right] I_{jo} c_{jo}$$

Price Recovery (Δ$) = Profitability (Δ$) - Productivity (Δ$)

Joint effects of changes in productivity and price recovery are assigned to price recovery.

Miller's Version

Instead of using Laspeyres and Paasche indices for deflation, Miller uses cumulative deflation , i.e. period to period price changes are chained together to produce a cumulative price deflator. Value of any input or output, say,

$$V_l^D = \frac{V_l}{\text{Deflator}_l} = \frac{\left[\sum_{j=1}^{N} Q_{jl}\, p_{jl}\right]}{\text{Deflator}_l}$$

where Deflator_l = cumulative deflator over periods 1, 2, 3,...l

$$= \prod_{a=1}^{l} \left[\frac{\sum_{j=1}^{N} Q_{ja}\, p_{ja}}{\sum_{j=1}^{N} Q_{j(a-1)}\, p_{j(a-1)}} \right]$$

Data Aggregation Problem:

Suppose some output or input were to be aggregated such that $M = M_1 + M_2 + M_3 + \ldots + M_x$, the change ratios will be different.

Consider the quantity: $\sum_{k=1}^{M} Q_{kn}\, p_{ko}$ (no aggregation).

With aggregation,this becomes:

$$\sum_{i=1}^{x} \left\{ \sum_{k=1}^{M_i} Q_{kn} \left[\frac{\sum_{k=1}^{M_i} Q_{ko}\, p_{ko}}{\sum_{k=1}^{M_i} Q_{ko}} \right] \right\}$$

An example can show that these two quantities may not be equal. An example is documented in Paul Rossler's Masters thesis, pp. 208 - 216. The problem was he added quantities of different items with different costs and used the sum as the aggregated quantity. Intuitively, this problem is about adding apples and oranges. Whenever related but not equally priced items are aggregated, an average price or a price index has to be used to obtain a relative quantity, i.e. the quantity has meaning only in a comparative sense but not in absolute terms. Examples of these quantities were shown in Chapter 7.

REALST Dollar Effects Computation

R = resource variability constant; 0 for fixed resources, 1 for 100% variable resources; can take other values.

Q_{ne} = new (current period) resource quantity normalized for constant efficiency

$$= \left[1 + \left(\frac{O_n - O_o}{O_o} \right) R \right] I_o$$

Q_{np} = new (current period) resource quantity normalized for constant productivity

$$= \left[1 + \left(\frac{O_n - O_o}{O_o} \right) \right] I_o$$

p_{nr} = new (current period) resource price normalized for constant price recovery

$$= \left[1 + \left(\frac{p_n - p_o}{p_o} \right) \right] c_o$$

Capacity Utilization (Δ$) $= (Q_{np} - Q_{ne})\, c_n$

Efficiency (Δ$) $= (Q_{ne} - Q_n)\, c_n$

Productivity (Δ$) = Capacity Utilization (Δ$) + Efficiency (Δ$) $= (Q_{np} - Q_n)\, c_n$

Price Recovery (Δ$) $= Q_{np}\, (c_{nr} - c_n)$

Profitability (Δ$) = Productivity (Δ$) + Price Recovery (Δ$)

$= Q_{np}\, c_n - Q_n c_n + Q_{np}\, c_{nr} - Q_{np} c_n$

$= Q_{np}\, c_{nr} - Q_n c_n$

These formulations are for a single output, single input case. The general formulation follows:

R_j = resource variability for input j

Q_{nej} = new resource quantity for input j normalized for constant efficiency

$$= \left[1 + \left(\frac{\sum_{k=1}^{M} O_{kn} p_{ko} - \sum_{k=1}^{M} O_{ko} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} \right) R_j \right] I_{jo}$$

Q_{npj} = new resource quantity for input j normalized for constant productivity

$$= \left[\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} \right] I_{jo}$$

