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Public administration efficiency through Total Quality Management

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Public Administration Efficiency through Total Quality Management

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University.

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PUBLIC ADMINISTRATION EFFICIENCY THROUGH TOTAL QUALITY MANAGEMENT

by

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A Dissertation
Submitted to the
Faculty of the Graduate School
of
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in Partial Fulfillment of
the Requirements for the Degree
of
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Dedication

to

Holly

My wife and love

Acknowledgments

Sofia Loren once remarked, "All I am I owe to pasta." All I am I owe to my Committee! My chairman, Roger Stough, taught me how to turn ideas into analysis, literally like Socrates, under the trees at George Mason University. This took a lot of time--at a time when he had no time. He is a wonderful teacher and a wise friend. While Dr. Stough focused on the center of the research, Kingsley Haynes guided the work at the beginning and the end. Dr. Haynes identified earlier research which provides a foundation for the study and he suggested the validations which strengthen it. Thomas Gulledge led me hand in hand through the mysteries of operations research. He pulled the software programs and statistical tools which support this research from under piles of books and cartons of files in a yet unfurnished office. Through his guidance, the project became an exciting adventure. All students should be blessed with teachers as wonderful as my Committee.

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List of Acronyms

CDA	Central Design Activity
CPI	Continuous Process Improvement
DBOF	Defense Business Operating Fund
DCSC	Defense Construction Supply Center
DEA	Data Envelopment Analysis
DESC	Defense Electronics Supply Center
DFSC	Defense Fuel Supply Center
DGSC	Defense General Supply Center
DISC	Defense Industrial Supply Center
DLA	Defense Logistics Agency
DLAH	Defense Logistics Agency Handbook
DMU	Decision Making Unit
DPSC	Defense Personnel Support Center
DoD	Department of Defense
DVD	Direct Vender Delivery
FAR	Federal Acquisition Regulation
FQI	Federal Quality Institute
ICP	Inventory Control Point
OMB	Office of Management and Budget
PAT	Process Action Team
POPS	Paperless Order Purchasing System
QIP	Quality Improvement Prototype
TQM	Total Quality Management

Abstract

PUBLIC ADMINISTRATION EFFICIENCY
THROUGH TOTAL QUALITY MANAGEMENT

Marshall Hamilton Bailey III

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Dissertation Director: Dr. Roger R. Stough

This research utilizes a methodology to monitor efficiency changes associated with the implementation of Total Quality Management (TQM) by examining four Defense Inventory Control Points (ICPs). These ICPs are in-house wholesalers to the Military Services which buy and sell spare parts and commodities. The study operationally defines TQM as a group of management practices which integrate process improvements and involvement of people to meet customer expectations. Efficiency is defined as the ratio of inputs to outputs organized to meet those expectations.

The original contributions of the study are the creation of an early indication as to whether TQM increased efficiency and the demonstration of Data Envelopment Analysis (DEA) as a tool for continuous monitoring of efficiency enhancement programs.

The study hypothesis is that TQM increased efficiency. TQM is measured through employee surveys administered at the ICPs in 1990 and 1991. Efficiency is measured using Data Envelopment Analysis, which computes ICP relative efficiency by comparing use of resources such as inventory with outputs such as stock availability. Spearman's Rho is used to measure correlation between TQM and efficiency. The correlation measures do not support the hypothesis.

There are several possible reasons why efficiency does not positively correlate with TQM in this study. Very possibly, the costs of TQM learning decrease efficiency over a longer time period than the three years studied here. It is also possible that, the Inventory Control Points studied are not good candidates for TQM or did not effectively implement TQM. Finally, it is possible that TQM does not cause an increase in efficiency.

Further studies of the TQM/Efficiency relationship need to be conducted in order to determine whether TQM is a tool for efficiency enhancement. Just as importantly, enterprises which are implementing TQM need to monitor efficiency changes as they invest time and money in TQM implementation. Data Envelopment Analysis (DEA) is used to create useful measurements for this study and could be used for continuous monitoring of organizational efficiency in the same way it is used to create the study measurements.

CHAPTER I

INTRODUCTION

Purpose of the Research

This dissertation has three purposes: (1) to conduct an initial policy evaluation of federal programs that are implementing a new management philosophy called Total Quality Management (TQM); (2) to provide a methodology for continuous oversight of the efficiency effects of TQM; and (3) to demonstrate the application of Data Envelopment Analysis (DEA) as a way to measure management actions and results. The dissertation's original contributions are set forth below.

TQM Policy Evaluation

TQM is relatively new to the federal sector. The activities, which are the decision making units (DMUs) for this study, have been striving to implement TQM for three years. Therefore, data concerning TQM's impact on efficiency is limited and relates to the earliest phase of TQM implementation. This study makes an initial evaluation

concerning the impact of TQM on efficiency for one area of one government agency.

TQM Oversight Methodology

The study provides a methodology for a continuous review of the efficiency benefits of TQM. The efficiency of Decision-Making Units (DMUs) is measured using Data Envelopment Analysis (DEA) and the results are compared to each DMU's level of TQM implementation. This methodology can be used by public administrators to monitor TQM payoffs and to decide the extent to which TQM should be implemented.

Applications of DEA

DEA has been used in many ways--especially as an organization diagnostic technique to identify slack resources. By comparing all DMUs to the best performing DMUs, DEA generates data (slack values) concerning where the poorer performers should decrease use of inputs or increase outputs in order to be more efficient. The Conference on New Uses of DEA in Management, held in Austin, Texas in September 1989, documented several studies to identify slack resources. Banker and Johnston (1989) identified slack resources in airline connections which did not use hubs. Desai and Vosti (1989) discovered slack resources in farms which did not use chemical fertilizer.

Until now, DEA has not been used as a tool to continuously oversee and assess efficiency enhancement programs. Encouraging the transition of DEA from a one time (static) study device to a means for continuous dynamic monitoring is an important contribution of the dissertation.

Study Plan

The research examines four case studies of TQM implementation at Defense Inventory Control Points (ICPs). The four ICPs are the decision-making units (DMUs) for this study. The research applies employee surveys to measure the level of perceived successful TQM implementation within each of the DMUs. The survey scores are compared to measures of relative efficiency for the same activities. The relative efficiency measures are constructed by combining the DMU's use of resources (inputs) and their accomplishments (outputs) into a single relative efficiency measure for each DMU by using Data Envelopment Analysis (DEA).

The dissertation hypothesis is that TQM increased DMU efficiency at these four ICPs. The hypothesis is supported if it meets two examinations. First, the hypothesis is supported if those DMUs with the highest efficiency results also have the highest scores on the TQM surveys. Second, the hypothesis is supported if the group of DMUs has achieved combined increases in efficiency from fiscal year 1989 (when implementation of TQM began) to fiscal year 1991.

Dissertation Overview

This dissertation contains nine chapters. This first chapter sets out the intent of the study. The second chapter defines efficiency and describes how it has been considered in the context of history and public administration theory. Chapter III defines TQM and explains the research hypothesis. The fourth chapter describes the decision-making units (DMUs) called Inventory Control Points (ICPs) that are the units of analysis for the study. Chapter V describes the analytical approach for measuring relative efficiency, Data Envelopment Analysis (DEA). The methodology is described in the sixth chapter and the formal analysis of the hypothesis is set forth in the seventh chapter. This is followed by study validations in the eighth chapter. The study's conclusions are presented in Chapter IX.

CHAPTER II

EFFICIENCY

This chapter explores public administration's interest in governmental efficiency. The question of whether Total Quality Management (TQM) contributes to governmental efficiency is important only if efficiency is important. There are three objectives: (1) *define efficiency*, (2) *place the importance of efficiency in historical context*, and (3) *identify current public administration thinking concerning how governmental operations may be made more efficient*.

Efficiency Defined

The classical engineering/science definition of efficiency has been widely used in public administration e.g., "results in comparison with energy expended" (Waldo, 1984, p. 19). However, other terms are also commonly used in public administration as elements of efficiency. These include the term `economy' which is often a way of saying `energy expended' and the term `effectiveness' which often means `results.' The use of both these terms is described below in order to arrive at a recognizable public

administration definition. This definition is then related to public administration theory.

Economy

Economy is often confused with efficiency. Economy means to use less resources. "For a considerable period in modern administrative history, economy and efficiency were equivalent to the minimization of expenditures" (Egger, 1975, p. 81). As a result, we often control the inputs to government operations in a way which suboptimizes efficiency. In his book, Breaking Through Bureaucracy, Barzelay (1992, p. 14) describes how a much-needed computer course was canceled because of a long delay in purchasing classroom computers through the centralized procurement process. Economy may contribute to efficiency, if used in a way to optimize the total governmental process. But economy only refers to inputs and is therefore an incomplete picture of efficiency, which refers to both inputs and outputs.

Effectiveness

Effectiveness is similar to `actual results'. It describes our ability to reach goals. Effectiveness is what Herbert Simon calls "adequacy". Simon, writing with C.E. Ridley in Measuring Municipal Activities (1938, p. 3), makes a basic distinction between the adequacy of service and the efficiency of a service. He says adequacy is the "absolute

measurement of accomplishment," whereas efficiency is "the accomplishment, relative to available resources".

Downs and Larkey (1986, p. 7) say that "Effectiveness is a measure of attainment". It is a ratio measure relating observed output to the planned or desired output for some time period. Accordingly, a very effective operation may not be efficient if it meets the output need for a given period of time. Correspondingly, a very efficient organization may not be effective if it fails to produce the output levels desired by the polity.

Waldo provides further understanding concerning effectiveness in The Administrative State (1984, p. 193). In ascribing two different meanings to efficiency, he actually first defines effectiveness and then defines efficiency. Waldo's first meaning is built on the notion of absolute energy. This is the idea that administration will be sufficient to complete the tasks at hand, that administration will get the job done whatever the costs. The second meaning is built on the notion of mechanical energy. Its essence is the idea of a proportion or ratio: "actual results in comparison with energy expended". This meaning of efficiency is used in this study. There is, in fact, no difference between the classical engineering/science definition and a good definition for public administration.

Public Administration Efficiency

Despite the definitional unity which can be found once terms are clarified, there has been a significant debate in public administration literature concerning how far efficiency experts can go in dictating the means--to the extent that their means may become the public's ends (Fesler, 1975, p. 106). The Decision-Making Units (DMUs) studied here, for instance, could improve their supply efficiency by treating small businesses exactly as they do large businesses, despite a congressionally mandated preference for contracts with small businesses. Thus, they would expand their production base and would more likely have items of supply in stock when their customers ordered them.

It is important to clarify the DMUs' latitude concerning ends and means and to make it clear what is measured under the label efficiency. It does no good to generate new information about efficiency if that information is to be caught up in a long-standing debate over what efficiency really is in a public enterprise. It is also necessary to assure that each of the DMUs is playing by the same rules concerning ends and means so that valid comparison can be made.

The ends/means debate concerning efficiency began in earnest during the 1930s. The Bureau of Municipal Research

was criticized for raising efficiency above the goals themselves. There is some credence for this charge. Efficient Democracy (Allen, 1907, p. ix), which was written by a Bureau writer, opens with the provocative statement that "efficiency is more important than uniformed goodness." Actually, the Bureau's definition of efficiency included elements of economy, effectiveness and efficiency. Bureau supporter William Prendergast (May 1912), also New York City's Comptroller, defined efficiency as "doing those activities that the public wants done, as well as possible, at the least expense."

Waldo was greatly concerned about undue focus on efficiency. He characterizes efficiency as a reflective value which supports the actual purposes of government. He sees efficiency as a relationship between energy and results. Public administrators must be careful not to manipulate the results merely to optimize the efficiency of this relationship. Results are normative and vary in their importance. It is for this reason that Waldo (1984, p. 194) rejects a proposal, which he ascribes to Luther Gulick to make efficiency "the fundamental value upon which the science of administration may be erected".

A primary concern of Appleby (1945, p. vii), was that the search for efficiency, without much concern for means in

the commercial sphere, might have a corresponding resonance in the government sphere (Fesler, 1975, p. 106).

> Appleby...had the clear conviction that, as an Appleby chapter title put it, `Government Is Different'. Public and private administration could not be fused, for a defining quality of public administration was its publicness, its belonging to government, its inexplicableness if one washed out as irrevelant the democratic system and the political context.

There have been several solutions proposed for the efficiency ends/means debate. Three of these are discussed below.

Downs and Larkey (1986, p. 6) distinguish two different types of efficiency: managerial and economic. "For all practical purposes, managerial efficiency is a relative [underlining supplied] measure based on previous performance levels or performance levels of other government agencies". Economic efficiency is more abstract. Downs and Larkey (1986, p. 7) apply the Kaldor-Hicks Compensation Principle (Myint, 1965, p. 103) as follows: "An economic state is economically efficient if it is not possible to change it so that those who are better off could compensate those worse off." Because it focuses more on options, the economic definition of efficiency raises questions about organization obligations to the public and the allocation of production roles between the public and private sector. In distinguishing managerial from economic efficiency, Downs and Larkey hope to focus public administration's attention

on `managerial' efficiency. This definition is consistent with the definition of efficiency in this study and the use of DEA which measures relative efficiency. Herbert Simon (1945, p. 49-50) further sets groundwork for a solution. Herbert Simon hoped to limit the debate between means and ends by focusing on the `premise' as a very small and distinct unit of analysis in decision-making that might be freed from values, or at least might be identified as value loaded or value free. Fesler (1975, p. 111) describes Simon's ideas as follows:

> Simon not only insisted on separating questions of value from questions of fact, he also admonished scholars to concentrate on the efficiency of means for achieving stated ends. What the ends were, was an important question of descriptive fact, an essential premise for the analysis of means, but their choice was so shot through with subjective value considerations that it was not the business of 'administrative science'.

Simon's distinction is similar to the idea of separating politics from administration; but it is more operative in that it may enable the researcher and the administrator to pursue efficiency at a level of detail which does not become embroiled in the ends/means debate.

Waldo (1984, p. 196) builds on Simon's ideas about decision premises in identifying a "hierarchy of purposes".

> This concept recognizes as valid what most students of administration have strongly felt: That there is a realm of 'science' where 'objectivity' is possible and 'efficiency' can be measured. On the other hand, it takes cognizance

> of the fact that, increasingly, as one's frame of reference widens and disagreement about ends becomes important, 'science' and 'objectivity' are more difficult, judgements of efficiency' less accurate, more controversial.

Waldo's "hierarchy of purposes" helps clarify the ends/means debate as it pertains to this study. There is great agreement regarding the ends pursued by the Inventory Control Points (ICPs) which are the DMUs studied here. Their objective is to provide supplies to the warfighter. The DMUs have little influence over the choice of ends because their activities are closely controlled by regulation. The primary control regulation is the Federal Acquisition Regulation (FAR)[1] which contains several volumes of detailed instructions concerning acquisition, which is the primary function of an ICP. The DMUs selected for this study were chosen because their activities are in the realm of science where objective measurement is possible. There should be no concern that the DMUs studied will redirect public ends to increase efficiency.

In summary, it is Waldo upon which this study is so dependent for its operational definition of efficiency and for the distinction between ends and means so necessary to make study results useful. The study uses Waldo's (1984, p.

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[1] Issued and maintained by the Department of Defense, the General Services Administration, and the National Aeronautics and Space Administration under several statutory authorizations of those agencies.

19) definition of efficiency "results in comparison with energy expended". The Downs and Larkey (1986, p. 7) definition of relative efficiency is consistent with Waldo's definition and supports the study's use of DEA, which measures relative efficiency. This study relies on control of the DMUs by the FAR to avoid the ends/means debate problem.

Efficiency in Historical Context

Throughout most of history, effectiveness--the ability to reach goals--was the paramount concern of government. The objective was to make the public accountable to the rulers for taxes, forced labor and military service in order to maintain the ruler's power. The arrival of democracy turned the table. Government became more accountable to the people for its expenditures. Economy--use of less resources--became a way to control power. The Industrial Age placed massive obligations on government's limited capability. This brought efficiency into the public's attention because it then became necessary to be both economical and effective.

The Age of Effectiveness

The application of effective administration as a means of staying in power is evidenced by the public administration in Persia during the reign of Darius, 500

years before Christ. The collection of taxes and the building of roads was refined for its time and had the effect of binding the empire together. *Satraps* were regional authorities established to collect taxes and to keep order. Also, an Imperial Public Works Department and labor exchanges under the control of the state were established. Gladden (1972, I, p. 35) points out that this control was necessary because "ultimately" the government was an autocracy and no means had yet been devised to ensure the spontaneous participation of the people.

Effective control over a population began in the ruler's home. Early administration in Egypt was conducted by the Pharaoh and his family (Heady, 1979, p. 142-143). As the complexity of administration increased, a *Visir* was appointed to represent the ruler and specific geographic areas or regions were overseen by *nomarches*. These offices, together with other dignitaries of state, did not regard themselves as public servants with a mission to further the public weal. Rather, they were servants of the Pharaoh (Heady, 1979, p. 142). Control over the Egyptian bureaucracy was facilitated by a system of writing, standardized methods and routines and by numerous checks and roundabout ways. Gladden (1972, I, p. 120) says of this condition:

> Red tape, as it would be called today, already existed and called forth protests. The

> duplication of offices and creation of *sinecures* became a scandal. Young men were advised to obtain an official job if they wanted an easy life. `Put writing in thy heart, so that thou mayes protect thine own person from any labour and be a respected official'.

Where ancient regions ignored the need for effective control, they suffered. In Perspective on Administration: The Vistas of History (1969, p. 11), Nash describes how, after a series of civil wars, the Athenians established a council of 500 to administer the city. This awkward arrangement created a lack of centralized direction which may have been responsible for Athens' defeat by Sparta in the Peloponnesian War.

The early days of the Roman Empire emulated the Egyptian experience. In seeking ways to cope with the administrative burdens of an expanding state Gaius Octavius (later Augustus, 63 B.C.-14 A.D.) never lost sight of the importance of the personal link for ensuring the effective transmission of authority. Heady (1979, p. 148) observes that the use of imperial household slaves to carry out public duties became so common that the slave ranks eventually produced the bulk of the civil service.

Despite the emergence during Octavius' time of a complex administration hierarchy referred to as the Equestrian Order (Heady, 1979, p. 148), the focus continued to be on effectiveness, rather than efficiency. Gladden (1972, I, p. 125) describes the pace as follows:

> In comparing the administrative arrangements of those early ages with those of our own day it is well to remember that the tempo was much different. ...The mechanical clock had not yet been invented to regulate men's lives. Consequently, the attitudes of the magistrates' staffs were similar to those of the field worker whose work rhythms were determined by the incidence of daylight and darkness, and the seasons. No doubt a special drive had sometimes to be made on constructional jobs, especially when ganged slave labour was being employed, but in the main there was little urgency in the conduct of current business and normal attitudes to work would not have been dissimilar to those usual among the dwellers in undeveloped tropical lands.

