A METHODOLOGY FOR LINKING THREE EFFICIENCIES FOR CAPITAL EXPENDITURE JUSTIFICATION

by

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This thesis develops and demonstrates a methodology for formulating a link between physical efficiency, economic efficiency, and organizational efficiency, and then uses the link developed earlier for justifying capital expenditures. Two scenarios have been used to demonstrate the methodology in two phases. The first phase deals with the formulation of the link between physical efficiency, economic efficiency, and organizational efficiency. The second phase uses the methodology developed in phase one to perform a multi-period analysis. This multi-period analysis shows that an increase in the efficiency of the physical environment results in an increase in the efficiency of the economic environment for two hypothetical companies. The increase in the efficiency of the economic environment results in increased profits, which are a necessary but not sufficient condition for the existence of the organization. The increase in profits further leads to satisfaction of individual wants for four classes of contributors to the organization, and, thus, to an increase in the overall efficiency of the organizational process.

The formulation of a link between physical efficiency, economic efficiency, and organizational efficiency may help justify capital expenditures for new technology. This would solve a long standing need of managers for such a justification technique.
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1.0 INTRODUCTION

The efficient use of physical resources has been an issue of importance for as long as humans have existed. Stone spears were used as weapons instead of hands to kill animals for food. Fire was used for warmth as well as protection from wild animals.

With the passage of time, humans started trading which gave birth to the concept of a barter system of trade. Instead of one person growing food and making clothes, the work was sub-divided. The goods produced were exchanged and this resulted in an economically and financially motivated atmosphere. With such a prevailing atmosphere came the issue of efficient organization of time and resources and thus, the picture of modern organization as a separate entity emerged in the late eighteenth century.

Although the present form of corporate organization developed in the recent past, it is believed that the U.S. industrialists have yet to grasp its full potential. They have not always been able to link the benefits of improvements in efficiency of physical processes to a positive increase in the overall performance of the organization. In addition, they often face obstacles in the introduction of improved technology due to their inability to
justify the increased investment in economic terms. The formulation of a relationship between physical efficiency, economic efficiency, and organizational efficiency may provide a positive impetus to industries planning on investing in new technology.

This research addresses the need for a positive link between physical efficiency and organizational efficiency. A mathematical model will show a link between increase in physical efficiency and increase in benefits to the contributors. This increase in benefits will show an increase in the overall efficiency of the organization. Utility functions for various participants in the organizational process will be formulated using a Vandermonde system of matrices. An aggregate utility function for expressing organizational efficiency will be derived.

### 1.1 Historical Perspective

Efficient use of time and resources has been a long standing concern. For centuries, humans have tried to correlate the better use of physical resources to more effective economics and a better sense of organization. The idea, in a subconscious sense, of organizing resources better to get a higher output has evolved over the years. To put forth this idea in a mathematical perspective, certain terms will be used. They are: efficient use of tools (physical efficiency), judicious use of finances (economic efficiency), and better organization of time and resources as a whole (organizational efficiency). The following text will further emphasize the use of these three efficiencies through the ages.
Bone and obsidian sickles were used as early as 8000 B.C. in agriculture to improve physical efficiency. The concept of a wheel existed centuries before it was invented, when humans used logs as a means of transporting heavy goods. A pre-industrial revolution was started with the invention of the wheel around 3500 B.C. and since then, in terms of technology, humankind has never looked back. The wheel was used by the ancient Egyptians for vehicles as well as for pottery. Shadow clocks were used in 1500 B.C. for efficient organization of time and resources. The use of water and wind as energy sources proliferated during the dark ages. By the 14th century, the tower mill had been developed to produce as much as 20 to 30 Horse-power.

The advent of the modern scientific revolution focused the concern of theorists and engineers on issues of physical and economic efficiency. This was partly due to the scarcity of naturally available resources, and partly to the introduction of sea and ocean transport. Merchants could travel across continents to trade for better and more exotic goods in order to satisfy their customers' demands. The steam engine was a marvel of technology prevalent in the 18th century. It made transportation faster and gradually more economical. The invention of the sextant in the eighteenth century made possible long forays into unknown waters. These journeys were probably the ancestors to the present forms of international trade.

With the dawn of the twentieth century, the emphasis shifted towards economic efficiency related to factory processes. A revolution was under way in the operations of industrial enterprises. This revolution came about as industries all over the world were discovering better and more efficient products, and using improved process control. The implications were global and not just confined to a particular region or country. The radical changes that occurred on the U.S. industrial scene in the first decade of this
century have affected the concept of organization ever since. It also marked the consolidation of great industrial enterprises.

The emergence in the early 1900's of the giant steel and automobile companies, plus the growth of corporations in complementary industries to supply these enterprises, marked the development of mass-production enterprises where great efficiencies, both physical and economic, were achieved through vertical integration and highly specialized machines, processes, and labor.

Perhaps the best example of this movement was the 1901 formation, by Andrew Carnegie, from the nation's three largest steel corporations, of U.S. Steel company, the world's first billion dollar steel corporation. The largest of the three merging companies was owned and managed by Carnegie whose management philosophy of efficiency and innovation resulted in the extraordinary success of the company.

As the Chairman of U.S. Steel, Carnegie was renowned for his overriding concern for reducing operating costs, which he achieved by investing in the latest technology even if this required him to scrap plants less than ten years old. Like similarly inclined managers in Japan almost a century later, Carnegie understood the powerful competitive advantage that accrues to the most efficient producer. Unfortunately, the aggressive entrepreneurial spirit of Andrew Carnegie did not persist among all subsequent leaders of the giant steel enterprises so that much of U.S. technological and productivity leadership was lost to foreign and small domestic competitors (Morison, 1966).

The first decade of this century also marked the birth of the U.S. automobile industry. In 1908, even though about 250 companies were producing automobiles, fifty percent of the automobile production was concentrated in just three corporations: Ford, General
Motors, and the ancestor of the Studebaker Corporation. In that same year, Ford transformed the industry with the first moving assembly line. That assembly line made possible three things: first, a great expansion in the number of cars that could be produced; second, large reductions in the price of cars to expand enormously the market for this product; and third, a significant increase in the wages that could be paid to attract skilled workers to the assembly-line production process. The improvements in physical efficiency introduced by the assembly line, along with innovations proposed by Carnegie, resulted in lower unit cost of products. This, in turn resulted in more profits due to larger sales and hence a greater economic efficiency.

The final strand in this historical tale can be traced to the organizational innovations of the Du Pont Powder Company, formed in 1903 by consolidating family-owned and other small, family-run firms. The transformation from many small, single-activity firms into a large, vertically-integrated, multiactivity corporation required new organizational forms and new measures to motivate and evaluate the performance of decentralized operating units.

As mentioned earlier, U.S. industrialists like Carnegie made short-term trade-offs to keep investing in improved and updated machinery. This had long-term implications, such as increased product market, improved quality of products, lower prices, and customer satisfaction. It also made the U.S. a world leader in manufacturing, and its products highly competitive. The period between 1950 and 1970 saw the U.S. at its peak as an industrial power (Williams, 1978). It was one of the few unaffected post war countries to have industries mass producing goods. Most countries in Europe and Asia had been badly affected by the Second World War, and had to rely on U.S.-made goods while they rebuilt their own economies. Since the demand for U.S. goods was so high, it is believed
that manufacturers had little problem disposing of goods of sub-standard quality at the prices of their choice. Few industries introduced improved product and process control, and machinery. On the other hand, most industries in other countries introduced more efficient processes to offset the prices of U.S. made goods. This led to intense business competition in the mid-seventies, and eventually in the decline of the U.S. as an industrial power. According to popular belief, the major reason for the decline was the policy of making quick and short term gains. Managers tried to extract as much work as possible from labor and machines alike. The machines often were not improved and updated to keep up with the changing technological trends since this required high capital expenditures.

The Japanese on the other hand, followed the revolutionary statistical quality control ideas of Deming, and introduced innovative concepts like Just-In-Time. The major industries apart from using improved methods and better worker motivation, understood the strategic implications of improved technology and kept on updating their equipment to keep up with the state-of-the-art. This resulted in the emergence of Japan as a major industrial force in the period after 1970.

1.2 The Modern Industrial Scene

The vigorous global competition of the 1980's has brought the importance of effective and efficient manufacturing operations to the attention of senior executives. Executives
have started focusing their efforts on reducing labor costs (Kaplan, 1986). Unlike the
environment of the past seventy-five years, however, the factors critical to the success
of manufacturing today have little to do with improving the efficiency of direct labor,
since labor costs are often less than ten percent of the total product costs. Rather, the
factors critical to success today are in knowing how to produce high quality products
efficiently for rapidly changing consumer demands (Kaplan, 1986).

As American companies face up to the challenge of restoring manufacturing
competitiveness, they usually turn their attention first to reducing the costs of the labor
operations on the floors of their plants and factories. But those costs, for all their im-
portance, have long represented a decreasing percentage of the total value added by
manufacturing (Kaplan, 1986).

The introduction of new technology has resulted in a change in the distribution of cost-
ing for products. The physical and economic efficiencies tied with manufacturing excel-
lence go beyond the traditional measures of easily quantifiable costs such as direct labor
and direct materials. They include physical aspects of a system like flexibility, quality,
throughput time, and customer responsiveness. Flexibility can be considered a physical
aspect of a system since flexibility results from increased automation and introduction
of high technology machines like CNC’s. The introduction of CNC’s and robots are
usually accompanied by an improvement of quality of goods produced, and at times, an
increase in production. These improvements accompanied by other physical aspects
may have a positive effect on the overall efficiency of the organization.

However, there exists an economic limit to increases in the physical efficiency of a sys-
tem, a point at which the benefits resulting from a higher efficiency are overtaken by
additional capital costs. These capital costs can be justified as long as they are offset
by lower operating costs. In the past, engineers have been concerned with two levels of efficiency, physical and economic. As the productivity and efficiency of the organization are linked to its physical and economic processes, it is only right that the engineer give due consideration to the organizational efficiency in the design, fabrication, and modification of physical systems, since increase in the physical efficiency of a system may improve the efficiency of the organization.

1.3 Problem Definition

With the formulation of a link between physical efficiency and organizational efficiency, rechanneling of the organizations’ profits may prove to be economically justifiable. This would show that with an increase in physical efficiency, there is an increase in organizational efficiency. This may help companies justify capital expenditures. Presently, available pertinent literature does not show a positive link between physical efficiency, economic efficiency, and organizational efficiency, beyond the report by Tiller (1983). There is need for further work in this area. This thesis reports one such methodology developed to formulate the afore-mentioned link.

To formulate the link, certain assumptions about the market conditions have been made. They are, first, that the technology is being updated from time to time, i.e., the state-of-the-art keeps on changing; and second, the contributors to the organization have other options and can leave if they find other organizations more beneficial to their well being, i.e., each contributor has to be individually satisfied.
Further, it is assumed that, in order to have an edge over the competition, constant product and process improvements and innovations have to be carried out. The physical product and process innovations may result in higher economic efficiencies. It is also assumed that with an increase in economic efficiency, there is an increase in the organizations' profits. An increase in profits distributed to the participants will result in higher organizational efficiency. One of the possible beneficiaries in a distribution of profits may be the investors; on the other hand, the organization might elect to keep some amount of the profits for reinvestment in new technology. This investment may contribute to the continuing existence of the organization and may influence its short-term or long-term competitive strategy.

The problem outlined above deals with the definitions and interpretations of the three terms: physical efficiency, economic efficiency, and organizational efficiency. Definitions of these terms, as available in the literature, are given in the second chapter. The interpretations of the three efficiencies, as used in this thesis, are given in the third chapter. Chapters Four and Five deal with the methodology, and Chapter Six presents conclusions and recommendations.

The research consists of two parts: first, of linking the three efficiencies using a suitable technique. One such technique is the theory of utility, which assigns mathematical values to the wants and needs of a person or a category of people as a whole. This theory has been reviewed in greater detail in the next chapter. The second part of the problem consists of performing a multi-period analysis for two hypothetical organizations. Five periods will be considered and profits distributed to the various contributors subjectively. The objective of this analysis will be to demonstrate the technique developed in part one.
that links improvements in physical efficiency in earlier periods to improved benefits at a later stage.
2.0 LITERATURE REVIEW

The literature review for this thesis research falls into four categories: first, literature pertaining to the three efficiencies - physical, economic, and organizational; second, concepts of organization; third, literature concerning marginal utility theory; and fourth, literature dealing with the development of mathematical utility functions.

2.1 Efficiencies

Efficiency in a generic sense is taken as the ratio of output product to input resource. If the ratio approaches one, the conversion process is said to be more efficient. Since this research deals with the interpretations of physical, economic, and organizational efficiencies, their definitions as found in the literature are reviewed.
2.1.1 Physical Efficiency

Extensive literature is available in engineering relating to the physical efficiency of systems (Reynolds & Perkins, 1977). Particular emphasis in this literature has been given to the input-output ratios of power plants and other fuel and energy related devices such as turbines, boilers or mechanical drives. Since the objective of an engineering application often is to achieve the greatest end result (output) per unit of resource (input), physical efficiency is defined to be:

$$\text{Physical efficiency} = \frac{\text{output}}{\text{input}}$$

Physical efficiency can be expressed in physical units, such as Btu’s, kilowatts, or foot-pounds. With these physical units, efficiency is always less than unity or less than 100%. This is so because of the various mechanical, thermal, and friction losses to overcome resistance. A machine or process, once established, will operate at or below its design efficiency; heat engines operate at 20% to 50% efficiency, while motors, generators, and gear-boxes may perform at efficiencies of 90% to 99%.

Physical efficiency may also apply to the utilization of capacities as in warehouses or water reservoirs (Tiller, 1983). In the case of a water reservoir, the physical input is the volume of water (acre-feet) that the reservoir can hold. The output of this system is the actual amount of water retained in the reservoir, in a given time period. This type of system can be operated over a range of efficiencies, from zero to unity, unlike a mechanical system. This can be easily shown with the following example:

Let the capacity of a water-reservoir be 100 liters. At any time “t”, if it holds 90 liters, then its physical efficiency will be $\frac{90}{100} = 0.9$. If at time “t”, it holds 100 liters, then its physical efficiency will be $\frac{100}{100} = 1.0$. 

2.0 LITERATURE REVIEW
2.1.2 Economic Efficiency

Economic efficiency is a concept which is used less often than physical efficiency. At a micro-level, it deals with the efficiency of production of each additional unit of the product. The optimal level of production is reached when the marginal cost of production of a unit is equal to the marginal revenue from that additional unit. At this level of production, the so-called economic efficiency reaches its maximum value (Sherman, 1974). The relationship between marginal cost and marginal revenue is shown in Figure 1. In this figure, with increases in the level of production, the cost of each additional unit produced (marginal cost) decreases in the initial stage and then increases constantly. Initially, a firm experiences increasing marginal returns, which results in a falling cost of production. Marginal cost falls because the marginal physical product of the variable resource is rising. Eventually, however, the marginal physical product of the variable resource declines as the firm experiences diminishing marginal returns. When the firm experiences diminishing marginal returns, the marginal cost of output increases.

The average cost, on the other hand, decreases up to a certain point and then increases. At low levels of output, the marginal cost curve declines as output expands because of increasing marginal returns. This falling marginal cost lowers average cost as output expands. Even after marginal cost starts to rise, marginal cost is still below average cost, so average cost will continue to fall. As long as marginal cost is below average cost, average cost will continue to decline. The two curves intersect where marginal cost equals average cost. Once marginal cost exceeds average cost, the average cost curve starts to rise as output expands -- higher marginal cost begins to pull up the average.
Figure 1. Curves showing relationship between marginal cost, average cost, and revenues.
The point at which the marginal cost is minimum is also the point at which marginal cost and marginal revenue are equal (McEachern, 1988).

At the macro-level, Thuesen and Fabrycky (1984) define economic efficiency as the worth to cost ratio. In this relationship, worth is the value of the output in dollars, and cost is the value of input in dollars. Thuesen and Fabrycky (1988, pg. 7) show this relationship with an example:

In the operation of a power plant, it is assumed that the plant efficiency is 36%. Assuming that the output BTU's in the form of electrical energy have an economic worth of $14.65 per million and the input BTU's in the form of coal have an economic cost of $1.80 per million, then

\[
E_{\text{conomic efficiency}} = \frac{\text{worth}}{\text{cost}}
\]

[1]

Therefore,

\[
E_{\text{conomic efficiency}} = \frac{\text{BTUs output}}{\text{BTUs input}} \times \frac{\text{worth of electricity}}{\text{cost of coal}}
\]

or

\[
E_{\text{conomic efficiency}} = 0.36 \times \frac{$14.65}{$1.80} = 293\%.
\]

In this equation, the ratio of Btu's out to Btu's in is the physical efficiency.