$p_{\pi j}$ = new resource cost for input j normalized for constant price recovery

$$= \left[\frac{\sum_{k=1}^{M} O_{kn} p_{kn}}{\sum_{k=1}^{M} O_{kn} p_{ko}} \right] c_{jo}$$

$$\text{Capacity Utilization } (\Delta\$) = \sum_{j=1}^{N} \left(Q_{npj} - Q_{nej} \right) c_{jn}$$

$$\text{Efficiency } (\Delta\$) = \sum_{j=1}^{N} \left(Q_{nej} - Q_{jn} \right) c_{jn}$$

$$\text{Productivity } (\Delta\$) = \sum_{j=1}^{N} \left(Q_{npj} - Q_{jn} \right) c_{jn}$$

$$\text{Price Recovery } (\Delta\$) = \sum_{j=1}^{N} \left(Q_{npj} \right) \left(c_{\pi j} - c_{jn} \right)$$

$$\text{Profitability } (\Delta\$) = \sum_{j=1}^{N} \left(Q_{npj} c_{\pi j} - Q_{jn} c_{jn} \right)$$

Gollop's Model

The following pages show Gollop's Model.

R_{kl} = total revenue or value of output k in period l

C_{jl} = total cost or value of input k in period l

p_{kl} = price or price index of output k in period l (constant $s)

c_{jl} = unit cost or cost index of input j in period l (constant $s)

M = # of outputs

N = # of inputs

$O_{kl} = {}^{R_{kl}}\!/_{p_{kl}}$ = output quantity in constant $s

$I_{jl} = {}^{R_{kl}}\!/_{c_{jl}}$ = input quantity in constant $s

$G_k = {}^{O_{kn}}\!/_{O_{ko}}$ = growth rate of output k

$G_j = {}^{I_{jn}}\!/_{I_{jo}}$ = growth rate of input j

$S_k = {}^{R_{ko}}\!/_{\sum_{k=1}^{M} R_{ko}}$ = price share of output k

$S_j = {}^{C_{jo}}\!/_{\sum_{k=1}^{N} C_{jo}}$ = cost share of input j

G = growth rate of TFP = $\sum_{k=1}^{M} S_k \; G_k \; - \sum_{j=1}^{N} S_j \; G_j$

Change in Operating Income:

$\equiv$ operating income in period n - operating income in period o

$$= \left(\sum_{k=1}^{M} R_{kn} - \sum_{j=1}^{N} C_{jn}\right) - \left(\sum_{k=1}^{M} R_{ko} - \sum_{j=1}^{N} C_{jo}\right)$$

$$\text{Productivity Contribution} = \left(\sum_{j=1}^{N} C_{jo}\right) G$$

Unit Sales Growth Contribution:

$\equiv$ (unit profit in period 0) x (period to period change in output)

$$= \left[\frac{\sum_{k=1}^{M} R_{ko} - \sum_{j=1}^{N} C_{jo}}{\sum_{k=1}^{M} O_{ko}}\right]\left[\sum_{k=1}^{M} R_{kn} - \sum_{k=1}^{M} R_{ko}\right]$$

Contribution of price changes:

$\equiv$ (period to period change in price) x output quantity in period n

$$= \sum_{k=1}^{M}\left[(p_{kn} - p_{ko})(O_{kn})\right] - \sum_{j=1}^{N}\left[(c_{jn} - c_{jo}) I_{jn}\right]$$

Gollop's Model Is Operationally Equivalent to APQC/VPC Versions

The following proof shows that Gollop's Model yields Productivity Indices and Dollar Effects due to productivity changes equal to those of APQC's or VPC's versions.

Prove:

$$\text{APQC/VPC's Productivity } (\Delta\$) = \sum_{j=1}^{N} \left[\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{I_{jn} c_{jo}}{I_{jo} c_{jo}} \right] I_{jo} c_{jo} = ?$$

$$\text{Gollop's Productivity Contribution} = \left(\sum_{j=1}^{N} C_{jo} \right) G$$

