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# Assessing Organizational Effectiveness Through the Competing Values Framework A Data Envelopment Approach

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# ASSESSING ORGANIZATIONAL EFFECTIVENESS THROUGH THE COMPETING VALUES FRAMEWORK: A DATA ENVELOPMENT APPROACH

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## ABSTRACT


### ASSESSING ORGANIZATIONAL EFFECTIVENESS THROUGH THE COMPETING VALUES FRAMEWORK: A DATA ENVELOPMENT APPROACH

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This study proposes a model to diagnose organizations using the mathematical principles of data envelopment analysis (DEA) to the variables generated using competing values framework (CVF) in order to evaluate overall organizational effectiveness. The notion of organizational effectiveness is abstract and difficult to measure due to its complexity and multi-functional nature. Over the years, measurement of organizational effectiveness has remained a challenge due to the lack of agreement on the factors that should be assessed to determine effectiveness. This research is aimed at shedding some light into this topic by using data envelopment analysis as a tool to measure relative efficiency based on a predefined effectiveness model. The effectiveness model is prepared on basis of competing values framework.

The relative efficiency scores that are obtained though this integrated approach compare and suggest the best practices that may be employed by an organization. In this research, a measurement model integrating CVF and DEA is developed and tested in context of power and hand tool manufacturers. The results obtained tested the feasibility of the model to assess organizational effectiveness. The findings may provide useful information to company stakeholders and business analysts about the factors that influence critical outcomes and compare that information with that of major competitors.

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# CHAPTER 1

# INTRODUCTION TO THE RESEARCH

## 1.1 INTRODUCTION

Organizational effectiveness is a measure of the extent to which the organization achieves its goals. Effectiveness can be determined by factors such as production maximization; cost minimization, technological excellence, etc. (Taylor & Bowers, 1972).

The notion of organizational effectiveness is abstract and difficult to measure due to its complexity and multi-functional nature. For a few organizations, it is the function of cost or profit, for others is a measure of productivity of employees, for a few others it may be customer satisfaction, and for most of them it may be a function of all these. With few exceptions, most of the research conducted on organizational effectiveness has taken a narrow approach with a focus on profits or productivity leaving the human aspect and individual behavior largely ignored. The resulting models were not able to achieve convergence across various measures of effectiveness (Katz & Kahn, 1966). The measurement of effectiveness is of key importance to organizations because it will facilitate better understanding of the key drivers of performance and it provides critical information to stakeholders (management, shareholders).

This research is aimed at developing a model to assess the organizational effectiveness of organizations and test the model in the context of power and hand tool manufacturers. This study will use data envelopment analysis (DEA) as a tool to measure relative efficiency based on a predefined effectiveness model. The effectiveness model is prepared on basis of the competing values framework (CVF).

The competing values framework is a theoretical model encompassing four distinct organizational effectiveness models, each represented by a quadrant. It is regarded as a relatively simple, comprehensive and concrete model that can be applied to organizational diagnosis. Over the years, measurement of organizational effectiveness has remained a challenge due to the lack of agreement on what factors should be assessed to determine effectiveness. The competing values framework provides a comprehensive view of the factors that are considered to be indicators of effectiveness. The framework proposes a model to assess effectiveness through multiple indicators in each quadrant of the competing values framework (CVF).

Data envelopment analysis was proposed by Charnes et al. in 1978. DEA is a mathematical programming approach that provides relative efficiency assessment for a group of decision making units (Qian-Wei, 2008). By employing DEA, one can be able to measure relative efficiency in all the four different quadrants under CVF, and then compare and suggest the best practices that may be employed by the organization.

This study proposes a model to diagnose organizations using the mathematical principles of DEA to the variables generated using CVF in order to evaluate overall organizational effectiveness. This study proposes a new model of diagnosis that allows the assessment of organizational effectiveness based on a diverse set of criteria simultaneously and using comparable metrics.

## 1.2 BACKGROUND

The measurement of organizational effectiveness is of core importance during investigation of organizational structures, process and outputs (Pennings & Goodman,

1980). Research on the topic of organizational effectiveness was largely based on convenience measures; that is, researchers used the measures that they had data for and operationalized the concept of organizational effectiveness based on this convenient data thus ignoring, to a large extent, the actual meaning of organizational effectiveness (Cameron & Whitten, 1981).

To understand the role of CVF on organizational diagnosis, it is important to look into past research studies and their limitations in measuring organizational effectiveness. Researchers say that the four main problems identified from the previous research of organizational effectiveness were:

- Inadequate use of indicators,
- Overreliance on a single indicator,
- Use of under-specified models, and
- Overgeneralization to dissimilar organizational units (Cameron, 1986).

Past models that evaluated organizational effectiveness can be broadly classified into univariate models and multivariate models. Thorndike (1949) noted that the main reason for having a plethora of failures in research of organizational effectiveness was due to the fact that the research was based on univariate effectiveness models. Univariate models tend to rely on measures of organizational effectiveness in terms of attainment of an "ultimate criterion" such as profit, productivity or attainment of stability (Steers, 1981). However, the rationale for such criterion was not well established or supported.

According to the review by Campbell's (1963) the five major variables selected as effectiveness measure in univariate models were:

- Overall performance of the organization which is measured by employee or supervisor ratings,
- Productivity, which is the measure of outputs over inputs,
- Employee satisfaction based on questionnaires,
- Profits, based on accounting data, and
- Attrition of employees or absence from work

Most univariate approaches to the assessment of organizational effectiveness failed to establish the adequacy of the variables used. The research based on univariate models revolves around the researchers value premise instead of assessing the accomplishment of the objectives the organization has established. Although prior research has dealt with the measures individually, they failed to integrate them, resulting on a univariate model that is weak (Steers, 1981).

The more comprehensive models to describe organizational effectiveness take a multivariate approach that includes several dimensions of effectiveness. Table 1 shows prior multivariate models used in past research. Though these models have overcome some of the limitations of univariate models, they lacked consistency in the metrics used (Katz & Kahn, 1966; Steers, 1981).

In summary, prior univariate and multivariate models of effectiveness fail to provide a comprehensive and consistent way to assess and compare organizational effectiveness. This study proposes the use of the competing values framework as guiding criteria for selecting comprehensive and consistent measures of effectiveness (Quinn & Rohrbaugh, 1981).

| Author | Year | Evaluation criteria |
|---|---|---|
| Georgopolus and Tannenbaum | 1957 | productivity, flexibility , absence of organizational strain |
| Bennis | 1962 | adaptability, sense of identity, capacity to test reality |
| Blake and Mouton | 1964 | simultaneous achievement of high production-centered and high people centered enterprise |
| Caplow | 1964 | stability, integration, voluntarism, achievement |
| Katz and Kahn | 1966 | growth, storage, survival, control ,over environment successful acquisition of scarce and valued resources |
| Yutchman and Seashore | 1967 | growth, storage, survival, control ,over environment successful acquisition of scarce and valued resources |
| Friedlander and Picke | 1968 | profitability, employee satisfaction and societal value |
| Mahoney and Weutze | 1969 | general business model, productivity, planning, reliability |
| Schein | 1970 | open communications model |
| Ducan | 1973 | goal attainment , integration, adaptation |
| Child | 1975 | profitability and growth |
| Webb | 1974 | efficiency, support , adaptability , cohesion |

Table 1: Multivariate models in measurement of effectiveness

The competing values framework is a three dimensional approach to the assessment of effectiveness. The three dimensions include organizational focus (internal vs. external), organizational structure (emphasis or control vs. flexibility) and distinction between means and ends (emphasis on processes vs. outcomes). These three dimensions result in a formation of a framework of four models and eight areas of focus. The rationale behind this three-dimensional approach is that past models do not reflect the

complexity of the organizational environment as organizations do not have a single static criterion for diagnosis and comparison but rather have a set of competing performance criteria (efficiency vs. learning or control vs. flexibility). CVF incorporates past models of effectiveness into a single framework so that several established criteria can be evaluated simultaneously. The four models in CVF are defined as open systems model, rational goal model, internal approach model, and human relations model (Lee, 2006).

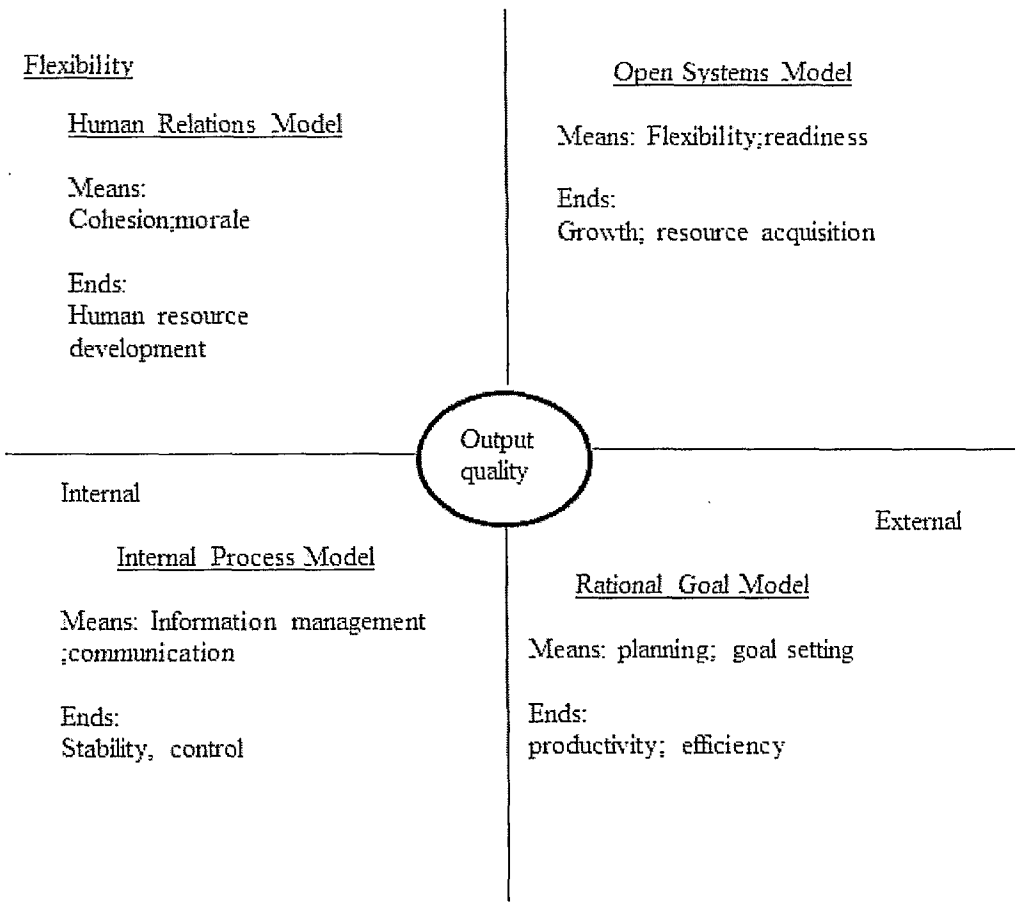



Figure 1: Competing Values Framework (Quinn & Cameron, 1981)

In this framework each model shares at least one dimension with its neighbor resulting on a framework of systematically integrated models to diagnose organizations (Lee, 2006). According to Campbell's (1966) methods (such as regression analysis, t-tests, and ANOVA) are not appropriate tools for comparing levels of effectiveness across organizations because they rely on static measures of central tendency (e.g. averages).