For an economic undertaking to be successful in the long run, the economic efficiency must exceed 100 percent. This is because if it keeps on losing money for an extended period of time and does not make profit, it may cease to exist (Thuesen and Fabrycky, 1984).
2.1.2.1 Productivity

According to Cross (1983), efficiency and productivity are similar concepts viewed from different perspectives. He states that, "Improved productivity is the result of any activity which reduces costs in the long run without compromising the corporate philosophy and the quality of the product in service or reducing gross revenue" (ibid, pp. 36-46). Productivity is most often associated with reducing costs and increasing profits. Like economic efficiency, it is also measured as outputs divided by inputs. Brayton (1983) has also defined productivity in terms of total profitability, and it is expressed as:

\[
\text{Total profitability} = \frac{\text{Total Output (dollars) Goods & Services}}{\text{Total Input (dollars) Resources}} \quad [2]
\]

Productivity is a measure of the efficiency with which products are produced. It is a ratio of the output to the factors needed to produce the output. An improvement in this relationship will reflect an increase in the efficiency of the system. Sink (1985, pg. 40) defines productivity as a "relationship between quantities of outputs from a system and quantities of input into that same system." Productivity can be measured in three ways: first, partial-factor productivity, second, multi-factor productivity, and third, total-factor productivity (Sink, 1985, pg. 26). In case of partial-factor productivity, output is measured against a single input factor. In multi-factor productivity measurement, more than one factor is used to measure productivity while in the case of total-factor productivity, the total output is measured against all the input factors that go to produce it. An increase in total-factor productivity may not signal a growing efficiency in the use of all factors. Total-factor productivity increases if there is improvement in the overall process through improved technology or management practices that lead to more efficient use of existing resources. "Total-factor productivity, thus, is the best expression for the ef-
ficiency of economic activity and the prospects for longer term growth” (Organization for Economic Cooperation and Development, 1976, pgs. 11 & 12). Further, an increase in partial-factor productivity is not necessarily accompanied by an increase in overall (total-factor) productivity (Organization for Economic Cooperation and Development, 1976, pgs. 11 & 12.). This is because an increase in the partial-factor productivity can be the result of substituting one factor for another. An increase in labor productivity can result from the replacement of labor by capital. It may result in the decrease in the productivity of capital while labor productivity may increase. This can be illustrated with the following example:

A company may choose to invest in an expensive CNC machine which will replace manually operated machines. Keeping the output and all other factors constant, the output per labor hour will increase, i.e. the labor productivity increases. This is so because less labor input is required for the same output. On the other hand, capital productivity decreases since more capital has been used for the same output.

Total-factor productivity is usually measured by considering only the two most important production factors, capital and labor, while partial factor productivity is commonly expressed using labor productivity. In most research and policy decisions, labor productivity is preferred (Organization for Economic Co-operation and Development, 1976, pg. 11 & 12). Output per labor-hour indicates how much labor is associated with the volume of output. Thus, the trend in output per labor-hour reflects technological innovation, changes in capital stock and capacity utilization, scale of production, flow of materials, education and skills of workers, quality of management, state of labor relations, and many other factors. On the other hand, the concept of capital input poses many complex problems: accounting for obsolescence, and measuring the services of
capital stock, among others (Organization for Economic Co-operation and Development, 1976, pg. 11 & 12).

For this research, the concept of total factor productivity as given by Equation 2, which is similar to economic efficiency as defined by Equation 1, will be used as economic efficiency in Chapter Four.

2.1.3 Organizational Efficiency

After discussions with faculty (Dr. Catherine Echel and Dr. Jacques Cremer, Department of Economics, VPI & SU, May 31, 1988) in the field of micro-economics and management, and reviewing the literature extensively, it was concluded that there is no currently acceptable definition of organizational efficiency at the micro-level or the macro-level. Barnard (1938) dealt extensively with organizational concepts at the macro-level, but did not discuss organizational efficiency. Barnard’s philosophy was reviewed in his book, The Functions of the Executive (1938), and also in his research papers in Organization and Management (1946). The book The Basic Barnard by Wolf (1974), provides a guide to Barnard’s concepts. A new expression for organizational efficiency will be derived in the next chapter, based on concepts put forward by Barnard.
2.2 Organizations and Social Cooperation

Although *The Functions of the Executive* (Barnard, 1938) was published fifty years ago, it is considered by scholars like Herbert Simon, Melville Dalton, and Robert Tannenbaum as one of the outstanding works in the area of organization and management (Wolf, 1974). It is a general consensus that almost every significant book on management refers to Barnard, and his influence can be found in the writings of some of the ablest social scientists like Lawrence J. Henderson, George Homans, and Kenneth Boulding (Wolf, 1974).

Even though Barnard is one of the outstanding authorities on organization and management, there is an aura of mystery about him and his work. This stems partly from the scarcity of his publications, since he published only one book and ten articles, and partly from the fact that little is known about Barnard himself. His goal was to provide generalizations about social cooperation which could provide an adequate theoretical basis for training in the administrative professions. *The Functions of the Executive* was written to develop concepts and ideas that would provide the framework of a theory of organization and management (Wolf, 1974).

The need to define organizations in terms of common elements guided Barnard’s thinking. The term “organization” used by Barnard was designed to meet his goal. He noted, however, that one must differentiate between formal and informal organizations. While these two are intimately related and a formal organization cannot exist for long without an informal one, Barnard built his definition around the concept of formal organization and identified it as a system.
Barnard (1938, pg. 73) defined a formal organization as a “system of consciously coordinated activities or forces of two or more persons.”

Barnard focused upon organization as “an integrated aggregate of actions and interactions having a continuity in time” (pg. 74). He rejected the concept of organization as a definite group of people coordinated to achieve a goal or goals. Instead his definition embraced actions contributing to the purpose of organizations. It included the actions of workers and managers, investors, customers, clients, and suppliers. He classified the organization in terms of the internal environment and the external environment. The workers and managers were taken as part of the internal environment while the investors, customers, clients, and suppliers were classified as part of the external environment.

For this thesis, only formal organizations at the macro level will be considered. Organization as defined by Barnard relates to the satisfaction of individual motives. According to him (pg. 56-57),

> The efficiency of a cooperative system is the resultant of the efficiencies of the individuals furnishing the constituent efforts, that is, as viewed by them. If the individual finds his motives being satisfied by what he does, he continues his cooperative effort; otherwise he does not. If he does not, this subtraction from the cooperative system may be fatal to it.

Thus, if an individual’s wants are being satisfied by the work being done for the organization, the individual will continue to work. Otherwise, the individual may leave the organization and this act may prove to be critical for the organization. Although the motivation for a contributor may be monetary or non-monetary, it will be assumed that the motivation for the contributor is in monetary terms only. Hence, if an individual is unhappy but his monetary wants are being satisfied, then he will continue to participate in the organizational process.

2.0 LITERATURE REVIEW
Barnard further illustrates the idea of cooperative participation with an example saying that;

If five men are required and the fifth man finds no satisfaction in cooperating, his contribution would be inefficient. He would withhold or withdraw his services, so that the cooperation would be destroyed. If he considers it to be efficient, it is continued. Thus, the efficiency of a cooperative system is its capacity to maintain itself by the individual satisfactions it affords. This may be called its capacity of equilibrium, the balancing of burdens by satisfactions which results in continuance.

For the organization to exist in a state of equilibrium, it is important that the satisfactions one receives exceed the burdens (Barnard, 1938, pg. 57). Since, even in the case of efficient systems, the amount of material and social benefits are limited, there is only a specific amount that can be contributed to each individual (Barnard, 1938, pg. 57). If more than a satisfactory amount is given to one individual, than an insufficient amount may be left for the remaining participants. This deficiency will result in an imbalance which may prove harmful for the sustenance of the organization (Barnard, 1938, pg. 58).

Further, the benefits to each individual or participant should exceed the effort put in. In the absence of this relationship, the participant will have no incentive to coexist with the organization (Barnard, 1938, pg. 58). In order to be efficient, a cooperative system must create satisfaction in excess of the effort put in. The satisfaction is generally in a different form from the contribution, as the individual requires a changed condition for himself (Barnard, 1938, pg. 59).

The organization should be able to distribute its benefits optimally in order to continue most efficiently. Its efficiency will depend on what it produces and how and what it distributes. Emphasizing this idea, Barnard says (1938, pg. 59),

The efficiency of cooperation therefore depends upon what it secures and produces on the one hand, and how it distributes its resources and how it changes motives on the other. Everything that it does involves physical, biological, and social forces, applied to particular factors -- physical, biological, personal, and social -- in the situation as a whole. From the change in this situation it furnishes in-
ducements or satisfactions. The distribution of these satisfactions is itself an application of physical, biological, and social forces to changing the total situation. A cooperative system is incessantly dynamic, a process of continual readjustment to physical, biological, and social environments as a whole. Its purpose is the satisfaction of individuals, and its efficiency requires that its effect be to change the history of its environment as a whole; it does this by changes in the physical, biological, and social components of that environment.

2.2.1 Torgersen's Interpretation of Barnard's Philosophy

According to Torgersen (1969, pg. 31), "The efficiency of a cooperative system is the sum of the efficiencies of the participants in that system as subjectively evaluated by them." The individual gives "something" to the cooperative system and this may be referred to as a contribution or a burden. The individual receives "something" in return and this may be referred to as an inducement or a benefit. In an industrial setting, the burdens may be time and effort. The benefits may be money and other satisfactions such as some social relationships and the feeling of pride in work accomplished. Each individual will subjectively evaluate the worth of contribution to the cooperative system and the worth of the inducements received in comparison to other alternatives known and available. In order for the individual to remain a part of the cooperative system, this subjective evaluation must be that the difference between benefits and burdens must be positive.

Torgersen (1969, pg. 32), says that, "The efficiency of a cooperative system will never be capable of measurement except in that it must exceed unity". In effect, a cooperative system creates "utility" (the power to satisfy human wants). This system takes what people value less and gives them in return what they value more. "A cooperative system that cannot do this, that cannot create utility, that does not operate at an efficiency of greater than 100%, will cease to exist (Torgersen, 1969, pg. 32)." The evaluation of value contributed to the cooperative system and received from the system will be indi-
individual and subjective and not capable of objective measurement except on an attribute basis. Thus, a subjective numerical value, or an attribute, will be assigned to quantify the utility of that particular exchange with the cooperative system. If the system exists, according to Torgersen, it must have been functioning at an efficiency of greater than "unity," and the benefits received may be tangible and immediate or probabilistic and of anticipated value.

Figure 2 (Tiller, 1983, pg. 6), shows the various participants in the organizational process. In this figure, each of the four contributors gives something (time, money, or resources) to the organization and gets back benefits in form of money, goods, or services. The vendors give supplies of raw materials, equipment, and power, and in return receive payment. The payment should have higher value to the vendors than the supplies provided. The investors put in a dollar investment and receive dividends. The dividends should be at a higher rate of return than the bank interest rate, otherwise the investors will find no incentive to invest in the organization. Workers and managers contribute their talents and efforts and receive wages and other benefits, such as medical care or education for their children. The subjective value of these wages and benefits has to be greater than the cost of the time put in, else the worker will quit the job and find employment with some other company. Finally, the customers give money to receive various goods and services provided by the organization. The value of these goods and services should be more than the money paid. In the absence of increased benefits as compared to the burdens for each class of contributor, the organization will collapse.
Figure 2. Economics of exchange (Tiller, 1983, pg.6)
2.3 Utility Theory

To evaluate the worth of contributions and benefits for the participants in the organizational process, a subjective value for the benefits to the contributors in terms of utilities will have to be attributed to each of them. Currently available literature uses the concept of utility to attribute subjective values in cases where the worth of a contribution is not easily quantifiable. For this research, therefore, utility theory will be used to attribute values to the worth of contributions and benefits. In order to introduce the concept of utility, it is essential to understand how a decision maker chooses one alternative over another, and what criteria are used to arrive at a decision. One decision criterion used in utility theory is called the Expected Monetary Value and is defined in the following section.

2.3.1 Expected Monetary Value

In many personal and business situations concerning monetary values, decisions are faced involving relatively large monetary amounts and commensurate high risks. According to Trueman (1977, pg. 109), if the monetary amounts are sufficiently high compared to the assets of the decision maker, the choice of the preferred alternative will frequently involve strong consideration of the current asset position. He further adds that an act may be selected which may not have the most favorable Expected Monetary Value, where the Expected Monetary Value (EMV) of an act is the summation of all the weighted profits associated with that act. In such cases, an indication by the decision maker may be that the act with the most favorable EMV is too risky, and it is rational...
to prefer an act with a less favorable EMV (Trueman, 1977, pp. 159-160). The following example by Trueman (pg. 159) shows one such decision situation involving high risks:

A reliable person offers the opportunity to participate in a high-risk oil-drilling venture. It requires an investment of $1000, and the odds are 3 to 2 in favor of bringing the well in, in which case the share of the profits would be $5000. In case of a dry hole, $1000 is lost. On an EMV basis,

\[
EMV = \frac{3}{5}(5000-1000) + \frac{2}{5}(0-1000) = 2400 - 400 = 2000.
\]

Since this amount is double the investment, the deal appears to be a good one. The individual gains $4000 or loses $1000. On the other hand, if a loss of $1000 practically bankrupts the individual, perhaps it would be wise to pass up the opportunity, since there is a high (40%) probability of losing that $1000.

In decision situations as given above, the preferred decision is said to have the highest expected utility. The definition and methods for measurement of utility are given in the next two sections.

2.3.2 Measuring Utility

Trueman defines utility (1977, pg. 160) as "a subjective numerical measure of the value of an act to a decision maker when a particular event occurs." Being subjective, the utility of a given combination of an act and event will differ from individual to individual and even for the same individual as circumstances change. A specific utility value is associated with an act and event and it is referred to as the utility of the combination of act \( A_i \) and event \( E_j \) (i.e. the utility of \( A_i E_j \)). The combination of act and event is called an outcome (Luce and Raiffa, 1958).
2.3.3 Cardinal Utility Theory

Utility can be measured in several different ways. For this thesis, only cardinal utility theory will be considered, whereby numerical values are assigned to different outcomes. The simplified concept of cardinal utility theory is that individuals try to optimize the expected values of their utilities, and that, for each individual, a relationship between utility of an act and its outcome (generally dollars) can be found in a particular set of circumstances (Trueman, 1977, pg. 161).

Utility is measured on an arbitrary interval scale and the unit of utility is referred to as a *utile*. The basic postulates of cardinal utility are as follows (Raiffa, 1968):

- If outcome A is preferred to outcome B, then the utility of outcome A, U(A), is greater than the utility of outcome B, U(B). If outcome B is preferred to outcome C, then U(B) > U(C). Then, if we make the assumption that preferences are transitive, outcome A would be preferred to outcome C, since U(A) > U(B) > U(C).

- If the decision maker is indifferent between outcome B for certain and a lottery in which he receives outcome A with probability p and outcome C with probability 1- p, then U(B) = p U(A) + (1- p)U(C).

In any decision involving uncertainty, a basic assumption of cardinal utility theory is that a rational individual will choose that alternative which maximizes expected utility. Once an individual's utility function is known (i.e., if the probabilities assigned by that individual to events in a decision making situation are known, and the consequences of each possible outcome are given) then that individual's choice in that situation can be
predicted. This is so because the individual will try to maximize the expected utility. An individual's utility function is determined in two ways, either by the "certainty equivalent technique" or by the "standard gamble technique" (Luce and Raiffa, 1958).

2.3.3.1 Certainty Equivalent Technique

The certainty equivalent hypothesis states (Bunn, 1984, pp.40-42):

If we have an uncertain prospect of SX with probability \( p \) and SY with probability 1- \( p \) then (if Y > X) there should be a prospect for certain SZ, where X < Z < Y, for which the decision maker is indifferent in terms of preference between: SX with probability \( p \), or SY with probability 1- \( p \), and SZ for certain.

This hypothesis can be illustrated with the following example:

Let there be a coin tossing game with a payoff schedule of $550 if heads comes up and $0 if tails comes up. Then, for any individual, there exists a dollar amount (say $200) which if given to him will make the individual indifferent between playing the game and taking that dollar amount, i.e. $200. The certainty equivalent (CE) of that individual for that particular game is therefore $200.

2.3.3.2 Standard Gamble Technique

The standard gamble technique is set up in the same manner as the certainty equivalent technique. Let there be three outcomes A, B, and C, preferred in that order. The individual has a choice of: (1) B or (2) a lottery between A and C, with probabilities of \( p \) and 1- \( p \), respectively.

An individual is asked to express his preference between the first and second alternatives. In this case, A, B, and C are fixed while \( p \) varies. If \( p = 1 \), the choice is between B and
A, and the individual will choose alternative 2. On the other hand, if $p = 0$, the choice is between B and C, and the individual will choose alternative 1. Thus, as $p$ decreases from 1 to 0, the decision, at some point changes from alternative 2 to 1. There is a value of $p$ at which the individual is indifferent to the choice of alternative 1 or alternative 2. At this point, the utility of alternative 1 is equal to the utility of alternative 2, or

$$U(B) = p U(A) + (1-p) U(C).$$

Using these two techniques, various utility curves dealing with monetary and non-monetary outcomes have been developed (Raiffa, 1968). These curves portray the behavior of an individual under a given set of circumstances, and offer a picture of attitude towards taking risks. (It should be noted that there is a dynamic element to utility for any individual and that utility curves may change over time. Treatment of this dynamic element is beyond the scope of this thesis and will not be discussed further.) From these utility curves, an individual can be classified as extremely conservative, conservative, moderately conservative, linear, inclined towards risk, or a gambler (Swalm, 1966, pp. 123-135).

### 2.3.4. Risk Attitudes

If an individual is facing an uncertain prospect $y$ (where $y$ is a random payoff variable), then risk premium $RP(y)$ is defined as

$$RP(y) = EMV(y) - CE(y).$$

That is, the risk premium is the difference between the expected value and the certainty equivalent (Bunn, 1984, pg. 47). This risk premium is the amount an individual is willing
to pay (forego) over the odds to avoid an uncertain prospect. The risk attitudes are defined as:

1. Risk-averse or conservative if and only if $\text{RP}(y) > 0$
2. Risk-neutral if and only if $\text{RP}(y) = 0$
3. Risk-seeking or a gambler if and only if $\text{RP}(y) < 0$

Figure 3 shows the typical shapes associated with these three risk attitudes. According to Bunn (1984, pg. 47), for an equal probability prospect on the best and worst outcomes of $y$, $U(y) = 1$ and $0$, respectively, the certainty equivalent CE of a risk-neutral person is equal to the expected value while that for a risk-averse person is less, and for a risk-seeking person, the CE is more.