Proof: $\left(\sum_{j=1}^{N} C_{jo} \right) G = \left(\sum_{j=1}^{N} I_{jo} c_{jo} \right) \left(\sum_{k=1}^{M} S_k \; G_k - \sum_{j=1}^{N} S_j \; C_j \right)$

$$= \left(\sum_{j=1}^{N} I_{jo} c_{jo} \right) \left\{ \sum_{j=1}^{N} \left[\left(\frac{O_{ko} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} \right) \left(\frac{O_{kn} - O_{ko}}{O_{ko}} \right) \right] - \sum_{j=1}^{N} \left[\left(\frac{I_{jo} c_{jo}}{\sum_{j=1}^{N} I_{jo} c_{jo}} \right) \left(\frac{I_{jn} - I_{jo}}{I_{jo}} \right) \right] \right\}$$

$$= \left(\sum_{j=1}^{N} I_{jo} c_{jo} \right) \left\{ \left[\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{\sum_{k=1}^{M} O_{ko} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} \right] - \left[\frac{\sum_{j=1}^{N} I_{jn} c_{jo}}{\sum_{j=1}^{N} I_{jo} c_{jo}} - \frac{\sum_{j=1}^{N} I_{jo} c_{jo}}{\sum_{j=1}^{N} I_{jo} c_{jo}} \right] \right\}$$

$$= \left(\sum_{j=1}^{N} I_{jo} c_{jo} \right) \left(\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{\sum_{j=1}^{N} I_{jn} c_{jo}}{\sum_{j=1}^{N} I_{jo} c_{jo}} \right) =$$

$$\text{APQC/VPC's Productivity } (\Delta\$) = \sum_{j=1}^{N} \left[\frac{\sum_{k=1}^{M} O_{kn} p_{ko}}{\sum_{k=1}^{M} O_{ko} p_{ko}} - \frac{I_{jn} c_{jo}}{I_{jo} c_{jo}} \right] I_{jo} c_{jo}$$

Appendix B - Interviews of Experts

The following general questions were asked each expert, after a brief introduction of my research:

- What organizations use your model/version?
- Do you think TFPM is still underutilized? Why?
- What are the latest developments in your research on TFPM? Any new references/papers?
- Is my research worthwhile?
- Are you willing to review some working papers for my research?

The experts were unanimous in saying that TFPM was still underutilized and more research and development could be done to make it a responsive and generally-accepted management tool. They were all willing to review working papers on my research and be resource persons.

In addition to these questions, issues related to each particular model/version were discussed with the concerned expert. Each interview lasted about an hour and was structured based on the guide questions I had prepared in advance, but was also unstructured as issues were not always discussed in the same order. Following are my notes on the interviews:

Frank Gollop, Ph.D., Boston College (2 February 1989)

Except for a couple of organizations who are using his model, there have been no other developments since he wrote his paper. Once in a while, he lectures about his model. Following are the detailed questions I asked and his responses:

1. Your model uses a production function in exponential form. This may be the generally-accepted form in Macroeconomics but is this also applicable to the plant or firm level measurement where the production functions may take on simpler functions such as linear functions?

Response: The exponential form is the most general form of production functions. Simpler forms of production functions may just be considered as subsets of the more general form. They can definitely be used for plant or firm level measures with simplified parameters such as what were used in the example shown in Chapter 3.

2. The theoretical model development assumes continuous functions. However, in applications, time is in periods or discrete variables. Doesn't this present a discrepancy?

Response: Most models are developed using continuous variables. When they are applied, formulas using discrete variables are used to approximate the theoretical continuous variable formulations. These discrete variable formulas are equivalent to the continuous variable forms in the limiting case. For example: $\partial \ln y / \partial T \approx \ln y_T - \ln y_{T-1}$.

3. I have developed a simple case where a plant has a manufacturing and a packaging operation. In one period, some of the output of manufacturing is used as an input of packaging while the rest stay in WIP. When I tried to parallel or replicate the calculations done in your example, I couldn't get the same results - the analysis of what contributes to profit change.

Response: One of the possible causes of the problem is aggregation of output. It will not be as simple as getting the total dollar value of all outputs. A weighted average using output growth rates must be used. (He asked me to go ahead and work out the example and send him the case if it still doesn't work.)