On the contrary, data envelopment analysis compares relative efficiency across companies on a broad set of criteria by calculating the optimal solution and then comparing the obtained values based to that solution.

This research proposes a model of organizational diagnosis that applies a solid multi criterion analytical tool known as data envelopment analysis to assess and compare organizations based on a widely accepted effectiveness framework (Lee, 2006).

## 1.3 RESEARCH PROBLEM STATEMENT

The aim is to evaluate the effectiveness by comparing goal accomplishment based on in each of the four quadrants under CVF. The proposed model enables the identification on how input might be driving the achievement of outcomes by the organization. The results of this study will provide a better understanding of the key drivers of organizational effectiveness and provide critical information to the stakeholders (management, shareholders). The DEA approach involves the creation of the best frontier in order to compare organizations with each other. The results can help identify strategies that may lead to improved effectiveness.

## 1.4 RESEARCH GOAL

The goal of this research is to provide a tool to manufacturing organizations to assess their current state and provide them with the insight on what factors will play a critical role to become more effective when compared to their competitors.

## 1.5 BENEFITS AND RELEVANCE OF THIS RESEARCH

This framework can be utilized by organizations to compare themselves with the competition and to benchmark qualities that can lead them to maximize their goal achievement. The results can also be interpreted by organizational analysts to set benchmarks in line with the goals of the organization. This research can be applied to organizations to provide information to stakeholders about the factors that influence critical outcomes and compare that information with that of major competitors.

## 1.6 IMPLICATIONS AND EXPECTED OUTCOMES

Although this research will use data pertaining to organizations that are in manufacturing, sales and service of power tools, the method followed in this study can also be implemented in other comparisons of homogeneous organizations. The proposed model can be used as a diagnostic tool for an individual organization but also for comparing organizations with their competitors. The tool can support the decision making process by enabling identification and benchmarking of organizations with the optimal level of outcomes. This research proposes a tool based on consistent criteria that can be used support decision making and governance.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

Organizations have been defined as socio-technical systems with specific purposes (Price, 1968). Examples of organizations are government agencies, business firms, industrial firms, trade unions, institutions etc. Effectiveness is determined by factors such as production maximization; cost minimization, technological excellence, customer satisfaction, innovation, etc. (Taylor & Bowers, 1972) . What makes organizational effectiveness so pragmatic is that it involves all the stakeholders including customers, suppliers, society at large, management, etc. (Goodman & Pennings, 1979) .

Measuring organizational effectiveness is of key importance to organizations as it identifies key indicators on which an organization should focus in order to achieve its goals, and it assesses the extent to which they achieved their goals. Indicators for an organization have been broadly classified into objective indicators (costs, profits), subjective indicators (employee satisfaction, quality of work) and social indicators (community service, environment friendly) (Jerald, 1989). Organizational goals may include profit maximization, cost minimization, improving customer satisfaction or employee satisfaction, increasing innovation, etc. In order to better diagnose problems and manage organizations we need to understand what goals companies set up to accomplish and to what extent they accomplish them.

This research focuses on organizational effectiveness of manufacturing organizations. These organizations experience a set of challenges at different levels both internal (human resource management, technology management, etc.) and external

(customer preferences, competition, financial fluctuations etc.). High uncertainties coupled with high degree of market fluctuations demand firms to focus on organizational effectiveness for their survival (Anantadjaya, Handojo, & Firandi, 2012).

The lack of consensus with regards to measures of effectiveness has been attributed to the reliance on convenient data sets that took a narrow approach and ignored the actual meaning of organizational effectiveness (Cameron & Whitten, 1981). This chapter of this thesis focuses on literature exploring the evolution of organizational effectiveness, its theoretical incoherence, and empirical methods used in evaluating organizational effectiveness.

## 2.2 ORGANIZATIONAL EFFECTIVENESS AS PARADOX

Though organizational effectiveness has both practical and theoretical importance in management and governance there is still much confusion and ambiguity regarding this subject (Lee, 2006). The theory of organizational effectiveness has never been well specified because there is a difference in interpretation of the construct among different interest groups (consumers, suppliers, owners etc.). The theoretical disarray in the field of organizational effectiveness can also be attributed to inability to identify predictors of organizational effectiveness and inability to distinguish between indicators and determinants of effectiveness. For example, is the organization's ability to adapt to the changing business environment an indicator or determinant of effectiveness (Goodman & Pennings, 1979)?

It is not only the theoretical literature but also the empirical literature that is in a state of disarray and confusion. There is abundance of literature on univariate and

multivariate models that tried to measure organizational effectiveness. These methods used different indicators and different procedures, therefore, failing to create a consistent body of knowledge (Steers, 1981). In his review of prior studies, Steers (1981) pointed out the scarcity of research aimed at determining valid measures of effectiveness and also highlighted issues pertaining to having a generalized form of organizational effectiveness that can be applied across all organizations. Due to theoretical and empirical inadequacies and methodological deficiencies quality research on this topic is lacking, and there is a lack of consensus regarding the concept of organizational effectiveness (Cameron, 1986; Freeman & Hannan, 1977).

### 2.2.1 Nature of Theoretical Literature on Organizational Effectiveness

There are a number of theoretical models developed to help us assess effectiveness. Among many of those models are the goal model (Etzoni, 1964; Price, 1968), the resource model (Yuchtman & Seashore, 1967) and the internal process model (Bennis, 1966; Cameron & Whitten, 1981; Nadler & Tushman, 1989). The rational goal model focuses on how an organization achieves its goal. The resource model focuses on assessing organizational effectiveness as the ability to obtain necessary resources from the external environment. The process model focuses on assessing the extent to which resources will be used to transform inputs into outputs (Giti, 2012). All these models argued about the domain of organizational activity on which to focus in order to have a legitimate study of organizational effectiveness. In addition to this, there is also lot of debate regarding the level of analysis. For example, while Scott (1977) argued about evaluating organizational effectiveness at the individual level, Van Den Ven and Ferry (1980) contended for evaluating it at the sub-unit level, Yuchtman and Seashore (1967) at

the organizational level, and Pfeffer and Salancik (1978) at the environment level (Goodman & Pennings, critical issues in assesssing organisational effectiveness, 1980) . This clearly shows that the lack of agreement is not only on the metrics used but also about the boundaries of the system being measured.

### 2.2.2 The Conceptual Anomaly

There has been disagreement in terms of the operational definition and measures of organizational effectiveness. There are many criterion and definitions of organizational effectiveness based on metrics of performance, efficiency, excellence, quality, productivity, etc. Organizational effectiveness and efficiency are considered two distinct metrics (Lee, 2006). Effectiveness is defined as the degree to which an organization realizes its goals when outcome and goals are well defined (Katz & Kahn, 1966). Efficiency is a ratio defined as the amount of resources used per unit of output (typically, especially in microeconomics and finance, efficiency is defined as units of output per unit of input). If an organization achieves its goal but does it using too many resources, then the organization is effective but not efficient (Lee, 2006). These various definitions have resulted in plethora of criterion to measure organizational effectiveness. Pennings and Goodman (1980) suggested that organizational effectiveness should comprise several criteria (Balduck & Bulens, 2008). The following sections of the chapter discuss the evolution of theoretical models of organizational effectiveness and the assumptions and drawbacks of each model.

## 2.3 PROMINENT MODELS IN ORGANIZATIONAL EFFECTIVENESS

Research on organizational effectiveness built its theoretical foundation using four different models; the systems approach, the goal approach, the strategic constituency approach, and the internal process approach. These four approaches were determined by their prominence in the field of organizational effectiveness (Giti, 2012).

The goal approach is the oldest and first extensively used approach. It describes effectiveness in terms of achievement of a set of organizational goals which usually are profits, quality, customer satisfaction, etc. This perspective of organizational effectiveness relates to goal accomplishment. Since organizations have multiple goals this approach to assess effectiveness requires the use of multivariate models in order to measure effectiveness. Some research primarily focused on categorizing goals into output and input goals. Output goals relate to the external environment (customers, society) whereas input goals focus on factors internal to the organization. Mohr (1973) classified goals into transitive (externally oriented) and reflexive (internally oriented). Finally, Perrow (1961) classified organizational goals as official goals (for reporting purposes) and operational goals (based on actual organizational decisions) (Lee, 2006).

This model makes certain basic assumptions. One assumption is that goals are clearly defined by the organization and every member in the organization is committed to achieving that goal. The next assumption is that goals are of certain finite number (limited) and achieving them requires some indispensable resources. The model is only suitable when goals and output measures are clearly defined, and the constraint is that each goal should be measurable. The major drawback of this model is that it ignores the fact that organizational goals evolve over time and though similar organizations have

similar set of goals the preference or weights of each goal vary over time and from organization to organization (Giti, 2012).

The systems approach defines organizational effectiveness as the ability to obtain necessary resources from the environment outside the organization. In the systems approach, the realization of system goals is one of the several factors that contribute to effectiveness. The systems approach can be considered as an integration of the natural systems model and the open systems model. The natural systems approach focuses on internal human resource management factors of an organization such as participant satisfaction, employee morale, interpersonal skills etc., whereas the open systems model focuses on the systems exchange to acquire resources from the external environment. Unlike the goal model, which is focus on the outcomes, the systems approach looks at the organization from the perspective of the inputs, infrastructure and external environment as contributors to the outputs (Giti, 2012; Lee, 2006).