The utility function of a risk-neutral person is a straight line. This person’s certainty equivalent always equals the expected value. The risk premium is always zero. The slope of the function is constant, that is, the second derivative $U''(y) = 0$ (Bunn, 1984, pg. 48).

The utility function of a risk-averse person lies above the risk-neutral line. Because the end points are fixed, this gives a curvature to the utility function. The slope is always positive, but keeps on decreasing, and the second derivative $U''(y) \leq 0$. The risk premium is positive, and the curvature of the function is technically termed as concave (Bunn, 1984, pg. 48).

The utility function of a risk-seeking person is always below that of the risk-neutral line. The risk-premium is negative, and the slope is always positive. The slope keeps on increasing, and the second derivative $U''(y) \geq 0$. The curvature of the function of a risk-seeking person is termed as convex (Bunn, 1984, pg. 48).

2.0 LITERATURE REVIEW
Figure 3. Risk-averse, risk-neutral, and risk-seeking utility functions (Bunn, 1984, pg. 48)
In most decision analysis situations, particularly in situations where the payoffs are significant to the well-being of the individuals, the decision makers tend to be cautious, i.e., risk-averse (Bunn, 1984, pg. 48).

2.3.5 Caveat in Interpreting Utility

According to Bunn (1984), if the ultimate payoff to a venture consists of a sequence of component payoffs, such as costs and revenues year by year, one cannot evaluate the expected utility of each component individually and then sum these expected utilities, i.e.,

\[ U(A + B) \neq U(A) + U(B) \]

A given risk at one asset position will be viewed differently when the asset base changes. However, if the utility function is linear, that is, the decision maker is risk-neutral and thereby adopts the expected value criterion, then the expected values of the components can be summed to give the total expected value for the venture. When applying expected utility to a venture, the net total payoffs for each option should be computed before transforming to utilities.

In summary, utility theory provides a way to quantify the values of benefits and burdens being experienced in a cooperative environment. For this thesis, the utility curves presented earlier will be used to formulate utility functions for the benefits available to the four classes of contributors in the organizational process. The formulation of utility functions will be done using a Vandermonde system of matrices presented in the following section.

2.0 LITERATURE REVIEW
2.4 Vandermonde Matrices

The literature on utility theory provides general curves which give the behavior and attitude of an individual towards risk under a particular set of circumstances. The curves assume that individual to portray the whole population, and mathematical functions have been developed for these utility curves. In a case where a utility curve does not fit the existing curves, no methodology has been proposed on how to develop mathematical functions.

The Vandermonde system of matrices is a procedure available in the mathematics literature whereby a cubic function can be developed from a given curve using four sets of data points. The procedure for formulating the equations is explained below (Golub, 1985):

Let \((X_0, Y_0), (X_1, Y_1), (X_2, Y_2), (X_3, Y_3)\) be four data points from a given curve. The matrix setup for these data points is as follows:

\[
\begin{bmatrix}
1 & X_0 & X_0^2 & X_0^3 \\
1 & X_1 & X_1^2 & X_1^3 \\
1 & X_2 & X_2^2 & X_2^3 \\
1 & X_3 & X_3^2 & X_3^3
\end{bmatrix}
\begin{bmatrix}
C_0 \\
C_1 \\
C_2 \\
C_3
\end{bmatrix}
=
\begin{bmatrix}
Y_0 \\
Y_1 \\
Y_2 \\
Y_3
\end{bmatrix}
\]

From the above matrix multiplication, the four coefficients \(C_0, C_1, C_2,\) and \(C_3\) can be easily determined. The first coefficient, \(C_0\), goes with the constant in the cubic equation while the last, \(C_3\), goes with \(X^3\), which is the cubic power of the X-coordinate of the ar-
bitrary point chosen. Since this procedure uses four arbitrary points, it does not give the exact equation of the curve. A good approximation of the curve can be obtained by using different combinations of the four points till the equation resembles the curve in question. At the same time, a major advantage of this procedure is that it can be used for any shape of the curve, and the equation of the curve can be easily determined.

As reviewed in the preceding text, the literature available defines physical efficiency and economic efficiency. Although some work has been done by Tiller (1983) and by Thuesen & Fabrycky (1984) towards the link between physical and economic efficiency, a positive mathematical link between economic efficiency and organizational efficiency has yet to be established. Further, a methodology for formulating a utility function for organizational efficiency has to be developed.

An expression for organizational efficiency will be formulated using utility relationships. This expression will be based on Barnard's concepts as was illustrated in Figure 2. Utility curves for different classes of contributors will be taken from the literature, and utility functions for each of the contributors will be formulated using the Vandermonde matrices. The utility functions of each of the four contributors will then be aggregated to give an aggregate utility expression for organizational efficiency.
This chapter describes the methodology developed for this research. Three propositions have been put forward which will be demonstrated in Chapters Four and Five with the help of two scenarios. Mathematical relationships for net income and retained earnings of an organization have been developed along with a relationship for organizational efficiency. Lastly, the procedure followed for solving the problem has been presented in detail.

3.1 Objective

As discussed in the previous two chapters, the problem consists of how to formulate a link between physical efficiency, economic efficiency, and organizational efficiency. The literature available defines physical efficiency and economic efficiency, but a mathematical definition for organizational efficiency is not available. In order to define organ-
izational efficiency, certain assumptions have been made which are presented in the following section.

The objective of this thesis is to formulate a mathematical link between physical efficiency, economic efficiency, and organizational efficiency. The link between the three efficiencies (physical efficiency, economic efficiency, and organizational efficiency) has been used to perform a multi-period analysis. In this analysis, five periods were used, and the net income of the organization was distributed subjectively, to satisfy the aspiration levels of the various contributors. This multi-period analysis demonstrates that improvements in physical efficiency in earlier periods may result in an increase in the efficiency of the organizational process in the long run.

3.2 Assumptions

Two assumptions in the interpretation of organizational efficiency have been made. These are:

1. Algebraic addition of the utilities (of the four classes of contributors and the utility of retained earnings by the organization called the "treasury") is defined as the organizational efficiency. The literature does not generally allow addition of utilities as pointed out in the previous section. It is argued that the aspiration level of an individual changes with a changing asset base. The utility of money also changes as the asset base changes. Therefore if, in successive periods, the individual has greater wealth, the utility of additional money probably decreases. As such, the
utility function changes for each period. It is pointed out that, although the literature does not generally permit addition or aggregation of non-linear utilities, it is done for this thesis; the expression for organizational efficiency is based on the assumption that non-linear utilities may be aggregated.

2. Mathematical expressions derived by using the Vandermonde system of matrices give the utility functions for the contributors and the treasury using the functional forms based on curves obtained from the existing literature. It is again emphasized here that the literature has not used the Vandermonde system to develop mathematical utility functions for a given set of curves. In fact, no set procedure has been used to formulate a mathematical utility function from a given utility curve. Although mathematical utility functions are available in the literature, these give the general behavior of an individual under a particular set of circumstances. Any deviation from this behavior will result in a different functional form for which no mathematical expression is available. Using the Vandermonde system, any risk attitude can be estimated and expressed in the form of mathematical equations.

3.3 Mathematical Relationships

To link the three efficiencies and to provide motivation for mathematical development, three propositions are presented:

Proposition 1: A change in the physical efficiency of a system results in a change in its economic efficiency.

Proposition 2: A change in the economic efficiency of a system results in a change in its organizational efficiency.
Proposition 3: There exists a cause and effect relationship between the three efficiencies -- physical, economic, and organizational.

In order to demonstrate these propositions, two different scenarios are described. They are a power plant and an inventory warehouse.

The precise measurement of economic and organizational efficiencies is a challenge to engineers even today. Brayton said (1983, pp. 48-56), “Although American business managers have become increasingly aware of the necessity of improving productivity, they are seriously hampered in their efforts to do so by a lack of effective methods for determining how efficiently they use their productive resources.”

Physical efficiency is objective in nature and, in most cases, can be experimentally derived. The correct derivation of economic efficiency is subject to the accurate reporting of worth-cost data. Since the accounting/cost reporting systems in many organizations are inadequate, these data are at times very difficult to obtain (Tiller, 1983, pg. 8), and thus the measurement of economic efficiency cannot be as precise as that of physical efficiency.

Organizational efficiency’s subjective nature makes its appraisal and measurement even more difficult. Barnard says that (1938, pg. 93), “the efficiency of the organization is its capacity to offer effective inducements in sufficient quantity to maintain the equilibrium of the system. It is efficiency in this sense and not the efficiency of material productiveness which maintains the vitality of organizations.” Torgersen further elaborates (1969, pg. 32) by saying that, “A cooperative system that cannot create utility, that does not operate at an efficiency of greater than 100%, will cease to exist.” Thus the
very existence of a system for the long run indicates that it is operating at an efficiency of greater than 100% although it may operate below 100% efficiency for short periods.

Tiller said (1983, pg. 9), "The principle of causality is parallel to the stimulus-response process. For every effect upon a system, there exists a cause or set of causes that acted as stimuli to influence this activity". Therefore, if the physical efficiency of a system is improved, the economic efficiency may be positively affected. A positive stimulus to economic efficiency can result in an increase in benefits generated by the organizational system. These benefits may be made available as higher profits. An increase in profits will be distributed subjectively by the managers, or it may be left in the treasury. This distribution may result in an increase in the efficiency of the organization.

The principal of causality has been illustrated (Tiller, 1983, pg. 10) with a diagram (Figure 4). In the diagram, the direction of the arrow shows the direction of causation, and the sign indicates the polarity of the relationship.

With an increase in the physical efficiency of a system, there may result a positive addition to economic efficiency. This positive stimulus to economic efficiency may result in increased benefits which can be distributed as higher profits. These increased profits can be distributed by the managers among the four classes of contributors (customers, suppliers, workers, and investors). This distribution will be subjectively decided and will depend upon the preferences and judgment of the managers or the CEO as the case may be.

Some of the literature in this research area has shown a link between physical efficiency and economic efficiency. More needs to be done to show a link between economic efficiency and organizational efficiency. The expression for organizational efficiency derived

3.0 PROBLEM DEVELOPMENT
Figure 4. Causal relationship of physical efficiency, economic efficiency, and organizational efficiency (Tiller, 1983, pg. 10)
in this work is based on concepts put forth by Barnard. In order to derive an expression for organizational efficiency, the utility of benefits to the four classes of contributors is aggregated. A fifth entity, called the treasury, which holds the retained earnings of the organization is introduced in the expression for organizational efficiency. Retained earnings is the amount of money used by the organization (after distributions) for miscellaneous expenses, for operating and maintaining the existing equipment, and for updating the equipment. The sum of utilities for the contributors and the utility of the retained earnings in the treasury is the organizational efficiency. A diagrammatic representation of the aggregation of organizational efficiency is shown in Figure 5.

A portion of the net income of the organization is to be distributed as profits to each contributor, and once the aspiration levels of the contributors have been satisfied, the balance is kept in the treasury as retained earnings. Net income can be expressed as follows:

Net Income = \sum (profits distributed to each contributor + profits retained in the treasury)

or

\[ NI_n = \sum_{i=1}^{4} C_i \Delta_i + F_{Tn} \]  

[3]

where NI is the net income in period (n), \( C_i \) equals the profits distributed to each contributor based on their aspiration levels, and \( \Delta_i \) equals 1 for all contributors except for the contributor or contributors, whose aspiration level increases at a given rate. In that case, \( \Delta_i = (1 + \text{rate of increase in the aspiration level}) \). Here, \( F_{Tn} \) = profits retained in the treasury in period n, i is one of the four classes of contributors, and n is the period in question.

3.0 PROBLEM DEVELOPMENT
Figure 5. Sum of utilities of four contributors, and the utility of the retained earnings is an expression for organizational efficiency
The net income to be distributed is the resultant of two amounts. One is the income after taxes in that period, the other is the money saved as operating and maintenance expense due to the installation of superior equipment. An underlying assumption made in this case is that investments in technology do result in either labor savings, or savings in operating and maintenance expense. The savings in operating and maintenance expense can be obtained by comparing the cost of goods sold in the two consecutive periods. In the previous period, since no improvements have been made, the labor expense or the maintenance expense will be higher than in the period in which improvements have been made. This improvement in the expense cost will show up in the cost of goods made and sold statement, where the cost of goods made and sold in the previous period will be higher, and the cost of goods sold in the period with improved physical efficiency will be less. This statement can be mathematically expressed as follows:

Net Income in Period (n) = Net Income in Period (n-1) +

\[ \text{Cost of Goods Sold in Period (n-1) - Cost of Goods Sold in Period (n) } \]. \[4\]

The distribution of the net income to the contributors is dependent on their aspiration levels. The balance left in the treasury is determined after each of the four contributors is individually satisfied. Further, the cost of increase in physical efficiency is subtracted from the net income of that period. Finally, the carried over retained earnings from the previous period are added to the net income figure to obtain the expression for retained earnings for that period. The expression for retained earnings in the treasury is mathematically expressed as:

\[ F_{r_n} = NI_n - \sum_{i=1}^{4} C_i \Delta m_n - \Delta T_n + F_{r_{n-1}}. \] \[5\]

Here, \( \Delta T_n \) denotes the cost of increase in physical efficiency, and

\( F_{r_{n-1}} \) denotes the retained earnings carried over from the previous period.

3.0 PROBLEM DEVELOPMENT
Therefore, the expression for organizational efficiency in period n is:

\[ \text{Organizational Efficiency}_n = \sum_{i=1}^{4} U(C_i \Delta_{i_n}) + U(F_{T_n}) \]  

[6]

In this expression, \( U \) denotes "Utility", \( C_i \Delta_{i_n} \) is the product of two terms: first, the money distributed to each class of contributor, and second, the aspiration level of that class of contributor. There are four such products for four different classes of contributors. The utilities for each of these products to the respective contributors are estimated from the utility functions presented later in this chapter, and the four utilities then aggregated. \( F_{T_n} \) is the money retained in the treasury after some portion of the net income has been distributed to the four classes of contributors. Once again, the utility for the retained earnings to the treasury is estimated using the curves presented later in the text. This utility is then added to the aggregate of the utilities for the four classes of contributors to finally give an expression for organizational efficiency of the firm.

Further, a distribution of the organization's retained earnings in order to justify new investments was formulated. This distribution has to be such that each of the four classes of contributors (customers, suppliers, workers, and investors) is individually satisfied in order for the organization to exist in a state of equilibrium. For each of the four classes of contributors, the utility of the output should exceed the utility of the input. In the absence of this relationship, the individual will find no satisfaction and hence refuse to participate. This will result in the demise of the organization in the long run (Torgersen, 1969).

Investment decisions, particularly in the area of new technology, are probably the most important and most difficult decisions that confront top management. According to Hespos and Strassman (1965, pp. 48-55), there are four reasons for this. First, they involve enormous amounts of money, a large part of which also goes into acquisition,
development of new products, and other investment decisions. Second, investment decisions have long-lasting effects. Unlike mistakes in inventory decisions, mistakes in investment decisions cannot be worked off in a short period of time. A major investment decision often commits management to a plan of action extending over several years, and the dollar penalty for reversing the decision can be very high. Third, investments are the implements of strategy. They are the tools by which top management controls the direction of a corporation. Fourth, finally and perhaps the most important, investment decisions are characterized by a high degree of uncertainty. They are based on predictions about the future, often involving a planning horizon of 10 to 20 years. And they often require judgmental estimates about future events, such as the consumer acceptance of a new product, competition, or obsolescence of technology (Hespos and Strassman, 1965, pp. 48-55).

For all the above mentioned reasons, investment decisions absorb large portions of the time and attention of top management. Very often, due to financial, social and personal constraints, top management ends up not investing in new and improved technology. The absence of immediate benefits and returns, presence of high degrees of uncertainty, and the pressures of stockholders may dissuade managers from making long term investments.

### 3.4 Methodology

The formulation of a mathematical model showing a positive correlation between an increase in physical efficiency (resulting from possible investments in new technology)
and organizational efficiency would help management in making critical and strategic
decisions, and in justifying increased capital expenditures in new technology.

Such a mathematical model was developed in this research and is demonstrated with the
help of two scenarios in Chapters Four and Five. This model involves the links derived
between physical efficiency, economic efficiency, and organizational efficiency.

In order to show a mathematical link between physical efficiency and organizational ef-
ficiency, a base period was assumed. The physical efficiency of this base period was also
assumed from the information available in the literature (power plant), or was calculated
(warehouse) using equations from Chapter 2. The economic efficiency was then calcu-
lated for that base period using equations one (power plant) and equation two (ware-
house). Finally, the organizational efficiency was computed using equations three
through six. The link between physical efficiency and economic efficiency involves dollar
amounts, as a relationship between these two efficiencies, and has already been formu-
lated by Thuesen and Fabrycky (1984). Since the distribution of profits to the various
contributors is subjective and involves arbitrary money-units, the link between economic
efficiency and organizational efficiency was formulated using these money-units. The
dollar amount of economic efficiency was converted to money-units with an arbitrary
scale, for demonstration purposes.