The Chinese Sui Dynasty, which was strong in 500 A.D., reflected the same emphasis on governmental effectiveness rather than efficiency. This was a time of considerable public works activity (Heady, 1969, p. 135). Gladden (1972, I, p. 156) describes the following event:

> The Khai Ho Chi, or 'Record of the Opening of the Canal', published during the Sui Dynasty remains as evidence of the tremendous concentration of resources involved. Five million and a half workers are said to have been assembled and put to work under the supervision of fifty thousand police. The immemorial Chinese method of using human hand power in innumerable small doses is exemplified in this vast undertaking and the episode of the Egyptian pyramids may well have been eclipsed. According to the 'Record' over two million men were 'lost'--either died or ran away--in the process. These losses could only have been partially due to cruelty and punishment involved in the actual work operations and it seems probable that such occurrences as epidemics and food shortages, against which the administrators had failed to provide, were even more to blame.

This is a dramatic example where effectiveness (building the canal) transcended efficiency (building the canal while conserving human resources).

As public administration became more complex, greater reliance was placed on the use of low level workers. The Middle Ages reveals increased sharing of the fruits of power between the ruler and his assistants, but little shift in emphasis from effectiveness to efficiency (Nash, 1979, p. 18). If anything, corruption probably undermined opportunities for efficiency. Tout (1937, p. 74) wrote in Chapters in Medieval Administrative History:

> Medieval administration depended upon the ordinary official rather than the occasional minister of character, upon the cumulative efforts of the lower many rather than upon the wayward excellencies of the upper few. It may well be that this is one of the universal peculiarities of administration which makes the achievements of these Obscure, rather than Dark, Ages of so great an interest to us.

One of the more obvious examples of a disinterested official was Geoffrey Chaucer. Having risen in the bureaucracy he made an excellent retirement from the proceeds of fines he collected as Justice of the Peace. One such fine was the princely sum (for that time) of 71 pounds levied on a man who had been condemned for evading duty on the export of wool to Dordrecht! (Gladden, 1972, II, p. 30-32).

The rise of strong centralized monarchs in the 16th century increased state control, but did not cause an

increase in efficiency. In the book The Bureaucratization of the World, Jacoby (1973, p. 27) says:

> The economic bureaucracy of the state never doubted that all economic processes were controllable. In spite of market forces to the contrary, they vainly tried to stabilize the relationship between money, gold, and silver.

Thus, the administration of England over colonial America was just as inefficient as medieval administrations. According to Gladden (1972, II, p. 265):

> The most notable, though far from powerful, of the offices concerned with the colonies was the Board of Trade and Plantation established in 1696. It [was] an advisory department, whose main function was to correspond with the colonies and to provide information to the Privy Council, Parliament and the several other departments responsible for taking the necessary action.... Usually these were but little interested or had ideas of their own to pursue. Little wonder that the administrative needs of the settlers so far away were given scant attention.

In Public Administration: A Comparative Perspective, Heady (1979, p. 156) explains that state policy was aimed at economic arrangements which were designed to achieve an excess of exports over imports which enabled the state to build up its wealth and power. "Overseas colonies...became a source of additional revenue for the benefit of the colonizing power."

Throughout the English bureaucracy which oversaw the American colonies, the state of affairs was chaotic (Gladden, 1972, II, p. 265).

> The general level of efficiency was low. Appointments were conditioned by patronage and there was a good deal of graft among the higher ranks. The financial arrangements were haphazard: some jobs were grossly overpaid, while the majority were way down on the poverty line. The English administrative machine, as it existed at the time, was a poor example to export overseas to settlers whose last inclination in any circumstance would have been to undertake administrative work.

Efficiency in the colonies was sacrificed in favor of effectiveness by administration of the mercantile doctrine by which all British colonies were run (Rossiter, 1953, p. 30).

> Internally, this called for elaborate regulation of production and labor. Externally, it called for a fantastic apparatus of law and policy-protective tariffs, embargoes, bounties, prohibitions, etc.... all designed to achieve a favorable balance of trade...for Britain at the expense of the colonies.

Mercantilist laws also favored agrarian and extractive pursuits and discouraged manufacturing from which a desire for efficiency might more easily have arisen.

In The First American Revolution, Rossiter (1953, p. 30) describes the colonial economy as "one of expansion--in freedom of choice, equality of opportunity, high level of productivity, and vitality of competition". There was little need for public efficiency as required by the current problems in our urban areas. Wages were generally higher, and working conditions were better in the colonies than in England. The reason for this happy condition was a distinct

shortage of labor; and a prime reason for the shortage was land for the asking (Rossiter, 1953, p. 15). Rossiter (1953, p. 29) describes colonists as mostly lower or middle-class people who migrated to the New World out of a longing for economic betterment. They were more likely to pursue a personal economic plan, focusing on individual effectiveness, than to pursue collective efficiency.

A host of volunteers for government work throughout the towns, especially in New England, also would likely have discouraged a collective search for efficiency. Rossiter (1953, p. 120) describes numerous unpaid officials such as tithingmen, fence-viewers, field-drivers, haywards, noticegivers, assessors, pound-keepers, hog constables, etc. A typical town, Ipswich, had 97 regular officials.

In the South, slavery stifled interest in efficiency. Rossiter (1953, p. 149) describes how Negroes were so plentiful that they cheapened respect for labor and stunted the growth of the Southern middle class.

In summary, control by England and the overall prosperity of the colonies overrode concerns of governmental efficiency. The paradigm remained effectiveness.

Democratic Revolution and Economy

During the 18th century, the development of democracy began to shift government control from the rulers to the polity. The rise of centralized monarchs had become

increasingly oppressive. In France, the centralized state required greater and greater finances and revenues, which meant higher taxation to the degree that duties, royal privileges, monopolies and finally the national debt itself proved insufficient (Jacoby, 1973, p. 22). The cost of maintaining the army alone was 50 percent of state revenues (Jacoby, 1973, p. 25). Democratic control was in strong measure gained through control over the public purse. Economy gained in importance over effectiveness because denial of funding was the primary financial control.

In England, the Economy Movement, led by Edmund Burke and spurred by the costs of the war with America, inspired an attack on overspending which was hallmarked by the establishment of a body of commissioners appointed to examine the public accounts and to provide reports to Parliament. This movement of economic control from the Crown to the Parliament was a watershed. The chief aim of the reforms was to diminish the extent of royal influence in Parliament (Gladden, 1972, II, p. 268), and thus economy rather than effectiveness became the focus of public administration in England for the next 100 years.

In similar fashion, America's founders placed control over the purse in the hands of the people. The Constitution grants the more popularly elected House of Representatives with power to appropriate funds. Thereafter, stress between

Congress and the Executive Branch over funds control has continued to result in Congressional reviews of the economy of public spending.

One such review was conducted by the Taft Commission in 1912. Although the Commission (1912, p. 77) cited the need to use annual budget reports to hold departments accountable for "results obtained and...efficiency of doing Government work", the thrust of the Commission's recommendations was toward use of less resources and thus focused on economy. The Commission (1912, p. 79-80) recommended passage of a single budget as an "instrument of legislative control over the administration" in lieu of administrative officers acting as the ministerial agents of the Congress within the Executive Branch. The Commission cited increased concern on the part of the private citizen in the control over tax dollars. They said (1912, p. 82):

> Now that population has become more dense, that large cities have developed, that people are required to live in congested centers, that the national resources frequently are the subject of private ownership and private control, and that transportation and other public-service facilities are held and operated by large corporations, what the Government does with nearly a thousand million dollars each year is of as much concern to the average citizen as is the manner of obtaining this amount of money for public use.

The Emergence of Efficiency

In the modern age, efficiency achieves prominence for public administration attention when limited resources must

meet massive challenges. Historically, the development of our major cities with the attendant challenges in traffic, sewer and housing is a case in point, as were our two world wars. Efficiency was the rallying cry of Progressivism immediately preceding the First Great War. B.P. DeWitt (1915, p. 320) distinguishes the search for efficiency as the underlying objective of many municipal movements. "Municipal home rule, commission government, and city managers are merely means to an end; ...that municipal problems depend for their solution upon the same scientific study and analysis that banking and railroad problems require; ...that any attempt to remove inefficiency and waste must be continuous...."

At the beginning of the 20th century, Frederick Taylor began to popularize the search for efficiency in the commercial sphere. "Post-World-War II public administration literature often argues that Taylorism enthrones efficiency as a public goal" (Schachter, 1989, p. 64). But Taylor's January 1912 testimony (pp. 26-27) before Congress gives a different account. According to Taylor:

> Scientific management is not any efficiency device, not a device of any kind for securing efficiency; nor is it any bunch or group of efficiency devices.... Its goal is a mental change in managers and workers with the substitution of hearty brotherly cooperation for contention and strife; of both pulling hard in the same direction instead of pulling apart.

Despite Taylor's denial, most students of public administration believe he had much to contribute to both public and private efficiency.

In public administration circles Morris Cooke was a leading exponent of Taylor's work. Cooke (1918, p. 267) saw government as a conversion mechanism for public demands. He recognized that 20th-century citizen demands emerge at an ever-increasing pace because science discovers more ways that organized action benefits people.

By 1933, many institutions devoted to more efficient public administration were established. "Reform organizations, such as the National Municipal League and the National Civil Service Reform League, had been in operation for many years.... By 1933 about thirty-five educational institutions had established training programs which purported to prepare students for employment in public administration" (Egger, 1975, p. 55-56). Then, the efficiency movement was temporarily set aside--for the Great Depression.

Rowland Egger (1975, p. 54) describes how, "when Franklin Roosevelt succeeded President Hoover in March, 1933, he confronted a country with one-fourth of its labor force out of work, underemployment rife, farm prices far below the cost of production, mortgage indebtedness defaulted in increasing volume, bank failures rampant,

commerce stagnant... and a population whose morale...had probably never in American history been at a lower ebb." A combination of desperation, a huge supply of surplus manpower, both educated and uneducated, and the unknown nature of the projects of the New Deal (Egger, 1975, p. 62) forced both economy and efficiency off the playing field in favor of effectiveness.

After Roosevelt's Economy Act had, for better or for worse, spent its force, it is the observation of this researcher that more of the Administration's interest centered on a balanced budget. Scientific management, which was a strong underpinning for efficiency enhancement, again became popular among public administration theorists. Work progressed in providing tools for the administrator searching for efficiency. Ridley and Simon, for instance, were establishing benchmarks and measurements (Egger, 1975, p. 80-82). In their book, Measuring Municipal Activities, Ridley and Simon (1938, p. 38) suggested possible output measures for fire, police, recreation, education, public libraries, personnel and municipal finance. The performance of libraries could be measured through, among other measures, the annual rate of book stock circulation (Ridley, 1938, p. 47).

In 1937, the Brownlow Committee (p. 112) decisively raised the issue of efficiency as a distinct public need:

> We are too practical a people to be satisfied by merely looking forward to glittering goals or with mere plans, talk and pledges. By democracy we mean getting things done that we, the American people, want done in the general interest.... The efficiency of government rests upon two factors: the consent of the governed and good management. Efficient management in a democracy is a factor of peculiar significance.

The Committee (1937, p. 113) went on to write that efficiency "must be built into the structure of a government just as it is built into a piece of machinery." The Committee (1937, p. 116) set its purpose to make our national government "an up-to-date, efficient and effective instrument for carrying out the will of the Nation." They made, and successfully staffed, proposals for a Presidential Staff, extension of the merit system and our current system of departments (1937, p. 135).

The reformers were not through. In 1949, the First Hoover Commission (1949) recommended what it called a "Performance Budget" that would analyze the work of government departments and agencies according to their major functions, activities, or projects. It would thus concentrate attention on the work to be done or service to be rendered rather than on things to be acquired such as personal services, contractual services, supplies, materials, and equipment. "It would show the relationship between the volume of work to be done and the cost of the work" (Hoover Commission, 1949, p. 209-210). This

recommendation preceded the introduction of Planning, Programming and Budgeting (PPBS) as a management tool. PPBS is very similar to a performance budget.

The most recent large scale efficiency study of the federal sector was the 1984 Grace Commission, or more correctly, the President's Private Sector Survey on Cost Control. The study combines an economy and efficiency focus on government. They estimated that "one-third" of the budget is consumed by waste and inefficiency to a tune of 424 billion dollars over a three-year period. The study is a collection of very particular recommendations that range from reducing government employee benefits to creating a single government-wide computer system (CBO/GAO, 1984, p. 374-394, Appendix of Actual Recommendations). Although some of the recommendations may be useful, the study does not leave the federal government service delivery system in any better position to continuously seek out and implement efficiency advances.

Conclusion

This review of public administration history discloses great stress in government's ascension of either effectiveness, economy or efficiency as public administration objectives. Four conclusions emerge concerning the preeminence of one objective over the other.

a. Whenever the primary goals of the country can be met with available resources, efficiency will take a backseat to effectiveness. This occurred throughout ancient times when the governments' primary objective was merely to stay in power, and it was true during the Great Depression when the government's primary objective was to get people back to work whatever the cost.

b. Economy without efficiency is likely to dominate our attention whenever there is concern about who is in control. This was true during the transition to democracy and will be true again. As nations seek to demilitarize, for instance, their military will more frequently be accused of waste, and resources may thus be withheld from efficient defense programs. In a more general way, Congress may seek to pass program money to state and local governments as a way to bypass what may be perceived as a "bloated" federal bureaucracy.

c. The necessity to complete massive initiatives with limited resources will cause governments to seek out and install ways to achieve efficiency. This was true when we built our cities. It was true during our world wars. It will be increasingly true as we meet the massive social challenges of drugs, crime and poverty facing America.

d. Ideally, government should embrace all three objectives in fair measure. It should be effective enough

to get the job done. It should be economical in the use of resources, especially nonreplenishable ones, and it should be efficient in providing all of the results those resources can produce. In The Strategy of Social Population: Discussion Frameworks for Policy, Lave (1971, p. 135) observes that "social regulation is in trouble, not because it is too costly, but because it is ineffective in accomplishing social goals." Lave (1971, p. 3) thinks that good policies are those based on facts, analysis and the appropriate framework for making decisions that are both effective and efficient.

Dwight Waldo (1984, p. 186-187), who was more suspicious of calls for efficiency than any modern public administration theorist, still concluded that "By the turn of the century,...it was generally agreed that morality, while perhaps desirable, is not enough. Democracy must be able...the machinery of government must not waste time, money, and energy...if our good purposes fail because of inefficiency--as it appears they may--then inefficiency is the cardinal sin."

How Government Operations May Be Made More Efficient

In Reinventing Government, Osborne and Gaebler (1992, p. xxi) raise a challenge that this section seeks to address.

> For the last 50 years, political debate in America has centered on questions of ends: what government should do, and for whom. We believe such debates are secondary today, because we simply do not have the means to achieve the new ends we seek. After ten years of education reform and $60 billion in new money, test scores are stagnant and dropout rates are higher than they were in 1980.... After only a few years of the savings-and-loan cleanup, the projected costs have skyrocketed from $50 billion to $500 billion. We have new goals, yes, but our governments cannot seem to achieve them. The central failure of government today is one of means, not ends.

Examples of both inefficiency and efficiency achievements in government are numerous. Here are a few examples of inefficiency (Downs and Larkey, 1986, p. 1-2):

> A new federal program designed to determine how well the nation's meat inspectors protect consumers found that 32 percent of the meat packing plants rated satisfactory by inspectors failed to meet minimum Department of Agriculture standards.
>
> Despite the fact that accountants estimate that $10 million a year in operating costs could be saved by moving the small staff assigned there a few miles up the road to a more modern facility, Fort Monroe remains an active army post. Characterized as an afterthought of the War of 1812, it is, in fact, the only post left with a moat around it.
>
> Mr. Gerald L. Lichty received a notice of overdue personal property taxes from Prince William County, Virginia. The notice told Lichty to pay promptly or legal action would begin on August 14. The amount in question was 1 cent.

One example of a lack of efficiency relates directly to the Inventory Control discipline studied here (Downs and Larkey, 1986, p. 1-2).

> Investigators for the House Appropriations Committee have charged that the Defense Department is needlessly wasting millions of dollars in excess procurement costs because it refuses to get competitive bids on spare parts for major weapons systems. Staffers cite a 10-foot aluminum ladder used by mechanics to service the A-10 attack plane. In 1980 the Air Force bought 71 such ladders at a cost of $1,167 each. Comparable models sell in hardware stores for $160.

There are also many examples of efficiency achievements in government. In their book Reinventing Government, Osborne and Gaebler[2] (1992, p. 197) cite the following:

> The Milwaukee Metropolitan Sewerage District transforms 60,000 tons of sewage sludge into fertilizer every year and sells it--generating $7.5 million in revenue. Phoenix earns $750,000 a year by siphoning off the methane gas generated by a large wastewater treatment plant and selling it to the city of Mesa, for home heating and cooking.
>
> The St. Louis County Police developed a system that allows officers to call in their reports, rather than write them up. The department then licensed the software to a private company--earning $425,000 every time it sells to another police department.

There are at least three schools of thought concerning ways to make government more efficient. First, outright privatization is proposed for many government enterprises. Government need not produce in order to provide. Second, many recent writers suggest that public enterprises be made

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[2] The exactness of the examples used by Osborne and Gaebler is challenged by James Fallows in the June 1992 edition of Atlantic Monthly (p. 119). Fallows specifically questions whether advances in efficiency in the Tactical Air Command were the result of better management or more money. The Tactical Air Command example is not used here.

entrepreneurial by being placed in competition with the public sector and with other public enterprises. Third, there are proposals, including TQM, to help government produce efficiently. Each of these schools will be examined in this section.

Privatization

E.S. Savas (1987, p. 3), a leading proponent of privatization defines privatization as the act of reducing the role of government, or increasing the role of the private sector, in an activity or in the ownership of assets. Privatization concerns the matter of who will produce for social needs. The polity may or may not choose to provide for social needs. In the case of trash service, for example, the polity may decide not to provide the service and let citizens fend for themselves--buy collection service or burn or bury the trash. If the polity does decide to provide trash collection the government must either buy trucks and hire employees to produce trash collection or provide trash collection by contracting with companies to collect the trash. The latter case is privatization. Merely ignoring a social need can also be construed as privatization in that the private sector will be used to fill the social need.

This section examines whether Americans should decide to totally rely on the marketplace for production and thus

give up on government production. If this is true, there is no need to study TQM as a way to enhance government production efficiency.

Privatization is not new. Gladden (1972, II, p. 379) observes that:

> At all stages in the development of society important administration has been carried on outside the strictly governmental sphere...during the Industrial Revolution in Britain there were Turnpike Trusts, empowered to provide effective main roads and to levy tolls to finance them and provide for their upkeep; Poor Law Corporations to spread the growing public assistance burden over a number of parishes; and Improvement Commissions to provide the new towns with lighting and police services....