The systems resource approach cannot display the entire performance of the organization, because resources invested in research and development activities may not have immediate impact on the output. For example, organizations may invest into a new technology to manage inventory, but the results may not be seen in the near future. This model ignores the human resource development aspect (Giti, 2012).

The strategic constituency approach refers to groups of individuals holding similar interests and preferences pertaining to the organization under consideration. In the strategic constituency approach, effectiveness is defined as the ability of the organization to minimally satisfy its strategic constituencies (Giti, 2012). Examples of strategic

constituencies are users of the goods and services, people who are the resource for the company, the customers, and the stakeholders.

This approach does a comprehensive assessment of organizational effectiveness and takes into account both environmental and internal factors. It also takes into consideration corporate social responsibility, which is neglected in many approaches. The strategic constituency approach is also known as the multiple constituency approach where organizations are systems and constituencies are the subsystems within the boundaries of the larger system. Through this approach, effectiveness is viewed from the point of view of the constituents, which contribute to the effectiveness of the whole system (Lee, 2006). This model considers effectiveness as satisfying one or more of its constituencies. The drawback to this approach is that satisfying one constituency does not necessarily mean that the other constituency is satisfied.

The competing values approach is a theoretical framework that describes the key organizational dimensions involved in assessing organizational effectiveness. CVF is an empirically derived model created by Bob Quinn and John Rohrbaugh in 1983. Through series of empirical studies with focus on organizational effectiveness, Quinn and Rohrbaugh (1983) discovered two dimensions of effectiveness. The first dimension deals with organizational focus, which can vary from an internal emphasis on people in the organization to an external focus on the organization itself. The other dimension pertains to structure and whether stability or flexibility is the dominant structural paradigm. Stability indicates a focus on top-down control and flexibility represents a value for learning and change. When studying the effectiveness of organizations in the field, a group of researchers (Cameron, 1986; Quinn & Cameron, 1983; Quinn & Rohrbaugh,

1981) established that some organizations were effective by achieving flexibility and adaptability, while others accomplished the same through stability and control. Similarly, findings suggested that some organizations achieved effectiveness through improving internal processes whereas others did it by maintaining a competitive external positioning (Cameron, 1986; Quinn & Cameron, 1983; Quinn & Rohrbaugh, 1981). As a result, these researchers developed a four-quadrant model based on those two dimensions. The model represent the different ways in which organizations can be evaluated based on outcomes, on how they interact with the environment, how they learn and how they organize, and it provides a set of indicators for organizational effectiveness (Cameron, Quinn, Degraff, & Thakor, 2006). CVF received its name because it proposes four models that have opposing value propositions. For example, if an organization aims at being adaptable to the environment and flexible to changing circumstances (open systems model) they may find it difficult to establish a state of stability and control (internal process model).

This framework serves as a theoretical base to study various aspects of organizations like corporate strategy, organizational culture core competencies, leadership, decision making, human resource practices, and employee selection (Cameron, Quinn, Degraff, & Thakor, 2006). In the past two decades, it has led to critical intervention processes and measurement devices that capture the overall view of the organization (Cameron, Quinn, Degraff, & Thakor, 2006). For practitioners, it serves as a very critical tool in decision making on aspects like mergers and acquisitions, leadership competencies, organizational culture, human resource management, financial investment, information processing, etc.(Cameron, Quinn, Degraff, & Thakor, 2006).

Based on Campbell's (1971) original 30 effectiveness criterion, Quinn and Rohrbaugh (1988) selected 17 criteria based on multi-dimensional scaling technique and distributed these 17 criterions into four clusters. Each cluster emerged from the combination of the two dimensions, focus and structure. Figure 2 depicts Campbell (1977) and Quinn & Cameron (1988) criteria.

The four clusters form four core values, and they represent competing assumptions. Each quadrant highlights a core value that is the opposite from the value on the other side of the quadrant example flexibility vs. stability, internal vs. external (Cameron & Quinn, 1998). Figure 3 shows a detailed view of competing values framework.

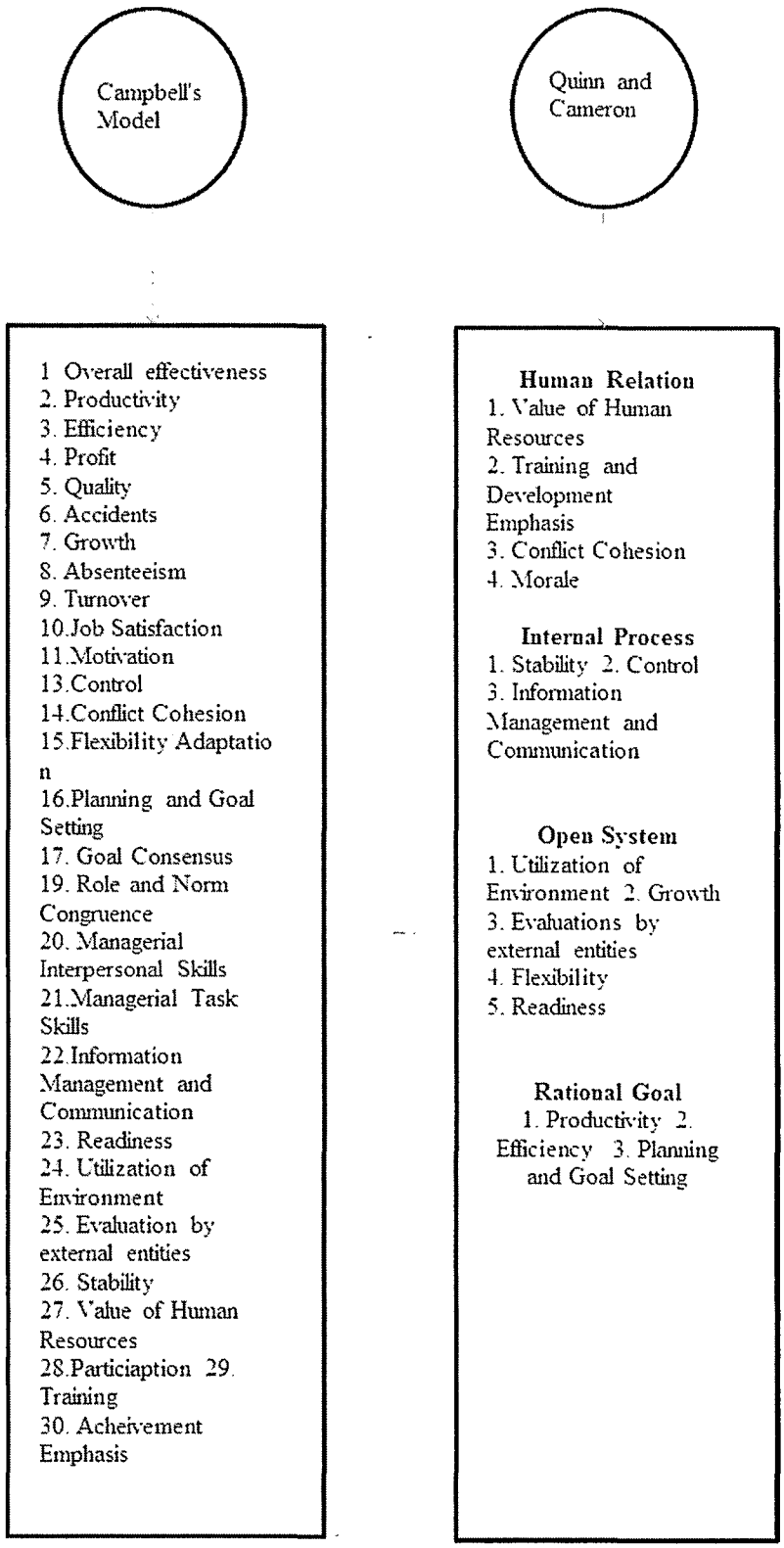



Figure 2: Organizational Effectiveness Criteria (Campbell, 1977; Quinn & Cameron, 1988)

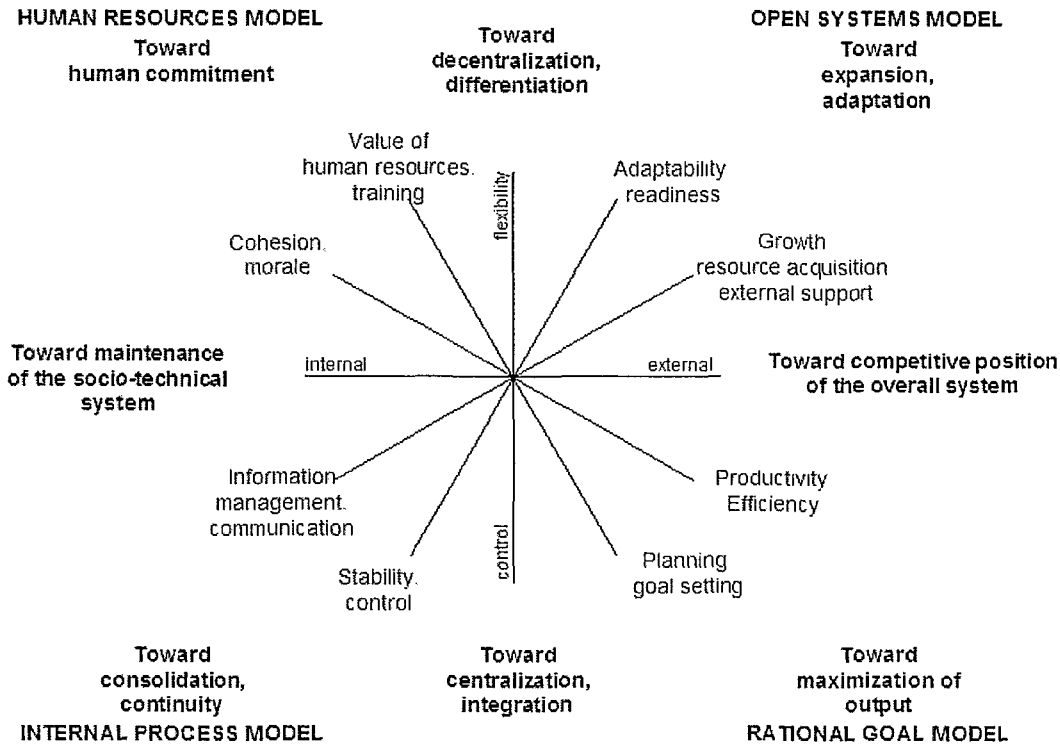



Figure 3: Competing Values Framework Skeletal Model (Quinn & Cameron, 1988)

The competing values framework in Figure 3 is broadly classified into four categories internal process model, human relations model, open systems model, and rational goal model. Internal process model refers to organizations that focus on establishing hierarchy and emphasize on measurement documentation and information management. These types of organizations take calculated and controlled risks and aim to minimize the chances of failure. In general, this type of organizations exhibits a controlled approach (Cameron, Quinn, Degraff, & Thakor, 2006).