In order to obtain an expression for organizational efficiency, mathematical utility
functions for the four contributors and the treasury were obtained (in cubic form) using
the Vandermonde matrix system. The Vandermonde matrix system was explained in
detail in Chapter Two. Four data points were arbitrarily chosen for the matrix computa-
tion from the curves developed by Swalm. Swalm (1966) has identified various curves
which give the risk attitudes of different individuals under a given set of circumstances.

3.0 PROBLEM DEVELOPMENT
The graphs can also be developed using either the certainty equivalent technique or the standard gamble technique as outlined in Chapter Two. These graphs are representative of the most likely behavior of an individual under a given set of circumstances and will vary from individual to individual. For a customer and supplier, it was assumed that they are moderately conservative. A worker was assumed to be conservative while for the investor and the treasury it was assumed that they can either behave in a risk-inclined manner or in a risk-averse (conservative) manner. The two scenarios in Chapter Four deal with both these possible attitudes for an investor and the treasury while calculating values for organizational efficiency. The curves for each class of contributor, and the treasury are presented in Figures 6 through 9. See Swalm (1966) for a discussion of the underlying assumptions.

An algorithm in BASIC was developed on the IBM personal computer to formulate the utility functions for the contributors and the treasury. The expression for organizational efficiency was then obtained by aggregating the utility functions of the contributors and the treasury, as discussed earlier in this chapter (Equation 6). The BASIC program and user instructions are presented in the Appendix. The aggregate polynomial obtained is also in cubic form and a diagrammatic representation of this function is shown in Figure 10.

To demonstrate the effect of increase in physical efficiency on economic efficiency and organizational efficiency, an increment was assumed for the base period. Equations 1 through 6 presented earlier in Chapters Two and Three were used for these incremental calculations.

A multi-period analysis for the effect of increases in physical efficiency on organizational efficiency was demonstrated using the same two scenarios as were used for demonstrat-
Figure 6. Curve showing the most likely utility function for customers and suppliers (Swalm, 1966, pg. 132)
Figure 7. Curves showing the two most likely utility functions for an investor (Swalm, 1966, pg. 132)
Figure 8. Curve showing the general utility function for a worker (Bunn, 1984, pg. 48; Swalm, 1966, pg. 132)
Figure 9. Curves showing the two most likely utility functions for a treasury (Swalm, 1966, pg. 132; Trueman, 1977, pg. 169)
Figure 10. Curve showing the aggregate utility function obtained from the Vandermonde matrix system.
ing a link between physical efficiency, economic efficiency, and organizational efficiency. This analysis can be done for any number of periods, but for demonstration purposes, it was carried out for five periods. An increase in physical efficiency was assumed (for periods 2 and 3 in case of power plant, and periods 2, 3, and 4 for warehouse). An increase in economic efficiency (and thus the total profits to be distributed) was demonstrated. The money available to each of the four contributors due to increases in physical efficiency was compared to the money available if no improvements in physical efficiency were made. The increase in the aspiration level of the contributors was taken to be 5% per period in both cases, i.e., the case where improvements in physical efficiency were made and the case where no improvements in physical efficiency were made. This comparison was used to analyze the effects of increases in physical efficiency on the benefits being distributed to the various contributors.

If the algorithm for formulating and aggregating utility functions for the contributors and the treasury were developed further, it could be used in industry by managers for the case where the utility functions of their organization's contributors resemble those used in the model. Further work developing these models could someday help managers to calculate distributions of profits to each of the contributors.
4.0 ANALYSIS - PART I

The methodology to be demonstrated was developed in the previous chapter and consists of two parts. Demonstration of part one consists of linking the three efficiencies: physical efficiency, economic efficiency, and organizational efficiency, and is addressed in this chapter; demonstration of part two consists of a multi-period utility analysis showing that increases in physical efficiency result in higher benefits to the various contributors in future periods, and eventually to higher organizational efficiency and is addressed separately in the fifth chapter using various examples.

A computer code was written in BASIC that calculates the aggregate utility function for the four classes of contributors and the retained earnings in the treasury. Utility functions for the four classes of contributors and the retained earnings of the organization in the treasury are considered as input. Another BASIC program was written to calculate the distribution of the profits of the organization to various classes. This program also calculates the values for organizational efficiency using various sets of utility curves. Results are presented in this chapter (the BASIC code is included in the Appendix).
sensitivity analysis of the effect of changes in physical efficiency on organizational efficiency is also performed for each scenario and is included in this chapter.

The economic efficiency of a system increases with increases in its physical efficiency, as defined earlier by equations one and two. The increase in economic efficiency results in increased profits. With the increase in profits, the returns to each of the four classes of contributors increase, and therefore, the organizational efficiency given by equation six, increases. It is demonstrated that in order for the organization to be competitive in the long run, the benefits distributed to the contributors should be less and the organization should elect to keep more for investments in technology. The methodology is demonstrated using the following scenarios.

4.1 Scenarios

The remainder of this chapter considers two scenarios demonstrating a mathematical link between the three efficiencies. The scenarios presented are ones involving a power plant and an inventory storage facility. In each case, the effect of an increase in physical efficiency on economic efficiency and consequently its effect on the organizational efficiency is observed. In each scenario, a change in the physical efficiency affects the profit and loss statement in a different way. The direct material costs and the overhead costs are affected in the power plant example and overhead expenses change in the inventory storage case. The following assumptions have been made:

1. There is no inflation.
2. Before the increase in physical efficiency occurs, a distribution of 20% of the total organization's profits is just enough to satisfy the aspiration level of the four classes of contributors.

4.1.1 Power Plant

Power plant efficiencies are of (direct or indirect) interest to almost everyone. Industry in general consumes approximately 40% of the total electric energy generated and the residential sector about one-third. Fossil-fuel power plants commonly operate at a physical efficiency of around 40% while nuclear plants operate at approximately 30% efficiency. (Tiller, 1983, pg. 15).

Fossil-fuel plants use heat engines whose operation is based on the Carnot cycle. The thermodynamic efficiency of the Carnot cycle is given as:

\[ e = \frac{T_1 - T_2}{T_1} \]

where \( T_1 \) is the highest temperature at which heat is added and \( T_2 \) is the lowest temperature (condenser temperature) at which it is removed. Therefore, the maximum physical efficiency obtained by a steam power plant is well below the ideal 100%. Power plant engineers have used various methods like superheating, reheating, economizers, pulverized coal for better combustion, and higher sensitivity controls and instrumentation for better physical efficiencies. In this example, it is assumed that the power plant engineers have completed a study indicating that the addition of an air preheater in the beginning of period two would boost the thermal efficiency by 15% in that period. It is further assumed that the use of higher sensitivity controls and instruments would in-
crease the physical efficiency by another 8% in period three, remaining constant through period five.

Stack gases are one of the main sources of loss of heat in fossil-fuel power plants. An air preheater is a heat exchanger that transfers heat from the stack gases to the incoming combustion air. The use of a preheater results in substantial energy savings. The transfer of heat from the stack gases to the incoming air increases the thermal energy associated with the combustion process and, hence, economic efficiency shows an increase due to a reduction in direct material costs. This will also hold true in the second set of improvements involving superior instrumentation.

Table 1 on page 58 gives a simplified weekly cost statement for a hypothetical fossil-fuel power plant. The three major cost components are the direct material costs, direct labor costs, and overhead costs. The “Period 1” column depicts costs prior to the installation of the preheater. “Period 2” column depicts the costs after the installation of the preheat unit, while “Periods 3, 4, & 5” column depicts the costs after installation of the higher sensitivity controls and instruments. The increase in thermal efficiency decreases the direct materials (i.e., coal requirements) of the power plant (by 9.3%) in its production of electricity in period two. The effects on labor and overhead costs can be considered negligible. In periods 3, 4, & 5, the use of better controls further reduces direct material costs by 4.9%. In each period, the “cost of goods sold” section shows a reduction over the previous period’s amount. In this table, the tonnage of coal used in periods 1, 2, and 3, and the price per ton are arbitrary figures. The reduction of the amount of coal used in periods 2 and 3 is also arbitrary and may not reflect the actual reduction in coal requirement due to a 15% or 8% increase in physical efficiency, respectively. Improve-
ments would have to be measured accurately for each installation before knowing the exact figures. This example is used as a demonstration of the methodology only.

Table 1. Simplified Weekly Cost Statement for a Fossil-Fuel Power Plant

<table>
<thead>
<tr>
<th>Cost Items</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Periods 3, 4 &amp; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Material (coal)</td>
<td>$790,000*</td>
<td>$716,500*</td>
<td>710,730*</td>
</tr>
<tr>
<td>Direct Labor</td>
<td>$180,000</td>
<td>$180,000</td>
<td>$180,000</td>
</tr>
<tr>
<td>Overhead</td>
<td>$825,000</td>
<td>$825,000</td>
<td>$825,000</td>
</tr>
<tr>
<td>Cost of Goods Sold</td>
<td>$1,795,000</td>
<td>$1,721,500</td>
<td>$1,715,730</td>
</tr>
</tbody>
</table>

a: 3762 tons of coal daily at $29.99 per ton.  
b: 3413 tons of coal daily at $29.99 per ton.  
c: 3386 tons of coal daily at $29.99 per ton.

4.1.1.1 Link between physical and economic efficiency

The increase in physical efficiency of the plant results in an increase in the economic efficiency. Let the physical efficiency of the plant before the installation of the preheater be 40%, and 55% after installation. The corresponding increase in the economic efficiency is calculated as follows:

The direct material cost from Table 1, in period 1, is $790,000 per week. The annual direct material costs for running the plant is $790,000 x 52 weeks = $41,080,000. The total annual cost of goods sold in Period 1 is $1,795,000 x 52 weeks = $93,340,000. Assuming that the production costs are 90% of the price of goods sold, the worth of electricity sold will be approximately $103,340,000 for a profit of approximately $10 million. Therefore, the economic efficiency, by definition (Equation 1), before installation of the preheater is:
Economic efficiency = \( \frac{\$103,340,000}{\$41,080,000} \)

\[ = 251.56\% \]

In period 2, the direct material cost is $716,500 per week. On an annual basis, the direct material cost associated with running the plant is $716,500 \times 52 \text{ weeks} = \$37,258,000. Assuming the worth of electricity remains the same i.e. $103,340,000, the

\[ \text{Economic efficiency} = \frac{\$103,340,000}{\$37,258,000} \]

\[ = 277.36\%. \]

Therefore, a fifteen percent increase in the physical efficiency results in an increase in economic efficiency from 251.56\% to 277.36\%, an increment of 25.8\%.

In period 3, due to the use of better control mechanisms, the physical efficiency of the plant further increases by 8\%. The cost of direct materials for one year is $710,730 \times 52 \text{ weeks} = \$36,957,960. Therefore, assuming the worth of electricity again remains the same, the economic efficiency for periods 3, 4, & 5 will be:

\[ \text{Economic efficiency} = \frac{\$103,340,000}{\$36,957,960} \]

\[ = 279.62\%. \]

As can be seen above, a 8\% increase in physical efficiency further increases the economic efficiency from 277.36\% to 279.62\%, i.e. an incremental increase of 2.26\%.
The effect of reductions in material costs on the income statement of the company are shown below:

<table>
<thead>
<tr>
<th></th>
<th>Income Statement</th>
<th>XYZ Power Plant</th>
<th>December 31, 1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>$X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Goods Sold</td>
<td>Decrease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Margin</td>
<td>Increase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selling &amp; Administrative Expenses</td>
<td>No Effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>Increase</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1.1.2 Link between economic and organizational efficiency

Due to the increase in the economic efficiency of the plant, the overall efficiency of the organizational process increases as shown in Table 2 on page 61. The "Period 1" column depicts the distribution of the profits from the power plant in terms of money-units (mu's) before the installation of the preheater. "Period 2" column depicts the distribution of profits after installation of preheater. The power plant presented in this example is assumed to be a non-utility company and therefore, the increase in profits do not have to be distributed necessarily to the customers in the form of lower electricity costs. "Period 3, 4, & 5" columns depict the distribution of profits after the installation of superior controls. In this table, it is assumed that the aspiration level of the investor class increases by 5% each period. It is further assumed that $2000 = 1 money-unit.
Table 2. Distribution of profits and total organizational efficiency assuming only the aspiration level of the investors increases

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 6911 mu's</th>
<th>Period 3 Profits = 7061 mu's</th>
<th>Period 4 Profits = 7061 mu's</th>
<th>Period 5 Profits = 7061 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1050 mu's</td>
<td>1102.5 mu's</td>
<td>1157.6 mu's</td>
<td>1215.5 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1361 mu's</td>
<td>1219.5 mu's</td>
<td>4122.88 mu's</td>
<td>6968.4 mu's</td>
</tr>
</tbody>
</table>

Total efficiency of Organization

<table>
<thead>
<tr>
<th>Set A</th>
<th>32285 utilies</th>
<th>82668 utilies</th>
<th>41665 utilies</th>
<th>3154045 utilies</th>
<th>15960130 utilies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set B</td>
<td>31706 utilies</td>
<td>78932 utilies</td>
<td>39812 utilies</td>
<td>2696302 utilies</td>
<td>13287130 utilies</td>
</tr>
<tr>
<td>Set C</td>
<td>143396 utilies</td>
<td>213533 utilies</td>
<td>195580 utilies</td>
<td>3334843 utilies</td>
<td>16172270 utilies</td>
</tr>
<tr>
<td>Set D</td>
<td>146371 utilies</td>
<td>213352 utilies</td>
<td>197282 utilies</td>
<td>2880655 utilies</td>
<td>13502820 utilies</td>
</tr>
</tbody>
</table>

The profits to be distributed in each of the columns are calculated as follows:

In period 1, the worth of electricity is $103,340,000 and the profit margin is $10 million. Since we have assumed that the worth of electricity remains constant, therefore, the profits are $10 million, or 5000 mu's for each of the five periods, if no improvements are made. At the same time, the cost of producing electricity is being reduced. The amount by which the cost is reduced is added on to the next period’s profit to give the total profit for the next period. Thus, it follows from equation four developed in Chapter 3 that, for period 2, the total profit is:

\[\text{Total Profit} = \text{Profit} + \text{Savings in Cost}\]

\[\text{Total Profit} = 10,000,000 + 3,822,000 = 13,822,000 \text{ or } 6911 \text{ mu's}\]
The savings in production costs between periods 1 and 2 is: $1,795,000 (cost of goods sold in period 1) \times 52 \text{ weeks} - $1,721,500 (cost of goods sold in period 2) \times 52 = $3,822,000. For periods 3, 4, & 5, the profits distributed are:

\[
= \text{profits in period 2} + \text{savings in production costs in period 3, 4, or 5} \\
= $13,822,000 + $300,000 = $14,122,000 \text{ or } 7061 \text{ mu's.}
\]

The savings in periods 3 on are calculated as follows: $1,721,500 (cost of goods sold in period 2) \times 52 \text{ weeks} - $1,715,730 (cost of goods sold in period 3, 4, and 5) \times 52 \text{ weeks} = $300,000.

The analysis and comparison of these is done at the end of the fifth period, and discounting has not been considered.

Further, the cost of increase in physical efficiency (investment in new technology) is deducted from the retained earnings in the treasury. It is assumed that the cost of the preheater is $5 million, i.e. 2500 mu's, and the cost of the higher sensitivity controls is $6.2 million, i.e. 3100 mu's. The cost of increase in physical efficiency is deducted at the end of the respective period from the retained earnings in the treasury as explained by Equation 5. For example, in period 2, the cost of preheater, i.e. 2500 mu's, is subtracted from the money in treasury -- 6911 mu's (total profits) + 1000 mu's (money carried over from the treasury in period 1) - 4050 mu's (profits distributed to the four contributors) - 2500 mu's (cost of increase in physical efficiency) = 1361 mu's. This gives the retained earnings at the end of period 2. This equation is similarly used for the next three periods to obtain the values for retained earnings in the treasury.

The four rows: Set A, Set B, Set C, and Set D give the organizational efficiency using four sets of curves (for the four classes of contributors and the treasury) given in Chapter
3. The values for organizational efficiency are calculated using equation six, which was also developed in Chapter 3.

The curves depict the behavior of the four different classes of contributors and the treasury. As some of the curves portray both risk-averse and risk-inclined behaviors, four combinations of these curves were used to aggregate the utility functions in order to obtain an expression for organizational efficiency. For demonstration purposes, the combinations of utility curves are:

Set A - Customers and Suppliers are moderately conservative, Investors and Workers are conservative, and the Treasury is risk averse.
Set B - Customers and Suppliers are moderately conservative, Investors and Workers are conservative, and the Treasury is risk seeking.
Set C - Customers and Suppliers are moderately conservative, Investors are risk inclined, Workers are conservative, and the Treasury is risk averse.
Set D - Customers and Suppliers are moderately conservative, Investors are risk inclined, Workers are conservative, and the Treasury is risk seeking.

In order to obtain the values for organizational efficiency, the utilities for profits distributed to each class of contributor are aggregated. The utility for profits retained in the treasury is estimated using the curves presented in Chapter 3, and aggregated with the utilities for the four contributors to obtain a value for organizational efficiency.