The current extent of privatization in America is reasonably well known. In 1982, the International City Management Association (ICMA) surveyed public officials concerning local government service delivery arrangements. The survey covered 477 cities and 43 services. On average, 35 percent of the services provided by a city were externally produced. Ferris (1986, p. 306) reviewed this study in Urban Affairs Quarterly. He conducted further research and concluded that, despite what he considers substantial evidence on cost savings, the decision to contract out is also predicated on other matters such as fiscal inducements to reduce the public sector costs and political impediments to altering the traditional public production arrangements.

The decision to contract out government services is encouraged by those economists who say that government is inherently inefficient. The economist Baumol (1967, p. 430-421) argues that the technological changes that raise productivity and resultantly wages in productivity progressive industries such as manufacturing will result in successful demands for higher wages in price inelastic sectors such as government monopolies, for such services as fire and police protection, despite their lack of productivity gains. According to Baumol, this will result in government cost increases.

Anthony Downs is also critical of government's ability to efficiently carry out programs. Downs examined government officials from a behavioral standpoint in Inside Bureaucracy (1967). He deduced the presence of many negative bureaucratic characteristics. An economic assumption in Down's work was that people are driven by self-interest which produces problems in control, communications and purpose in government organizations. He described a life cycle for bureaus in which he forecasts an initial period of success dominated by advocates and zealots followed by a rise of conservers with a resultant reduction in innovation.

Wolf (1979, p. 107) further explored bureaucratic weaknesses. He developed a model which predicts poor

performance by government entities in an article entitled "A Theory of Nonmarket Failure". Wolf states that the basis for a distinction between government and industry is that market organizations derive their revenues from prices charged for output sold in markets where buyers can choose what to buy, as well as who to buy from. Market organizations use the information from this customer reaction to direct their activities. In contrast, governments are nonmarket entities. They derive their income from taxes and therefore lack the same market mechanisms as business with which to reconsider their decisions. Wolf predicts that officials will therefore indulge in self-interest activities, which he calls "internalities", that increase costs.

Public choice proponents, such as Buchanan and Tullock (1962, pp. 28-30), support the view that officials may act in the public's disinterest. They believe that all participants in collective activities indulge in utility maximizing behavior. This results in factional behavior unless all individual utility functions in the collectivity are identical. Since the interest of public officials is not identical to that of the public they serve, Buchanan and Tullock's view supports Wolf's idea that officials engage in self-interest activities.

There are also criticisms of the market sector's ability to produce public goods. In his book, American Bureaucracy, Stillman (1987, p. 225) raises serious questions concerning government's ability to control contract activities. Stillman says that contractors do not have the same value system as bureaucracy. Stillman contrasts the direct accountability controls available over government employees with the indirect control over contract employees. Stillman (1987, p. 159) references specific security leaks as an example of such control problems.

Charles Wolf (1979, p. 134) has constructed a theory of implementation to guide the analyst in choosing the best market/nonmarket combination and in constructing the policy or program so as to avoid the more undesirable consequences of each marketplace. Wolf recommends a variety of activities to aid the analyst in constructing a new policy or program to accommodate its implementation. He recommends evaluating the agency chosen to implement the program to determine what reward system or communication channel will best assure success. Where the market is used, he recommends constructing competitive devices, such as multiple competing contracts, to assure that the profit motive does not supersede the public motive.

The assignment decision concerning the responsibility to provide goods is inextricably linked to the decision as

to who should produce the goods. Ross (1988, p. 5) has identified four alternative roles for various segments of society: funder, producer, user and controller. A local government which hires men, buys trucks and picks up your trash, for instance, acts as funder, producer and controller. A ball park which hires the city to provide internal police protection acts as funder, user and controller. Ross proposes that the choice of roles be based on the mix of assignments that results in the greatest efficiency, equity, participation, and accountability.

Ross's topology is significant for two reasons. First, he recognizes that there are many combinations available to produce public goods. We may obtain the services of other political entities and thus increase economies of scale. We may regulate as a means of assuring public goods. As an example, a legal requirement for smoke detectors may preclude the government from buying one for every household. Ross makes it clear that contracting out or producing in-house are not the only alternatives. Second, Ross recognizes the need to obtain accountability from the chosen producer. According to Ross (1988, p. 17):

> An important assumption underlying the expectation of gains is that program actors will serve the interests of their constituents. However, history tells us that these actors may harbor private or organizational incentives that run counter to the interests of their constituents.

Therefore, program effectiveness entails that all actors be held accountable for carrying out their assigned roles. Ross recognizes that the mere choice of either the marketplace or government as producer may not facilitate accountability. We must have follow through.

This overview of privatization leads to the conclusion that efficiency is not gained merely by using the private marketplace. There are situations where the public sector is the best choice to produce and to provide. In such situations, however, steps must be taken to assure efficiency. When they select public production public administrators need to know if TQM, which is described in the next chapter as a management philosophy focusing on the involvement of people to improve processes to better meet customer expectations, is one way to assure efficiency. This study begins to answer that question.

Entrepreneurial Government

The second school of ideas concerning how to make government efficient builds on the ideas of Ross and Wolf concerning the importance of constructing an accountable relationship with government enterprises which will cause them to desire to perform. In Breaking Through Bureaucracy, Barzelay (1922, pp. 112-123) suggests that consideration be given to distinguishing government production operations as competitive, utility or compliance. In this way marketplace

dynamics may be applied by placing government enterprises in the organization environment most likely to result in motivated performance. This idea of adopting the market arrangement suitable to the mission of the government enterprise is repeated by Osborne and Gaebler (1992, p. 79). They say that "competition makes little sense in most *regulatory functions*." But they have discovered that "when *service providers* must compete, they keep their costs down, respond quickly to changing demands, and strive mightily to satisfy their customers...competition drives us to embrace innovation and strive for excellence".

Helping Government Produce Efficiently

Placing government enterprises in a marketplace environment may motivate government managers but it does not assure that they will succeed. Many private enterprises fail. Reconstructing government enterprises to make them efficient and preparing government managers to become efficient entrepreneurs is just as important. Osborne and Gaebler (1992, pp.209-218) identify at least four ways to turn government managers into entrepreneurs. First, they recommend that managers be allowed to keep a share of earnings for themselves, their employees, and for investment pools in support of future enterprises. Second, they suggest that ways, such as innovation bonds, be found to provide public managers with innovation capital. Third,

they recommend that line-item budgets give way to enterprise funds such as DoD's Defense Business Operating Fund (DBOF), which is a revolving fund used to finance the operations of the Inventory Control Points which are the DMUs for this study. Such funds are replenished from customer sales. Finally, they recommend that government enterprises be encouraged to identify the true costs of their operation.

Reconstructions such as Osborne and Gaebler describe are happening. Many government agencies encourage efficiency and cost savings by allowing subordinate units to keep and reallocate a portion of savings achieved in a given fiscal year. Here is an example from a General Accounting Office report (Wholey, 1990, p. 421):

> This incentive has been successfully used by the Internal Revenue Service. They call it profit-sharing and use the technique with their regional managers.... If a manager improves his or her organization's productivity over a period of a year, he or she is given back resources equal to about one-half of the annual savings. The manager can use these resources as he or she deems appropriate.

It is at this point in public administration's search for efficiency that TQM can be applied. TQM does not guide the administrator regarding privatization of governmental functions. TQM does not describe how to place government enterprises in market environments. TQM is a complement to such actions. TQM is recommended by its supporters as a help to enterprises, public or private, to be more

responsive to customer requirements for both high quality and lower costs and thus to succeed in market environments. In order to achieve lower costs, TQM must lead to greater efficiency. If, however, TQM does not lead to efficiency, government enterprises which are adopting TQM will be forced to charge higher prices for their services and thus will experience serious difficulties in the new public administration marketplace described above. In the next chapter, TQM will be closely examined.

CHAPTER III

TOTAL QUALITY MANAGEMENT

This chapter defines Total Quality Management (TQM) for the purposes of this study, and examines the current status of TQM implementation in industry and government. The definition establishes what is studied, and the status of implementation establishes why TQM is used as a primary variable in this analysis.

TQM did not spring forth as a cohesive theory. Rather, it is an amalgam of components, each with its own origins which meet the needs of the current environment and which may interact synergistically to make organizations work better. The review of TQM in this chapter supports the hypothesis that TQM will increase a government organization's efficiency.

Definition

This study defines TQM as the synergistic integration of three areas: customers, business process, and people.

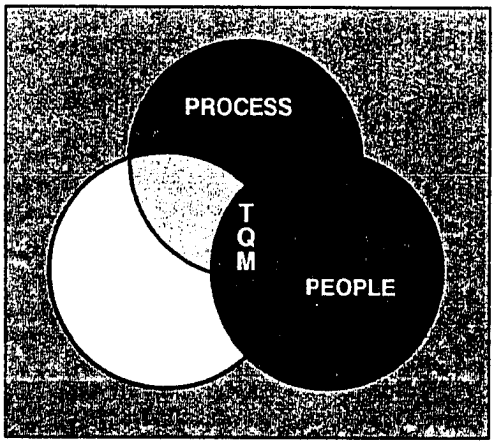

Figure 1: Areas of TQM Integration

These three areas of focus have developed from the historical quality movement described in this chapter. Despite TQM's American origins, it has been slow to take hold in the United States. This may have been caused by the extraordinary profitability of American business after World War II which encouraged focus on new products and markets rather than on quality production. The human behavior movement, with its early emphasis on the individual, also distracted American industry from benefiting from the quality movement which is more interested in the welfare of the organization as a whole (McGovern, 1990, p. 19). Nevertheless, the TQM movement is now advancing in the United States primarily because our international competitors are using TQM to better meet customer expectations and capture our U.S. and overseas markets.

Three environmental conditions make the use of TQM inevitable; these are scarcity, information and liberty. The following discussion defines and describes the development of TQM. Figure 2 serves as a guide to the discussion.

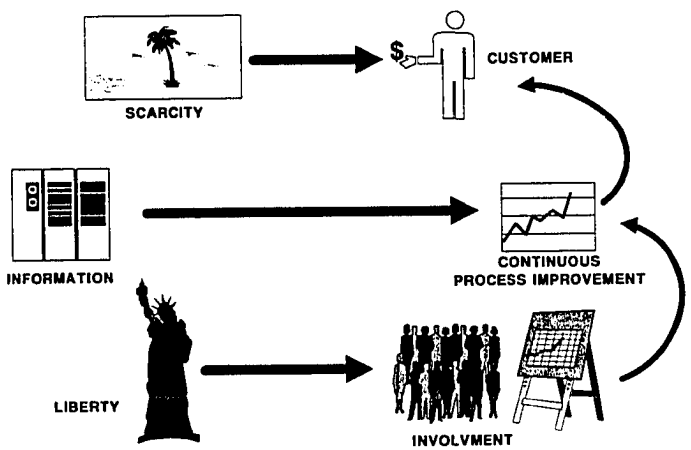

Figure 2: Factors Influencing the Adoption of TQM

The first area of TQM focus seems obvious--meet customer expectations. Ultimately the product or service must meet the expectations of a final customer. Dr. Walter Shewart of Bell Laboratories is credited with advancing this quality objective through his refinement of U.S. industry quality control standards. Specifically, Dr. Shewart worked with the American Standards Association on a government project to develop quality controls for war equipment just prior to World War II. The Standards Association published

the first three quality standards as Z1.1-Z1.3 (McGovern, 1990, p. 16). Under these standards, quality and timeliness control limits are established for each subprocess, and measurement and feedback are used to discipline the system.

A large portion of the goods produced in the U.S. are competing with goods produced in other countries (IBM, 1991). The U.S. ability to challenge this competition is enhanced by meeting customer expectations for high quality and low prices. Focus on meeting customer requirements in government is likely to grow due to increases in competition for scarce public resources. Scarcity and competition make it essential that items and services have a lower price and lasting value and this can be achieved through quality control and efficiency.

In public sector TQM implementations, meeting customer expectations can be encouraged by placing government enterprises in a market situation as discussed in Chapter II. Such enterprises no longer enjoy the benefits of captive customers and must recoup their costs through customer sales. County water, for instance, might be purchased from the county-owned water plant or from another county, depending upon price and service. Public and private enterprises find that in competitive situations both costs and quality must be controlled if customer sales are to be maintained.

The second focus area associated with TQM is Continuous Process Improvement (CPI). This idea recognizes that customer needs continue to increase and that competitors develop ways to meet these needs. Advancement of CPI may be partially credited to W. Edwards Deming (1986). During the period 1947 through 1954 Dr. Deming delivered a series of lectures to the Japanese Union of Scientists and Engineers in which he described how any process could be improved and controlled (McGovern, 1990, p. 18). This early training is one of the factors which spurred the Japanese economic advance.

America has been trying to catch up. Motorola's struggles to meet the changing requirements of a Japanese purchaser required several dramatic leaps in quality levels (Motorola, 1990). Such escalating requirements can only be met through Continuous Process Improvement (CPI). CPI requires the construction of systems to continuously collect, analyze and act on cost, defect and timeliness data. "TQM emphasizes that problems are systemic in nature--a fault in design or management" (Federal Quality Institute, Myths and Facts about TQM, p. 1). As illustrated on the next page, CPI requires treating processes as open systems with inputs, processes (where value is added) and outputs.

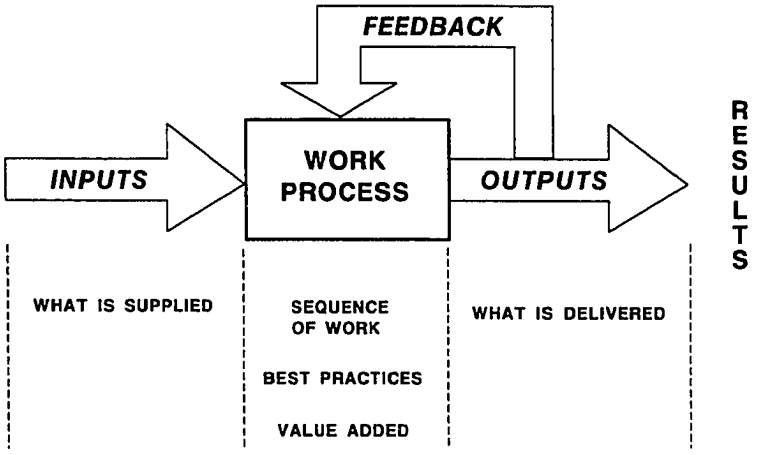

Figure 3: Process Improvement

The application of CPI to delays in the assignment of public housing is an example of how CPI improves results. Such delays (outputs) would be measured and the causative factors, such as construction delays (inputs), and repair cycles (value added) would be explored in an effort to decrease the waiting time. A housing department Process Action Team (PAT), composed of managers, suppliers and employees with various skills, could be formed. This team could be charged with identifying each step in housing rehabilitation and measuring the time for each step which has been historically expended. They might find that rewiring the building is the greatest delay and then analyze the steps involved in rewiring, such as ordering switches. Actions to eliminate delays, such as stocking switches, could change the process and thus improve timeliness.

The PAT would examine each subprocess of public housing until timeliness met the requirements of eligible citizens. Some changes, such as use of contractor versus in-house resources, may be dramatic breakthrough strategies and other changes such as stocking switches might be small. As public needs for timely public housing increase, the process would be continuously improved to meet these needs.

Process action teams use many decision-making tools to analyze and improve processes. Warfield (1992, p. 11) has identified seven such tools, which he calls the Japanese Tool Box. The first tool is the 'Cause and Effect Diagram'. This diagram helps the PAT understand the interplay of events in a complex process. The second tool is the 'Affinity Diagram'. This is used to discover design options through observing the multiple process connections. The third tool, the 'Relations Diagram', displays the interconnections of subprocesses. The fourth and fifth tools are the 'Tree Diagram' and 'Matrix Diagram', which display process structure and objectives. The 'Process Decision Program Chart' is the sixth tool. It is similar to a Program Evaluation Review Chart. It is used to track progress in the implementation of process changes. Finally, Warfield describes the 'Arrow Diagram', which displays whether process activities are mutually supportive. Warfield (1992, pp. 48-51) explains that such tools are

similar to tools already in use in U.S. companies. Doing process improvements is not new to U.S. companies. Doing it extensively is.

Continuous process improvement is driven by the increased customer demands which grow out of scarcity and competition, discussed above, and by a second driving factor--information. The Computer Age makes it possible to gather and use a great many statistics which would earlier have been too costly to obtain. This increase in the availability of high-quality data makes it possible to measure cycle time and defects per unit in ways which help enterprises develop needed process improvements.

The third focus area of TQM is involvement of people. It is the involvement of stakeholders in continuous process improvement. Stakeholders include suppliers, owners, customers and employees. This idea may have grown out of the strong Japanese sense of community. Quality Circles, in which employees developed process improvements, were popularized by a Japanese correspondence course developed and televised by Japan Broadcasting Corporation in 1957 (McGovern, 1990, p. 19). Kaora Ishikawa (1985), an early and effective proponent of using teams to pursue continuous process improvement, wrote a book about the use of quality teams, entitled What is Total Quality Control? (The Japanese Way). Another Japanese writer, Masaaki Imai (1986)

recommends involving everyone in a continuous cycle of process improvement, innovation and progress. He calls such continuous improvement 'KAIZEN', which is also his title for the book on the subject.

The use of employees on quality improvement teams is a significant feature of TQM. Under TQM, management does not set the "one best way" to accomplish a process, such as occurred under scientific management. Employees and managers are formed into PATs to measure both internal and external customer needs through focus groups, surveys and conferences; to redesign the process to meet those needs; and to establish process control limits to guarantee consistency. This activity should improve the efficiency of each process and should ensure that each process supports the efficiency of those successive processes which it supports.

Involving employees in developing work methods assures better compliance to quality standards because participation encourages commitment. This idea has been advanced by Ouchi (1981). Writing in Theory Z: How American Business Can Meet the Japanese Challenge, Ouchi (1981, p. 23) creates Theory Z, which states that managers must involve employees, in particular, in idea development and workplace problem solving. Individual performance evaluation is often eliminated under TQM, in favor of group performance

evaluation. This is particularly significant to service enterprises, such as government, because it is more difficult to measure individual performance in many service jobs where the service is coproduced with the customer in a manner which makes it difficult to distinguish employee performance from customer impact.

The practice of involving employees and others in the continuous improvement process is encouraged by the increased liberty found in society today. Affirmative action programs and people's access to information make it increasingly difficult for management to successfully dictate all of the steps and the pace of job activity while at the same time maintaining high morale. The works of McGregor (1960, p. 67), Argyris (1964, pp. 83-84), Likert (1974, pp. 20-32) and Maslow (1954, pp. 143-145) lead to the inescapable conclusion that people thrive when the work situation allows them more personal control.

The overall interaction of customer focus, improvement of the business process and involvement of people is clearly the best way to define TQM. The integration of these factors to increase competitiveness has been widely demonstrated; and it is this success that has led to attempts to adopt TQM in the federal agencies. Whether these factors can be integrated in a synergistic way to increase efficiency is the subject of this study.