The rational goal model refers to organizations aggressive and forceful in the pursuit of competitiveness. Their philosophy is to compete hard, move fast, and play only to win. They believe that planning and goal setting will contribute to high productivity and efficiency. Tasks are clarified, goals are set, and performance is demanded. Organizations in this category tend to take aggressive measures to increase working capital. Customers are the highest priority and then come the employees. In general this type of organizations is profit driven (Cameron, Quinn, DeGraff, & Thakor, 2006).

In the open systems model, organizations are open to ideas and are driven by innovation in their products and services. The organizations that excel in this quadrant can handle risk and discontinuity with ease. They give their employees freedom to implement their own ideas, and they encourage constant change and development. This model also focuses on growth through acquisitions, and their employees are not controlled but are expected to invent and innovate (Cameron, Quinn, DeGraff, & Thakor, 2006).

In the human resource model, organizations fall under the collaborate quadrant. They are more concerned with building human competencies, developing people, and organizational culture. These types of organizations are the best places to work for employees, and they typically rely on human capacity and capability to achieve success. They produce work environments that are free from tension and conflict, and employees generally tend to be loyal to this type of organizations.

The major assumption of this model is that when we take a closer look at the four quadrants, the human relations model and rational goal model form the opposite ends

similar to the internal process model and open systems model. This does not mean that the approaches are mutually exclusive, and it is possible that organizations are effective based on the human relations and rational goal approach at the same time.
Since this model integrates four different models, evaluators can apply different weights to each quadrant depending on the goal and context of the study (Giti, 2012).

## 2.4 METHODS EMPLOYED IN ASSESSMENT OF ORGANIZATIONAL EFFECTIVENESS

Theoretical understanding gives knowledge about what is to be considered when measuring organizational effectiveness. However, it is also important to discuss some analytical tools that help us integrate all the metrics, so that we can determine and compare effectiveness across different organizations. Some of the available tools that have been used to analyze effectiveness metrics are ratio analysis, regression analysis, and data envelopment analysis. This section gives an overview on previous research that was conducted using these techniques to evaluate effectiveness (Lee, 2006).

Ratio analysis evaluates the relationship between a single input and output variable, and they have often been used in the assessment of organizational performance, efficiency and effectiveness. Ratios are simple and an effective way to depict parameters like performance, efficiency and effectiveness; therefore, it has been extensively used in theoretical and practical studies (Lee, 2006). Ratios also are typically used to compare organizational performance and involve a quotient of output to input variables. For example, inventory turnover rate (ratio of cost of goods sold to average inventory) has been used to compare performance across organizations of different sizes. It is hard to see

everything as a ratio, and it is one of the practical constraints of ratio analysis. For example, if the output and input quantities have different units and they cannot always be easily interpreted as ratios.

Regression analysis is a technique that is mainly employed to see the relationship among variables. Prior studies relating to organizational effectiveness and performance have used multiple regression technique where more than one input variable can be regressed with one or more output variables. Regression analysis gives the average relationship between input and output variables under consideration. For example, two input variables like manpower and cost of goods sold can be simultaneously regressed over profit and turnover.

Rushing (1974) studied profit and non-profit hospitals and compared their performance using multiple regression. The results showed that the number of management and support personnel is negatively correlated with the occupancy rate in profit based hospitals as compared to that of nonprofit based hospitals. Reimann (1975) did a study involving multiple regression technique to observe the impact of a set of factors on organizational performance. The research concluded that management values are stronger predictors of organizational performance than organizational size and technology.

The main drawback of regression methods is that they are concerned with comparative effectiveness relative to population averages. This method can establish whether organizations are below (ineffective) or above average (effective) but it cannot simultaneously compare multiple output measures (Lee, 2006).

Data envelopment analysis was proposed by Charles, Cooper and Rhodes in 1978. DEA is a mathematical programing approach that develops performance frontiers for organizational units or companies ,also termed as Decision Making Units (DMU), and then measures the relative efficiency of organizations by comparing them with those frontiers. DEA is a mathematical model that uses a given set of inputs and outputs and then through a mathematical linear programing method, it calculates the relative efficiency of the DMUs when compared to the best DMU or frontier on a multiple set of criteria (Lee Yen & Othman, 2011).

DEA develops a frontier to which the relative efficiencies of all the decision making units can be compared. DEA compares each DMU to the best DMU. DMUs may be units in the same organization or different organizations. For example, if we are measuring the relative efficiencies of three automobiles manufacturers, the DMUs are those organizations. If we want to measure the effectiveness of research centers in a university system then the DMUs are each of the individual research centers.

The first DEA model was developed by Cooper and Rhodes (1984), this model assumes Constant Returns to Scale (change in outputs is directly propotional to the change in inputs) also abbreviated as the CRS model. Banker, Charnes and Cooper (1984) in introduced a model which is based on variable returns to scale (VRS) (Lee Yen & Othman, 2011).

In addition to CRS an VRS, there are five other models for DEA. The additive model is used to identify the excesses in the inputs and the shortfalls in the output simultaneously. The assurance model also called the assurance region approach imposes weights on the special inputs and outputs. These weights are determined by expert

opinion, opportunity cost or other appropriate parameters, and then, by imposing weights, the model constraints the efficieny to single best performing decision making unit (Charnes, Cooper, Goolany, Seiford, & Stuz, 1985). The super efficiency model gives efficiency scores by eliminating the data on the DMU to be evaluated from the solution set. This approach then is used to rank DMU and determine the best DMU (Lee Yen & Othman, 2011). DEA can be applied to unit assessment of homogeneous units such as banks, hospitals and any profit or non profit organization.The application of DEA will be discussed in detail in the following chapter (Lee Yen & Othman, 2011).

## 2.5 CONCLUSION

The above sections depicted various models and tools to diagnose organizations. Prior research in organizational effectiveness has used a great variety of models and tools with a diverse set of strengths and weaknesses (Cameron, 1986). The above sections also signify that assessment of organizational effectiveness should incorporate findings from empirical studies as they provide us the complete review on organizational effectiveness (Reimann, 1975). Models of organizational effectiveness that have a unique criteria for assessment like the goal model or the strategic constituency model fail to incorporate the complex nature of organizational effectiveness. According to Kirchhoff (1977), a unidirectional approach in organizational study is like imagining a cube without perceiving its depth. He also states that the future studies should focus on conducting empirical research aimed at developing a universal criterion for organizational effectiveness that is suitable for all organizations (Lee, 2006).

# CHAPTER 3

# METHODOLOGY

## 3.1 RESEARCH GOAL

The goal of this research is to provide a tool to manufacturing organizations to assess their current state and provide them with the insight on what factors will play a critical role to become more effective when compared to their competitors.

## 3.2 DATA ENVELOPMENT ANALYSIS

Evaluating effectiveness is of key importance to organizations as it identifies the extent to which the organization meets a set of goals they have set for themselves. Effectiveness is abstract and difficult to assess due to its multivariate nature. Due to a lack of universal criterion to define and assess organizational effectiveness, most of the research has focused on evaluating organizational effectiveness for organizations with similar characteristics or goals. Traditionally, ratio analysis and regression analysis have been used to measure the relative effectiveness of the organization, but ratio analysis can only be applied simultaneously to a single input and a single output variable. In cases with multiple inputs and output variables, weights are usually assigned arbitrarily to each input making the results biased (Lee, 2006).

Data envelopment analysis was utilized in the past as an attempt to overcome the limitations of the existing methods. Data envelopment analysis is a linear programming technique which was initially applied to measure relative efficiency (Golani & Tamir, 1995). Previous research has used DEA to identify the relative effectiveness of schools,

organizations, banks etc. It has wide applications in engineering, economics, social sciences and decision sciences.

## 3.3 BASIC CONCEPT AND RATIONALE BEHIND DATA ENVELOPMENT ANALYSIS

Data envelopment analysis is a linear programming technique that has been utilized to assess the relative efficiency of the units under consideration, which are termed decision making units (DMU'S). For example, if we are comparing efficiencies of branches of a particular bank, then these branches are termed as DMU'S. DEA is mostly used in the cases where the effect of input variables on output variables cannot be directly interpreted. For example, just by looking at the data we cannot assess and compare the simultaneous relationship between human resources development initiatives (input variable) and raw material cost (input) on company's growth (output variable) for a group of companies.

DEA develops a frontier to which the relative efficiencies of all the decision making units can be compared. DEA compares each DMU to the best DMU. DMUs may be units in the same organization or different organizations with a comon goal. For example, if we are measuring the relative effeciencies of three automobile manufacturers, the DMUs are those organisations. If we want to measure the effectiveness of research centers in a university system then the DMUs are each of the individual research centers. The following example illustrates the way DEA methodology functions with a specific set of inputs and outputs. The goal of the example is just to illustrate how relative efficiency is calculated using DEA algorithm. In this example let us consider Citibank is

looking at measuring relative efficiencies of its branches in Virginia using data envelopment analysis. Consider a scenario that Citibank had six branches in Virginia and they are at Norfolk, Vienna, Richmond, Chesapeake, Newport News, and Suffolk. They want to measure the relative efficiency considering manpower as the input and number of personal and business transactions processed per day as outputs. Hypothetical data for the analysis is shown below.

| Citibank Hypothetical Example | | | |
|---|---|---|---|
| Branch | Number of Employees | Personal Transactions | Business Transactions |
| Norfolk | 16 | 44 | 20 |
| Vienna | 10 | 23 | 12 |
| Richmond | 20 | 125 | 50 |
| Chesapeake | 22 | 80 | 52 |
| Newport News | 30 | 140 | 40 |
| Suffolk | 12 | 50 | 45 |

Table 2: Citibank Hypothetical Data

The above data are analyzed using Frontier Analyst software and the results below were obtained.

| | PT/Number of Employees | BT/ Number of Employees | Weighted Sum |
|---|---|---|---|
| Weights | 12 | 6 | |
| Norfolk | 2.75 | 1.25 | 40.5 |
| Vienna | 2.3 | 1.2 | 34.8 |
| Richmond | 6.25 | 2.5 | 90 |
| Chesapeake | 3.6363636 | 2.3636364 | 57.818 |
| Newport News | 4.667 | 1.33 | 64 |
| Suffolk | 4.16 | 7.75 | 72.5 |

Table 3: Citibank Hypothetical Data-Scores.