It is seen from Tables 1 and 2 that increases in physical efficiency in the hypothetical power plant have a profound effect on economic efficiency, and finally organizational efficiency. A 15% increase in physical efficiency causes a 25.8% increase in economic efficiency in this example. An additional increase of 8% in physical efficiency further increases the economic efficiency by 2.26%. In both these cases, there is a correspond-
ing increase in the overall efficiency of the organization as seen in the four rows of Set A, B, C, and D. Although the organizational efficiency reduces in the third period, it increases for periods four and five. The decrease in organizational efficiency in period three is attributed to the cost involved in the installation of more efficient equipment. It should be noted here that this decrease in organizational efficiency is for one period only and with the other increase in physical efficiency, the organizational efficiency shows an increase. From these results, it may be inferred that in this case, it is in this company's best interest (in the long run) to update its existing equipment and to invest in better technology in order to retain its competitive edge. In this way, it can satisfy the various contributors by giving them additional benefits in later periods. The contributors, on the other hand, have to forego profits in the earlier periods so that the company can retain the profits and use this retained capital for future investments in equipment which improve physical and economic efficiencies.

It is also seen from the four sets -- Set A, B, C, and D, that the organizational efficiency of the company is higher in the earlier periods when either one or two of the contributors are risk inclined. This is due to the nature of the curve for a risk inclined contributor. For a risk inclined contributor, the efficiency increases at an increasing rate. This is because the utility for a risk inclined individual with higher distribution of profits, is much more than the utility for a risk averse individual with the same distribution of profits. It may be concluded from these organizational efficiency values that a company may have to take risks in earlier periods in order to have a high organizational efficiency, at least under the assumptions and conditions specified herein. This may or may not be pragmatic in real world situations.
4.1.1.3 Sensitivity Analysis

As seen earlier, organizational efficiency is highly sensitive to changes in physical efficiency. Figure 11 shows the variation of organizational efficiency, graphically, for the first four periods. Since the physical efficiency is the same for periods 3 & 4, the X-axis on the graph is plotted for the periods 1-4. This graph shows how the organizational efficiency changes each period.

From each of these curves, it is seen that a small increase in physical efficiency results eventually in substantial increases in the organizational efficiency of the system. The increase in organizational efficiency in the first three periods is less as compared to the increase in organizational efficiency in period four. This is because in the first three periods, money is being reduced from the treasury to invest in improvements in physical efficiency. Once these improvements have been made, the money retained in the treasury increases. This raises the organizational efficiency greatly in the fourth period.

From the shape of the curves in Figure 11, it is concluded that investments to improve physical efficiency in earlier periods improve the overall efficiency of this organization. The increase in organizational efficiency is very large once the improvements have been completed and the organizational process carries on for a few periods.

Thus, if the management of the power plant distributes the profits from the electricity sales in such a manner that more profits are retained for improving the physical efficiency of the plant, they will be able to make higher profits a few periods later. This will also result in the four classes of contributors being satisfied to a larger extent, and will thus increase the efficiency of the whole organization.
Figure 11. Effect of changes in physical efficiency on organizational efficiency - Power Plant
4.1.2 Inventory Storage

In this scenario presented by Tiller (1983), the storage problems encountered by a single product firm in its warehousing are considered. The overhead expenses are affected by a change in physical efficiency. The costs involved in the overhead expense result from the storage and moving of raw materials, in-process inventory, and finished goods inventory. The physical efficiency of the warehouse is the subject of this example.

The organization in this example manufactures batteries for automobiles and light trucks. A warehouse at the main plant facility is utilized for product storage and an additional warehouse outside the main plant facility is rented to meet the storage requirements of the company. The physical input is the actual warehouse volume in cubic meters and the output is the volume utilized in cubic meters. The physical efficiency as discussed in the literature review is defined as the ratio of the actual cubic meters of storage utilized to the volume in cubic meters available.

The finished product (i.e. a boxed battery) enters the stockroom and a credit-to-stock form is generated for inventory record purposes. Also, a shelf-life tag is attached to the package. The boxed battery is then placed on a wooden pallet where it remains until shipment. A study is conducted to evaluate the existing inventory system. The focus of the study is to increase the physical efficiency of the warehouse (percentage of cubic meters utilized) and thereby to reduce one of the cost elements contributing to overhead expense.

The report issued at the conclusion of the study recommends the procurement of a modular storage system. The various tiers of this storage system will better utilize the
20 meter floor-to-ceiling zone in providing a higher density storage in the warehouse. A stacker crane with 2000-lb capacity can easily transport and position the pallets. The incorporation of this modular system increases the physical efficiency of the warehouse, since it utilizes more of the cubic meters available.

The increase in physical efficiency of the warehouse lowers the expense associated with the storage of the batteries. This increases the profits of the company due to the decrease in cost-of-goods-manufactured as shown on the cost-of-goods-made statement in Table 3. Direct material costs, direct labor costs, and overhead costs contribute to the cost of goods manufactured. The increase in physical efficiency does not affect the direct material costs or the direct labor costs, but reduces the overhead expenditure. This results in a decrease in the cost of goods sold, if the assumption is made that it is possible to sell everything manufactured in each period.

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Material (rubber case, vent plugs, terminal posts, lead plates)</td>
<td>None</td>
</tr>
<tr>
<td>Direct Labor (fabrication &amp; storage)</td>
<td>None</td>
</tr>
<tr>
<td>Overhead (building rent &amp; maintenance, moving &amp; storage expenses)</td>
<td>Decrease</td>
</tr>
<tr>
<td>Cost-of-goods-manufactured</td>
<td>Decrease</td>
</tr>
</tbody>
</table>

Let the total storage requirements of the company in any period be 20,000 cubic meters. Also, let the warehouse available to the company have dimensions of 40m x 25m x 20m. At present, the warehouse has a single-tier storage system 5m high. Therefore, only 40m x 25m x 5m or 5000 cubic meters of floor space is being utilized. The additional re-
requirement of 15,000 cubic meters is being met by renting another warehouse whose rental costs are $1 per cubic meter per month.

In the following example developed further from Tiller's scenario, it is assumed that the company opts for increasing the storage capacity by one tier each period. In period 1, it has one tier; in period 2, it puts on another tier; in period 3, a third tier; and in period 4, the final tier. It should be noted here that the tiers are added in the beginning of each period so that savings from adding the tier are available in the same period. The four-tier system provides 20,000 cubic meters of space. In periods 4 and 5, there is no need to rent another warehouse as the company's storage requirements total 20,000 cubic meters.

Using the definition of physical efficiency presented by Tiller (1983) in Chapter Two, the storage system currently being used has a physical efficiency of:

\[
\frac{5,000 \text{ cubic meters}}{20,000 \text{ cubic meters}} = 25\%.
\]

In period 2, another tier is added and the physical efficiency changes to 50%. In all, there is an overall increase of 75% in the physical efficiency of the warehouse, from 25% in the first period to 100% in the fourth period.

4.1.2.1 Link between physical efficiency and economic efficiency

It is emphasized here that the expression used for calculating economic efficiency in this scenario is the same as equation two, i.e., the relationship for productivity of a system. A relationship for economic efficiency of a warehouse was not available (unlike the case of a power plant, where Thuesen and Fabrycky had defined economic efficiency). A suitable definition involving worth to cost ratios had to be assumed to show the eco-
nomic efficiency which will increase due to reduction in the cost for hiring additional
rental space. Since the definition for economic efficiency given by Thuesen and
Fabrycky could not be used due to absence of thermal relationships, the relationship for
total factor productivity which involves worth to cost ratios and is analogous to the re-
lationship for economic efficiency has been used.

In this example, it is assumed that the cost of a stacker crane for stacking boxes onto
the various tiers is $20,000. The same crane can be used for a two-tier, three-tier, or a
four-tier system. Further, the cost of adding a tier is $5000. Therefore, a two-tier system
excluding the cost of a crane costs $10,000. This cost includes first cost for constructing
a foundation (which was not present with the old, one tier system) which amounts to
$5000. A three-tier system costs $15,000 and a four-tier system costs $20,000. After
including the cost of the crane in each case, the total cost of a two-tier system is $30,000,
the cost of a three-tier system is $35,000, and the cost of a four-tier system is $40,000.
As shown in Tables 4 & 5, with the installation of a two-tier system, the rental costs are
reduced to $120,000, and with a three-tier system the rental costs are $60,000. Finally,
the four-tier system reduces the rental costs to $0.

Let the cost of batteries being produced be $9 million per year and assume that pro-
duction costs are 90% of the price of goods sold. The selling price of the batteries is,
therefore, $10 million; i.e., the worth of the batteries is $10 million and the associated
cost is $9 million. The increase in physical efficiency results in a corresponding increase
in the economic efficiency of the system as shown in Table 4 on page 71, and Table 5
on page 72. The period 1 column depicts the costs associated with the present form of
storage system, the period 2 column depicts the costs associated with the two-tier sys-
tem, period 3 column depicts the costs associated with the three-tier system, and period 4 column depicts the costs associated with the installation of the four-tier system.

In Table 4, $30,000 is subtracted from the denominator of the equation for economic efficiency in period 2, because this is the net savings after adding the savings from rental costs for period 2, and subtracting the cost for crane and modular storage system. Similarly, in period 3, the net savings are $180,000 - ($60,000 + $5,000) = $115,000. In period 4, the net savings are: $180,000 - ($0 + $5,000) = $175,000. In periods 3 & 4, the costs for the modular storage system are reduced to $5,000 in each period as the company has already invested in the crane and foundation, and the cost of adding each additional tier is $5,000 as stated earlier.

<table>
<thead>
<tr>
<th>Table 4. Improvement in physical efficiency and its effect on the economic system: Period 1 and Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before installation of modular storage system - Period 1</strong></td>
</tr>
<tr>
<td>5,000 cubic meters of space utilized</td>
</tr>
<tr>
<td>15,000 cubic meters of space rented at a cost of 15,000 x $1 x 12 months i.e. = $180,000 per year</td>
</tr>
<tr>
<td>Modular storage system not yet installed</td>
</tr>
<tr>
<td>Net savings in period 2 = $30,000</td>
</tr>
<tr>
<td>$9 million</td>
</tr>
<tr>
<td>= 111.11 percent</td>
</tr>
</tbody>
</table>

4.0 ANALYSIS - PART 1
Table 5. Improvement in physical efficiency and its effect on the economic system: Period 3 and Period 4

<table>
<thead>
<tr>
<th>After installation of three tier modular storage system - Period 3</th>
<th>After installation of four tier modular storage system - Period 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>15,000 cubic meters of space utilized</td>
<td>20,000 cubic meters of space utilized</td>
</tr>
<tr>
<td>5,000 cubic meters of space rented at a cost of 5,000 x $1 x 12 months i.e. = $60,000 per year</td>
<td>Rental costs reduced to $0</td>
</tr>
<tr>
<td>Cost of adding the third tier = $5,000</td>
<td>Cost of adding the fourth tier = $5,000</td>
</tr>
<tr>
<td>Net savings = $180,000 - $60,000 - $5,000 = $115,000.</td>
<td>Net savings = $180,000 - $0 - $5,000 = $175,000.</td>
</tr>
<tr>
<td>Economic Efficiency = $10 million</td>
<td>Economic Efficiency = $10 million</td>
</tr>
<tr>
<td>$9 million - $115,000 = 112.54 percent</td>
<td>$9 million - $175,000 = 113.31 percent</td>
</tr>
</tbody>
</table>

The effect of the decrease in labor and overhead expenses on the income statement is as follows:

<table>
<thead>
<tr>
<th>Income Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ Batteries Incorporated</td>
</tr>
<tr>
<td>December 31, 1988</td>
</tr>
<tr>
<td>Sales</td>
</tr>
<tr>
<td>Cost of Goods Sold</td>
</tr>
<tr>
<td>Gross Margin</td>
</tr>
<tr>
<td>Selling &amp; Administrative Expenses</td>
</tr>
<tr>
<td>Income</td>
</tr>
</tbody>
</table>
4.1.2.2 Link between economic efficiency & organizational efficiency

Table 6. Distribution of company’s profits and total organizational efficiency

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 530 mu’s</th>
<th>Period 3 Profits = 560 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>105 mu’s</td>
<td>110.25 mu’s</td>
<td>115.8 mu’s</td>
<td>121.6 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>210 mu’s</td>
<td>357.3 mu’s</td>
<td>528.9 mu’s</td>
<td>697.4 mu’s</td>
</tr>
</tbody>
</table>

Total efficiency of Organization

<table>
<thead>
<tr>
<th>Set</th>
<th>Period 1 Profits</th>
<th>Period 2 Profits</th>
<th>Period 3 Profits</th>
<th>Period 4 Profits</th>
<th>Period 5 Profits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set A</td>
<td>469 utiles</td>
<td>540 utiles</td>
<td>1177 utiles</td>
<td>3880 utiles</td>
<td>9980 utiles</td>
</tr>
<tr>
<td>Set B</td>
<td>407 utiles</td>
<td>684 utiles</td>
<td>1912 utiles</td>
<td>5527 utiles</td>
<td>12472 utiles</td>
</tr>
<tr>
<td>Set C</td>
<td>426 utiles</td>
<td>494 utiles</td>
<td>1128 utiles</td>
<td>3830 utiles</td>
<td>9929 utiles</td>
</tr>
<tr>
<td>Set D</td>
<td>364 utiles</td>
<td>638 utiles</td>
<td>1863 utiles</td>
<td>5476 utiles</td>
<td>12420 utiles</td>
</tr>
</tbody>
</table>

As a result of an increase in the physical efficiency and consequently the economic efficiency, the efficiency of the total organizational system increases. The effect of this increase on the organizational system is shown in Table 6. The “Period 1” column depicts the distribution of the organization’s profits before the installation of the modular storage system while the “Periods 2, 3, 4, & 5” columns depict the distribution of the organization’s profits after the installation of the modular storage system. In this table, it is assumed that the company chooses to install a two-tier system initially. It improves this by converting to a three-tier system in period 3 and finally to a four-tier system in period 4. Once again, it is pointed out that improvements in physical efficiency (addition of tiers) is done at the beginning of each period. Therefore, the two tier system is added.
in the beginning of period 2, the third tier is added at the beginning of period 3, and the fourth tier is added at the beginning of period 4. Again, the aspiration level of the investors changes by 5% each period while that of the other three contributors remains constant, as in the prior example. The values for retained earnings in the treasury are calculated using equation five, and the values for organizational efficiency are calculated using equation six. The BASIC program was used to obtain the utile values for organizational efficiency in Table 6.

It is seen from tables 4, 5, & 6 that increases in physical efficiency in this situation result in increased economic efficiency and corresponding increases in the efficiency of the organization.

4.1.2.3 Sensitivity Analysis

As seen in this scenario, a 25% increase in physical efficiency each period increases the economic efficiency by an increment of 0.37% [111.48% (economic efficiency in period 2) - 111.11% (economic efficiency in period 1)] in period 2; by 1.06% [112.54% (economic efficiency in period 3) - 111.48% (economic efficiency in period 2)] in period 3; and by 0.77% [113.31% (economic efficiency in period 4) - 112.54% (economic efficiency in period 3)] in period 4. With a 25% increase in physical efficiency in period 2, the organizational efficiency increases by 15% to 75%. The increase in organizational efficiency is more in Set B and Set D, as compared to Set A and Set C, for each of the periods two through five. This may be attributed to the risk seeking nature of the investors and the treasury. In periods three through five, the organizational efficiency increases at a rate of 200% to 300% depending on the behavior of the contributors or the treasury. It shows a larger increase in the cases where either the investor or the treasury are risk in-
clined. Figure 12 shows the relationship between physical efficiency and organizational efficiency each period. It is once again seen that increases in physical efficiency result in an increase in the organizational efficiency. Due to the additions of the tiers, the company is able to save a substantial rental expense. In each period, as another tier is added, the physical efficiency increases. This results in less cost for renting storage space and thus, results in additional profits made available to the company. These profits, if reinvested to further improve the storage system by adding more tiers, result in further savings. These increased savings, once distributed to the four classes of contributors, will have more utility and may thus improve the functioning of the organization by increasing the organizational efficiency.

It can thus be concluded that improvements in physical efficiency (for this scenario) in earlier periods result in larger profits being distributed to the participants in the organizational process. These profits have more utility for the participants which increases the overall efficiency of the organizational process.
Figure 12. Effect of changes in physical efficiency on organizational efficiency
This chapter deals with the second part of the problem, that is, of performing a multiperiod analysis showing the long term effects of increases in physical efficiency on organizational efficiency of the system.

5.1 Scenarios

The scenarios used in this chapter are the same as those used in Chapter Four. They have been further sub-divided into multiple cases using three different aspiration levels. In the first set of cases, it is assumed that the aspiration level of only one of the classes of contributors, say investors, increases at 5%, 10%, or 15%. In the second set of cases, it is assumed that the aspiration level of two of the classes of contributors, say workers and investors, increases at 5%, 10%, or 15%.
The BASIC program used in Chapter Four for the calculation of profits to the various contributors is also used in this chapter. An extension of the same program gives the distribution of profits for the second set of cases when the aspiration levels of two of the classes of contributors changes at a time.

5.1.1 Power Plant

The first scenario is once again the power plant. In order to show the long term benefits of improvements in physical efficiency on organizational efficiency, six sub-cases are considered. In the first set of three cases, it is assumed that the aspiration level of one of the contributors, investors, changes. The three cases will have three different aspiration levels of 5% (Table 7), 10% (Table 9), or 15% (Table 11) for the investors [Tables 8, 10, & 12 show results for no changes in physical efficiency]. In the second set of three cases, it is assumed that the aspiration level of two of the contributors changes each period, and the rate of increase is 5% (Table 13), 10% (Table 15), or 15% (Table 17). [Tables 14, 16, & 18 show results for no changes in physical efficiency.]