The indications are mixed as to whether TQM improves efficiency. There have been documented benefits of increased quality. The Strategic Planning Institute in research on 3,000 businesses has reported that as quality increases, efficiency, market share, profitability and return on investment also increase (Cocheu, 1989, p. 56). In one specific example, Solectron in San Jose, California reduced product defect rates to less than five per million during a two-year quality improvement drive while achieving on-time delivery of 97.7 percent (Kendrick, 1992, p. 13-18).

The success of quality management in Japanese companies is legendary. In their book, Kaisha: The Japanese Corporation, Abegglen and Stalk (1986) describe how the best Japanese companies--the Kaisha--pour money into technical product improvements until they capture a sufficient market share to easily cover overhead and win big profits.

There are examples where the implementation of the TQM philosophy within government organizations has resulted in benefits. The IRS Service Center in Cincinnati has aggressively implemented TQM and saved $270,000 on paper processing costs in 1989 by helping citizens file electronically (Penzer, 1991, p. 6). This also speeds up filing so that taxpayer refunds arrive sooner. NASA's Johnson Space Center saved 12 million dollars on the construction of space shuttles by adopting a quality action

team's suggestion which reduced the thickness criteria for shuttle thermal control system blankets (Penzer, 1991, p. 7).

Not all the evidence on TQM is favorable. There are concerns that the massive conversion required for most organizations to adopt TQM actually distracts them from pursuing needed business objectives. Writing in Harvard Business Review, Robert Schaffer and Harvey Thomson (1992, p. 84) provide evidence showing that the rewards from employee involvement, process controls and continuous process improvement may be illusionary. They cite a bank which, after two years of TQM effort, has two success stories and no bottom-line impact. Florida Power and Light won Japan's prestigious Deming Award for quality in 1987 but in recent years they have suffered financial setbacks, replaced their quality-oriented president and reduced the scope of their TQM program.

Schaffer and Thomson (1992, pp. 82-89) say that "activity centered" TQM programs are not keyed to specific results, are too large and diffuse and have a bias toward specific TQM rules which may not always be appropriate to the business challenge. They recommend results-driven improvement activities, which focus on achieving specific measurable operational improvements within a few months. They also indicate that organizations should only introduce

those innovations in management methods that can help achieve specific goals. They conclude by advising: "By marrying long-term strategic objectives with short-term improvement projects...management can translate strategic direction into reality and resist the temptation to inculcate the rain-dance of activity centered programs."

In contrast with Schaffer and Thomson's call for focused efforts, the federal competition for TQM excellence requires a general infusion of training and broad quality improvement activity. It is this form of TQM implementation which is the subject of this study. Such implementations take several years to install and may incur efficiency costs due to the expense of implementation and unlearning old practices. This could influence DMU efficiency during the three-year period studied here.

Status of Total Quality Management Implementation

This study is a policy evaluation to provide the groundwork for continuing oversight of U.S. Government TQM implementation. The scope of current implementation in the U.S. Government is widespread and thus justifies evaluation. A GAO survey (1992, p. 2) of 2,800 federal installations found that 68 percent reported they were working on various phases of TQM.

The federal commitment to TQM implementation is unclear. Executive Branch commitment to implementing TQM in the federal sector began during the Reagan Administration through the establishment of the President's Council for Management Improvement. This organization originally searched merely for ways to reduce government costs. The input of corporate executives caused a shift of the Council's focus from productivity to quality during the Reagan Administration. The new focus was implemented in 1988 through an organizational initiative that established the Federal Quality Institute (FQI) (Stratton, 1991, p. 67-69). The Federal Quality Institute has become the primary government source of information, training, and consultation to agencies seeking to make the TQM transformation.

President Bush spoke glowingly about the benefits of quality when presenting a Malcolm Baldrige Award to Xerox (Kirkpatrick, 1990, p. 186). President Bush stated that: "...quality improvement principles apply to...the public sector as well as private enterprises" (Federal Quality Institute, Total Quality Quiz, p. 1). However, there has been no publicized push for quality in the federal sector, specifically from the Bush Administration. Until 1990, there was a declared federal policy mandated by OMB Circular A-132, which required federal departments and agencies to

convert into TQM managed enterprises. That circular has lapsed, but the push to implement TQM in the executive branch continues to be pursued by many federal agencies.[1] TQM is being implemented in the Defense Department despite the lack of a written DoD policy to do so.

Comprehensive TQM implementation does not come easy. A depiction of a TQM activity is set forth in Figure 4.

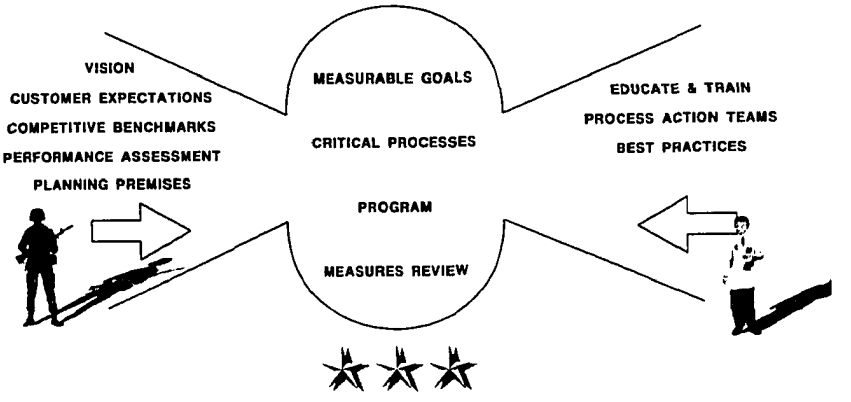

Figure 4: TQM End Result

All of the managerial functions need to be executed consistently with the three TQM areas of customer focus, continuous process improvement and involvement of people. Planning must be focused on initiatives designed to identify and meet customer expectations. Organizations must be

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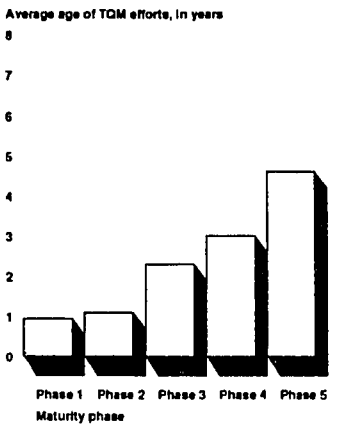
[1] Colorado National Guard, 1992; DoD TQM Master Plan, 1988; McCausland, 1989, OMB Roadmap to the 90s; U.S. Department of the Interior, 1992; GAO, 1992.

reengineered to align with critical processes so that continuous process improvement can optimize the entire process. The budget program must encourage rather than restrict the inputs necessary to assure delivery of a quality product, on time, to meet customer needs. Training must provide employees with the statistical, interpersonal and analytical skills necessary to work together in improving processes. Finally, management's attitude must shift from controlling people to controlling processes; to identifying and exporting best practices; and to providing all stakeholders with the measures necessary to improve those processes.

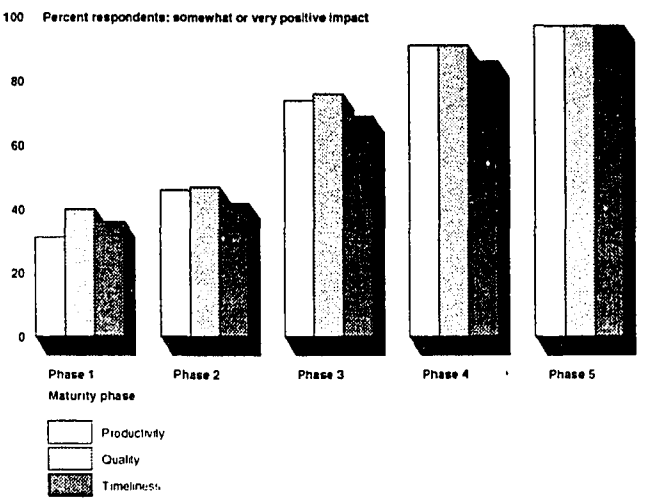
Implementation of TQM usually begins with a structured program lasting between five and seven years. GAO (1992) described and measured agency progress in five maturity phases: Phase 1--Deciding whether to implement; Phase 2--Just getting started; Phase 3--Implementation; Phase 4--Achieving results; and Phase 5--Institutionalization. According to their survey of federal installations, the average TQM age for Phase 3 installations was about 2.5 years, and Phase 4 was three years. Phase 5 installations reported that they have been involved an average of slightly less than five years. This learning cycle is depicted in Figure 5.



Source: 1992 GAO Survey

Figure 5: Average Age of TQM Effort in Years

Also the survey found the individual performance factors improve with TQM maturity as illustrated below:



Source: 1992 GAO Survey

Figure 6: Individual Performance Factors Improve with TQM Maturity

Implementation of TQM by the DMUs for this study began in January 1989 with the publication of the Defense Logistics Agency (DLA) TQM Master Plan (McCausland, 1989). TQM implementation offices have been established at DLA field activities. A TQM training course has been provided to over 2,000 managers through cascading training, whereby students from earlier classes teach the course to successive classes.[2]

Despite the efforts described above, TQM as depicted in Figure 4 is not yet fully implemented throughout DLA or at the Inventory Control Points which are the objects of this

[2] This information was posted in the DLA TQM Executive Course given in May 1992.

study. There is no DLA program to comprehensively measure the extent of TQM implementation other than an annual employee/manager survey which will be used in this study. There is therefore no way to determine whether DLA is in a phase of TQM implementation where efficiency advances should be expected, or is in an implementation phase where the distraction of learning the new TQM skills might be reducing efficiency.[3]

TQM costs a great deal of resources and management time to institute. DLA, the government agency proposed as the object of this study, does not measure TQM implementation costs. However, as the training program requirements described above might suggest, DLA's TQM implementation costs must be significant.

In view of the importance of governmental efficiency established in Chapter II, and in view of the scope of current federal TQM implementation efforts, the conversion of government enterprises to TQM management is a major public policy issue. The research reported by this paper is a policy evaluation intended to provide initial information and an early evaluation to act as a guide for future decisions concerning TQM.

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[3] This is discussed further in Chapters VII and IX of this dissertation. Specifically, we do not know whether the pattern of efficiency changes with TQM are linear or curvilinear, but the pattern in Figure 6 suggests the relationship is positive but nonlinear.

Agencies need to know whether to invest large sums in TQM implementation with the expectation that efficiency will improve. As agencies implement TQM, they will need ways to track efficiency gains to determine whether to continue TQM implementation. Because of the need for governmental efficiency described in Chapter II, TQM must bring increased efficiency if it is to be continued. In view of TQM's emphasis on process improvements, and in consideration of the anecdotal evidence set forth here, efficiency increases are expected. Therefore, the hypothesis is that TQM improved governmental efficiency at the four Inventory Control Points (ICPs) described in the next chapter.

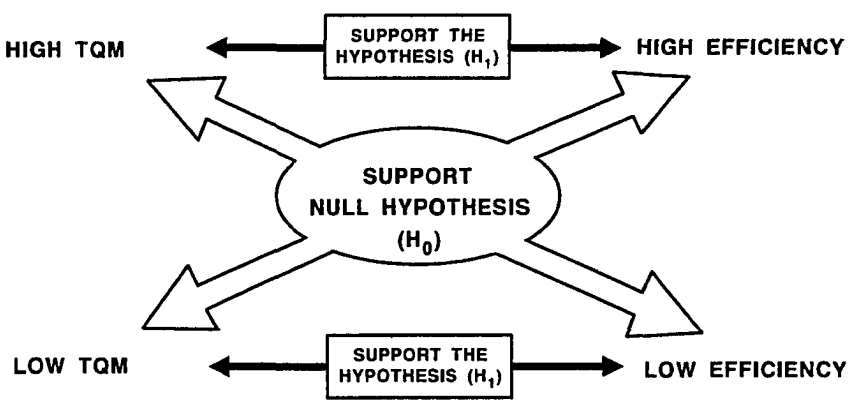

Figure 7: Hypothesis

CHAPTER IV

INVENTORY CONTROL POINTS

The Decision-Making Units (DMUs) which are the units of analysis of this study are labeled by the Defense Department as Inventory Control Points (ICPs) operated by the Department of Defense's Defense Logistics Agency (DLA). This chapter describes ICP operations and distinguishes the characteristics of each of the DLA Inventory Control Points. The descriptions facilitate the study's comparison of the ICPs.

The DLA is an agency within the Department of Defense (DoD) which performs logistic services for the Military Departments. DLA administers contracts valued at over $700 billion. It maintains the national stockpile of raw material, controls DoD distribution sites, and manages reutilization and sales of surplus defense materiel. Notable to this study, DLA's organization units, called Inventory Control Points (ICPs), buy consumable materiel from industry and sell the materiel to the military departments.

Although the DLA is undertaking the implementation of TQM throughout all of its organizations, the study focuses

on DLA ICPs in order to examine DMUs with a common set of inputs and outputs and general goals. Other DLA activities were not chosen because they have recently been subject to significant mission changes. This has made yearly historical data incompatible.

There are six ICPs within the DLA. These are the Defense Construction Supply Center (DCSC), the Defense Electronics Supply Center (DESC), the Defense General Supply Center (DGSC), the Defense Industrial Supply Center (DISC), the Defense Fuel Supply Center (DFSC) and the Defense Personnel Support Center (DPSC). DPSC actually encompasses three ICP organizations: medical, subsistence and clothing. Four of the ICPs are units of analysis for this study. These are DCSC, DESC, DGSC, and DISC. These four ICPs are known as 'hardware' centers. They manage similar commodities which include a large number of spare parts. Their management data is comparable. Subsistence and fuel are managed using data which measures continuous product flow rather than individual orders as in the case of the hardware centers. Medical and clothing share the DPSC overhead base with subsistence and their relative share is not known because overhead costs are not measured on an activity basis. The figure below describes the hardware ICP process.

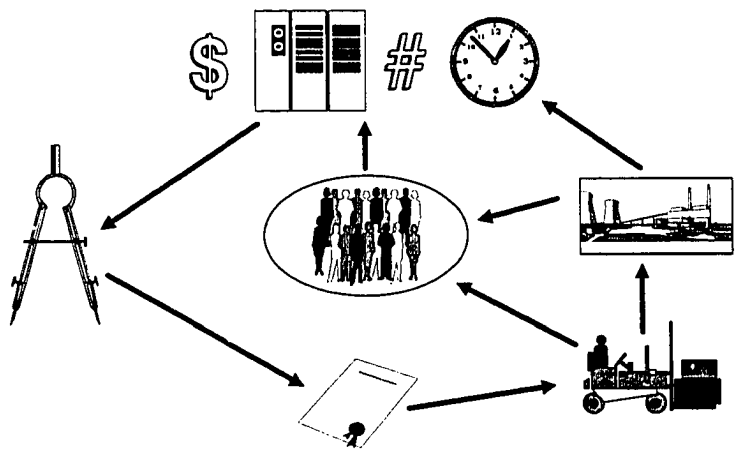

Figure 8: Hardware Inventory Control Points' Process

The ICPs describe the items for which they are responsible, predict customer demands, purchase items and direct shipment either from suppliers or from government depots. They are paid for each shipment by their military customers. In short, they are wholesalers to the Military Departments.

The ICPs began implementing TQM during 1989. As discussed in Chapter III, TQM implementation takes a considerable length of time. It involves extensive training in process analysis tools and the establishment of new organization interactions such as process action teams (PATs).

Although each of the hardware centers was directed in 1989 to begin the TQM transformation, the degree of progress of each ICP has been substantially dependent on the interest of the activity commander and on the culture existing within

the activity. Therefore, each activity has achieved a different degree of TQM implementation. This has been measured by employee surveys. A description of each of the hardware ICPs is set forth below.

Defense Construction Supply Center (DCSC)

Columbus, Ohio

DCSC manages a variety of military supplies which include lumber, concertina wire, automobile parts and such diverse items as ship hatch covers. DCSC has experimented with contracting-out the purchasing function for automotive parts. In this experiment, automotive parts are provided by a contractor located in a military warehouse. The contract price increases if the contractor achieves specified delivery times and levels of availability.

The reader will remember the widely publicized $600 toilet seats purchased during the Reagan Administration. DCSC bought the seats. They are actually tall, plastic shrouds which cover airplane toilets. As a result of the public and official criticism, purchases at DCSC were subjected to such a high level of in-house scrutiny that a backlog of unawarded contracts developed during 1985. The backlog took years to rectify and resulted in reductions in customer support.

Defense Electronics Supply Center (DESC)

Dayton, Ohio

As its name implies, DESC manages electronics supplies. These are distinguished from electrical supplies by the use of electron tubes and resistors in their construction. Electrical supplies are managed by the Defense General Supply Center (DGSC) discussed below.

Electronic items are characterized by rapid obsolescence. Frequently, manufacturers discontinue the manufacture of an electronic item because the demand base moves to a modern substitute. However, electronic parts are difficult to eliminate from the defense supply system because they are imbedded in various repairable end items. When they fail, they must be replaced. As a result, DESC has been a pioneer in developing ways to continue to provide obsolete items. Specifically, DESC developed programs to identify potential manufacture discontinuance and to buy a quantity of the item to cover all expected future needs. They have also experimented with parts emulation, whereby detailed item characteristics are stored electronically in order to facilitate immediate manufacture on an as needed basis.

Engineering receives significant emphasis at DESC. Recent engineering enhancement initiatives include peer

performance oversight and the installation of computer-aided design equipment.

During the time period covered by this study DESC was the only ICP which had the authority to prepare military specifications. All other DLA ICPs used specifications prepared by the Military Services. DESC is also the focal point for DoD review of unique parts proposed by prime contractors for new weapons system. DESC coordinates the review of such parts with the ICP responsible for the applicable class of supply in order to determine whether a standard military item could be used as a way of avoiding the introduction of sole source items.

Defense General Supply Center (DGSC)

Richmond, Virginia

DGSC manages a hodgepodge of items which include packaged petroleum products, sandbags, wood products, electrical supplies, chemicals, photographic items and measuring instruments. This variety requires that DGSC personnel understand many different industrial markets.

DGSC has been a leader in converting defense depot stocked items to Direct Vendor Delivery (DVD) supported items through establishing computer hookups with manufacturers and distributors. The program to do this is called the Paperless Order Purchasing System (POPS). POPS

has been exported in various forms throughout DLA. At DGSC, the POPS system is expanded through a special POPS buying team which makes the contracts necessary for automated transactions.

Defense Industrial Supply Center (DISC)

Philadelphia, Pennsylvania

DISC manages many of the items found in a common hardware store: nuts, bolts, screws, washers, cable, etcetera. The variety of such items found in the military supply system is enormous.

The widespread availability of the DISC items can cause quality problems. A recent incident involved a contractor which substituted normal bolts for the special grade of hardened bolts ordered. Since that time, DISC has been more actively involved in product quality improvement programs. These include a program to randomly test selected items received from contractors and a program to pay a premium price for delivery from quality-oriented vendors.