The data obtained show that the Richmond and Suffolk branches have 100% relative efficiency and are considered to be efficient relative to all the other branches. When the model evaluated Richmond individually with respect to other five branches it was able to come up with the set of weights for the variables such that the weighted sum for Richmond was the highest when compared to the other branches, which was similar to Suffolk. For the other four branches, the model was not able to come up with any weights such that it could make the branch have the maximum weighted sum, so these branches ended up getting relative efficiency score less than 100%. The above statement is illustrated below. In case of Richmond, when weights of 12 and six were plugged in, we get weighted sum of 90 which is the highest when compared to other branches. Similarly in the case of Suffolk when we plug in two and 30 for Suffolk we get the highest weighted sum.

| Citibank Hypothetical Example | | | | |
|---|---|---|---|---|
| Branch | Number of Employees | Personal Transactions | Business Transactions | Efficiency score |
| Norfolk | 16 | 44 | 20 | 46.10% |
| Vienna | 10 | 23 | 12 | 40.70% |
| Richmond | 20 | 125 | 50 | 100.00% |
| Chesapeake | 22 | 80 | 52 | 70.80% |
| Newport News | 30 | 140 | 40 | 74.70% |
| Suffolk | 12 | 50 | 45 | 100.00% |

Table 4: Citibank Hypothetical Data-Scores

| | PT/Number of Employees | BT/Number of Employees | |
|---|---|---|---|
| Weights | 2 | 30 | |
| Norfolk | 2.75 | 1.25 | 43 |
| Vienna | 2.3 | 1.2 | 40.6 |
| Richmond | 6.25 | 2.5 | 87.5 |
| Chesapeake | 3.636363636 | 2.363636364 | 78.18182 |
| Newport News | 4.666666667 | 1.333333333 | 49.33333 |
| Suffolk | 4.166666667 | 3.75 | 120.8333 |

Table 5: Citibank Hypothetical Data-Scores

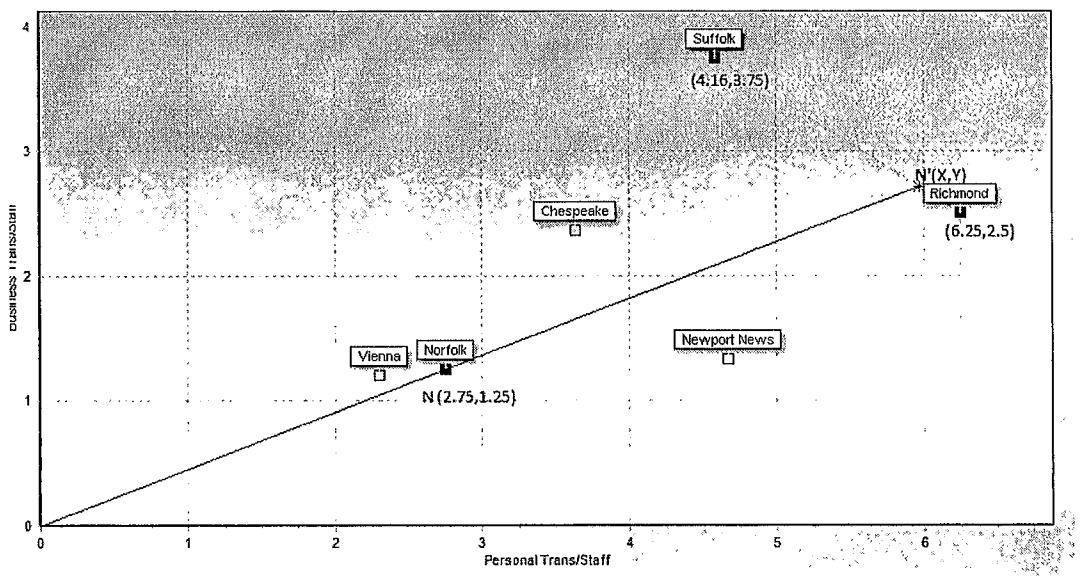
This means that when the model plugged in these arbitrary weights, it found that the weighted sum was highest for these weights, so the model considered it to be efficient. Now, for other four branches, no matter what values we plug in as weights we will not get the highest weighted sum; therefore these branches are considered less efficient than Richmond and Suffolk.

After determining the efficient DMU the model will create a frontier and calculate the relative efficiencies of the other less efficient DMU with respect to that frontier. This method is illustrated below.

| | PT/Number of Employees | BT/Number of Employees |
|---|---|---|
| Weights | 2 | 30 |
| Norfolk | 2.75 | 1.25 |
| Vienna | 2.3 | 1.2 |
| Richmond | 6.25 | 2.5 |
| Chesapeake | 3.636363636 | 2.363636364 |
| Newport News | 4.666666667 | 1.333333333 |
| Suffolk | 4.166666667 | 3.75 |

Table 6: Citibank Hypothetical Data-Weights

These values are plotted to examine the efficiencies of individual units in a 2D graph as shown.




Graph 1: Citibank Hypothetical Data - DEA Graphical Interpretation.

From the above graph, we can see that the efficient frontier encompasses the Suffolk and Richmond branches. Now to estimate the relative efficiency of the Norfolk

branch, we project the coordinates of Norfolk branch from N (2.75, 1.25) to the new coordinates N'(X, Y). Suffolk, Richmond and N' lie on the same line so we can conclude that their slopes are equal.

The slope for Suffolk and Richmond is -0.6, which means that the slope between Suffolk and N' should also be -0.6

$$\frac{y-3.75}{X-4.16} = -0.6 \quad \text{---------- (1)}$$

Since, N and N' are on the same line, the ratio of their coordinates should be the same.

$$\frac{X}{Y} = \frac{2.75}{1.25} = 2.20 \quad \text{---------- (2)}$$

Substituting (2) for (1) we get N' (5.91, 2.69). Now, the relative efficiency of Norfolk is $\frac{Length\ of\ ON}{Length\ of\ ON'} = 0.461$ which means Norfolk is 46.1% efficient relative to its efficient frontier and its efficiency can be improved by 53.9%. Similarly, the efficiencies of all the other inefficient branches can be calculated. This graphical interpretation is easy if we have one input and two outputs or vice versa, but if we have multiple inputs and outputs the graphical interpretation of the model is not possible. In that case, we can form a mathematical equation and formulate a linear programming model and run the model using the software to get the results.

## 3.4 MATHEMATICAL MODEL FORMATION

The mathematical model formulation in the linear programming approach has three classes of equations, the first being the objective functions, followed by the set of constraints, and last is the non-negativity requirement (Dowing, 1992). The objective function is either minimized or maximized subject to the constraints. The objective may

refer to maximizing profit, minimizing cost or maximizing production capacity and the constraints are the resources that need to be constrained example labor, material, demand etc. The model is linear since the objective function or constraint change at the same rate for each unit change in a decision variable (Dowing, 1992; Dwivedi, 2008). Data envelopment analysis has two types of linear programming models, the constant returns to scale (CRS) model and variable returns to scale (VRS) model. The constant returns to scale model assumes that output changes at the same rate as that of input (i.e. increase of decrease in input has a proportionate increase or decrease of output). In variable returns to scale model, the scaling factor is not constant (i.e. the increase or decrease in input will not cause a same constant increase or decrease in output). Both these two models can be written as output maximization or input minimization models. The variable returns to scale model is used when we want to incorporate market fluctuations, financial constraints etc. In this research, a constant returns to scale model is used because using a variable returns to scale model will require the rate at which inputs vary with respect to outputs and the data pertaining to this not only varies across organizations but also is difficult to obtain.

The mathematical programming model to calculate the effectiveness using data envelopment analysis can be described by the following equation

Maximize $Ek = \sum_{r=1}^{S} Ur\, Yrk \,/\, \sum_{r=1}^{M} V\} Xik$ objective function

Ek = efficiency of organization K,

Ur = weight for output r,

Vi = weight for input i,

Yrk = amount of output r= 1… s produced by organization K,

Xik = amount of input i= 1… m consumed by organization K,

S = number of outputs,

M = number of inputs.

Subject to

$$\left.\begin{array}{l} \sum_{r=1}^{S} Ur\,Yrk \,/\, \sum_{r=1}^{M} Vi\,Xik \leq 1 \\ Ur,\ Vi \geq 0 \end{array}\right\} \quad \text{Constraint}$$

The above mathematical model is converted into linear by imposing $\sum_{r=1}^{M} Vi\,Xik=1$ as a constraint and substituting in the objective function the final model reduces to

$$\text{Maximize } Ek = \sum_{r=1}^{S} Ur\,Yrk$$

Subject to

$$\left.\begin{array}{l} \sum_{r=1}^{S} Ur\,Yrk - \sum_{r=1}^{M} Vi\,Xik \leq 0 \\ Ur,\ Vi \geq 0 \end{array}\right\} \quad \text{Constraints}$$

$$\sum_{r=1}^{M} Vi\,Xik=1$$

For the bank example above the mathematical model can be formed as follows Output Maximization CCR model.