It is further assumed that the cost of increase in physical efficiency is subtracted from the amount in the treasury in the same period. For example, in Table 7, in the second period, the cost of increase in physical efficiency is 2500 mu's. Therefore, 2500 mu's are subtracted from the profits in the treasury in the second period to give 1361 mu's = 6911 mu's (total profits) + 1000 mu's (retained earnings carried over from the previous period) - 4050 mu's (profits distributed to the four contributors) - 2500 mu's (cost of increase in physical efficiency). The cost of increase in physical efficiency in the third period is 3100 mu's. Similarly, the amount in the treasury in period 3 is 1219.5 mu's.
5.1.1.1 Cases with aspiration level of one contributor increasing

In each of the following cases, first a table with an increase in physical efficiency is presented and then it is compared to a table where no increase in physical efficiency occurs. The increase in physical efficiency is similar to the increase shown in the previous chapter. The comparison is done by dividing the money in the treasury after five periods equally among the four contributors, and then adding this sum to the profits already distributed to the four classes of contributors. It is also assumed that, in the first period, 20% of the total profits is enough to satisfy the aspiration level of each class of contributor.

Table 7 gives the distribution of the organizations profits to various contributors assuming that the aspiration level of investors increases at 5%, and the physical efficiency also increases.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 6911 mu's</th>
<th>Period 3 Profits = 7061 mu's</th>
<th>Period 4 Profits = 7061 mu's</th>
<th>Period 5 Profits = 7061 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1050 mu's</td>
<td>1102.5 mu's</td>
<td>1157.6 mu's</td>
<td>1215.5 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1361 mu's</td>
<td>1219.5 mu's</td>
<td>4122.8 mu's</td>
<td>6968.4 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money after five periods, to each contributor is:

Customer = 1000 + 6968.4/4 = 2742.09 mu's
Supplier = 1000 + 6968.4/4 = 2742.09 mu's
Investor = 1215.5 + 6968.4/4 = 2957.6 mu’s
Worker = 1000 + 6968.4/4 = 2742.09 mu’s

Table 8 gives the distribution of profits assuming there is no increase in physical efficiency, and the aspiration level of investors increases at 5%.

Table 8. Distribution of profits and total organizational efficiency: constant physical efficiency, aspiration level increases at 5%

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu’s</th>
<th>Period 2 Profits = 5000 mu’s</th>
<th>Period 3 Profits = 5000 mu’s</th>
<th>Period 4 Profits = 5000 mu’s</th>
<th>Period 5 Profits = 5000 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu’s</td>
<td>1050 mu’s</td>
<td>1102.5 mu’s</td>
<td>1157.6 mu’s</td>
<td>1215.5 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu’s</td>
<td>1950 mu’s</td>
<td>2847.5 mu’s</td>
<td>3689.9 mu’s</td>
<td>4474.4 mu’s</td>
</tr>
</tbody>
</table>

In this table, the retained earnings in the treasury keep on growing as no money is being reinvested for improvements in physical efficiency. The distribution of profits after adding one-fourth of the treasury money at the end of period five, to each contributor with no improvement in physical efficiency is:

Customer = 1000 + 4474.4/4 = 2118.59 mu’s
Supplier = 1000 + 4474.4/4 = 2118.59 mu’s
Investor = 1215.5 + 4474.4/4 = 2334.10 mu’s
Worker = 1000 + 4474.4/4 = 2118.59 mu’s

Comparing Tables 7 and 8, it is seen that the mu’s available to each of four contributors after increases in physical efficiency are more than those available had the increases in physical efficiency not taken place. It is thus demonstrated that improvements in physical efficiency in this scenario resulted in higher benefits being distributed to the contributors in the long run.

5.0 MULTIPERIOD ANALYSIS - PART II
Table 9 gives the distribution of profits and values for organizational efficiency with the aspiration level of investors changing 10% in each period.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 6911 mu's</th>
<th>Period 3 Profits = 7061 mu's</th>
<th>Period 4 Profits = 7061 mu's</th>
<th>Period 5 Profits = 7061 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1100 mu's</td>
<td>1210 mu's</td>
<td>1331 mu's</td>
<td>1464.1 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1311 mu's</td>
<td>1062 mu's</td>
<td>3792 mu's</td>
<td>6388.9 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

- Customer = 2597.23 mu's
- Supplier = 2597.23 mu's
- Investor = 3061.33 mu's
- Worker = 2597.23 mu's

Table 10 gives the distribution of profits and values for organizational efficiency with no increase in physical efficiency, and aspiration level of investors increasing at 10%.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 5000 mu's</th>
<th>Period 3 Profits = 5000 mu's</th>
<th>Period 4 Profits = 5000 mu's</th>
<th>Period 5 Profits = 5000 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1100 mu's</td>
<td>1210 mu's</td>
<td>1331 mu's</td>
<td>1464.1 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1900 mu's</td>
<td>2690 mu's</td>
<td>3359 mu's</td>
<td>3894.9 mu's</td>
</tr>
</tbody>
</table>
The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 1973.73 mu’s
Supplier = 1973.73 mu’s
Investor = 2437.73 mu’s
Worker = 1973.73 mu’s

From Tables 9 and 10, it is seen that with increases in physical efficiency, all classes of contributors stand to benefit.

Table 11 gives the distribution of profits and values for organizational efficiency with the aspiration level of investors changing 15% each period, and the physical efficiency also increases.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu’s</th>
<th>Period 2 Profits = 6911 mu’s</th>
<th>Period 3 Profits = 7061 mu’s</th>
<th>Period 4 Profits = 7061 mu’s</th>
<th>Period 5 Profits = 7061 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu’s</td>
<td>1150 mu’s</td>
<td>1322.5 mu’s</td>
<td>1520.9 mu’s</td>
<td>1749 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu’s</td>
<td>1261 mu’s</td>
<td>899.5 mu’s</td>
<td>3439.63 mu’s</td>
<td>5751.6 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 2437.91 mu’s
Supplier = 2437.91 mu’s
Investor = 3186.91 mu’s
Worker = 2437.91 mu’s
Table 12 gives the distribution of profits and values for organizational efficiency with no increase in physical efficiency but increase in aspiration level of investors by 15% each period.

Table 12. Distribution of profits and total organizational efficiency: constant physical efficiency, aspiration level increases at 15%

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 5000 mu's</th>
<th>Period 3 Profits = 5000 mu's</th>
<th>Period 4 Profits = 5000 mu's</th>
<th>Period 5 Profits = 5000 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1150 mu's</td>
<td>1322.5 mu's</td>
<td>1520.9 mu's</td>
<td>1749 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1850 mu's</td>
<td>2527.5 mu's</td>
<td>3006.6 mu's</td>
<td>3257.6 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 1814.41 mu's
Supplier = 1814.41 mu's
Investor = 2563.42 mu's
Worker = 1814.41 mu's

Once again, comparing tables 11 and 12, it is obvious that the various contributors to the organizational process stand to gain more benefits if improvements in physical efficiency are made for a few periods. It is also seen that if the aspiration level of investors is low, the other three participants in the organizational process benefit more.

From the previous six tables, it is concluded that the management of the power plant should improve the physical efficiency of the plant so that higher benefits can be made available to the participants in the long run. In the initial periods, the management should retain more profits for investments in improved technology. Once the improve-
ments have been made, the profits available can be distributed to any or all of the participants in one form or another.

5.1.1.2 Cases with aspiration levels of two classes of contributors increasing

In the following cases, it is assumed that the aspiration level of two classes of contributors, investors and workers, increases at 5%, 10%, or 15%. The cost of increase in physical efficiency in period 2 is assumed to be $5 million or 2500 mu’s and in period 3, it is assumed to be $6.03 million or 3015 mu’s. In these cases, the cost of increase in physical efficiency in the second period has been assumed to be different from that used in the earlier example. It has been done to simplify the problem and to keep it as similar to the earlier part as possible.

Table 13 depicts the distribution of profits and values for organizational efficiency assuming that the aspiration levels of the workers and investors increases at 5% each period.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu’s</th>
<th>Period 2 Profits = 6911 mu’s</th>
<th>Period 3 Profits = 7061 mu’s</th>
<th>Period 4 Profits = 7061 mu’s</th>
<th>Period 5 Profits = 7061 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu’s</td>
<td>1050 mu’s</td>
<td>1102.5 mu’s</td>
<td>1157.6 mu’s</td>
<td>1215.5 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu’s</td>
<td>1050 mu’s</td>
<td>1102.5 mu’s</td>
<td>1157.6 mu’s</td>
<td>1215.5 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu’s</td>
<td>1311 mu’s</td>
<td>1152 mu’s</td>
<td>3897.8 mu’s</td>
<td>6527.7 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:
Customer = 2631.94 mu's
Supplier = 2631.94 mu's
Investor = 2847.45 mu's
Worker = 2847.45 mu's

Table 14 gives the distribution of profits and values for organizational efficiency assuming there is no increase in physical efficiency, and aspiration level increases by 5%.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 5000 mu's</th>
<th>Period 3 Profits = 5000 mu's</th>
<th>Period 4 Profits = 5000 mu's</th>
<th>Period 5 Profits = 5000 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1050 mu's</td>
<td>1102.5 mu's</td>
<td>1157.6 mu's</td>
<td>1215.5 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1050 mu's</td>
<td>1102.5 mu's</td>
<td>1157.6 mu's</td>
<td>1215.5 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>1900 mu's</td>
<td>2695 mu's</td>
<td>3379.8 mu's</td>
<td>3948.8 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 1987.19 mu's
Supplier = 1987.19 mu's
Investor = 2202.69 mu's
Worker = 2202.69 mu's

From tables 13 and 14, it is seen that all the classes of contributors stand to benefit in the long run if improvements in physical efficiency are made in the earlier periods. Improvements in physical efficiency result in higher profits being distributed to the participants in the organizational process. This will have higher utility for the participants, and thus will increase the overall efficiency of the organizational process. This increase

5.0 MULTIPERIOD ANALYSIS - PART II
in the efficiency of the organizational process may influence the long term health of the company by insuring the continued participation of all of the classes of contributors.

Table 15 depicts the distribution of profits and values for organizational efficiency assuming that the aspiration level of workers and investors increases by 10% each period.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu’s</th>
<th>Period 2 Profits = 6911 mu’s</th>
<th>Period 3 Profits = 7061 mu’s</th>
<th>Period 4 Profits = 7061 mu’s</th>
<th>Period 5 Profits = 7061 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1331 mu’s</td>
<td>1464.1 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu’s</td>
<td>1100 mu’s</td>
<td>1210 mu’s</td>
<td>1331 mu’s</td>
<td>1464.1 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu’s</td>
<td>1100 mu’s</td>
<td>1210 mu’s</td>
<td>1331 mu’s</td>
<td>5368.8 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu’s</td>
<td>1211 mu’s</td>
<td>837 mu’s</td>
<td>3236 mu’s</td>
<td>5368.8 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 2342.2 mu’s
Supplier = 2342.2 mu’s
Investor = 2806.3 mu’s
Worker = 2806.3 mu’s

Table 16 gives the distribution of profits and values for organizational efficiency with an increase in aspiration level of 10% each period to the investors and workers. There is no increase in physical efficiency.
The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 1697.45 mu's
Supplier = 1697.45 mu's
Investor = 2161.55 mu’s
Worker = 2161.55 mu’s

From Tables 15 and 16, it is again seen that due to improvements made to physical efficiency in earlier periods, all contributors benefit in the long run.

Table 17 depicts the distribution of profits and values for organizational efficiency assuming that the aspiration level of investors and workers increases at 15%.
In Table 17, it is seen that in period 3, there is a drop in the retained earnings of the organization. This occurs as the firm invests capital to improve the physical efficiency of the organization. Once the improvements have been made, there is once again an increase in the retained earnings of the organization.

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 2023.56 mu’s
Supplier = 2023.56 mu’s
Investor = 2772.56 mu’s
Worker = 2772.56 mu’s

Table 18 gives the distribution of profits and values for organizational efficiency with an increase in aspiration level of 15% to investors and workers. There is no increase in physical efficiency.

<p>| Table 18. Distribution of profits and total organizational efficiency: constant physical efficiency, aspiration level increases by 15% |</p>
<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu’s</th>
<th>Period 2 Profits = 5000 mu’s</th>
<th>Period 3 Profits = 5000 mu’s</th>
<th>Period 4 Profits = 5000 mu’s</th>
<th>Period 5 Profits = 5000 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu’s</td>
<td>1000 mu’s</td>
<td>1322.5 mu’s</td>
<td>1520.9 mu’s</td>
<td>1749 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu’s</td>
<td>1150 mu’s</td>
<td>1322.5 mu’s</td>
<td>1520.9 mu’s</td>
<td>1749 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu’s</td>
<td>1150 mu’s</td>
<td>2055 mu’s</td>
<td>2013.2 mu’s</td>
<td>1515.2 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu’s</td>
<td>1700 mu’s</td>
<td>2055 mu’s</td>
<td>2013.2 mu’s</td>
<td>1515.2 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 1378.81 mu’s
Supplier = 1378.81 mu’s
Investor = 2127.82 mu’s
Worker = 2127.82 mu's

It is demonstrated in the comparison between Tables 13 and 14, 15 and 16, 17 and 18, that, in each of the cases, all classes of contributors stand to benefit if investments to improve physical efficiency are made. A lower aspiration level of the investors results in higher benefits being distributed to the other three contributors. If the aspiration level of two contributors increases, the other two contributors have fewer benefits available. The distribution of benefits has to be subjectively decided by a manager, and if any one particular class or classes are more important and have to be given more benefits, then the distribution to other classes suffers. This may lead to dissatisfaction among the other participants and may result in one or more of the contributors leaving the organization, which may prove fatal in the long run.

In all the tables presented for this scenario, improvements in the physical efficiency (through investments in technology) resulted in higher benefits being made available to the participants. These benefits had a positive impact on the overall efficiency of the organizational process. It is thus concluded that investments for improving the existing technology in a firm can be economically justified as they result in higher profits being distributed to the contributors (a help for companies which may have to look towards quick returns as a performance criteria), and also improve the efficiency of the organization.

5.1.2 Inventory Storage

The second scenario considered is the inventory storage case. Once again, to show the benefits of improvements in physical efficiency, a number of cases are taken and com-
pared with the case when no improvements in physical efficiency take place. The analysis of the results is done at the end of each set of four tables.

In the cases enumerated here, it is assumed that the company has three possible options for introducing the modular storage system. These are:

- Introduce a two tier system in the second period. Add a third tier in the third period and a fourth tier in the fourth period.

- Introduce a three tier system in the second period. Add the fourth tier in the third period.

- Introduce a four tier system in the second period.

Each of the above three options are dealt with using three different aspiration levels and assuming first that the aspiration level of only one of the contributors increases and second, the aspiration level of two of the contributors increases. The assumptions made in the following cases are the same as those made in the similar example in the previous chapter. A 20% distribution of the total profits is enough to satisfy initially the aspiration level of each one of the four classes of contributors.

5.1.2.1 Cases where aspiration levels of contributors increase at 5%

Table 19 gives the distribution of profits to the contributors assuming the aspiration level of investors increases at 5%, and the company starts with a two-tier system in period 2.
Table 19. Distribution of company's profits and total organizational efficiency - 5% increase, start with 2 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 530 mu's</th>
<th>Period 3 Profits = 560 mu's</th>
<th>Period 4 Profits = 590 mu's</th>
<th>Period 5 Profits = 590 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>105 mu's</td>
<td>110.25 mu's</td>
<td>115.8 mu's</td>
<td>121.6 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>210 mu's</td>
<td>357.3 mu's</td>
<td>528.9 mu's</td>
<td>697.4 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 274.36 mu's
Supplier = 274.36 mu's
Investor = 295.91 mu's
Worker = 274.36 mu's

Table 20 depicts the distribution of the profits and values for organizational efficiency assuming that the company improves its storage capacity by installing a three tier system in period 2, and also, the aspiration level of investors changes at 5% each period.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 560 mu's</th>
<th>Period 3 Profits = 590 mu's</th>
<th>Period 4 Profits = 590 mu's</th>
<th>Period 5 Profits = 590 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>105 mu's</td>
<td>110.25 mu's</td>
<td>115.8 mu's</td>
<td>121.6 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>237.5 mu's</td>
<td>414.8 mu's</td>
<td>588.9 mu's</td>
<td>757.4 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

5.0 MULTIPERIOD ANALYSIS - PART II
Table 21 depicts the distribution of the profits and values for organizational efficiency assuming that the company improves its storage capacity by installing a four tier system in period 2, and also, the aspiration level of investors changes at 5% each period.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
</tr>
<tr>
<td></td>
<td>500 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
</tr>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>105 mu's</td>
<td>110.3 mu's</td>
<td>115.8 mu's</td>
<td>121.6 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>265 mu's</td>
<td>444.8 mu's</td>
<td>618.9 mu's</td>
<td>787.4 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 296.86 mu's
Supplier = 296.86 mu's
Investor = 318.41 mu's
Worker = 296.86 mu's

Table 22 gives the distribution of profits assuming there is no increase in physical efficiency i.e., a tier system is not installed and the aspiration level of investors increases at 5%.
Table 22. Distribution of company's profits and total organizational efficiency - 5% increase, constant physical efficiency

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 500 mu's</th>
<th>Period 3 Profits = 500 mu's</th>
<th>Period 4 Profits = 500 mu's</th>
<th>Period 5 Profits = 500 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>105 mu's</td>
<td>110.25 mu's</td>
<td>115.8 mu's</td>
<td>121.6 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>105 mu's</td>
<td>110.25 mu's</td>
<td>115.8 mu's</td>
<td>121.6 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>195 mu's</td>
<td>284.8 mu's</td>
<td>368.9 mu's</td>
<td>447.4 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 211.85 mu's
Supplier = 211.85 mu's
Investor = 233.45 mu's
Worker = 211.85 mu's

From Tables 19, 20, 21, and 22, it is seen that all classes stand to benefit more if improvements in physical efficiency are made. Further, if the company chooses to invest in a four tier modular storage system in period two, the benefits available to the contributors are more than those compared to the case if the company invests in a three tier system in period two or a two tier system in period two. Therefore, to be competitive in the long run, the company should opt for a four tier system in period two.