DISC has been a focal point for the DLA's design of computer systems. DISC was the design center for the DLA's 1966-1976 program which designed the current computer system called the Standard Automated Materiel Management System. Therefore, even though the responsibility for computer system development has been centralized at a Central Design

Activity (CDA), DISC continues to press for permission to prototype projects in the computer systems area. Noteworthy has been DISC's recent achievement in teaming with the DLA CDA to develop a new desktop computer system which links communications between the buyer, technician and item manager. DISC also participated in development of an interactive computer system to assist the item manager in making supply management decisions. These systems are now being exported to the other DLA ICPs.

DISC has been a leader in TQM implementation. This is evidenced by receipt of the President's 1990 Award for Prototype Achievements in Quality and Productivity. Only two activities in the federal sector won this award. Much of DISC's improvement has been accomplished through TQM process improvement activities. The 1990 report to the DLA Director is replete with analysis of the procurement, supply and technical processes. As a result of process improvements, procurement lead-time decreased between 1986 and 1988 by 77 days.

Conclusion

In summary, the ICPs are good candidates for TQM. Their repetitive processes, direct customer support and large workforces of 2,000 or more people should benefit greatly from process improvement. If TQM increases

efficiency, it should do so at ICPs. The ICPs also are rigorously bound by common regulations, which place them on equal footing and assure that they do not manipulate public ends to achieve efficient means. The ICPs are decision-making units which seek efficiency and therefore are good units of analysis for this study.

CHAPTER V

DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis (DEA) is used to create measures of efficiency for each of the four ICPs. This chapter defines DEA and examines the advantages DEA offers for this application.

DEA was proposed by Charnes, Cooper and Rhodes (1978, p. 1) as a means of measuring the relative efficiency of nonprofit entities engaged in performing equivalent public programs. It has since been used to measure efficiency in a variety of empirical settings such as school districts, courts, parks, manufacturing operations, coal mining, pharmacies and hospitals (Banker and Johnston, 1989, p. 1). Seiford (1992) has compiled a bibliography of DEA which is helpful to DEA users.

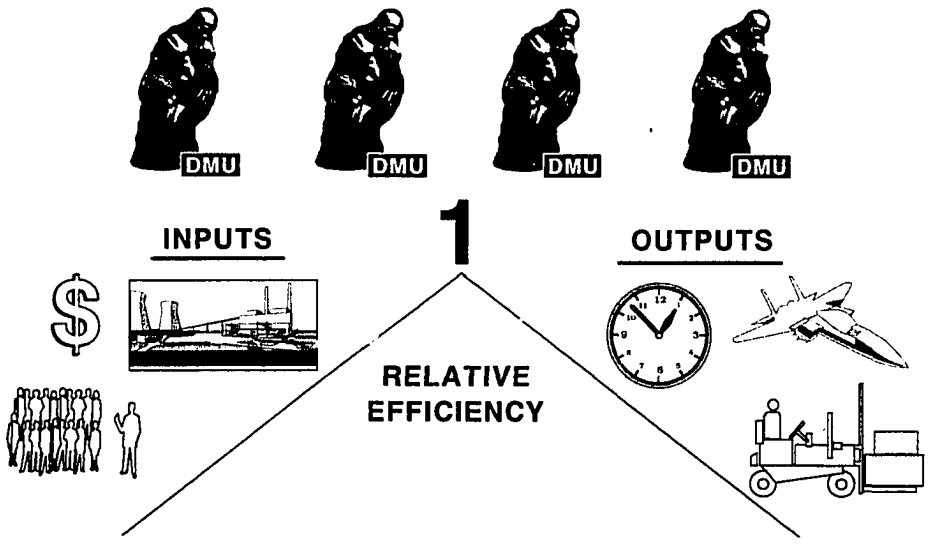

Figure 9: DEA Produces a Measure of DMU Relative Efficiency

As illustrated above, DEA produces a measure of relative efficiency. A DMU is not fully efficient if some other DMU can produce the same outputs with less of some resources and not more of any other resource (Lewin and Morey, 1980, p. 3). For example, if a unit achieves a 70 percent score on DEA, then some other DMU is 30 percent more efficient than the DMUs in its peer group.

The mathematical model used for the computation of DEA in this study was developed by Banker, Charnes and Cooper in 1984. It is set forth in Figure 10 (Charnes et al., 1992). The model was programmed by Chang and Sueyoshi (1986) for the computer software application used for the calculations in this study.

$$\min_{u,v,v_o} \quad \frac{vX_o + \tilde{v}_o}{uY_o}$$

$$s.t. \quad \frac{vX_j + \tilde{v}_o}{uY_j} \geq 1 \qquad j = 1,\ldots,n$$

$$u/uY_o \geq \epsilon \cdot \tilde{1}$$

$$v/uY_o \geq \epsilon \cdot \tilde{1}$$

Figure 10: The BCC Ratio Model

The above model is solved as a sequence of linear programs, one for each DMU, where X is a vector of DMU inputs and Y represents DMU outputs. The objective function expresses the calculation of a minimum inefficiency score for each DMU, subject to the constraints, which require that all DMU inefficiencies exceed one.

The symbols v and u are virtual multipliers which transform each DMU's outputs and inputs into a "virtual output" and a "virtual input". These are used in the objective function to produce a ratio measure of each DMU's inefficiency. These virtual multipliers are the decision variables resulting from the solution variables obtained by solving the problem.

The lower two lines of the formula utilize the symbol ϵ to produce an infinitesimal to insure that dominated solutions cannot be considered efficient for zero data

values. This allows calculations to be conducted even if the value of an X or Y observation happens to be zero.

The variable returns to scale properties of the BCC model are achieved through introduction of $\tilde{v}$, which acts as an intercept and does not require the relative changes in DMU input and output to be expressed relative to a ray through the origin as in normal linear programming. Thus, changes in the slope are used to introduce variations in returns to scale.[1]

The Chang and Sueyoshi program used in this study transforms the above ratio form to a linear program expressed in the dual form and provides the measurements used to express each DMU's periodic efficiency applied in this study. The linear program dual form is used because it produces data relative to existing efficiency rather than information concerning the best mix of inputs and outputs for future efficiency. This creates efficiency measures for comparison with TQM measures.

The formula enables calculation of an efficiency measure of each unit such that a score of .80 will mean that there exists one or more DMUs, which, given the same resources, produces levels of outputs resulting in the DMU

[1] Thomas Gulledge explained this technique in a November 1992 series of lectures at George Mason University.

in question only producing 80 percent as much as the fully efficient ones (Lewin and Morey, 1980, p. 3).

DEA creates a piecewise linear extremal production function (Lewin and Morey, 1990, p. 3) made up of the most efficient DMUs. This is illustrated in Figure 11 for the case of one input and one output.

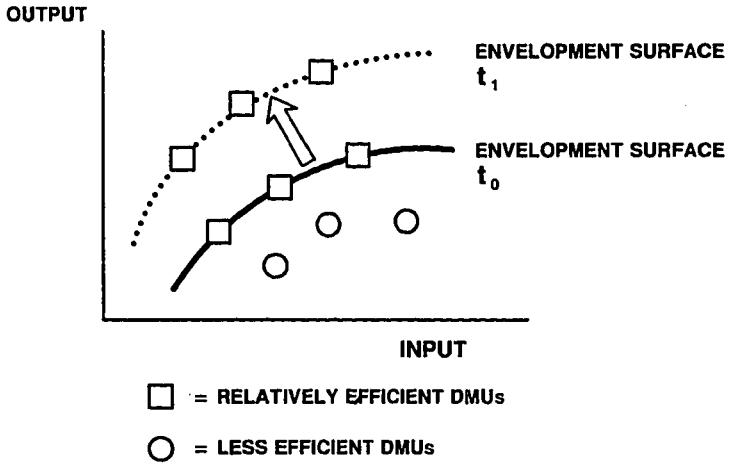

Figure 11: DEA Envelopment Surface

It is called an envelopment surface (Charnes et al., 1987, p. 2) but in the economic sense it is a production frontier in that it represents the maximum outputs attainable from the DMUs if they were perfectly efficient, relative to the best among them (Lewin and Morey, 1990, p. 3). Note from the illustration that some DMUs are not on the envelopment surface. They are not efficient relative to those DMUs on the envelopment surface.

DEA measures of overall efficiency, both on and off the frontier, will be correlated with TQM survey results in order to test the hypothesis that TQM increased DMU efficiency. The hypothesis is supported if the DMUs represented as squares on the production frontier have higher TQM survey scores than the DMUs represented as circles off the frontier. Moreover, all other things being equal, if TQM produces greater efficiency the production frontier will move higher over time as all DMUs increase efficiency.

DEA is an excellent tool for this analysis. By creating a single efficiency measure for each of the several DMUs, DEA offers singular advantages for this study. It identifies an efficiency score for each of the DMUs, rather than burying the individual DMU efficiency into an overall DLA average. This facilitates comparison of each DMU's efficiency with its respective degree of TQM implementation (Charnes et al., 1987, p. 3-4).

DEA enables the researcher to accomodate the individual circumstance of each ICP (Charnes et al., 1987, p. 5). As revealed in the ICP analysis in this proposal, each ICP/DMU is in a particular market situation. In consideration of this difference, DEA accommodates each DMU's need to manage as fits it best, because it allows the DMU to choose its own strategic mix of input and output priorities. DEA then

maintains equity among DMUs by maximizing the efficiency score of each DMU relative to all the others (Lewin and Morey, 1980, p. 20).

DEA provides for the consideration of multiple inputs and outputs (Lewin and Morey, 1980, p. 1). This permits examination of several different measures of mission effectiveness as outputs, such as stock availability and customer satisfaction. It facilitates the analysis of several measures of input, such as manpower and inventory.

Several additional characteristics of DEA, which are important to this study, were identified by Haynes, Stough and Shroff in a 1990 article in Computers, Environment and Urban Systems. First, DEA does not rely on a priori assumptions such as the condition of a normal distribution (Haynes, et al., p. 86). The GAO report discussed in the TQM chapter of this study reveals that TQM implementation has not progressed sufficiently to establish its typical parameters. Second, DEA enables the researcher to use different metrics in the same calculation (Haynes, et al., p. 85). In this study, percentages, dollars and units are mixed in the same calculations. Finally, DEA avoids the use of averages as in normal econometrics (Haynes, et al., p. 85). This is particularly important because of this study's need to obtain the relative efficiency ranking for

comparison with the TQM survey scores, rather than the average efficiencies of the DMUs being studied.

DEA is especially useful for studies such as this one, which seek to examine efficiency changes over time. Performance periods may be established and DEA efficiency scores for each DMU can be calculated in each time period. This is called 'windows' analysis. Charnes, et al., (1982) appear to be the first users of windows analysis with DEA. They measured the change in efficiency of Army Recruiting Organizations in 1982.

The general flexibility of the 'windows' procedure enables the comparison of each DMU with all other DMUs and from the same computation to compare the performance of all the DMUs in one year with the performance of all the DMUs in a different year. The particular moving-window technique discussed in Charne's study is used in this analysis to examine change from one quarter to another.[2]

The mathematical foundations of DEA are still under development. Shroff (1992) identified some of the extensions of DEA in his dissertation entitled Siting Efficiencies of Long-Term Health Care Facilities: The Northern Virginia Health System. According to Shroff (1992, p. 50), these include:

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[2] A more complete discussion of the moving-window model is found in Chapter VI of this dissertation, entitled Research Methodology.

> the use of categorical variables (Banker and Morey, 1986); estimating productive scale size (Banker, 1984); estimating technical and scale inefficiencies (Banker, et al., 1984); cone ratio DEA and multi-objective programming (Charnes, et al., 1989); extended facet approaches (Olesen and Petersen, 1991):...envelopment-efficiency-score-projections and units invariance (Ali, 1990); importance of zeros in DEA (Thompson, et al., 1991); and effects of outliers and leverage points on efficiency measures (Seaver and Triantis, 1991).

In summary, despite ongoing development, DEA is a good choice as the primary analytical technique for this study. DEA facilitates the creation of summary measures of efficiency with which to compare DMU efficiency to the level of TQM implementation measured by the TQM surveys.

The four DMUs of this study are too small a number to devise a clear production frontier from which to prescribe corrective action for individual efforts to improve performance. The production frontier results revealed by DEA in future analyses with larger populations, however, may be of use in the DLA budget process as a way to identify and limit the funding of slack resources and as a means of identifying the actions necessary to economically increase or decrease output for those activities on the production frontier. Such a prescription is not the purpose of the study. The purpose is to arrive at an efficiency measure for each DMU with which to compare the DMU to its measure of TQM implementation.

CHAPTER VI

RESEARCH METHODOLOGY

Overview

This chapter explains the data configuration for two examinations of the hypothesis. In the analysis, TQM and efficiency are the variables. This analysis encompasses the entire population of DLA hardware ICPs, which includes DCSC, DESC, DGSC and DISC. The analysis excludes the nonhardware ICPs, DFSC and DPSC, for the reasons explained in Chapter IV. This is a set of four case studies. Interest is focused on the relationship between the variables in the four hardware ICPs for the time period fiscal year 1989 through fiscal year 1991. The conclusions of this study concern only the four hardware ICPs.

The first hypothesis test is a comparison of the DMUs' TQM implementation levels in fiscal year 1990 and fiscal year 1991 with their relative efficiency achievements during the same time frame. The hypothesis is supported if the more efficient DMUs are also those with the highest TQM scores.

The second hypothesis test is a comparison of the efficiency change for the group of four DMUs between fiscal

year 1989 and fiscal year 1991. For this test, the TQM variable is not measured. The hypothesis is supported if average combined DMU relative efficiency increases between fiscal year 1989 and fiscal year 1991, after three years of TQM implementation. The absolute input/output DMU values will also be compared to assure that DMUs which are not on the envelopment surface do not greatly restrict surface movement and thus falsely indicate a lack of overall efficiency improvement.

In order to perform the tests described above, it is necessary to measure the TQM variable and the efficiency variable. This chapter explains how these variable measurements are accomplished. There are three sections. The first section describes the measurement of TQM implementation through employee surveys administered in fiscal year 1990 and fiscal year 1991. The second section describes the steps taken to choose and configure resource inputs and performance outputs and measure DMU efficiencies using Data Envelopment Analysis (DEA). The third section arranges the survey scores and DEA scores in data configurations in order to conduct the hypothesis tests described above.

Total Quality Management Implementation Level Measurement

The primary measurement instrument for DMU TQM implementation levels is a TQM survey which was administered in the last quarter of fiscal year 1990 and again in the last quarter of fiscal year 1991. The survey can be found in the Appendix. It is divided into eight sections. Within each section, the questions measure employees' perceptions of the degree of achievement in one of the eight specific dimensions of TQM. The dimensions are the same as those considered by the Federal Quality Institute in evaluating candidates for the Federal Quality Improvement Prototype (QIP) Award. They are set forth below, together with the maximum number of points which can be awarded for each category and with a label indicating which of the three TQM focus areas set forth in Chapter III each dimension supports:

1. Top Management Leadership and Support (20 points; all);
2. Strategic Quality Planning (15 points; all);
3. Customer Focus (35 points; customer);
4. Training and Recognition (15 points; involvement);
5. Employee Empowerment and Teamwork (20 points; involvement);
6. Measurement and Analysis (15 points; process);

7. Quality Assurance (30 points; all);

8. Quality and Productivity Improvement Results (50 points; all).

The QIP evaluation scheme represents the federal government benchmark for quality improvement (Federal Quality Institute, Quality Improvement).

The survey had 105 TQM questions. The respondents were asked to rate each question on the five-point Likert scale. In a prior analysis, Patrick (1992) of George Mason University determined that several of the questions were poorly worded and might be misunderstood by respondents. These are marked on the sample questionnaire in the Appendix. The responses to the questions were not included in the questionnaire results used in this analysis.

The survey was administered by full-time TQM officials located at each of the four ICPs. DLA headquarters guidance required that a sample be taken which would provide a statistically valid representation of the ICP population as a whole and that the anonymity of the respondents be maintained (DLA Total Quality Management Office). No survey was conducted at DGSC in 1990 because DGSC management staff did not believe that DGSC was far enough toward TQM implementation to measure. DGSC did administer the survey in 1991. Accordingly, 1990 observations relating DGSC TQM with DGSC efficiency are not included in this study. The

hypothesis was tested using seven intersectors of TQM and efficiency rather than eight as would have been the case if DGSC had tested in 1991. These intersectors are DCSC/90, DCSC/91, DESC/90, DESC/91, DGSC/91, DISC/90 and DISC/91.

The sample sizes and survey results are set forth in Table 1. In order to relate the survey results to the relative importance of TQM achievements, the scores have been weighted by the point maximums for each of the QIP areas. For instance, scores for the questions relating to top management leadership and support in the DCSC 1990 survey averaged 3.34. This figure was multiplied by the QIP 20-point maximum for top management leadership to produce a score of 66.87. This was done in the same manner for all the DCSC 1990 survey scores. These were weighted and totaled to produce the score of 630.79 which was used in the analysis.

Table 1: Survey Scores

	DCSC 90			DCSC 91		
TQM Categories	Average Category Score	Weighted Score	Sample Size	Average Category Score	Weighted Score	Sample Size
Top Management Leadership and Support (20 pts)	3.34	66.87	114.00	3.39	67.87	218.00
Strategic Planning and Goals (15 pts)	3.21	48.15	114.00	3.11	46.87	218.00
Focus on the Customer (35 pts)	3.32	116.11	114.00	3.08	107.68	216.00
Employee Training and Recognition (15 pts)	2.90	43.56	113.00	2.76	41.40	218.00
Employee Empowerment & Teamwork (20 pts)	2.78	55.60	112.00	2.86	57.10	218.00
Measurement and Analysis (15 pts)	2.90	43.50	111.00	2.81	42.15	218.00
Quality Control (30 pts)	3.20	96.00	109.00	3.16	94.80	214.00
Quality Improvement & Success (50 pts)	3.22	161.00	106.00	3.15	157.50	204.00
TOTALS	24.87	630.79		24.32	615.15	

	DESC 90			DESC 91		
TQM Categories	Average Category Score	Weighted Score	Sample Size	Average Category Score	Weighted Score	Sample Size
Top Management Leadership and Support (20 pts)	3.26	65.20	100.00	3.17	63.33	102.00
Strategic Planning and Goals (15 pts)	3.17	47.55	100.00	3.01	45.15	102.00
Focus on the Customer (35 pts)	3.43	119.88	100.00	3.26	114.16	99.00
Employee Training and Recognition (15 pts)	2.74	41.07	100.00	2.74	41.40	101.00
Employee Empowerment & Teamwork (20 pts)	2.77	55.40	100.00	2.65	52.90	100.00
Measurement and Analysis (15 pts)	2.86	42.90	100.00	2.72	40.80	97.00
Quality Control (30 pts)	3.18	95.40	100.00	3.04	91.20	92.00
Quality Improvement & Success (50 pts)	3.25	162.50	99.00	2.94	147.00	87.00
TOTALS	24.65	629.90		23.52	595.58	

Table 1: Survey Scores (cont.)