Carl Thor, President, American Productivity and Quality Center (21 February 1989)

APQC teaches about three models: Physical Productivity (or what I call Productivity Indices model of Davis, Craig and Harris, etc.); Cost Center Accounting -- using standard costs and quantities; and Profitability ratio = Productivity ratio x Price

Recovery ratio model. He sent me a copy of the notebook they are using for their two-day seminar/workshop entitled, "How to Measure Productivity (1989)." He also sent me the results of the UCCEL/APQC survey done in late 1985, getting feedback from the attendees of their workshop on how and why they have or have not used TFPM. He said the main problem is selling the concept to managers.

Regarding the measurement of capital input, it is necessary to consider not just depreciation costs but also the cost of money, to make managers aware of actual "surplus" profits, over and above what investors would have made if they chose to invest in financial markets instead. Mr. Thor also believes that many managers still don't fully understand and appreciate Accounting data and information. Hence, there is a need to present data and information in very simple terms.

Mr. Thor has agreed to be in my Graduate Advisory Committee to represent industry.

David Miller,Ph.D., Director, Alabama Productivity Center (22 February 1989)

Dr. Miller has received many phone inquiries and given a few briefings but knows only of Ethyl Corporation's continued usage of his TFPM model/version, called PPP for Profitability = Productivity + Price Recovery. Contact persons at Ethyl Corporation are Paul Weimer (VP) and Ross Gottwald. They can provide implementation experiences and modifications based on actual needs.

GM IEs wanted to use his TFPM version but encountered opposition with Accounting people. In Ethyl Corporation, however, there was no opposition as a top-down approach was used. TFPM was an integral part of the annual general performance review process done prior to the budgeting system.

PPP version's deflation method was developed at Ethyl Corporation as a result of their particular needs. PPP is equivalent to APQC's except for the deflation method and the exclusion of weighted performance indices in the reports.

David Sumanth, Ph.D., Director, Productivity Research Group, University of Miami (22 February 1989)

Dr. Sumanth says his students have developed 70 sample applications for various organizations. Twelve of the applications were to be published in his new book which was supposed to come out by the end of the year along with a software for his TPM model/version.

He told me that he and Kitty Tang published a review of TFPM models/versions in an IIE conference proceedings in 1983 or 1984. (I got a copy of this.)

When I inquired about the difficulties associated with allocating input costs by product, Dr. Sumanth said there shouldn't be any problems as cost accountants do it all the time. This was the same response he gave me when I asked if proportional allocation of input costs based on output quantities would defeat the purpose of computing product and partial productivities.

Shoni Dhir, TFPM Champion of LTV/Vought Aero Products (5 July 1990)

Based on the main questions I outlined at the beginning of this appendix, following were Mr. Dhir's responses:

"Every corporation needs to know whether they are doing better or worse. If the world were free from inflation, profitability = total-factor productivity." He believes that one-half of Fortune 500 managers don't even look at financial information and are therefore not aware of the issues surrounding financial measures. Inflation muddies the financial measures of performance. Therefore, there is a need for measurement approaches such as TFPM to be able to measure performance in constant dollars to separate, but also relate the effects of inflation and total-factor productivity to profitability. And this information should be presented in very simple terms for managers to quickly understand and appreciate.

There is a need for a powerful champion to bring together the convictions of people regarding measurement, for something like TFPM to be successfully implemented in firms. TFPM implementation is the litmus test for all improvement programs within a firm as it measures the overall impact of changes in performance and also indirectly tests managers' understanding and commitment to continuous improvement by using TFPM for both measurement and planning. Unfortunately, at LTV/VAPD (and in some organizations who have implemented TFPM, according to the APQC/UCCEL survey, 1985), it is no longer used as extensively because the champion has been moved to another job. However, at LTV/VAPD, TFPM was able to forecast ups and downs in the business due to factoring out of inflation.

When I asked why LTV uses cost-to-sales ratios for the challenge budget process instead of the standard definition of productivity of output/input, Mr. Dhir said LTV managers have been very familiar with cost-to-sales ratios and they felt it was not necessary to change it with a very similar concept.