For the Norfolk branch

Maximize $Y= 44U_1+20U_2$

Subject to

$-16V_1=1$

$44U_1+20U_2-16V_1\leq 0$

$23U_1+12U_2-10V_1\leq 0$

$125U_1+50U_2-20V_1\leq 0$

$80U_1+52U_2-22V_1 \leq 0$

$140U_1+40U_2-30V_1 \leq 0$

$50U_1+45U_2-12V_1 \leq 0$

$U_1, U_2, V_1 \geq 0$

Similarly, a mathematical model can be created for the other five other branches. Table 8 shows the results when the model was run using Frontier Analyst software. The results show that Suffolk and Richmond are 100% effective when compared to their peer branches. The table below clearly exemplifies the targeted number and the potential improvement for all the other branches except Suffolk and Richmond to become 100% efficient.

| Variable | Actual | Target | Potential Improvement | 46.09% |
|---|---|---|---|---|
| Business Transactions | 20 | 43.4 | 116.98% | |
| Personal Transactions | 44 | 95.47 | 116.98% | Norfolk |
| Staff | 16 | 16 | 0.00% | |
| | | | | |
| Variable | Actual | Target | Potential Improvement | 40.70% |
| Business Transactions | 12 | 29.49 | 145.73% | |
| Personal Transactions | 23 | 56.52 | 145.73% | Vienna |
| Staff | 10 | 10 | 0.00% | |
| | | | | |
| Variable | Actual | Target | Potential Improvement | 100.00% |
| Business Transactions | 50 | 50 | 0.00% | |
| Personal Transactions | 125 | 125 | 0.00% | Richmond |
| Staff | 20 | 20 | 0.00% | |
| | | | | |
| Variable | Actual | Target | Potential Improvement | 70.83% |
| Business Transactions | 52 | 73.42 | 41.08% | |
| Personal Transactions | 80 | 112.95 | 41.18% | Chespeake |
| Staff | 22 | 22 | 0.00% | |
| | | | | |
| Variable | Actual | Target | Potential Improvement | 74.67% |
| Business Transactions | 40 | 75 | 87.50% | |
| Personal Transactions | 140 | 187 | 33.93% | Newport News |
| Staff | 30 | 30 | 0.00% | |
| | | | | |
| Variable | Actual | Target | Potential Improvement | 100.00% |
| Business Transactions | 45 | 45 | 0.00% | |
| Personal Transactions | 55 | 55 | 0.00% | Suffolk |
| Staff | 12 | 12 | 0.00% | |

Table 7: Citibank Hypothetical Data –Final results

DEA is very sensitive to input and output variables. The change in values or metrics of the variables can cause serious variations in the level of effectiveness. It has also been observed that an increase in number of input or output variables, keeping the DMU constant, will result in having greater proportion of DMU in the efficient frontier, thus making the analysis lose its sensitivity. It is observed that as the number of input and

output variables increase, the proportion of DMU in the efficient frontier will increase and analysis losses its descriptive power (Tankersley & Tankersely, 1996). Secondly, DEA is a non-parametric measure and cannot calculate the error in measurement as opposed to regression analysis, least squared, or ANOVA methods (Nythan & Martin, 1999).

## 3.5 METHODOLOGICAL FRAMEWORK FOR DATA ANALYSIS

This research aims at evaluating organizational effectiveness of manufacturing organization's using competing values framework as the theoretical background and data envelopment analysis as the mathematical model. The input and the output variables that go into the mathematical model are based on the theoretical framework. CVF encompasses four different individual criteria that provides a comprehensive evaluation of organizations and stands out among all the other theoretical models of effectiveness (Lee, 2006).

### 3.6 Data Collection and Selection of Variables.

The study aims to test the method for evaluating organizational effectiveness using competing values framework as a theoretical approach and data envelopment analysis as the mathematical model. The sample to test the validity of the effectiveness model is taken from four similar organizations that manufacture, sale, and service power/hand tools.

The first step is to select input and output variables that are specific to the industry under consideration. These variables are selected with a broad idea that inputs to

manufacturing organizations can be classified in the form of working capital (money used to buy something only in order to sell it again to realize a financial profit) and manpower. Working capital as an input accounts for the costs that go in manufacturing, marketing and sales of a product. This includes cost of raw material, labor costs, sales costs, capital expenditure, administrative costs, etc. In this research, the cost of goods sold, sales general and administrative expense, and capital expense are included as capital inputs to the organization. The cost of goods sold includes: the cost of products or raw materials, including freight or shipping charges; cost of storing products as a unprocessed inventory; direct labor costs for workers who produce the products; and factory overhead expenses. The cost of goods sold is listed in the expenses side of the company's income statement. Sales general and administrative expenses refer to the expense incurred in marketing and selling the product and all other labor costs excluding the direct labor.

Apart from capital, the number of people working for the company is also a key input. In this research, total number of current employees in the organization is taken into account. In practical real-time applications, companies can also add subcategories to this input like number of managerial staff, number of non-managerial staff, number of temporary workers ,trainee staff etc., this will allow a more clear picture on what parameter in this category needs to be improved.

The output variables are specifically selected aligning the four quadrants of the competing values framework. In the open systems model, organizations are open to ideas and are driven by innovation in their products and services and interact with the external environment to aid them in their growth. Keeping that perspective in mind, total number

of acquisitions, reach-subsidiaries, number of new product patents and trademarks introduced in the market are selected as output variables.

In rational goal models, organizations are aggressive and forceful in the pursuit of competitiveness. Keeping this in mind, percentage increase in market share, net profit margin, gross profit margin and inventory turnover rate were selected as the output measures. In the human resource model organizations are more concerned with building human competencies, developing people and organizational culture. These types of organizations are the employee's best places to work for. The organizations rely on human capacity and capability rather than customer or client happiness. Keeping this as the background, hiring rate, retention rate were selected as the output variables for this quadrant.

The internal focus model companies aim at standardization and continuous improvement through optimizing the existing processes. Effective organizations in this model are generally those who have been in business for a long time, and organizational age is an important factor in this model. The number of process certifications number of years in business, total recordable lost time rate, score of sustainability parameters are the variables that will be considered for this model.

The following table gives the input and output variables that were used in this study. The input variables are consistent in all the four quadrants of CVF whereas the output variables are quadrant specific because the focus on each quadrant focuses on a different set of outcomes but uses a common set of inputs (resources). Table 9, below, shows input and output variables for the model followed by their operational definition

and metric used to measure them. The input variables in Table 8 are common for all four quadrants.

| Type | Variable Name |
|---|---|
| INPUT(I1) | Total Number of Employees |
| INPUT(I2) | Cost of Goods Sold |
| INPUT(I3) | Sales General and Administrative Expense |

Table 8: Input Variables

Table 9 indicates the output variables by quadrant in the CVF.

| S.No | Output Variable* | Variable Name |
|---|---|---|
| 1 | OSM | Total Number of Acquisitions |
| 2 | OSM | Reach-Subsidiaries |
| 3 | OSM | Number of New Product Patents Developed |
| 4 | OSM | Trade Marks Introduced In the Market |
| 5 | RGM | Percentage Increase in Market share |
| 6 | RGM | Net Profit Margin |
| 7 | RGM | Gross Profit Margin |
| 8 | RGM | Inventory Turnover rate |
| 9 | HRM | Hiring Rate |
| 10 | HRM | Retention Rate |
| 11 | IFM | Company Process Certifications |
| 12 | IFM | Number of years in Business |
| 13 | IFM | Total Recordable lost time rate |
| 14 | IFM | Score of Sustainability Parameters |

Table 9: Output Variables

* OSM = Open Systems Model, RGM = Rational Goal Model, HRM = Human Resource Model, IFM = Internal Focus Model.

| S.No | Operational definition (very specific definition that should allow anyone to understand how the values are being calculated) |
|---|---|
| I1 | Total full time, part time, contract employees in the company. Please include all the locations in USA and abroad. |
| I2 | This is a numeric figure of the company's income statement, must be in US dollars. Cost of goods sold is for group and not for any individual subsidiary or entity within the company. The number is an average value for FY2010, 2011, 2012. |
| I3 | Sales, general and administrative expense are also an entry from the income statement. The number is an average value for FY2010, 2011, and 2012 and is calculated for the entire group. Must be in US dollars. |
| 1 | Total number of mergers/acquisitions made during FY2010, FY2011, and FY2012. |
| 2 | Total number of authorized distributors include company owned and operated outlets, it also includes exclusive showroom or outlets, retailers, outdoor dealers shouldn't be included. The distributors for the products that are manufactured by the company and its subsidiaries. Include both international and domestic distributors |
| 3 | Number of Patents earned during FY2010, FY2011, and FY2012. This includes only approved patents and not the patents that are under process. The patents used in the report are only US patents and no other country's patents (We do not included the patents obtained in other countries for ease of uniformity in data). |
| 4 | Number of trademarks from the inception. United States state and federal trademarks and also international Trademarks. This does not include non-renewed or inactive trademarks but includes current, renewed and in process trademarks. |
| 5 | This is the percentage increase in (total sales of company)/ total industry sales for current year over previous year. This value is an average for FY 2010, 2011, 2012. |
| 6 | Average net profit margin from FY2010-FY2012. |
| 7 | Average gross profit margin from FY2010-FY2012. |
| 8 | The ratio of cost of goods sold to average inventory. Average value from FY2010-FY2012. |
| 9 | Increase in the total employee strength from FY2011- FY2012. |
| 10 | During FY2010-FY2012 average number of employees the company had retained per year. |
| 11 | Number of process certifications. ISO, OSHAS, or any other external certification body. For example if the company has ISO9001 and ISO14001 and OSHAS then it its considered to have three certifications |
| 12 | Number of years in operation from the year of inception of the company. |
| 13 | Total recordable lost time is the rate is calculated as # of applicable incidents per 100 employees per year, taken as an average of three years FY 2010, FY 2011, FY2012. |
| 14 | This is the average of % increase/decrease of each of the below parameters. %increase or decrease is calculated from FY2011-FY2012.<br>Parameters<br>1. Waste generation (lbs. /$), 2. Energy consumption (kbtu/$), 3. CO2 emission (C/$), 4. Water consumption (gal/$). |

Table 10: Operational Definitions.

The above table gives the operational definitions of input and output variables and the metrics used to measure these variables.

### 3.7 DATA ANALYSIS

Data envelopment analysis was carried out using Frontier Analyst 3.0 by Banxia Holdings. The data are sourced from four companies who are into manufacturing, sales, and service of hand held power tools (the names of companies are not directly mentioned for data privacy). The primary business stream of all these companies is manufacturing, sales and service of hand held power tools. The selection of companies was not an easy task. Factors like the companies' origins, and business line of operation had to be considered. All the above companies publish their annual reports in U.S. dollars and have their main unit of operation in United States. This regional uniformity is important as non-uniformity would account for conversion specific analysis errors. The size of the company is not considered a factor because we are measuring relative efficiency, which as a ratio neutralizes the effect of size.