	DISC 90			DISC 91		
TQM Categories	Average Category Score	Weighted Score	Sample Size	Average Category Score	Weighted Score	Sample Size
Top Management Leadership and Support (20 pts)	3.50	69.93	169.00	3.23	64.60	1403.00
Strategic Planning and Goals (15 pts)	3.40	51.00	169.00	3.21	48.15	1391.00
Focus on the Customer (35 pts)	3.26	113.93	169.00	3.24	113.55	1343.00
Employee Training and Recognition (15 pts)	3.12	46.80	169.00	2.99	44.79	1386.00
Employee Empowerment & Teamwork (20 pts)	3.08	61.50	169.00	2.74	54.70	1379.00
Measurement and Analysis (15 pts)	3.09	46.35	169.00	2.86	42.90	1346.00
Quality Control (30 pts)	3.12	93.60	167.00	3.10	93.00	1290.00
Quality Improvement & Success (50 pts)	3.31	165.50	163.00	3.19	159.50	1226.00
TOTALS	25.87	648.61		24.56	621.19	

	DGSC 91		
TQM Categories	Average Category Score	Weighted Score	Sample Size
Top Management Leadership and Support (20 pts)	3.20	64.07	222.00
Strategic Planning and Goals (15 pts)	3.23	48.45	223.00
Focus on the Customer (35 pts)	3.37	117.78	222.00
Employee Training and Recognition (15 pts)	2.93	44.01	223.00
Employee Empowerment & Teamwork (20 pts)	2.85	56.90	222.00
Measurement and Analysis (15 pts)	2.93	43.95	216.00
Quality Control (30 pts)	3.12	93.60	211.00
Quality Improvement & Success (50 pts)	3.16	158.00	210.00
TOTALS	24.79	626.75	

Use of QIP weighted scores, rather than actual scores, is important to this study because the study is a policy evaluation. The QIP weights, which vary widely from 15 to 50 points, represent the federal TQM policy's perspective on the relative importance of TQM implementation achievements. Nevertheless, it should be noted that there is only one minor difference in the ICP/Year rankings between actual and weighted scores as exhibited below:

WEIGHTED	ACTUAL
DESC '91	DESC '91
DCSC '91	DCSC '91
DISC '91	DISC '91
DGSC '91	DESC '90
DESC '90	DGSC '91
DCSC '90	DCSC '90
DISC '90	DISC '90

Efficiency Measurement

This section identifies the performance data used in the study; explains how the performance data were chosen; describes how the data were configured for DEA computations; and, demonstrates how the data were arrayed so as to provide sufficient observations to construct a DEA envelopment surface. The results of the DEA computations are located in the final part of this section.

Performance Data

The performance data used in the study are contained in Table 2.

Table 2: Performance Data

INPUT DATA

SALES$(000,000)	DCSC	DESC	DGSC	DISC
1 QTR 91	276	168	271	198
2 QTR 91	317	182	298	221
3 QTR 91	258	154	359	188
4 QTR 91	522	213	241	233
1 QTR 90	197	147	207	153
2 QTR 90	210	154	207	155
3 QTR 90	197	142	200	145
4 QTR 90	215	144	231	150
1 QTR 89	193	148	187	158
2 QTR 89	198	144	202	150
3 QTR 89	197	144	206	150
4 QTR 89	195	148	212	151

INVENTORY $ (000,000)	DCSC	DESC	DGSC	DISC
1 QTR 91	2169	2625	1754	1967
2 QTR 91	2218	2640	1810	1945
3 QTR 91	2321	2660	1874	1977
4 QTR 91	1797	2011	1568	1423
1 QTR 90	1724	2231	1619	1619
2 QTR 90	1662	2227	1622	1596
3 QTR 90	1742	2242	1656	1605
4 QTR 90	1790	2151	1564	1594
1 QTR 89	1711	2155	1532	1651
2 QTR 89	1705	2152	1599	1575
3 QTR 89	1708	2386	1599	1591
4 QTR 89	1647	2176	1540	1563

Table 2: Performance Data (cont.)

INPUT DATA (cont.)

TOTAL MAN-HOURS	DCSC	DESC	DGSC	DISC
1 QTR 91	2321517	2582425	2115064	2267549
2 QTR 91	2453596	2590887	2178909	2422681
3 QTR 91	2467627	2579601	2219256	2473547
4 QTR 91	2420363	2415653	2097804	2278215
1 QTR 90	2719372	2788696	2320242	2503912
2 QTR 90	2842941	2890817	2378530	2552159
3 QTR 90	2737136	2799179	2330295	2586740
4 QTR 90	2622672	2625410	2192870	2382557
1 QTR 89	2746005	2889581	2375376	2700812
2 QTR 89	2846547	2991799	2465012	2781047
3 QTR 89	2977999	3079772	2560310	2828862
4 QTR 89	2833105	3057367	2439226	2627593
STOCKED NATIONAL STOCK NUMBERS MANAGED	DCSC	DESC	DGSC	DISC
1 QTR 91	318000	718000	255000	653000
2 QTR 91	319000	717000	258000	644000
3 QTR 91	320000	178000	259000	645000
4 QTR 90	323000	698000	269000	649000
1 QTR 90	317000	713000	251000	658000
2 QTR 90	315000	718000	253000	658000
3 QTR 90	317000	720000	254000	663000
4 QTR 90	313000	715000	256000	667000
1 QTR 89	327000	720000	239000	689000
2 QTR 89	320000	723000	252000	680000
3 QTR 89	323000	717000	249000	665000
4 QTR 89	320000	715000	252000	666000

Table 2: Performance Data (cont.)

OUTPUT DATA

STOCKED REQUISITIONS	DCSC	DESC	DGSC	DISC
1 QTR 91	983	712	633	1411
2 QTR 91	1025	762	769	1565
3 QTR 91	805	619	619	1276
4 QTR 91	1059	689	740	1505
1 QTR 90	831	761	694	1446
2 QTR 90	898	823	760	1575
3 QTR 90	848	749	695	1464
4 QTR 90	883	752	722	1483
1 QTR 89	806	776	657	1397
2 QTR 89	899	810	741	1494
3 QTR 89	907	838	737	1549
4 QTR 89	852	810	707	1521
NONSTOCKED REQUISITIONS (000)	DCSC	DESC	DGSC	DISC
1 QTR 91	69	35	47	51
2 QTR 91	75	36	52	54
3 QTR 91	66	30	48	46
4 QTR 91	73	32	53	51
1 QTR 90	71	35	47	46
2 QTR 90	80	38	56	54
3 QTR 90	74	38	51	51
4 QTR 90	73	37	53	51
1 QTR 89	81	67	56	65
2 QTR 89	77	53	50	57
3 QTR 89	87	41	52	56
4 QTR 89	72	38	50	49

Table 2: Performance Data (cont.)

OUTPUT DATA (cont.)

STOCK AVAILABILITY (%)	DCSC	DESC	DGSC	DISC
1 QTR 91	86.90	96.50	86.30	87.40
2 QTR 91	85.50	90.80	85.00	87.20
3 QTR 91	87.60	91.50	87.60	87.50
4 QTR 91	87.30	92.70	87.00	87.80
1 QTR 90	88.70	92.60	89.40	87.70
2 QTR 90	88.90	92.80	89.10	87.70
3 QTR 90	88.70	92.60	89.10	86.80
4 QTR 90	88.80	92.30	89.60	87.10
1 QTR 89	89.10	92.80	92.30	86.50
2 QTR 89	89.30	92.80	90.80	87.60
3 QTR 89	88.60	93.00	90.50	88.20
4 QTR 89	88.30	92.60	90.30	88.10
STOCKED BACKORDER >180 DAYS OLD	DCSC	DESC	DGSC	DISC
1 QTR 91	73728	47243	79881	276910
2 QTR 91	77243	48594	78176	252236
3 QTR 91	69316	42928	71569	210234
4 QTR 91	66298	35614	71516	181929
1 QTR 90	70062	43683	74497	240670
2 QTR 90	72161	44148	76458	244421
3 QTR 90	70806	45491	78172	250866
4 QTR 90	72986	45419	76355	272125
1 QTR 89	72704	49402	33590	242014
2 QTR 89	71617	44058	33089	228972
3 QTR 89	71489	42970	40506	220168
3 QTR 89	70335	43191	64339	222489

Table 2: Performance Data (cont.)

OUTPUT DATA (cont.)

DIRECT VENDOR DELIVERY (DVD) >180 DAYS OLD	DCSC	DESC	DGSC	DISC
1 QTR 91	1259	1396	1099	2326
2 QTR 91	1426	1528	1101	2452
3 QTR 91	1625	1415	1139	2658
4 QTR 91	1662	1473	1149	2342
1 QTR 90	1097	1370	837	1625
2 QTR 90	1093	1264	938	1680
3 QTR 90	1067	1194	983	1889
4 QTR 90	1150	1287	1133	2059
1 QTR 89	1052	1357	661	1162
2 QTR 89	1041	1229	597	1214
3 QTR 89	994	1226	571	1273
4 QTR 89	1042	1343	710	1462
COMPLAINTS	DCSC	DESC	DGSC	DISC
1 QTR 91	833	407	515	1248
2 QTR 91	962	574	484	757
3 QTR 91	1035	630	529	195
4 QTR 91	1044	745	551	865
1 QTR 90	971	523	1447	950
2 QTR 90	921	547	600	1147
3 QTR 90	980	589	710	1139
4 QTR 90	858	543	537	962
1 QTR 89	799	570	606	648
2 QTR 89	863	503	609	802
3 QTR 89	1237	605	630	935
4 QTR 89	976	599	558	823

This data represents activity covering the three fiscal years of 1989, 1990 and 1991. Each fiscal year began on the first day of October of the preceding calendar year. These three years were chosen to coincide with the beginning of the DLA TQM implementation program in the fall of 1988 and with the 1991 survey administration at the end of fiscal year 1991. The performance data were collected from transactions entered into the DLA standard information resource management systems. A description of each of the nine data categories is set forth below. The first four categories were used to construct DEA input measures and the last five were used to create DEA output measures.

a. *Sales* - The ICPs sell materiel to the military services and to a lesser degree to foreign governments and other federal departments. They bill these customers at a standard price, which is established based on the cost of the actual materiel, plus a proportional charge to cover the operations costs of the ICP and the other government activities which support it. Defense Logistics Agency Handbook 7730.2, Volume I defines sales as the "gross value (at standard price) of materiel issued" (DLAH 7730.2, p. 26-200-2). Sales are counted at several points in the logistics process. First, sales are counted at the

distribution sites after release of a materiel release order to the distribution site from the ICP and the accomplishment of the shipment by the distribution site. Second, sales are counted from direct vendor deliveries upon receipt of the vendor's notice of shipment. Finally, in the case of advance payment to vendors, the sales are counted from receipt of disbursement vouchers in the Finance and Accounting Office. The unit of measurement is dollars.

Sales reporting requirements are directed by Management Data Report RCS 26 as data no. 57.B. (DLAH 7730.2, p. 26-200-2).

b. *Inventory* is defined by DLA Handbook 7730.2 as the value of inventory on hand and in transit at the end of the reporting period. This includes materiel in transit from contractors and from customers making returns, and material in the possession of contractors as government-furnished material. This reporting requirement is established by Management Data Report RCS 26 as data no. 46A (DLAH 7730.2, p. 26-200-1). The inventory records are maintained by the ICPs. The unit of measurement is dollars.

c. *Man-Hours* is defined in DLA Handbook 7730.2 as the number of paid man-hours associated with full-time permanent employees and other than full-time permanent employees

combined to form the total paid man-hours during the reporting period. This reporting requirement is established by Management Data Report RCS 1388 (DLAH 7730.2, p. 1388-994-1). The unit of measurement is hours.

d. *Stocked National Stock Numbers Managed* - A national stock number is an item of supply for which a description has been entered into the National Catalog maintained by the Defense Logistics Service Center. This indicator is an addition of national stock numbers for items which are assigned for management by the ICP and which the ICP plans to maintain in stock. Stocked national stock numbers have sufficient demand from customers to require significant management attention at the ICPs. This reporting requirement is established by Management Data Report RCS 26 as data no. 69E (DLAH 7730.2, p. 26-200-5). The unit of measurement is units.

e. *Requisitions Received* are customer orders. The DLA Handbook defines this data element as "a one-line entry of demand to a supply manager for materiel to be shipped to a customer" (DLAH 7730.2, p. 96-200-23). The Handbook requires the ICPs to report this data and identifies the data as numbers B02A0, F02A0 and H02A0. These numbers are different cumulations by type of requisition. They are

totaled for use in the analysis. The unit of measure is units.

f. *Stock Availability* is computed by the DLA Directorate of Supply Operations by dividing all the requisitions for stocked items by those which could be immediately shipped. It is recorded on DLA data sheets maintained by that directorate. The unit of measurement is percentage.

g. *Backorders for Stocked Items Over 180 Days Old* - A backorder is established at that point in time when a customer is advised that materiel is not immediately available for issue. This category of backorders relates to those items for which the ICP had intended to have stock on hand for delivery but failed to do so and had continued to fail to deliver for a period in excess of 180 days from the time the ICP first received the customer requisition. These backorders are counted at the end of each reporting period. This reporting requirement is directed by DLA Handbook 7730.2 (p. 96-200-8) and identified as data element RCS-96 no. A23DO.

h. *Backorders for Direct Vendor Delivery Items Over 180 Days Old* - The description of this performance data is the same as the one above, except that it applies to items

which ICP had no intention to stock. The reporting requirement is directed by the same report as data no. F23C0 (DLAH 7730.2, p. 96-200-8). The unit of measurement is units.

i. *Complaints Received* - The complaints measured in this study fall into the broader category of Customer/Depot Complaints. The data element selected limited the count to those Customer/Depot Complaints which required ICP resolution. This avoided including complaints directed to depots, such as overages, which result from inaccurate stock picking at depots. ICP complaints generally focus on product deficiencies. This reporting element is directed by the RCS 26 report as data no. 279B1 (DLAH 7730.2, p. 26-400-15). The unit of measurement is units.

The above performance indicators were deemed most appropriate among hundreds which were available. Some indicators were not selected because they reflected internal processes. Procurement administrative lead time, for instance, measures how long it takes to purchase required items. Such indicators, however, are not system efficiency measures. System efficiency is measured at the beginning (inputs) and end (outputs) of a system. Sub-process results contribute to or detract from efficiency. System efficiency

is dependent on sub-process results. But sub-process measures do not sum up the final results of all processes and are therefore not final measures of efficiency.

There are, of course, alternative system performance indicators which could have been used. Weapons system spare parts availability, customer requisition cancellation rates, and availability of stock for high-priority requisitions were all candidates. The measures selected for this study best reflect efficiency because they provide a measure of the final results for the vast majority of ICP effort. Stock requisitions account for over 90 percent of customer requirements. Inventory accounts for about the same percentage of costs. In addition, timeliness and quality measures are included, in terms of aged backorders and complaints, to reflect some of those areas in which any excellent ICP should excel.

In summary, the chosen measures reflect the areas under study in this dissertation. The focus on final performance is consistent with TQM's focus on the external customer. The inclusion of performance data concerning such matters as customer complaints is consistent with a TQM focus on customer needs. The inclusion of data reflecting a large volume of transactions, such as stock availability, and the

inclusion of data concerning great sums of money, such as inventory, are appropriate to the study's inquiry concerning efficiency.

The argument can be made that, since not every measure is used, a total efficiency measure for each ICP is not achieved. The calculations for such a measure are not necessary here. This study merely requires a measure which realistically reflects efficiency to compare with the TQM level. Finally, the reader will observe in the following section that the study is conducted using two groupings of measures which reflect alternative views about what constitutes efficient ICP performance.

ICP Performance Data Configuration

The performance data discussed above are configured in order to serve three purposes. First, it is important to make the data relevant to transaction volume to obtain an equal comparison among DMUs. Second, the data are needed to conform to the classical engineering/science definition of efficiency. An efficient DMU should attain the maximum possible output using as little input as possible. Finally, it is recognized that different interest groups may have different ideas about what is efficient performance. A fighter mechanic may be intensely concerned about the

availability of parts while the taxpayer may be more focused on the volume of inventory. Therefore, the data are configured in two ways: 1) to reflect efficiency in the core business, and 2) to reflect the core business plus some of the refinements in performance expected in a TQM operation. The two inputs and four outputs created for the DEA computation set are presented in Table 3.

Table 3: Performance Data Configuration

INPUT VARIABLES				
INVENTORY/SALES	DCSC	DESC	DGSC	DISC
1 QTR 89	8.87	14.56	8.19	10.45
	8.61	14.94	7.92	10.50
	8.67	16.57	7.76	10.61
	8.45	14.70	7.26	10.35
	8.75	15.18	7.82	10.58
	7.91	14.46	8.84	10.30
	8.84	15.79	8.28	11.07
	8.33	14.94	6.77	10.63
	7.86	15.63	6.47	9.93
	7.00	14.51	6.07	8.80
	9.00	17.27	5.22	10.52
4 QTR 91	3.44	9.44	6.51	6.11
MAN-HOURS/STOCK NUMBERS MANAGED				
1 QTR 89	8.40	4.01	9.94	3.92
	8.90	4.14	9.78	4.09
	9.22	4.30	10.28	4.25
	8.85	4.28	9.68	3.95
	8.58	3.91	9.24	3.81
	9.03	4.03	9.40	3.88
	8.63	3.89	9.17	3.90
	8.38	3.67	8.57	3.57
	7.31	3.60	8.29	3.47
	7.69	3.61	8.45	3.76
	7.71	3.59	8.57	3.83
4 QTR 91	7.49	3.46	7.80	3.51

Table 3: Performance Data Configuration (cont.)

OUTPUT VARIABLES				
STOCK AVAILABILITY	DCSC	DESC	DGSC	DISC
1 QTR 91	86.90	91.50	86.30	87.40
	85.50	90.80	85.00	87.20
	87.60	91.50	87.60	87.50
	87.30	92.70	87.00	87.80
	88.70	92.60	89.40	87.70
	88.90	92.80	89.10	87.70
	88.70	92.60	89.10	86.80
	88.80	92.30	89.60	87.10
	89.10	92.80	92.30	86.50
	89.30	92.80	90.80	87.60
	88.60	93.00	90.50	88.20
4 QTR 91	88.30	92.60	90.30	88.10
STOCKED REQUISITIONS/BACKORDERS > 180 DAYS OLD				
1 QTR 89	11.09	15.71	19.56	5.77
	12.55	18.38	22.39	6.52
	12.69	19.50	18.19	7.04
	12.11	18.75	10.99	6.84
	11.86	17.42	9.32	6.01
	12.44	18.64	9.94	6.44
	11.98	16.46	8.89	5.84
	12.10	16.56	9.46	5.45
	12.11	15.07	7.92	5.10
	13.27	15.68	9.84	6.20
	11.61	14.42	8.65	6.07
4 QTR 91	15.97	19.35	10.35	8.27

Table 3: Performance Data Configuration (cont.)