Appendix C: Raw Data on Interviews/Meetings With Users

This appendix documents the specific questions I asked and the the answers I received from the managers and analysts I interviewed or met with to collect data on management information needs related to performance improvement. Relevant data from other data collection methods such as review of documents, forms, databases, and data processing systems were documented in the case studies. Summaries of the information needs were also documented in the case studies but this appendix is aimed at showing the details of how those information needs were collected.

As mentioned in Chapters 2: Methodology, Chapters 4-7: Case Studies, and Chapters 8 and 9, I initially thought I could structure my questions and ask direct ones such as, "What information do you need to make decisions and initiate actions to improve performance?" I soon found out it was not as simple as that. Managers do not usually communicate in such academic language. Hence, what follows is a documentation of what specific questions I asked and the answers I received.

Plant A

Plant A's Manager of Industrial Engineering had read about TFPM and SCORBORD in particular, and had assigned a Senior Industrial Engineer and another IE to investigate the possibility of using TFPM at Plant A. Hence, before we came to visit Plant A, they had read about TFPM and in fact, tried to develop an application by themselves. Hence, they had earlier thought of why they want to try TFPM and what issues were involved in developing the application. Joy Davis, VPC's software manager helped me collect the data from Plant A.

The specific questions we asked the IE team were the following: What information do you want to get out of SCORBORD? What types of decisions do you want to be able to make from SCORBORD reports?

Following were the responses:

1. They have been implementing a number of performance improvement efforts within the plant. Each of those efforts have estimated savings and costs. However, they don't know the overall impact of all those efforts put together, on plant performance in general and profitability in particular. They want TFPM to give them this information.

2. They also wanted to measure the contribution of indirect labor to overall performance.

3. They want to show that material productivity is more important and significant than direct labor productivity. They want to be able to use TFPM to focus management's attention on reducing scrap during the good times to gear up for possible bad times.

4. They want to be able to simulate what changes are needed to achieve desired operating results. They want to be able to play 'what if' games using TFPM.

5. They want to be able to pinpoint productivity improvement opportunities.

Division B

Division B was in a similar situation as Plant A. Division B's Operations Technology Group was developing a comprehensive performance improvement program that included a suggestion subsystem, a cost/benefit analysis subsystem, a screening and approval system, and a performance measurement subsystem. The meetings and interviews were conducted by Greg Sedrick, A VPC Research Associate and myself.

When we asked the Engineering Manager about what concerns or issues he had encountered in improving his organization's performance, his response was that he wanted to know the contribution of his department to the overall performance of the division. His organization's performance was usually measured based on actual expenses against budget, output against schedules, and shop floor standards. He wanted to know how the present measures related to the overall profitability of the division. This way he would be able to pinpoint the factors in his operations that he should pay more attention to. In relation to this information need, the staff analysts also wanted to measure the contribution of indirect departments to overall division performance.

The Operations Technology Manager, being aware of LTV's TFPM version, and being in the same industry, wanted a system just like LTV's. The question we then asked was, "what about LTV's TFPM application do you like?" His response was that he wanted the use of the challenge budget process in terms of being able to generate general budgeting guidelines and being able to evaluate if a detailed budget is reasonable or achievable based on past performance.

Company C

Company C had previous experience with the Craig and Harris TFPM version. Their Productivity Services Group, however, thought the that the data and information provided by the Craig and Harris version was not enough to justify the amount of effort needed to implement it. Hence, they asked for VPC's assistance in "developing a comprehensive measurement system tied in with work standards and relatable to profitability." When asked why they wanted to develop a TFPM application, the Assistant Vice President for Productivity Management Services replied that the CEO had given them a task to provide operating managers with physical measures that directly related to financial measures. Their managers use financial measures and plant floor measures that are decoupled. They would like to see a more integrated set of measures so they can understand the main factors affecting overall performance and pinpoint opportunites for improvement.