Table 23 depicts the profits and the values for organizational efficiency assuming that the company chooses to install a two tier system initially. It improves this by converting to a three tier system in period 3 and finally to a four tier system in period 4. Also, the aspiration level of the investors and workers increases by 5% each period while that of the other two contributors remains constant.
The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 262.22 mu's
Supplier = 262.22 mu's
Investor = 282.77 mu's
Worker = 282.77 mu's

Table 24 depicts the distribution of profits and values for organizational efficiency assuming that the company chooses to invest in a three tier storage system in period 2. It improves upon this system by adding another tier in period 3. Also, the aspiration level of the investors and workers changes by 5% each period.
The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 276.22 mu's
Supplier = 276.22 mu's
Investor = 297.77 mu's
Worker = 297.77 mu's

Table 25 depicts the distribution of profits and values for organizational efficiency assuming that the company chooses to invest in a four tier system in period 2. The aspiration level of the investors increases at 5% each period.

<table>
<thead>
<tr>
<th>Table 25. Distribution of company's profits and total organizational efficiency - 5% increase, start with a 4 tier system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributors</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Customers</td>
</tr>
<tr>
<td>Suppliers</td>
</tr>
<tr>
<td>Investors</td>
</tr>
<tr>
<td>Workers</td>
</tr>
<tr>
<td>Treasurer</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 283.72 mu's
Supplier = 283.72 mu's
Investor = 305.27 mu's
Worker = 305.27 mu's

Table 26 depicts the distribution of profits and values for organizational efficiency assuming that there is no increase in physical efficiency of the system. The aspiration level of the investors increases at 5% each period.
Table 26. Distribution of company’s profits and total organizational efficiency: constant physical efficiency

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 500 mu’s</th>
<th>Period 3 Profits = 500 mu’s</th>
<th>Period 4 Profits = 500 mu’s</th>
<th>Period 5 Profits = 500 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>105 mu’s</td>
<td>110.3 mu’s</td>
<td>115.8 mu’s</td>
<td>121.6 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>105 mu’s</td>
<td>110.3 mu’s</td>
<td>115.8 mu’s</td>
<td>121.6 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>105 mu’s</td>
<td>269.5 mu’s</td>
<td>337.9 mu’s</td>
<td>394.9 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>190 mu’s</td>
<td>269.5 mu’s</td>
<td>337.9 mu’s</td>
<td>394.9 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:
Customer = 198.73 mu’s
Supplier = 198.73 mu’s
Investor = 220.33 mu’s
Worker = 220.33 mu’s

It is observed from Tables 23, 24, 25, and 26, that all classes of contributors benefit immensely from increases in physical efficiency and they receive added benefits in future periods. In order to receive higher profits, improvements in physical efficiency (addition of tiers) should be made as early as the economic health of the company permits.

5.1.2.2 Cases where aspiration levels of contributors increase at 10%

The next sixteen tables (i.e., Tables 27 through 42) depict the same set of calculations and assumptions except that the aspiration level of the investors and workers increases by 10% in the first eight tables and by 15% in the last eight tables.
Table 27 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a two tier system in period 2. The aspiration level increases by 10% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 530 mu’s</th>
<th>Period 3 Profits = 560 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>110 mu’s</td>
<td>121 mu’s</td>
<td>133.1 mu’s</td>
<td>146.41 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>205 mu’s</td>
<td>341.5 mu’s</td>
<td>495.9 mu’s</td>
<td>639.49 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 259.87 mu’s
Supplier = 259.87 mu’s
Investor = 306.28 mu’s
Worker = 259.87 mu’s

Table 28 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a three-tier system in period 2. The aspiration level increases by 10% in this case.
Table 28. Distribution of company's profits and total organizational efficiency - 10% increase, start with a three-tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 560 mu's</th>
<th>Period 3 Profits = 590 mu's</th>
<th>Period 4 Profits = 590 mu's</th>
<th>Period 5 Profits = 590 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.41 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>232.5 mu's</td>
<td>399 mu's</td>
<td>555.9 mu's</td>
<td>699.49 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 274.87 mu's
Supplier = 274.87 mu's
Investor = 321.28 mu's
Worker = 274.87 mu's

Table 29 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a four-tier system in period 2. The aspiration level increases by 10% in this case.

Table 29. Distribution of company's profits and total organizational efficiency - 10% increase, start with a 4 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 590 mu's</th>
<th>Period 3 Profits = 590 mu's</th>
<th>Period 4 Profits = 590 mu's</th>
<th>Period 5 Profits = 590 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.41 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>260 mu's</td>
<td>429 mu's</td>
<td>585.9 mu's</td>
<td>729.5 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

5.0 MULTIPERIOD ANALYSIS - PART II

98
Customer = 282.37 mu's
Supplier = 282.37 mu's
Investor = 328.78 mu's
Worker = 282.37 mu's

Table 30 depicts the distribution of profits and values for organizational efficiency assuming that there is no increase in physical efficiency. The aspiration level increases by 10% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 500 mu's</th>
<th>Period 3 Profits = 500 mu's</th>
<th>Period 4 Profits = 500 mu's</th>
<th>Period 5 Profits = 500 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>190 mu's</td>
<td>269 mu's</td>
<td>335.9 mu's</td>
<td>389.5 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 197.38 mu's
Supplier = 197.38 mu's
Investor = 243.78 mu's
Worker = 197.38 mu's

From Tables 27, 28, 29, and 30, it is seen that the use of a four tier system in period 2 gives the maximum benefits after four periods. This again reinforces the analysis presented earlier that if the improvements in physical efficiency are made earlier, more benefits are available in subsequent periods.
Table 31 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a two tier system in period 2. The aspiration level of two classes of contributors increases by 10% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu's</th>
<th>Period 2 Profits = 530 mu's</th>
<th>Period 3 Profits = 560 mu's</th>
<th>Period 4 Profits = 590 mu's</th>
<th>Period 5 Profits = 590 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>195 mu's</td>
<td>310.5 mu's</td>
<td>431.8 mu's</td>
<td>528.9 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 232.25 mu's
Supplier = 232.25 mu's
Investor = 278.66 mu's
Worker = 278.66 mu's

Table 32 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a three-tier system in period 2. The aspiration level of two classes of contributors increases by 10% in this case.
Table 32. Distribution of company's profits and total organizational efficiency - 10% increase, start with 3 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
</tr>
<tr>
<td></td>
<td>500 mu's</td>
<td>560 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
</tr>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>222.5 mu's</td>
<td>368 mu's</td>
<td>491.8 mu's</td>
<td>588.9 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 247.25 mu's
Supplier = 247.25 mu's
Investor = 293.66 mu's
Worker = 293.66 mu's

Table 33 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a four-tier system in period 2. The aspiration level of two classes of contributors increases by 10% in this case.

Table 33. Distribution of company's profits and total organizational efficiency - 10% increase, start with 4 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
<td>Profits =</td>
</tr>
<tr>
<td></td>
<td>500 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
<td>590 mu's</td>
</tr>
<tr>
<td>Customers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
<td>100 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu's</td>
<td>110 mu's</td>
<td>121 mu's</td>
<td>133.1 mu's</td>
<td>146.4 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu's</td>
<td>250 mu's</td>
<td>398 mu's</td>
<td>521.8 mu's</td>
<td>618.9 mu's</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:
Customer = 254.75 mu’s
Supplier = 254.75 mu’s
Investor = 301.16 mu’s
Worker = 301.16 mu’s

Table 34 depicts the distribution of profits and values for organizational efficiency assuming that there is no improvement in physical efficiency. The aspiration level increases by 10% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 500 mu’s</th>
<th>Period 3 Profits = 500 mu’s</th>
<th>Period 4 Profits = 500 mu’s</th>
<th>Period 5 Profits = 500 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>110 mu’s</td>
<td>121 mu’s</td>
<td>133.1 mu’s</td>
<td>146.4 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>110 mu’s</td>
<td>121 mu’s</td>
<td>133.1 mu’s</td>
<td>146.4 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>180 mu’s</td>
<td>238 mu’s</td>
<td>271.8 mu’s</td>
<td>278.9 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 169.73 mu’s
Supplier = 169.73 mu’s
Investor = 216.13 mu’s
Worker = 216.13 mu’s

Comparing Tables 31 through 34, once again it is seen that maximum benefits are available to the contributors if increases in physical efficiency are made in earlier periods. This supports the analysis presented earlier that investments to improve physical efficiency are economically justifiable. These investments in technology further improve the total efficiency of the organizational process.

5.0 MULTIPERIOD ANALYSIS - PART II
5.1.2.3 Cases where aspiration levels of contributors increase at 15%

This set of eight tables (i.e., Tables 35 through 42) are again formulated in the same manner as the previous sixteen except that the aspiration level of the investors and workers increases at 15% each period. First, only the investors demand 15% (Tables 35 through 38) and then both investors and workers demand 15% (Tables 39 through 42).

Table 35 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a two-tier system in period 2. The aspiration level of investors increases by 15% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profits = 500 mu’s</td>
<td>Profits = 530 mu’s</td>
<td>Profits = 560 mu’s</td>
<td>Profits = 590 mu’s</td>
<td>Profits = 590 mu’s</td>
</tr>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>200 mu’s</td>
<td>325.3 mu’s</td>
<td>460.7 mu’s</td>
<td>575.8 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 243.94 mu’s
Supplier = 243.94 mu’s
Investor = 318.84 mu’s
Worker = 243.94 mu’s
Table 36 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a three-tier system in period 2. The aspiration level of investors increases by 15% in this case.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 560 mu’s</th>
<th>Period 3 Profits = 590 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>227.5 mu’s</td>
<td>382.8 mu’s</td>
<td>520.7 mu’s</td>
<td>635.8 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 258.94 mu’s
Supplier = 258.94 mu’s
Investor = 333.84 mu’s
Worker = 258.94 mu’s

Table 37 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a four-tier system in period 2. The aspiration level of investors increases by 15% in this case.
Table 37. Distribution of company’s profits and total organizational efficiency - 15% increase, start with 4 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 590 mu’s</th>
<th>Period 3 Profits = 590 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>255 mu’s</td>
<td>412.8 mu’s</td>
<td>550.7 mu’s</td>
<td>665.8 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 266.44 mu’s
Supplier = 266.44 mu’s
Investor = 341.34 mu’s
Worker = 266.44 mu’s

Table 38 depicts the distribution of profits and values for organizational efficiency assuming that there is no increase in physical efficiency. The aspiration level increases by 15%.

Table 38. Distribution of company’s profits and total organizational efficiency - 15% increase, constant physical efficiency

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 500 mu’s</th>
<th>Period 3 Profits = 500 mu’s</th>
<th>Period 4 Profits = 500 mu’s</th>
<th>Period 5 Profits = 500 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>185 mu’s</td>
<td>252.8 mu’s</td>
<td>300.7 mu’s</td>
<td>325.8 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:
Customer = 181.45 mu’s  
Supplier = 181.45 mu’s  
Investor = 256.35 mu’s  
Worker = 181.45 mu’s

From Tables 35, 36, 37, and 38, it is once again concluded that an organization should invest in improvements as soon as economically feasible as the expense incurred for these improvements can be justified for that period. The next four tables give the distribution of profits with the aspiration level of two of the contributors (investors and contributors) increasing at 15%.

Table 39 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a two-tier system in period 2. The aspiration level increases by 15%.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profits = 500 mu’s</td>
<td>Profits = 530 mu’s</td>
<td>Profits = 560 mu’s</td>
<td>Profits = 590 mu’s</td>
<td>Profits = 590 mu’s</td>
</tr>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>185 mu’s</td>
<td>278 mu’s</td>
<td>361.3 mu’s</td>
<td>401.5 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>185 mu’s</td>
<td>278 mu’s</td>
<td>361.3 mu’s</td>
<td>401.5 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 200.38 mu’s  
Supplier = 200.38 mu’s  
Investor = 275.28 mu’s
Worker = 275.28 mu’s

Table 40 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a three-tier system in period 2. The aspiration level increases by 15%.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 560 mu’s</th>
<th>Period 3 Profits = 590 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>212.5 mu’s</td>
<td>335.5 mu’s</td>
<td>421.33 mu’s</td>
<td>461.5 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 215.38 mu’s
Supplier = 215.38 mu’s
Investor = 290.28 mu’s
Worker = 290.28 mu’s

Table 41 depicts the distribution of profits and values for organizational efficiency assuming that the company starts with a four-tier system in period 2. The aspiration level increases by 15%.
Table 41. Distribution of company’s profits and total organizational efficiency - 15% increase, start with 4 tier system

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 590 mu’s</th>
<th>Period 3 Profits = 590 mu’s</th>
<th>Period 4 Profits = 590 mu’s</th>
<th>Period 5 Profits = 590 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>240 mu’s</td>
<td>365.5 mu’s</td>
<td>451.33 mu’s</td>
<td>491.5 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

Customer = 222.88 mu’s
Supplier = 222.88 mu’s
Investor = 297.78 mu’s
Worker = 297.78 mu’s

Table 42 depicts the distribution of profits and values for organizational efficiency assuming that there is no improvement in the physical efficiency of the system. The aspiration level increases by 15%.

Table 42. Distribution of company’s profits and total organizational efficiency - 15% increase, constant physical efficiency

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 500 mu’s</th>
<th>Period 2 Profits = 500 mu’s</th>
<th>Period 3 Profits = 500 mu’s</th>
<th>Period 4 Profits = 500 mu’s</th>
<th>Period 5 Profits = 500 mu’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Suppliers</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
<td>100 mu’s</td>
</tr>
<tr>
<td>Investors</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Workers</td>
<td>100 mu’s</td>
<td>115 mu’s</td>
<td>132.3 mu’s</td>
<td>152.1 mu’s</td>
<td>174.9 mu’s</td>
</tr>
<tr>
<td>Treasurer</td>
<td>100 mu’s</td>
<td>170 mu’s</td>
<td>205.5 mu’s</td>
<td>201.33 mu’s</td>
<td>151.5 mu’s</td>
</tr>
</tbody>
</table>

The distribution of profits after adding one-fourth of the treasury money to each contributor is:

5.0 MULTIPERIOD ANALYSIS - PART II 108
Customer = 137.88 mu’s
Supplier = 137.88 mu’s
Investor = 212.78 mu’s
Worker = 212.78 mu’s

It is demonstrated in all the previous cases that, to have a successful organization and to keep the contributors to the organizational process satisfied, improvements to the existing systems should be made for some periods. This is because improvements in physical efficiency result in higher benefits made available to the participants in the organizational process. These added benefits have a higher overall utility for the participants, and the increase in their utilities increases the organizational efficiency.

The earlier the improvements are made, the more profits are available in later periods. It is also seen from the previous tables that if the aspiration level of only one contributor increases as compared to two contributors, the benefits available to the remaining three contributors are more. If the aspiration level of two contributors increases, a loss is suffered by that class of contributor which had benefited more in the case where the aspiration level of only that contributor had increased. If the contributor is willing to absorb a small loss early, the firm may continue existing satisfactorily. If not, then the firm may die as some participant may leave the organization.

It is thus concluded that if investments are made according to the methodology developed and demonstrated in this research, improvements in physical efficiency (investments in new and improved technology) can be economically justified since these improvements result in a higher level of benefits being distributed to one or all the classes of contributors. These extra benefits due to their higher utilities result in increased organizational efficiency, which should be the ultimate goal of any company.
5.1.3 Special Cases

In the following two power plant cases, it is shown that due to the high aspiration levels of the investors and workers, the organization does not have enough retained earnings in the treasury to satisfy the aspiration levels of the other two contributors, that is, of the customers and the suppliers. As the organization cannot satisfy the aspiration levels of all the contributors, it may lead to the demise of the organization, according to arguments presented earlier.

The first example, shown in Table 43, deals with the case when aspiration level of only one contributor, say the investors, increases at 45% while the aspiration level of the other three contributors remains constant.

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 6911 mu's</th>
<th>Period 3 Profits = 7061 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1450 mu's</td>
<td>2102.5 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>961 mu's</td>
<td>-180.5 mu's</td>
</tr>
</tbody>
</table>

It is observed from Table 43 that if the aspiration level of the investors increases at 45% per period, the organization is left with a negative balance of 180.5 mu's in period 3. This implies that if the organization has to break even, then it has to ignore either one or all of the other three contributors and not distribute enough to satisfy their aspiration levels. In this case, the contributors may refuse to participate and the organizational
process may collapse. On the other hand, if the treasury goes deeper into debt, the organization may have to file for bankruptcy eventually.

The second example, shown in Table 44, deals with the case when the aspiration levels of two of the contributors increases at 25%.