OUTPUT VARIABLES (cont.)				
DVD REQ/DVDBO > 180 DAYS OLD	DCSC	DESC	DGSC	DISC
1 QTR 89	77.00	49.37	84.72	55.94
	73.97	43.12	83.75	46.95
	87.53	33.44	91.07	43.99
	69.10	28.29	70.42	33.52
	64.72	25.55	56.15	28.31
	73.19	30.06	59.70	32.14
	69.35	31.83	51.88	27.00
	63.48	28.75	46.78	24.77
	54.81	25.07	42.77	21.93
	52.59	23.56	47.23	22.02
	40.62	21.20	42.14	17.31
4 QTR 91	43.92	21.72	46.13	21.78
TOTAL REQUISITIONS/COMPLAINTS				
1 QTR 89	1110.14	1478.95	1176.57	2256.17
	1130.94	1715.71	1298.85	1933.92
	803.56	1452.89	1252.38	1716.58
	946.72	1415.69	1356.63	1907.65
	928.94	1521.99	512.09	1570.53
	1061.89	1574.04	1360.00	1420.23
	940.82	1336.16	1050.70	1330.11
	1114.22	1453.04	1443.20	1594.59
	1154.86	1835.38	1320.39	1171.47
	1143.45	1390.24	1696.28	2138.71
	841.55	1030.11	1260.87	6779.49
4 QTR 91	1084.29	967.79	1439.20	1798.84

The first input is *inventory/sales*. This is the reciprocal of the business `inventory turn' statistic. As may be noted from the data in Table 2, billions of dollars in tax money are invested in this inventory. It is the primary input for ICP efficiency. Dividing inventory by sales creates an input variable which is lower when performance is efficient as required in the classical engineering definition of efficiency.

The use of the inventory sales ratio equalizes those ICPs which manage more expensive items with those ICPs which manage cheaper items. If they buy expensive items, they are expected to sell the same. Use of the ratio also obviates the impact of price changes between time periods, such as the addition of operating costs to the standard price under the Defense Business Operating Fund (DBOF). Such price changes uniformly impact both sales and the value of inventory. Use of this ratio thus enables the comparison of ICPs between time periods without concern regarding price changes.

The second input is *Man-hours/Stocked Stock Numbers Managed*. Here again, the ratio is formed so that smaller input values are associated with improved performance. If the ICP can manage more stock numbers with the use of fewer

labor man-hours it will be more efficient and this input measure will be small. A case can be made that those ICPs with a more homogenous package of stock numbers, such as the Defense Electronics Supply Center (DESC), show higher performance and may be able to use fewer man-hours.[1] This phenomenon, however, may be a function of the fact that all the ICPs are organized into three large, functionally specialized directorates for item management, purchasing and specification management, respectively. This organization construction does not lend itself to tailored treatment of varying commodities. However, a TQM-oriented ICP could reorganize around its various commodities so as to optimize its processes.

The first of the four outputs is *stock availability*. In accordance with the engineering/science definition of efficiency, high stock availability is preferred. Customers receive prompter support if an item is in stock when it is planned to be in stock. Typically, delivery of such items will occur within 20 days, whereas purchase of such items generally consumes months.

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[1] Discussions between Mr. Roy, assistant director, Defense Logistics Agency, Policy and Plans Directorate, and researcher, on July 31, 1992.

Stock Availability is one of two outputs constructed to reflect the ICPs' core business. The proportion of requisitions for stock items is at least 10 times that of requisitions for nonstocked items, for all ICPs and at all times during the period of this study.[2] In using this measure, the researcher acknowledges that where customer delivery expectations can be met through dependence on direct vendor delivery, such delivery is preferable to maintaining costly inventory. High stock availability, however, does not depend on the number of stock numbers planned for stockage versus direct vendor delivery. This indicator measures whether the ICP accomplished what it set out to accomplish--to have the item in stock when the customer orders it.

The second output variable is also a core business measure. It is *stocked requisitions/backorders held in excess of 180 days*. This is a ratio constructed so that the greater the number of requisitions for items planned for stock which can be processed without requiring customer wait time in excess of 180 days, the higher the value of this output variable. Larger values indicate better customer

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[2] This statistic ranges from a low of ten-fold to a high of twenty-three-fold.

support and contribute to efficiency. As in the case of stock availability, this variable encompasses the vast majority of the requisitions processed and is considered a core business measure.

The next two output measures concern direct vendor deliveries and customer complaints. They are referred to as `refinement variables'. They are important. They reflect the consistently excellent customer support which TQM is expected to engender. Attention to such matters is what makes corporations such as McDonalds profitable. But, achievements in these areas should be in addition to excellence in the core business areas where efficiency has a greater impact on the polity. Accordingly, they will be included with the core output measures in a separate DEA computation. A separate hypothesis test with the TQM survey will be conducted using this DEA computation.[3]

The first refinement variable is *nonstocked requisitions/direct vendor delivery backorders in excess of 180 days old.* As in the case of stocked requisitions in excess of 180 days old, this variable measures the number

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[3] Further discussion of the measurement of core business variables and refinement variables is found in the section entitled `ICP DEA Arrays'.

of requisitions which can be processed without excessive aging. The higher this variable measure, the better.

Direct vendor deliveries present a challenge to the ICPs because they have to be separately purchased. Pre-awarded indefinite delivery contracts and computer hookups with suppliers can ease this burden and assure speedier customer support. Through such arrangements, an ICP which achieves continuous process improvement can avoid excessive aging of direct vendor delivery requisitions and at the same time reduce investment costs.

It is instructive to examine the alignment of backorders over 180 days old with new requisitions. It would have been preferable to align similar time periods. However, standard measures do not reveal when the requisition over 180 days old was received. Accordingly, this study relies on the requisition volume in the more immediate period as a way to standardize the variables for each ICP.

The final output variable is *requisitions/complaints*. This is considered a refinement variable primarily because of the low volume of complaints compared to the number of requisitions--one in 1,000. DLA's customers may not yet be ready to provide the frequent customer feedback needed by a

TQM operation. Nevertheless, those complaints, which the ICPs do receive, are valuable as a means of conducting process improvements. The ICPs should be able to increase the number of non-complaint requisitions through their TQM efforts.

ICP DEA Arrays

Applying DEA in studies concerning a small number of DMUs presents a unique challenge. Numerous DMUs must be identified as relatively efficient in order to construct an envelopment surface made up of the most efficient DMUs. In the case of a small number of DMUs, most, if not all, will be identified as highly efficient. This situation provides no framework against which to compare the relative efficiency among the DMUs. Charnes et al. (1982, p. 7) advise that to reduce the impact of this problem the number of DMUs should exceed twice the number of inputs plus outputs. In this study, the number of DMUs is four and the combined inputs and outputs is six. This is not a sufficient number of DMUs. Accordingly, the time dimension of the study is used to create additional DMUs for analysis.

Sufficient numbers of DMUs are created through the use of time `windows', in which the inputs and outputs of each DMU are measured each quarter. Each window is treated as a

distinctly different DMU for analysis. This technique not only provides sufficient DMUs to reveal greater discrimination in the performance of each DMU, but it provides a framework for analyzing efficiency over time. As discussed in Chapter V, this strategy was modeled after a DEA analysis performed on Army Recruiting Commands (Charnes, et al., 1982, pp. 8-9).

Two different window arrays were prepared. In the first array, the DMUs were arranged in nine time-windows containing four quarters of data for each DMU. The first window contained the four quarters of fiscal year 1989; the second window contained the last three quarters of 1989 and the first quarter of 1990; the third window contained the last two quarters of 1989 and the first two quarters of 1990. The separate windows are thus arranged through time, one quarter in a step, each window containing only four quarters, until the ninth and final quarter contains the four quarters of 1991. This framework is displayed in Figure 12 using a coding for the DMUs in accordance with the example Q19C; where the Q means quarter, the 1 in the first position is the number of the quarter, the nine is the last digit in the year,[198{9}], and the C designates the ICP

which is D{C}SC. The other DMUs are coded as E for D{E}SC, G for D{G}SC and I for D{I}SC.

WINDOW W1	WINDOW W2	WINDOW W3	WINDOW W4	WINDOW W5	WINDOW W6	WINDOW W7	WINDOW W8	WINDOW W9
Q19C	Q29C	Q39C	Q49C	Q10C	Q20C	Q30C	Q40C	Q11C
Q19E	Q29E	Q39E	Q49E	Q10E	Q20E	Q30E	Q40E	Q11E
Q19G	Q29G	Q39G	Q49G	Q10G	Q20G	Q30G	Q40G	Q11G
Q19I	Q29I	Q39I	Q49I	Q10I	Q20I	Q30I	Q40I	Q11I
Q29C	Q39C	Q49C	Q10C	Q20C	Q30C	Q40C	Q11C	Q21C
Q29E	Q39E	Q49E	Q10E	Q20E	Q30E	Q40E	Q11E	Q21E
Q29G	Q39G	Q49G	Q10G	Q20G	Q30G	Q40G	Q11G	Q21G
Q29I	Q39I	Q49I	Q10I	Q20I	Q30I	Q40I	Q11I	Q21I
Q39C	Q49C	Q10C	Q20C	Q30C	Q40C	Q11C	Q21C	Q31C
Q39E	Q49E	Q10E	Q20E	Q30E	Q40E	Q11E	Q21E	Q31E
Q39G	Q49G	Q10G	Q20G	Q30G	Q40G	Q11G	Q21G	Q31G
Q39I	Q49I	Q10I	Q20I	Q30I	Q40I	Q11I	Q21I	Q31I
Q49C	Q10C	Q20C	Q30C	Q40C	Q11C	Q21C	Q31C	Q41C
Q49E	Q10E	Q20E	Q30E	Q40E	Q11E	Q21E	Q31E	Q41E
Q49G	Q10G	Q20G	Q30G	Q40G	Q11G	Q21G	Q31G	Q41G
Q491	Q10I	Q20I	Q30I	Q40I	Q11I	Q21I	Q31I	Q41I

Figure 12: Nine-Window Array

Separate DEA analyses are performed on each of these windows. This results in four separate DEA scores each time the quarterly variables for a DMU appeared in any window. These scores are achieved through competition with the quarterly variables of those DMU quarters in the same window. DCSC, for example, is scored for efficiency four

times in each window and, because there are nine windows, DCSC received 36 efficiency scores in the nine-window array.[4]

The second window array is a single window covering the entire fiscal year 1989 through fiscal year 1991 time frame. There are 48 DMUs in the window, representing 12 quarters for each of the four ICPs. Each ICP is measured for efficiency 12 times in this window--once for its performance in each quarter in the three-year span. Each of these efficiency scores is achieved in competition with all of the 48 ICP/quarter DMUs. The level of the efficiency score for DCSC in the second quarter of fiscal year 1991, for example, is influenced by how efficient DISC was in the first quarter of 1989.

DEA computations are performed on both of the window arrays described above. This was accomplished twice for each window array, once for data configurations using a two-output (core business) model and once for a four-output (refined business) model. In the case of the two-output model, the two inputs plus the outputs for stock availability and stocked backorders in excess of 180 days old were included. In the case of the four-output model,

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[4] Please refer to Table 4.

the outputs concerning complaints and DVD backorders in excess of 180 days are added to the two-output model.

The results of these four DEA window-array computations are displayed in Table 4.

Table 4: Data Envelopment Analysis Scores

	NINE-WINDOW, TWO OUTPUT						FY 90	SCORES OF ONE			FY 91
DCSC	0.94	0.94	0.94	0.97	0.95	1.00	1	0.93	1.00	0.68	1
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	0.97	1
DGSC	1.00	1.00	1.00	1.00	0.90	0.89	1	0.85	1.00	0.70	1
DISC	1.00	0.98	0.96	0.96	1.00	0.92	2	0.91	0.97	1.00	1
DCSC	0.94	0.93	0.96	0.96	1.00	0.92	1	1.00	0.97	0.72	1
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	0.97	2
DGSC	1.00	0.99	1.00	0.98	0.90	0.86	0	1.00	0.92	0.72	1
DISC	0.98	0.96	1.00	1.00	1.00	0.91	2	0.97	1.00	0.92	1
DCSC	0.93	0.95	0.95	1.00	0.94	0.98	1	0.98	1.00	0.62	1
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	0.97	1
DGSC	0.99	1.00	0.98	0.97	0.87	1.00	1	0.99	0.97	0.78	0
DISC	0.96	1.00	1.00	1.00	0.95	0.97	1	1.00	1.00	0.92	2
DCSC	0.95	0.94	1.00	0.96	0.99	1.00	3	1.00	1.00	1.00	3
DESC	1.00	1.00	1.00	1.00	1.00	1.00	2	1.00	1.00	0.72	2
DGSC	1.00	0.98	0.97	0.94	1.00	1.00	2	1.00	1.00	0.72	2
DISC	1.00	1.00	1.00	0.97	1.00	1.00	2	1.00	0.95	1.00	2

Table 4: Data Envelopment Analysis Scores (cont.)

SINGLE WINDOW--TWO ARRAY OUTPUT					
	DMU SCORES			FY AVERAGES	
	FY 89	FY 90	FY 91	FY 90	FY 91
DCSC	0.66	0.64	0.68	0.66	0.75
DESC	0.94	0.90	0.97	0.91	0.98
DGSC	1.00	0.73	0.70	0.74	0.73
DISC	0.90	0.92	1.00	0.92	0.96
DCSC	0.67	0.68	0.72		
DESC	0.92	0.87	0.97		
DGSC	1.00	0.69	0.72		
DISC	0.85	0.90	0.92		
DCSC	0.62	0.63	0.61		
DESC	1.00	0.90	0.97		
DGSC	0.84	0.66	0.78		
DISC	0.81	0.90	0.92		
DCSC	0.62	0.67	1.00		
DESC	0.81	0.95	1.00		
DGSC	0.88	0.86	0.72		
DISC	0.90	0.97	1.00		
FY AVERAGES	0.84	0.80	0.86		

NINE WINDOW - FOUR OUTPUT							FY 90	SCORES OF ONE			FY 91
DCSC	0.97	0.96	1.00	0.97	0.96	1.00	1	1.00	1.00	1.00	3
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	1.00	3
DGSC	1.00	1.00	1.00	1.00	0.94	1.00	2	0.89	1.00	0.81	1
DISC	1.00	1.00	1.00	1.00	1.00	1.00	3	0.98	1.00	1.00	2
DCSC	0.95	1.00	0.96	0.96	1.00	0.99	1	1.00	1.00	1.00	3
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	0.99	2
DGSC	1.00	1.00	1.00	0.98	1.00	0.89	1	1.00	0.94	1.00	2
DISC	1.00	1.00	1.00	1.00	1.00	0.95	2	1.00	1.00	0.93	2
DCSC	1.00	.096	0.95	1.00	0.99	0.98	1	1.00	1.00	.076	2
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	0.97	2
DGSC	1.00	1.00	0.98	0.97	0.89	1.00	1	0.99	1.00	0.82	1
DISC	0.99	1.00	1.00	1.00	0.95	1.00	2	1.00	1.00	1.00	3
DCSC	0.95	0.95	1.00	0.99	0.99	1.00	1	1.00	0.89	1.00	2
DESC	1.00	1.00	1.00	1.00	1.00	1.00	3	1.00	1.00	1.00	3
DGSC	1.00	0.98	0.97	0.94	1.00	1.00	2	1.00	1.00	0.90	2
DISC	1.00	1.00	1.00	0.97	1.00	1.00	2	1.00	1.00	1.00	3

Table 4: Data Envelopment Analysis Scores (cont.)

SINGLE WINDOW-FOUR OUTPUT					
	DMU SCORES			FY AVERAGES	
	FY 89	FY 90	FY 91	FY 90	FY 91
DCSC	0.96	0.85	0.87	0.88	0.85
DESC	1.00	0.97	1.00	0.98	0.99
DGSC	1.00	0.80	0.77	0.82	0.81
DISC	1.00	0.94	1.00	0.94	0.98
DCSC	0.92	0.92	0.83		
DESC	1.00	0.99	0.98		
DGSC	1.00	0.81	0.85		
DISC	0.93	0.93	0.93		
DCSC	1.00	0.88	0.70		
DESC	1.00	0.95	0.97		
DGSC	1.00	0.75	0.80		
DISC	0.90	0.91	1.00		
DCSC	0.86	0.87	1.00		
DESC	0.89	0.99	1.00		
DGSC	0.93	0.90	0.82		
DISC	0.93	0.98	1.00		
FY AVERAGES	0.96	0.90	0.91		

Although actual DEA scores were computed, it is more useful to consider the nine-window model scores in terms of each DMU's number of scores of one. Scores of one represent a case where the ICP was on the envelopment surface in that quarter. Calculation of efficiency for each DMU in the nine-window model was accomplished by counting the number of scores of one for each DMU because the low number of DMUs in each window proportional to the low combined number of inputs and outputs may have caused the scores to cluster near the high end of the zero to one scale. This makes

differentiation among the DMUs difficult. Therefore, analysis applying the nine-window array in this study uses the number of scores of one in lieu of actual scores.

In contrast to the windows in the nine-window array, the one-window array has many DMUs in its single window. There is therefore greater differentiation among them. Therefore, the actual scores from the one-window arrays are used in this study.

Hypothesis Test Configurations

In the correlation analyses, TQM and efficiency are the variables. The fiscal year 1990 and fiscal year 1991 TQM survey results are used as measures of TQM and the DEA scores achieved in fiscal year 1990 and fiscal year 1991 are used as measures of efficiency. These data are arranged into four configurations as follows:

1. Single Window Configuration using two outputs.
2. Single Window Configuration using four outputs.
3. Nine-Window Configuration using two outputs.
4. Nine-Window Configuration using four outputs.

These are set forth in Table 5.