I interviewed the Vice Presidents/General Managers of Divisions A,. B, D, and E. All of them have not had any exposure to TFPM although I was introduced as an action researcher who would be assisting them to develop a productivity measurement system. The specific questions I asked them were: what concerns, problems, or issues do you have regarding your management information systems? Do you have access to all the data and information you need to make decisions and initiate actions to improve your organization's performance? What data or information do you need to let you know if your organization's performance is improving or not? What data or information do you need to pinpoint opportunities for improvement? I asked the four general managers the same questions. Following were their responses:

Division A

We need to take a second look at what we're doing as we may be blinded by our paradigms. We know the detailed plant measures because we have been using them for years. We don't have a clear understanding of how the detailed measures add up to overall performance. We need to be able to distinguish what critical factors significantly affect our operations. We get so involved with the numbers that we sometimes lose sight of the meaning of those numbers. We need to change the format of our operations review from mostly explaining variances to looking at trends and thinking about what needs to be done. There's a need to look at measures that will point out ways to improve performance in the next period - and we need to see this data within the next 10 days of the month.

Division B

Our thrusts are to provide the highest quality products in the domestic markets at the lowest cost and to get into the international market for particular products. Our machinery is world class and we are trying to develop our labor to also become world class to prepare for possible international competition. We are experimenting with incentive programs where employees' families get to pick rewards when groups of employees perform better than standards. We need measures to support these thrusts and which are consistent with the planning and control systems already in place.

Division D

Division D's General Manager was in the midst of a labor crisis when I met with him. He said he felt he had access to the necessary data and information he needed to make decisions and initiate actions to improve performance. He wanted to know what additional information TFPM might provide.

Division E

They have excess capacity to respond to the highly volatile market demand. He is interested in better ways to forecast and respond to fluctuations in the market.

Based on this interviews, I translated what I heard from them in terms of information needs. These information needs are documented in the case study which I asked them to review to verify the accuracy.

Center D

Center D has tried to implement TFPM two years ago but felt that they did not have enough meaningful data. This time, I first started to collect information needs as I did with the other cases. Since Center D's managers were familiar with TFPM, I felt comfortable with directly asking them what their information needs were. I posed this question in a meeting with the three directors of the Center. Following were the responses I got:

- Center's output / month and by type of output
- trends in price recovery
- labor productivity
- income and expense by project, programs, and departments
- billable labor hours/total hours
- product/service lines to develop or cut
- overload/underload - staffing by functions
- what is our General & Administrative expense and how do we cover it?
- how do we ensure a level of gainsharing?

Since I had the opportunity to closely interact with Center D's directors, I decided not to limit the development of the TFPM application to providing the data and information the directors said they needed. Along with Paul Rossler, a VPC Research Associate, we developed two parallel TFPM applications using REALST and SCORBORD, compared results and presented a report to Center D's directors. We then asked them to rate which information they needed most. These information needs were all discussed in the case study.

One final note: before asking specific questions to identify the information needs of the users, I had asked about background information regarding the scenario of how they even thought of using TFPM. In fact, I had already asked the most basic question. Of course this question was always addressed to the staff analysts who were originally interested in developing a TFPM application and had some idea of what TFPM could provide. With the managers, who mostly did not have any previous exposure to TFPM, the questions had to be phrased differently. The questions raised were: What types of concerns, problems, or issues do you have about improving the performance of your organization?. What are your present basis for making decisions to improve performance? What data or information do you want to receive to be more confident about the decisions you make?

VITA

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EDUCATION

Ph.D. in Industrial and Systems Engineering
August 1990
Virginia Polytechnic Institute and State University (Virginia Tech)
Dissertation: A Multiple Case Study Research to Determine and Respond to Management Information Needs Using Total-Factor Productivity Measurement, Advisor: Dr. D. Scott Sink
Fulbright Scholar

M. S. in Applied Mathematics (October 1976)
Ateneo de Manila University, Metro Manila, Philippines
Thesis: Linear Programming Sensitivity Analysis of a Bakery's Daily Production

B. S. in Mathematics - Cum Laude (October 1973)
Ateneo de Manila University, Metro Manila, Philippines

WORK EXPERIENCE

Virginia Productivity Center, Virginia Tech, Blacksburg, VA
Associate Director, International Activities July 1989 - August 1990
Graduate Project Assistant September 1989 to August 1990
Graduate Research Assistant March 1986 - August 1989