The required data for the analysis were obtained from several paid and unpaid database companies that offer company-specific data. Databases used include Hoovers, LexisNexis, Mergent Online, Business Source Complete, company's annual reports published on their websites, and Securities and Exchange Commission filings, like 10k and 12k. In the analysis phase of the research, a mathematical model was created for each quadrant under competing values framework that incorporates the corresponding input and output variables. Then the companies in the sample are analyzed and compared by feeding the mathematical model into Frontier Analyst 3.0. The analysis provides a

measure of effectiveness for each of the DMU's in each of the competing quadrants, compares the effectiveness of each of the DMU'S with each other, and reports which variable needs to be improved for an inefficient DMU to become an efficient DMU.

# CHAPTER 4

# RESEARCH FINDINGS

## 4.1 INTRODUCTION

One of the most compelling purposes of this research was to develop a model to assess organizational effectiveness and to demonstrate its applicability to the context of power and hand tool manufacturers. This research integrates the mathematical principles of DEA to the variables generated using CVF to evaluate organizational effectiveness of the organization's under consideration and compares it to other organizations within the same industry. The sample data set used in the study consisted of four similar organizations in the sector of manufacturing and service of hand held power tools and agricultural equipment. The first step of the research was to develop an effectiveness model aligned with the quadrants of competing values framework. The effectiveness model was based on the concept that inputs to manufacturing organizations can be classified in the form dollar amount that is required by the company to produce that product and manpower that are required for its operation. The outputs are specific for each quadrant of the competing values framework. The four organizations under consideration will be termed as decision making units (DMU). This chapter describes the development of a mathematical model that will include output maximization equations for each DMU under every quadrant of the competing values framework. Data on input and output values were fed into Frontier Analyst software in order to obtain relative efficiency scores. The results obtained by data effectiveness analysis are discussed in context of the competing values framework.

## 4.2 DATA PREPARATION AND MATHEMATICAL MODELING

Table 11 and Table 12 show the values of input and output data for the companies under consideration. Operational definition for each of the variables used in input and output tables is discussed in Chapter 3. Actual names of company are not mentioned due to data privacy and confidentiality.

| Inputs | Total Number of Employees (Number) | Cost of Goods Sold (In Million Dollars) | Sales, General and Administrative expense. (In Million Dollars) |
|---|---|---|---|
| A | 45327 | $6,526 | $2,520 |
| B | 4700 | $551 | $148.90 |
| C | 15429 | $4,848 | $1,065 |
| D | 4823 | $1,215 | $448 |

Table 11. Data for input variables

## 4.3 MATHEMATICAL MODELING

Though the use of Frontier Analyst software eliminates the requirement of forming mathematical models for solving data envelopment analysis, mathematical models were developed as a part of this research in interest of general audience who may want to run the results without the aid of Frontier analyst (i.e. by using Excel, lingo or any other software that can solve linear programming models) and also mathematical models play a vital role in interpreting and understanding the underlying concept of data envelopment analysis. Please refer to Section 3.1.1 for detailed explanation on formation of mathematical model for data envelopment analysis.

| Output Variable | Variable name | A | B | C | D |
|---|---|---|---|---|---|
| OSM | Total Number of Acquisitions | 21 | 17 | 12 | 17 |
| | Reach-Number of Subsidiaries | 236 | 6 | 18 | 16 |
| | Number of New Product Patents Developed (Number) | 37 | 192 | 17 | 48 |
| | Total Number of Trade Marks Introduced in the Market (Number) | 14 | 13 | 7 | 82 |
| RGM | Percentage Increase in Market share (Values in %) | 30% | 9% | 20% | 1% |
| | Net Profit Margin (Values in Million Dollars) | $585 | $45 | $158 | $24 |
| | Gross Profit Margin (Values in Million Dollars) | $3,842 | $255 | $1,305 | $151 |
| | Inventory Turnover rate (days) | 4.5 | 4 | 2.83 | 5.03 |
| HRM | Hiring Rate (Values in %) | 7% | 3% | 2% | 5.06% |
| | Retention Rate (Values in %) | 86% | 95% | 98% | 90% |
| IFM | Number of Company Process Certifications | 6 | 2 | 3 | 3 |
| | Number of Years in Business | 170 | 66 | 342 | 19 |
| | Total Recordable Lost Time Rate (Days) | 0.56 | 0.23 | 0.02 | 0.63 |
| | Score of Sustainability Parameters (Values in %) | 21% | 18% | 40% | 14% |

Table 12: Data for output variables.

## 4.4 FRONTIER ANALYST RESULTS

The results obtained by frontier analyst software are discussed in line with the quadrants of the competing values framework. The inputs I2 and I3 are added and loaded as one input into the software, because as the sample size of the study is only four companies and if we have three inputs and four outputs we will be giving the DEA model too many degrees of freedom to run a valid model and, as a result, it will conclude that all the DMU are effective. To get a more usable report, the sample size should be at least ten times more than the output and input variables combined.

4.4.1 Open Systems Model

As already discussed, organizations deemed to be effective under this model focus on expanding their business and their development capabilities with a belief that innovation and interaction are the ways to achieve growth. The input and the output variables selected for this model closely replicate the above sentence. In this research, total number of acquisitions, reach-number of subsidiaries, number of new product patents developed, and total number of trademarks introduced in the market are the basis of measuring relative efficiencies under this quadrant.

When input variables I1, I2, I3 and output variable O1, O2, O3 were analyzed through frontier analyst software following results were obtained.

| OSM | I1 | I2 | I3 | O1 | O2 | O3 | O4 | Relative Efficiency |
|---|---|---|---|---|---|---|---|---|
| A | 45327 | $6,526 | $2,520 | 21 | 236 | 37 | 14 | 100% |
| B | 4700 | $551 | $148.90 | 17 | 6 | 192 | 13 | 100% |
| C | 15429 | $4,848 | $1,065 | 12 | 18 | 17 | 7 | 30% |
| D | 4823 | $1,215 | $448 | 17 | 16 | 48 | 82 | 100% |

Table 13. OSM Results

The results obtained are shown in Table 13. The output shows that relative efficiency for all the companies except for Company 'C' are 100% (i.e. all the companies except 'C' are considered to be relatively efficient and 'C' is considered to be inefficient). In an open systems perspective, this statement means that Company 'C', has to either increase its output variables or decrease its inputs or do both to function more efficiently. It completely depends upon the management of Company 'B' to decide if they are willing

to decrease the inputs or increase the outputs or do both at the same time. This is assumed to be a purview of management's judgment, but in this case an analyst can suggest increase the outputs and keep the inputs because the percentage decrease in outputs is significantly less that the increase in outputs. A closer look at a frontier analyst detailed output gives us the precise value to which input or output variable needs to adjust to achieve the goal of 100% relative efficiency.

| C | Actual | Target | Potential Improvement |
|---|---|---|---|
| Total Number of Employees | 15429 | 15429 | 0.00% |
| COGS+SGA | 5913 | 4639.02 | -21.55% |
| Total Number of Acquisitions | 12 | 40.03 | 233.57% |
| Reach-Number of Subsidiaries | 18 | 60.04 | 233.57% |
| Number of New Product Patents Developed (Number) | 17 | 110.72 | 551.27% |
| Total Number of Trade Marks Introduced In the Market(Number) | 7 | 184.05 | 2529.27% |

Table 14. Company 'C' Results Analysis

The above table shows that Input I2 (which is a combination of two inputs cost of goods sold and SGA expense) and all the outputs need to be improved in order to achieve 100% relative efficiency score for Company 'C'. The quantities of increase or decrease of outputs and inputs are shown in Table 4. This concludes that the management of Company 'C' has to decrease its input costs from $5,913 to $4,639 while increasing its total number of acquisitions from 12 to 40, the number of subsidiaries from 18 to 60, the number of new products and patents from 17 to 110 and total number of trademarks from seven to 184 in order to become 100% efficient. The above statement may not seem

practical mathematically because in real life scenarios increasing number of trademarks from seven to 185 is a quantum jump and may not be practically possible, but we need to remember that DEA is a tool to highlight the areas that we are lacking when compared to our peers and it is solely upon the management of the company to decide on by what quantity they want to increase the outputs or decrease there inputs.

### 4.4.2 Rational Goal Model

Organizations deemed effective in this model have the ability to maximize profits, market share with minimum input cost. In this research, if the company can obtain relatively high increase in market share, net profit margin, gross profit margin and inventory turn overrate with minimum manpower and input costs then the company is said to be efficient.

The results obtained are shown in Table 15. The output shows that all the DMU are having the scores of 100% relative efficiency which means that every DMU is relatively efficient with every other DMU. With this, we can conclude that all the companies under consideration are focused towards their rational goal approach. This can also be supported by the fact that all these companies operate in the private sector and are for profit. Also, through a closer look at Table 15, we can observe that inputs are directly proportional to outputs. For example, Company 'A' operates with high input costs and manpower when compared to all the other companies under consideration and at the same time it delivers highest percentage increase in market share, net profit margin, gross profit margin and inventory turnover rate.

| RGM | I1 | I2 | I3 | O5 | O6 | O7 | O8 | Relative Efficiency |
|---|---|---|---|---|---|---|---|---|
| A | 45327 | $6,526 | $2,520 | 30% | $585 | $3,842 | 4.5 | 100% |
| B | 4700 | $551 | $148.90 | 9% | $45 | $255 | 4 | 100% |
| C | 15429 | $4,848 | $1,065 | 20% | $158 | $1,305 | 2.83 | 100% |
| D | 4823 | $1,215 | $448 | 1% | $24 | $151 | 5.03 | 100% |

Table 15. RGM Results

4.4.3 Internal Focus Model.

Organizations deemed effective in this model are usually those who have strong processes in place and who have been in the industry for a long time. In addition, these organizations focus on improving their process internally. The input and output variables in this model were selected to capture the status of internal processes. In this research number of company process certifications, years in business, recordable lost time rate and sustainability parameter score go as outputs that determine relative efficiency in this model.