<p>| Table 44. Distribution of company's profits and total organizational efficiency - aspiration levels increase by 25% |</p>
<table>
<thead>
<tr>
<th>Contributors</th>
<th>Period 1 Profits = 5000 mu's</th>
<th>Period 2 Profits = 6911 mu's</th>
<th>Period 3 Profits = 7061 mu's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Suppliers</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
<td>1000 mu's</td>
</tr>
<tr>
<td>Investors</td>
<td>1000 mu's</td>
<td>1250 mu's</td>
<td>1562.5 mu's</td>
</tr>
<tr>
<td>Workers</td>
<td>1000 mu's</td>
<td>1250 mu's</td>
<td>1562.5 mu's</td>
</tr>
<tr>
<td>Treasurer</td>
<td>1000 mu's</td>
<td>911 mu's</td>
<td>-253 mu's</td>
</tr>
</tbody>
</table>

Once again, it is demonstrated that due to the high aspiration levels of both the investors and workers, the treasury is left with a negative amount at the end of the third period. This may ultimately lead to the collapse of the organizational process. It is observed in all the previous tables that the aspiration level of investors increases in each case. This is based on the assumption that the investors have to be given a return at least equal to market rate (which can be 5%, 10%, or 15%) for them to participate in the organizational process, otherwise they will not invest any capital and the firm will immediately die. It is also assumed that the other contributors can be given a fixed amount each period to satisfy their aspirations.

Therefore, from the previous discussion, it is inferred that improvements in physical efficiency in the early stages result in higher benefits being made available to all classes of contributors in later periods for these two organizations. Although various authors have addressed the strategic implications of investing in new and improved technology,
a mathematical algorithm to show these benefits had not been formulated. This thesis, although formulated with numerous assumptions and constraints, has suggested one approach that may provide some areas for further profitable research in the field of economic justification.
This study focused on methodology for formulating a mathematical link between three efficiencies: physical efficiency, economic efficiency, and organizational efficiency. The methodology was illustrated with two scenarios. A multi-period analysis was performed to show the potential benefits of increases in physical efficiency in a hypothetical company on the overall efficiency of the organizational process. The study has been subject to a large number of assumptions and constraints. This chapter consists of a summary of results obtained from the study, and suggestions for further work which might be done to extend it.
6.1 Summary of Results

The first two chapters of this thesis provided the introduction to the problem and the literature review. Chapter Three dealt with the problem development and Chapters Four and Five demonstrated one suggested approach to the problem.

Physical efficiency can be accurately measured once defined properly. The correct derivation of economic efficiency relies on the ability to assign and report costs accurately. For this research, the organization as a whole has been considered. It encompasses four classes of participants in the organizational process including workers, suppliers, investors, and the customers. An additional class, "the treasury", was introduced. Organizational efficiency depends on the participants' evaluations of the value of benefits less burdens, and this value must exceed 100% for the long term sustenance of the organization. Increased profits are one way to increase the organizational efficiency of the system.

Two scenarios were used in Chapter Four to demonstrate the methodology for formulating a link between physical efficiency, economic efficiency, and organizational efficiency. It was shown that a change in physical efficiency results in a change in the economic efficiency of a system. This change in the economic efficiency was followed by a change in the organizational efficiency of that system.

The link between the three efficiencies was then used to perform a multi-period analysis. This analysis demonstrated that if investments to improve the physical efficiency are made in earlier periods, more benefits may be distributed to the various participants in the organizational process in later periods if the cost of the improvements are not ex-
cessive. The distribution of benefits depends on the aspiration levels of the contributors. A lower aspiration level of contributors in earlier periods gives more benefits to be distributed in later periods, and provides the organization with more resources for investment in new technology.

Sensitivity analysis was done to show the effect of increases in physical efficiency on the overall organizational efficiency.

**6.2 Advantages**

The methodology developed in this research has various advantages. These advantages are enumerated below.

1. Unlike traditional evaluation techniques, this method is not based on historical data. It is based on the presumed utilities and aspiration levels of the contributors at present.

2. The analysis of benefits can be done for any number of periods provided the cost of the project, the aspiration levels of contributors, and the savings that result from the project are known.

3. It provides a theoretical framework for viewing the link between physical efficiency, economic efficiency, and organizational efficiency, and this had not been addressed before in the literature.
6.3 Recommendations

Since this study is an illustration of a procedure, more work has to be carried out to test or implement the approach. For any decision situation, data should be gathered for classes of contributors and graphed as utility functions. The data can be acquired using the certainty equivalent technique, or the standard gamble technique. The methodology for aggregating non-linear utilities presented in this research has to be accepted for this model to be implemented in real world situations.

Additional research is needed to verify that the utility functions derived from the Vandermonde matrix system represent the actual behavior of an individual under specific conditions. Once a procedure for obtaining and aggregating utility functions has been proven to be correct, the methodology demonstrated in this thesis can be applied in real world situations to justify new investments.

Previous research in the field of economic justification does not deal with the concept of the organization as a whole. Marginal costs and average costs are used by economists to justify the additional investment to increase production rates. They ignore the suppliers, customers, and workers in the organizational process. This research considers all the participants in the organizational process, and profits from increases in physical efficiency can be subjectively distributed as deemed appropriate by the managers.

Finally, the use of discounted cash flow analysis should be incorporated in future research to test whether early benefits or later benefits (deferred profit distributions) will be more acceptable to all the classes of contributors.


The programs (1) to formulate utility functions for the four classes of contributors and the treasury, (2) to formulate the aggregate utility function, and (3) to calculate the distribution of the organizations' profits to various contributors are presented here. All three are written in BASIC and should be implementable on most computers (both mainframes and personal computers). The programs are interactive and can be run with a minimum of effort.

The first program deals with the formulation of utility functions. In the first step, the four data points for each curve are read in. There are five sets of data points and these give the coefficients of the cubic functions for each class of contributor. The program then aggregates the coefficients to give an aggregate utility function over the five classes.

**PROGRAM FOR CALCULATING UTILITY FUNCTIONS FOR EACH CLASS OF CONTRIBUTOR, THE TREASURY, AND THE AGGREGATE UTILITY FUNCTION**
10 FOR NE = 1 TO 5
20 PRINT"INPUT THE FOUR X,Y POINTS"
30 FOR P = 0 TO 3
40 INPUT X(P),Y(P)
50 NEXT P
60 N = 3
70 GOSUB 600
80 PRINT'THIS ARE THE COEFFICIENTS OF THE CUBIC WITH FIRST AS CONSTANT
     AND THE LAST AS CUBIC'
90 FOR R = 0 TO 3
100 C(NE, R) = Y(R)
110 PRINT Y(R)
120 NEXT R
130 NEXT NE
140 FOR I = 0 TO 3
150 S(I) = 0
160 FOR J = 1 TO 5
170 S(I) = S(I)+C(J,I)
180 NEXT J
190 NEXT I
200 PRINT'
210 PRINT'This is the aggregate utility function for organizational
     efficiency'
220 PRINT'constant coefficient is first, cubic coefficient is last'
230 FOR I = 0 TO 3
240 PRINT S(I)

APPENDIX - PROGRAM DESCRIPTION
250 NEXT I
260 PRINT "INPUT THE 8 X VALUES"
270 FOR I = 0 TO 7
280 INPUT X(I)
290 FOR J = 1 TO 5
300 Z(I,J) = C(J,3)*X(I)**3 + C(J,2)*X(I)**2 + C(J,1)*X(I) + C(J,0)
310 NEXT J
320 NEXT I
330 PRINT 'THIS IS A MATRIX OF Y VALUES FOR EACH X VALUE. THE X VALUES TAKE THE FIRST COLUMN.'
340 FOR I = 0 TO 7
350 PRINT X(I),Z(I,1),Z(I,2),Z(I,3),Z(I,4),Z(I,5)
360 NEXT I
370 FOR I = 0 TO 7
380 M(I) = 1
390 Y(I) = Z(I,1)
400 FOR J = 2 TO 5
410 IF Z(I,J) >= Y(I) THEN Y(I) = Z(I,J)
420 IF Z(I,J) >= Y(I) THEN M(I) = J
430 NEXT J
440 NEXT I
450 N = 7
460 GOSUB 600
470 PRINT 'COEFFICIENTS OF SEPTIC FUNCTION INTERPOLATING THE MAX OF 5 FUNCTIONS. 2ND COLUMN IS THE FUNCTION NUMBER WHERE THE Y IS MAX'
480 FOR I = 0 TO 7
490 PRINT Y(I);M(I)
500 NEXT I
510 FOR CO = 0 TO 200 STEP 25
520 F = 0
530 PRINT 'FIRST COLUMN IS X VALUE 2ND COLUMN IS Y VALUE OF THE FINAL INTERPOLATED FUNCTION'
540 FOR I = 0 TO 7
550 F = F + Y(I)*CO**I
560 NEXT I
570 PRINT CO; F
580 NEXT CO
590 END
600 FOR K = 0 TO N-1
610 FOR I = N TO K+1 STEP -1
620 Y(I) = (Y(I)-Y(I-1))/(X(I)-X(I-K-1))
630 NEXT I
640 NEXT K
650 FOR K = N-1 TO 0 STEP -1
660 FOR I = K TO N-1
670 Y(I) = Y(I)-(Y(I+1)*X(K))
680 NEXT I
690 NEXT K
700 RETURN
The following two programs are used to calculate the distribution of the organization's benefits to the five classes (four classes of contributors and the treasury). The four contributors are denoted by "IND1", "IND2", "IND3", and "IND4". The treasury is denoted by "DEP" since the distribution to the treasury is dependent on the distribution to the four contributors. "RATE" denotes the aspiration level of the contributors and "CHANGE" denotes the amount by which the money in the treasury has to be reduced to compensate for cost of increase in physical efficiency.

**THIS PROGRAM GIVES THE DISTRIBUTION OF PROFITS TO THE FOUR CLASSES OF CONTRIBUTORS AND THE TREASURY OF THE ORGANIZATION. IT ALSO GIVES THE VALUES FOR ORGANIZATIONAL EFFICIENCY USING VARIOUS SETS OF CURVES FROM CHAPTER 3. IN THIS PROGRAM, IT IS ASSUMED THAT THE ASPIRATION LEVEL OF ONLY ONE CONTRIBUTOR INCREASES.**

10 DIM IND1(10),IND2(10),IND3(10),IND4(10)
20 DIM DEP(10)

**********************************************************************************************************************************************

**********************************************************************************************************************************************

THE RATE CAN BE CHANGED ACCORDING TO THE ASPIRATION LEVEL OF THE CONTRIBUTORS

**********************************************************************************************************************************************

**********************************************************************************************************************************************

30 RATE = 1.1
40 PRINT "input total"
50 INPUT TOTAL
60 DEP(1) = TOTAL/5
70 IND1(1) = TOTAL/5
80 IND2(1) = TOTAL/5
90 IND3(1) = TOTAL/5
100 IND4(1) = TOTAL/5
110 PRINT IND1(1), IND2(1), IND3(1), IND4(1), DEP(1)
120 FOR I = 2 TO 5
130 PRINT "Input total"
140 INPUT TOTAL
150 IND2(I) = IND2(I-1)
160 IND3(I) = IND3(I-1)
170 IND4(I) = IND4(I-1)
180 IND1(I) = IND1(I-1)*RATE
190 DEP(I) = TOTAL-(IND1(I) + IND2(I) + IND3(I) + IND4(I))
200 DEP(I) = DEP(I) + DEP(I-1)
210 PRINT "Input change"
220 INPUT CHANGE
230 DEP(I) = DEP(I)-CHANGE
240 PRINT IND1(I), IND2(I), IND3(I), IND4(I), DEP(I)
250 NEXT I
260 FOR I = 1 TO 5
270 X(I,1) = IND1(I)
280 X(I,2) = IND2(I)
290 X(I,3) = IND3(I)
300 X(I,4) = IND4(I)
310 X(I,5) = DEP(I)
320 NEXT I
330 FOR Z = 1 TO 4
340 FOR E = 1 TO 5
350 FOR C = 0 TO 3
360 READ MM
370 M(E,C) = MM
380 NEXT C
390 NEXT E
400 FOR J = 1 TO 5
410 FOR I = 1 TO 5
420 YT(I) = M(I,3)*X(J,I)**3 + M(I,2)*X(J,I)**2 + M(I,1)*X(J,I) + M(I,0)
430 NEXT I
440 Y(J) = 0
450 FOR I = 1 TO 5
460 Y(J) = Y(J) + YT(I)
470 NEXT I
480 PRINT Y(J)
490 NEXT J
500 NEXT Z

**************************************************************

**************************************************************

510 DATA -67.5, 868334, 0134,-7.533e-05
520 DATA 0, 2.325,-.0195,.00006
530 DATA 0,1.29,-5.966e-03,1.13333e-05
540 DATA 0, 1.3738,-7.357e-03,1.619e-05
550 DATA 0,2.725,-.019,.00005
560 DATA -67.5, 8683334, 0134,-7.5333e-05
570 DATA 0, 2.325,-.0195,.00006
580 DATA 0,1.29,-5.9666666e-03,1.13333e-05
590 DATA 0,1.29,-5.9666666e-03,1.1333336e-05
600 DATA 0,7000001,-4.000001e-03,.00004
610 DATA -82.5, 2.481667,-.0202,7.133336e-05
620 DATA 0, 2.325,-.0195,.00006
630 DATA 0,1.29,-5.9666666e-03,1.133333E-05
640 DATA 0,1.29,-5.9666666e-03,1.133333E-05
650 DATA 0,2.725,-.019,.00005
660 DATA -82.5, 2.481667,-.0202,7.133333e-05
670 DATA 0, 2.325,-.0195,.00006
680 DATA 0,1.29,-5.966666e-03,1.133333e-05
690 DATA 0,1.29,-5.966666e-03,1.133333e-05
700 DATA 0,.7000001,-4.000001E-03,.00004
710 STOP
720 END
THIS PROGRAM GIVES THE DISTRIBUTION OF PROFITS TO THE FOUR CLASSES OF CONTRIBUTORS AND THE TREASURY OF THE ORGANIZATION. IT ALSO GIVES THE VALUES FOR ORGANIZATIONAL EFFICIENCY USING VARIOUS SETS OF CURVES FROM CHAPTER 3. IN THIS PROGRAM, IT IS ASSUMED THAT THE ASPIRATION LEVEL OF TWO OF THE CONTRIBUTORS INCREASES.

10 DIM IND1(10),IND2(10),IND3(10),IND4(10)
20 DIM DEP(10)

THE RATE CAN BE CHANGED ACCORDING TO THE ASPIRATION LEVEL OF THE CONTRIBUTORS

30 RATE = 1.1
40 PRINT "input total"
50 INPUT TOTAL
60 DEP(1) = TOTAL/5
70 IND1(1) = TOTAL/5
80 IND2(1) = TOTAL/5
90 IND3(1) = TOTAL/5
100 IND4(1) = TOTAL/5
110 PRINT IND1(1),IND2(1),IND3(1),IND4(1),DEP(1)
120 FOR I = 2 TO 5
130 PRINT "input total"
140 INPUT TOTAL
150 IND2(I) = IND2(I-1) * RATE
160 IND3(I) = IND3(I-1)
170 IND4(I) = IND4(I-1)
180 IND1(I) = IND1(I-1) * RATE
190 DEP(I) = TOTAL - (IND1(I) + IND2(I) + IND3(I) + IND4(I))
200 DEP(I) = DEP(I) + DEP(I-1)
210 PRINT "input change"
220 INPUT CHANGE
230 DEP(I) = DEP(I) - CHANGE
240 PRINT IND1(I), IND2(I), IND3(I), IND4(I), DEP(I)
250 NEXT I
260 FOR I = 1 TO 5
270 X(I,1) = IND1(I)
280 X(I,2) = IND2(I)
290 X(I,3) = IND3(I)
300 X(I,4) = IND4(I)
310 X(I,5) = DEP(I)
320 NEXT I
330 FOR Z = 1 TO 4
340 FOR E = 1 TO 5
350 FOR C = 0 TO 3
360 READ MM
370 M(E,C) = MM
380 NEXT C
390 NEXT E
400 FOR J = 1 TO 5
410 FOR I = 1 TO 5
420 YT(I) = M(I,3)*X(J,I)**3 + M(I,2)*X(J,I)**2 + M(I,1)*X(J,I) + M(I,0)
430 NEXT I
440 Y(J) = 0
450 FOR I = 1 TO 5
460 Y(J) = Y(J) + YT(I)
470 NEXT I
480 PRINT Y(J)
490 NEXT J
500 NEXT Z

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510 DATA -67.5, .868334, 0.0134, -7.5336e-05
520 DATA 0, 2.325, -0.0195, 0.0006
530 DATA 0, 1.29, -5.966e-03, 1.1333e-05
540 DATA 0, 1.3738, -7.357e-03, 1.6196e-05
550 DATA 0, 2.725, -0.019, 0.0005
560 DATA -67.5, .868334, 0.0134, -7.5333e-05
570 DATA 0, 2.325, -0.0195, 0.0006

APPENDIX - PROGRAM DESCRIPTION
580 DATA 0,1.29,-5.966666e-03,1.133333e-05
590 DATA 0,1.29,-5.966666e-03,1.133333e-05
600 DATA 0,.7000001,-4.0000016-03,.00004
610 DATA -82.5,2.481667,-.0202,7.133333e-05
620 DATA 0,2.325,-.0195,.00006
630 DATA 0,1.29,-5.966666E-03,1.133333E-05
640 DATA 0,1.29,-5.966666e-03,1.133333e-05
650 DATA 0,2.725,-.019,.00005
660 DATA -82.5,2.481667,-.0202,7.133333e-05
670 DATA 0,2.325,-.0195,.00006
680 DATA 0,1.29,-5.966666e-03,1.133333e-05
690 DATA 0,1.29,-5.966666e-03,1.133333e-05
700 DATA 0,.7000001,-4.000001E-03,.00004
710 STOP
720 END
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