• managed projects including the Department of the Navy Productivity Improvement Planning, U.S. Senate Productivity Award, Rhone-Poulenc, International/ Rhodia (Brazil) Performance Improvement Process, Glaxo Pharmaceuticals Plant Productivity Measurement, and Deming Teleconference;
• researched on productivity measurement, wrote papers, project proposals and reports and reviewed papers for publication;
• assisted in planning, designing, and facilitating several workshops;
• conceptualized and managed the production of educational/promotional video tapes;
• responsible for budgets totalling over $100,000 annually;
• researched on Total-Factor Productivity Measurement applications for General Dynamics and San Miguel Corporation;
• coordinated activities with international organizations; represented VPC at an International Labor Organization Technical Consultation meeting in Thailand (December, 1990)

Atlas Consolidated Mining and Development Corporation, Cebu, Philippines

Assistant Vice President
Industrial Engineering and Strategic Planning August 1990

Director, Purchasing April 1985 - July 1985
• organized and managed a department responsible for purchasing from local suppliers and placing orders with international purchasing agents.

Director, Procurement and Inventory Control September 1983 - March 1985
• managed the ordering, communications with local suppliers and foreign purchasing agents, cargo movement and receiving, maintenance of computer files, and development of systems and procedures.

Director, Management Services January 1980 - August 1983
• responsible for Human Resources and Management Systems Development, Industrial Engineering and Operations Research;
• implemented management and technical training, Quality Circles, Performance Appraisal and Wage and Salary Administration.

Secretary, Mining Business Family June 1982 - August 1983
• served as process consultant for the Strategic Planning of A. Soriano Corp. - managers of Atlas Mining.

Management Specialist November 1978 - December 1979
• audited and developed management systems

Computer Information Systems, Inc., Metro Manila, Philippines

Head, Operations Support Unit January 1978 - November 1978
• organized and managed the scheduling, preparing, running, and controlling of production jobs;
• developed systems, procedures, and organizational structures.

Operations Research Analyst October 1976 - December 1977
• developed the Fuel Oil Movement System using Systems Dynamics and the Heat Rate Variance Monitoring System for an electric company.

Ateneo Graduate School of Business, Metro Manila, Philippines

Lecturer, Statistics November 1977 - November 1978

Ateneo de Manila University, Metro Manila, Philippines

Assistant Instructor, Math Department October 1973 - October 1976
• Taught Statistical Quality Control, Mathematics of Investments, Algebra, and Trigonometry.

PUBLICATIONS

Refereed Abstracts

Pineda, A. J. (1988). "Total-Factor Productivity Measurement: Theoretical and Methodological Issues." *IIE Fall Conference Proceedings*, St. Louis, Missouri.

Pineda, A. J., Coleman, G. C., and Sink, D. S. (1988). "Participative Planning Process: A Public Sector Case Study." *Sixth World Productivity Congress Proceedings*, Montreal.

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Sink, D. S. and Pineda, A. J. (1987). "Quality, Productivity, and Performance Management Training." *First International Conference in Productivity Research*, Miami.

Pineda, A. J. (1982). "Quality Circles - Atlas Mining Experience." Second Annual QC Convention, Manila, Philippines.

Editorship

Sink, D. S., et. al. (1989). Planning and Measurement in Your Organization of the Future. IIE Press, Atlanta. (I edited one chapter and wrote one section)

Pineda, A. J.(Associate Editor) *Quality and Productivity Management.* Vol. 6, # 2 and Vol. 7 # 1. VPC.

Quimpo, N., et. al. (1975). *Topics in Finite Mathematics.* Ateneo de Manila University. (I contributed 2 chapters in this textbook.)

Videotapes - Planned and produced the following:

Pineda, A. J. and Menon, H. (1988). "Lessons from the Best in Virginia: The U.S. Senate Productivity Award." VPC/LRC, Blacksburg.

Sink, D. S. (1988). "Performance Basics." VPC/LRC, Blacksburg.

Sink, D. S. (1987). "Performance Management Process." VPC/LRC, Blacksburg.

PROFESSIONAL MEMBERSHIPS

Institute of Industrial Engineers
Academy of Management