The results obtained in Table 16 show that all the other DMUS except Company 'A', which means that they exhibit strong internal focus and a process oriented approach in their operation. Furthermore, a closer look at the analysis report reveals that Company 'A' would need to decrease its manpower and input costs in addition to enhancing its lost time rate and sustainability score, Though the mathematical results show that inputs of Company 'A' should be decreased by 70-75% to become efficient, this in practical sense means that company 'A' is using more inputs to get same or lesser output when compared to its peers. A closer look at a frontier analyst detailed output in Table 17 gives

us the precise value to which input or output variable needs to adjust to achieve the goal of 100% relative efficiency.

| IFM | I1 | I2 | I3 | O5 | O6 | O7 | O8 | Relative Efficiency |
|---|---|---|---|---|---|---|---|---|
| A | 45327 | $6,526 | $2,520 | 6 | 170 | 0.56 | 21% | 29% |
| B | 4700 | $551 | $148.90 | 2 | 66 | 0.23 | 18% | 100% |
| C | 15429 | $4,848 | $1,065 | 3 | 342 | 0.02 | 40% | 100% |
| D | 4823 | $1,215 | $448 | 3 | 19 | 0.63 | 14% | 100% |

Table 16. IFM Results

| Company 'A' | Actual | Target | Potential Improvement |
|---|---|---|---|
| I1 | 45327 | 13320.6 | -70.61% |
| I2 | 9046 | 2312.08 | -74.44% |
| O1 | 6 | 6 | 0.00% |
| O2 | 170 | 170 | 0.00% |
| O3 | 0.56 | 0.79 | 41.03% |
| O4 | 21 | 49.45 | 135.48% |

Table 17. Company 'A' result analysis

### 4.4.4 Human Resource Model

Organizations deemed effective in this model tend to be employee centric. They believe that empowerment and development of workforce will be a key factor in their organizational growth and future performance. Organizations deemed effective in this model focus on manpower development, employee satisfaction, and retention. In this research, we consider hiring rate and retention rate as the output parameters to measure relative efficiency of the organization. However, many other variables can be considered while measuring relative efficiency, like manpower separation rate, employee career

progression rate, etc., but these variables are difficult to obtain from companies, therefore were not considered in this research.

The results obtained in Table 18 shows that Company 'A' and Company 'C' have very low relative efficiency as compared to Company 'B' and Company 'D'. This clearly shows that hiring and retention rates of Company 'A' and Company 'C' are not proportional to the inputs that these companies utilize. For example, Company 'A' consumes maximum inputs when compared to other three organizations but its employee retention rate (O9) is the least amongst all and similarly Company 'C' though it utilizes more manpower than Company 'B' and Company 'D' combined and also higher input costs, it exhibits least hiring rate (O10). Below, Table 19 and Table 20 shows the value to which input and output variable need to adjust to achieve 100% efficiency for Company 'A' and company 'C'.

| HRM | I1 | I2 | I3 | O9 (%) | O10 (%) | Relative Efficiency |
|---|---|---|---|---|---|---|
| A | 45327 | $6,526 | $2,520 | 86 | 7 | 20% |
| B | 4700 | $551 | $148.90 | 95 | 3 | 100% |
| C | 15429 | $4,848 | $1,065 | 98 | 2 | 31.4% |
| D | 4823 | $1,215 | $448 | 90 | 5.60 | 100% |

Table 18. HRM Results

| A | Actual | Target | Potential Improvement |
|---|---|---|---|
| I1 | 45327 | 45327 | 0.00% |
| I2 | 9046 | 9046 | 0.00% |
| O9 | 86 | 89 | 3.40% |
| O10 | 7 | 35 | 401.00% |

Table 19. Company 'A' Results Analysis

| C | Actual | Target | Potential Improvement |
|---|---|---|---|
| I1 | 15429 | 154297 | 0.00% |
| I2 | 5913 | 2294 | -61.00% |
| O9 | 98 | 100 | 2% |
| O10 | 2 | 10 | 390.00% |

Table 20. Company 'C' Results Analysis

Table 19 shows Company 'A' has to achieve 89% retention rate and should aim at 35% hiring rate to exhibit 100% relative efficiency. Similarly, Company 'C' has to achieve 100% retention rate and aim at 10% hiring rate and also has to decrease its cash input by 61%. As stated earlier, these mathematical numbers need human justification and use of DEA should be limited to identifying the parameters where a particular company lacks w.r.t to its peers. It is solely on the management of Company 'A' and Company 'C' to decide to what extent the hiring and retention rate should be increased.

## 4.5 CONCLUSION AND IMPLICATIONS

The results of Frontier Analyst clearly depict the multifaceted nature of organizational effectiveness. If an organization is not efficient in one quadrant it does not mean the organization is inefficient, it only indicates management that it has to focus on that particular quadrant to improve effectiveness. The aim is always to strive to be efficient in all the quadrants, but to do that all the effectiveness parameters need to be used optimally.

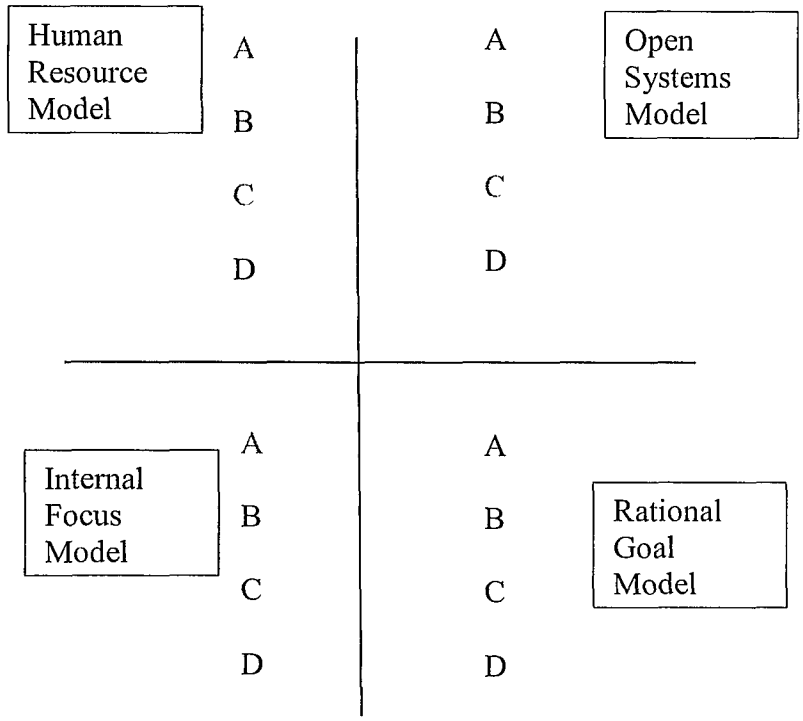



Figure 4: Consolidated Results in all Four Quadrants

The above figure shows that Company 'A' is more externally focused and works on the principles of profit maximization. Whereas, Companies 'B' and 'D' have 100% relative efficiency in all quadrants, which means that both these Companies either equal or are more efficient that other companies. Finally, Company 'C' depicts strong internal focus primarily on concentrating on their internal process to drive profits and has scope for improvement to become more open to the environment and become more employees centric as compared to that of Company 'A' which should concentrate on being more employee centric and internally focused.

The main application of this study is an analyst of any organization from the above organizations can use this to develop a strategic plan after comparing one organization to its peer and also may use the best practices followed by Companies 'B' and 'D' in order to become 100% efficient in all quadrants.

# CHAPTER 5

# CONCLUSIONS

The analysis of the literature suggests that organizational effectiveness should not be determined based on one–dimensional approaches that focus on narrow types of metrics. The theory and frameworks behind the assessment of organizational effectiveness is so complex that looking at organizational effectiveness in one direction will result in incomplete, partial, or biased results. Therefore, this study introduced an integrated framework that can be used to measure relative efficiency of an organization on a predetermined effectiveness model that provides a comprehensive view of organizations. This research developed a model to assess organizational effectiveness and tested the model in the context of a sample of four power and hand tool manufacturers. The study employed an analytical tool based on data envelopment analysis to measure relative performance of a group of organizations based on a validated effectiveness model known as the competing values framework.

The relative efficiency scores for the sample were obtained using an integrated approach of CVF and DEA leading some important findings. It can be inferred from the results that not all the companies are effective in all quadrants of CVF, which means that if an evaluator chooses one model of effectiveness they are likely to end up in completely different conclusions about the organizational effectiveness of the companies. Therefore, it is important that relative efficiency scores and effectiveness parameters of all the four quadrants are taken into consideration to obtain a balanced opinion on organizational effectiveness.

It can also be inferred from the results of the study that half of the organizations were found to be less effective with respect to the human resource model. These results suggest that outcomes related to human factors were somewhat neglected or secondary for these organizations. This also highlights the fact that use of competing values framework takes into consideration human factors while measuring organizational effectiveness, which are greatly neglected in other models that claim to assess organizational effectiveness.

This study illustrates that input and output variables of each model of the competing values framework can be evaluated with the aim of maximizing effectiveness. Finally, the results obtained by using this diagnostic tool, will give us a better understanding of the key drivers of organizational effectiveness, provide critical information to the stakeholders (management, shareholders etc.) and aid them in identifying strategies that may lead to improved effectiveness.

# CHAPTER 6

# RESEARCH LIMITATIONS

Though the approach discussed in this research paper is robust and practical in developing a diagnostic tool to measure organizational effectiveness and introducing a hybrid way to evaluate organizational effectiveness, the model has some limitations which pave way to requirement of further research in this area. The competing values framework serves as a theoretical background based on which effectiveness parameters are obtained. These effectiveness parameters largely control the efficiency scores, so it is very important to choose effectiveness parameters that are unbiased to any organization, which is a challenge and this highlights the need for a third party analyst to perform this study.

DEA is sensitive towards with respect to the number of input and output variables that are considered and also the number of DMUs used to carry out the analysis. In order to get a good detailed analysis report on the measurement of organizational effectiveness, the total number of input variables should be greater than the number of output variables. In addition, the total number of DMUs should be at least twice the number of input and output variables combined. If the above criteria are not met the DEA model might not be able to discriminate between more and less effective DMUs.

In this research, as we had only considered four DMU and number of outputs variables in each quadrant were greater than the number of input variables, the explanatory power of the results obtained in the model was limited. This study was not able to source more inputs because of the data collection limitations.

Finally, extensions of this research involve measurement of bias, variances, and confidence intervals of the variables that are used in measuring effectiveness, as data envelopment analysis provides static measurement (measurement for a particular year or period of time) avenues to run dynamic data envelopment analysis need to be explored, this will help to incorporate market fluctuations, running the model with large data sets and also over greater time frame will enhance the explanatory power of the research findings.

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This project involves proposing a tool to measure organizational effectiveness for manufacturing organizations in Virginia using competing values framework as a theoretical background and data envelopment analysis an analytical tool.

***Realizing Process Improvement through DMAIC Strategy for MIDCO***

The aim of the project was to increase a company's market share, strategic and tactical goals by the method of improving yields and decreasing the defect Rates of core processes, thus improving the process capability of core process