Table 5: Correlation configurations

ICP FY	WEIGHTED SURVEY SCORES	EFFICIENCY SINGLE WINDOW, TWO OUTPUTS	EFFICIENCY SINGLE WINDOW, FOUR OUTPUTS
DCSC 90	630.79	0.66	0.88
DESC 90	629.90	0.91	0.98
DISC 90	648.61	0.92	0.94
DCSC 91	615.15	0.75	0.85
DESC 91	595.58	0.98	0.99
DGSC 91	626.75	0.73	0.81
DISC 91	621.19	0.96	0.98

ICP FY	WEIGHTED SURVEY SCORES	EFFICIENCY NINE WINDOW TWO OUTPUTS	EFFICIENCY NINE WINDOW FOUR OUTPUTS
DCSC 90	630.79	1	1
DESC 90	629.90	3	3
DISC 90	648.61	2	3
DCSC 90	630.79	1	1
DESC 90	629.90	3	3
DISC 90	648.61	2	2
DCSC 90	630.79	1	1
DESC 90	629.90	3	3
DISC 90	648.61	1	2
DCSC 90	630.79	1	1
DESC 90	629.90	3	3
DISC 90	648.61	2	2
DCSC 91	615.15	1	3
DESC 91	595.58	1	3
DGSC 91	626.75	1	1
DISC 91	621.19	1	2
DCSC 91	615.15	1	3
DESC 91	595.58	2	2
DGSC 91	626.75	1	1
DISC 91	621.19	1	2
DCSC 91	615.15	1	2
DESC 91	595.58	1	2
DGSC 91	626.75	0	1
DISC 91	621.19	2	3
DCSC 91	615.15	2	2
DESC 91	595.58	3	3
DGSC 91	626.75	2	2
DISC 91	621.19	2	2
DCSC 91	615.15	2	2

It should be noted that, although the single-window DEA data align perfectly with the fiscal year 1990 and fiscal year 1991 TQM surveys, some of the windows in the nine-

window model overlap fiscal years. In order to use fully the information in the nine-window model, it is necessary to align the most appropriate DEA windows with the fiscal year 1990 and fiscal year 1991 survey results. Fiscal year 1990 survey results are aligned with the middle three DEA windows and fiscal year 1991 survey results are aligned with the last three DEA windows. This convention divides the nine-window analysis into three sections, each section closely representing a fiscal year. The division includes one quarter of fiscal year 1989 data in the fiscal year 1990 DEA averages and three quarters of fiscal year 1990 data in the fiscal year 1991 averages.

Actual DEA scores are applied in the configurations, using the data from the single-window model, while the number of scores of one are applied in the configurations, using the data from the nine-window model. This is in accord with the discussion set forth above, in which it was observed that due to the closeness of the scores in the nine-window model greater discrimination is obtained by distinguishing those DMUs which are on the envelopment surface from those which are not.

The next chapter uses the above variable data to examine the hypothesis that TQM increases efficiency.

CHAPTER VII

HYPOTHESIS TESTS

The hypothesis that TQM increased efficiency at the ICP/DMUs is tested in the two ways described in Chapter VI. The first examination is a correlation between individual DMU DEA efficiency scores and individual DMU TQM surveys scores. The hypothesis is supported if the most efficient DMUs are also those DMUs with the highest TQM survey scores. The second examination aggregates all of the DMUs studied. The hypothesis is supported if their combined average relative efficiency scores in 1991, after three years of TQM implementation, are higher than the year 1989, when TQM implementation began.

Hypothesis Test I: Correlation Measures

In the view of the results of the GAO TQM survey, discussed in Chapter III of this study, it is likely that the relationship between TQM and efficiency is curvilinear--characterized by low correlation in the early stages where costly learning must occur. Nevertheless, it is too early in the worldwide development of TQM to know the form of the relationship. Therefore, the non-parametric Spearman's rho is used to measure the correlation of TQM with efficiency.

Rho measures the degree of relationship between two sets of ranked observations (Mason, 1986, p. 548). Rho ranges from -1 to 1 in ascribing degrees of correlation.

The Rho for the single-window DEA calculation is -0.42857 for the two-output model and -0.25226 for the four-output model. The t tests for significance of these correlations are 0.3374 and 0.5852 respectively. The Rho for the nine-window DEA calculation is 0.09488 for the two-output model and -0.29152 for the four-output model. The t tests for significance of these correlations are 0.6310 and 0.1323 respectively.

No positive correlation between TQM and efficiency has been established. All of the test results are closer to zero or -1 than they are to one. There is little difference between those examinations conducted for the two output model, reflecting the core business activities, and those examinations conducted on the four-output model which included TQM refinement activities such as reduction in customer complaints.

Hypothesis Test II: 1989 to 1991 Efficiency Change

This test is performed through observation of the average yearly relative efficiency scores for all the DMUs in the single-window model. All other things being equal, if TQM is increasing overall DMU efficiency, the relative efficiency scores for fiscal year 1991 should be higher than

those for 1989. This would mean that TQM is pushing the DEA envelopment surface outward as would be expected if the hypothesis is supported. The reader may observe from the single-window DEA results in Table 4 that this is not the case. The combined DMU/quarter fiscal year scores for the two-output model fell from 84 to 80 between fiscal year 1989 and fiscal year 1990 and rose again to 86 in 1991. The DEA scores for the four-output model fell from 96 to 90 and rose slightly to 91 in the same time frame. Although there has been a slight increase in the efficiency with which DLA handles the bulk of its resources (two-outputs/core business model) there is not sufficient change to support the hypothesis and no positive change in efficiency has occurred in the TQM-associated service improvements (four-output/refined business model).[1]

It is recognized that other factors besides TQM may have influenced overall hardware ICP efficiency during the study period. Such factors include the Persian Gulf war, implementation of the Defense Business Operating Fund and defense retrenchment. These factors may have caused larger than normal variations in sales volume and thus impacted such efficiency factors as inventory turn. Therefore, no

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[1] It is possible that the decline in DCSC '90 to '91 performance restricted overall curve movement but the three-point difference from .88 to .85 is too small to change the above conclusion.

inference should be drawn from this examination concerning the effective management of these field activities. The examination was conducted as a second attempt to support the hypothesis that TQM increases efficiency. Had this examination been positive, it would have been inconclusive due to the factors discussed above. However, it would have encouraged further review to identify the impact of those factors as a way to validate the examination results.

Summary of Results

No positive correlation between TQM and efficiency of the DMUs has been established by this study. It is possible that the costs of TQM learning and the unlearning of old habits decreased efficiency at the DMUs over the study period--particularly given that overall efficiency increased slightly in the second time period. If this is true, the study may be measuring the TQM/Efficiency relationship at a low point, while a more positive relationship could be expected in the future. This idea is supported by the slight rise in overall efficiency in the core business area from fiscal year 1990 to fiscal year 1991.

It is also possible that the inventory control points studied here are not good candidates for TQM or did not have the flexibility due to regulatory constraints to effectively implement TQM. In any case, as long as DLA continues to implement TQM, DEA should be used to monitor efficiency

changes.

CHAPTER VIII

VALIDITY CONSIDERATIONS

Overview

Two particularly significant validity issues were addressed in the conduct of this study. The first concerned the validity of the survey as a variable which was representative of the level of DMU TQM attainment. Two confirmations of the survey results were attempted: one with training and one with TQM award scores. The second validity issue concerned the selection of the most appropriate DEA analysis method. The mathematical model used had to be validated as the best one and a decision to deseasonalize the measures used for DEA efficiency calculations needed validation. All these validations are described below.

TQM Survey Validation

In order to validate the survey data, both the training investments for each DMU and the results of the 1992 Quality Improvement Prototype Award evaluation were applied.

Training Investments

The proportion of training hours conducted in fiscal year 1990 and fiscal year 1991 is compared to the man-hours expended for each of the DMUs in the same years in Table 6.

Table 6: Training

Man-hours	DCSC	DESC	DGSC	DISC
FY 1990	10,922,121	11,104,102	9,221,937	10,025,368
FY 1991	9,666,743	10,168,566	8,611,033	9,441,992
Total	20,588,864	21,272,668	17,832,970	19,467,360
Training Hours				
FY 1990	81,771	70,810	109,808	123,798
FY 1991	33,029	50,231	82,284	107,943
Training hours/Man-hours				
FY 1990 & 1992	0.005576	0.005690	0.010772	0.011904
FY 1990	0.007487	0.006377	0.011907	0.012348
FY 1991	0.003417	0.004940	0.009556	0.011432

The results are inconclusive.

DGSC and DISC conducted twice as much training per man-hour as DCSC and DESC. This investment did not reflect in the perceived level of TQM measured by the survey. Although DESC, which invested fewer training hours, ranks significantly lower on the survey than DGSC and DISC; DCSC which also invested less training hours did equally well on

the survey. Moreover, changes in the survey do not vary consistently with changes in training investment. Training was decreased at two DMUs, DCSC and DESC, and survey scores decreased. On the other hand, survey scores also went down at DISC where the training level remained relatively constant.

The training data does not validate the TQM survey. But DLA does not identify TQM training as part of the larger training budget. Accordingly, the extent to which the training at each ICP was TQM focused is not known. Therefore the training data cannot be used to validate the survey results.

In view of the inconsistent association of training investment with TQM survey results, a TQM training breakdown would be helpful in overseeing the TQM implementation program.

Quality Improvement Prototype Award

A second attempt to independently validate the survey data was conducted using the results of the July 1992, Quality Improvement Prototype (QIP) Award evaluations. During the summer of 1992, all ICPs were required to submit applications for this award to Headquarters DLA; even if they had no intention to compete nationally (Ambrose, 1992). These applications were evaluated by separate Committees at

Headquarters DLA for each of the eight QIP categories. The results of these evaluations appear in Table 7.

Table 7: Quality Improvement Prototype Award

Categories	Evaluation Components	DCSC	DESC	DGSC	DISC
Top Management Leadership and Support	A1	70.00	70.00	55.00	50.00
	B1	55.00	55.00	65.00	70.00
	C1	50.00	65.00	70.00	50.00
	D1	60.00	75.00	70.00	70.00
	E1	65.00	80.00	40.00	40.00
	F1	55.00	45.00	70.00	65.00
	G1	80.00	15.00		70.00
	H1	45.00	85.00		
Avg per 'Q'		60.00	61.25	61.67	59.29
Weighted 'Q' 20 pts		12.00	12.25	12.33	11.86
Strategic Quality Planning	A2	80.00	85.00	40.00	65.00
	B2	75.00	80.00	60.00	45.00
	C2	75.00	85.00	60.00	50.00
	D2	55.00	85.00	10.00	60.00
	E2	80.00	60.00		70.00
Avg per 'Q'		73.00	79.00	42.50	58.00
Weighted 'Q' 15 pts		10.95	11.85	6.38	8.70
Customer Focus	A3	75.00	65.00	70.00	40.00
	B3	40.00	40.00	65.00	40.00
	C3	55.00	70.00	45.00	65.00
	D3	40.00	45.00	45.00	40.00
	E3	40.00	60.00		40.00
Avg per 'Q'		50.00	56.00	56.25	45.00
Weighted 'Q' 35 pts		17.50	19.60	19.69	15.75

Table 7: Quality Improvement Prototype Award (cont.)

Categories	Evaluation Components	DCSC	DESC	DGSC	DISC
Training and Recognition	A4	40.00	70.00	45.00	50.00
	B4	30.00	70.00	40.00	50.00
	C4	50.00	30.00	40.00	25.00
	D4	40.00	25.00		25.00
	E4	50.00	60.00		40.00
	F4	50.00	40.00		20.00
Avg per 'Q'		43.33	49.17	42.00	35.00
Weighted 'Q' 15 pts		6.50	7.38	6.25	5.25
Employee Empowerment and Teamwork	A5	40.00	50.00	60.00	50.00
	B5	40.00	50.00	60.00	50.00
	C5	45.00	60.00	40.00	60.00
	D5	40.00	30.00	40.00	40.00
Avg per 'Q'		41.25	47.50	50.00	50.00
Weighted 'Q' 20 pts		8.25	9.50	10.00	10.00
Measurement and Analysis	A6	40.00	20.00	40.00	100.00
	B6	40.00	80.00	30.00	
	C6	50.00	80.00	45.00	20.00
	D6	30.00	100.00	35.00	80.00
	E6	90.00	100.00		
	F6	45.00	50.00		
Avg per 'Q'		49.17	71.67	37.50	66.67
Weighted 'Q' 15 pts		7.38	10.75	5.63	10.00

Table 7: Quality Improvement Prototype Award (cont.)

Categories	Evaluation Components	DCSC	DESC	DGSC	DISC
Quality Assurance	A7	40.00	30.00	55.00	60.00
	B7	40.00	35.00	50.00	35.00
	C7	40.00	45.00	10.00	90.00
	D7	45.00	55.00	20.00	90.00
Avg per 'Q'		41.25	41.25	33.75	68.75
Weighted 'Q' 30 pts		12.38	12.38	10.13	20.63
Quality Productivity Improvement Results	A8	45.00	5.00	65.00	45.00
	B8	40.00	10.00	60.00	50.00
	C8	35.00	35.00	45.00	35.00
	D8	35.00	20.00	50.00	
Avg per 'Q'		38.75	17.50	55.00	43.33
Weighted 'Q' 50 pts		19.38	8.75	27.50	21.67
Total Score		94.33	92.45	97.90	103.85

The ICPs were authorized to submit applications under either the 1992 or 1993 award criteria.[1] Although the eight categories and their respective weights remained unchanged between 1992 and 1993, minor evaluation instructions did change. DCSC and DESC used the 1993 criteria and DGSC used the 1992 criteria. The results in Table 7 reflect the results under the criteria chosen by the ICP.

DISC won the national QIP Award last year. This year they submitted an application for the, more prestigious,

[1] Teleconference between Dorothy Ambrose, DLA-DQ, Cameron Station, and author on August 17, 1992.

Presidential Award for Quality, which uses the same categories and weights as the QIP (Federal Quality Institute, Presidential Award). However, for the Presidential Award certain additional evaluation components are added within each category. In order to assure an equal comparison among ICPs, the results for DISC (see Table 7) reflect only the evaluation components which were identical to those of the QIP.

The QIP results in Table 7 were correlated with the TQM survey results using Spearman's Rank Order Coefficient as follows:

	Survey	QIP	Difference
DCSC	3	3	0
DESC	4	4	0
DISC	2	1	1
DGSC	1	2	1

Rho = .80

There is a strong correlation. This confirms the survey measure as representative of TQM. Although the number of ranks is small [four], this is not of concern because the entire population is under study.

In addition to directly correlating the QIP and survey data, validation of the hypothesis examinations was obtained by substituting the QIP data for the survey data in the Spearman's Rho correlation with the DEA efficiency data. As with the survey data, there is no positive correlation. This was performed using the results of the QIP, together with the single-window DEA data from the core business two-

output model (see Table 4). The Spearman's Rho is -0.40. Thus, use of the QIP data in lieu of the survey scores made no difference; i.e., no positive correlation exists between the QIP data, measuring TQM, and the DEA scores measuring efficiency.

DEA Analysis Method

Two decisions were made concerning the use of DEA in this study. First, a choice was made between the use of constant returns to scale CCR DEA model and the variable returns to scale BCC model. Second, it was decided not to deseasonalize the performance data used in the DEA model. These decisions are discussed below.

DEA Model

There are several DEA models available for analysis. A distinctive difference of application to this study exists between the CCR model of Charnes, Cooper and Rhodes (1978) and the later BCC model of Banker, Charnes and Cooper (1984). The former model assumes constant returns to scale and the latter model accommodates variable returns to scale. In this study, it is not possible to determine the manner in which each of the four outputs react to variations in the two inputs. Accordingly, a decision was made to use the BCC model.

In a validation of the choice of the BCC model, the two-output single-window array in Table 4 was analyzed using both the CCR and BCC models. The differences among the DEA results with these alternative models are set forth in Table 8. The choice of models has little impact on these results.

Table 8: Difference Between BCC and CCR DEA Models

	BBC Model Single-window Two-output			CCR Model Single-window Two-output			Model Differences		
DCSC	0.66	0.64	0.68	0.59	0.60	0.68	0.07	0.04	0.00
DESC	0.94	0.90	0.97	0.88	0.90	0.96	0.06	0.00	0.01
DGSC	1.00	0.73	0.70	0.74	0.62	0.69	0.26	0.11	0.01
DISC	0.90	0.92	1.00	0.84	0.87	0.94	0.06	0.05	0.06
DCSC	0.67	0.68	0.72	0.60	0.62	0.70	0.07	0.06	0.02
DESC	0.92	0.87	0.97	0.85	0.84	0.95	0.07	0.03	0.02
DGSC	1.00	0.69	0.72	0.86	0.61	0.70	0.14	0.08	0.02
DISC	0.85	0.90	0.92	0.81	0.85	0.89	0.04	0.05	0.03
DCSC	0.62	0.63	0.61	0.59	0.60	0.61	0.03	0.03	0.00
DESC	1.00	0.90	0.97	0.82	0.90	0.96	0.18	0.00	0.01
DGSC	0.84	0.66	0.78	0.69	0.60	0.77	0.15	0.06	0.01
DISC	0.81	0.90	0.92	0.78	0.84	0.87	0.03	0.06	0.05
DCSC	0.62	0.67	1.00	0.60	0.62	1.00	0.02	0.05	0.00
DESC	0.81	0.95	1.00	0.81	0.94	1.00	0.00	0.01	0.00
DGSC	0.88	0.86	0.72	0.63	0.69	0.71	0.25	0.17	0.01
DISC	0.90	0.97	1.00	0.85	0.91	1.00	0.05	0.06	0.00

Seasonality

The second decision regarding the DEA analysis method concerned the possibility of seasonality in the DMU performance data. Seasonal patterns are possible. It is likely that the requisitioning and spending habits of DLA

customers are influenced by the budget cycle. Thus, there appeared to be the possibility that such seasonal business patterns might influence the performance of the ICP/quarter-DMUs in a manner which would generate results inconsistent with what their performance would have been in the absence of seasonal variation. This could be a special problem in the nine-window array where the efficiency of any particular DMU is more influential than in the three-year single-window array. If such a DMU's performance were influenced by seasonal variation, it could influence the results of the entire window.

It is unlikely that seasonal patterns differ markedly between DMUs because they are all influenced by the same budget cycle. Nevertheless, steps were taken to control for the effects of seasonality in this study. Ratios were applied to relate inputs such as inventory to the changing sales pattern and to relate outputs such as complaints to the changing requisition pattern. Thus, as a given DMU experienced seasonal cycles at variance to other DMUs, the ratio should balance out the impact. Seasonal variation, among the elements of each ratio, could be another problem. For example, it is possible that complaints do not vary consistently with the volume of requisitions. In view of this possibility, a test was conducted whereby all of the ratio components in the performance data which might be

affected by seasons were deseasonalized using the ratio to moving average method (Lapin, 1991). The results were not significantly different from the seasonal data, although the scores were generally closer to one. The DEA computation differences between seasonal and deseasonalized data for the nine-window two-output array are set forth in Table 9 below. The choice of models had very little impact on the results.

Table 9: Difference Between Seasonal and Deseasonalized Data

-0.02	0.00	-0.01	-0.02	-0.02	0.00	-0.04	0.00	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	-0.01	-0.03	-0.11	0.00	0.00
0.00	0.03	-0.02	0.00	0.00	0.04	-0.04	-0.01	0.00
0.00	-0.03	-0.01	-0.04	0.00	-0.04	0.00	-0.03	0.02
0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	-0.01
0.00	-0.01	0.01	0.01	-0.05	-0.11	0.00	-0.02	0.03
0.03	-0.02	0.00	0.00	0.04	-0.04	-0.01	0.00	0.00
-0.03	-0.04	-0.01	0.00	-0.01	-0.02	-0.01	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
-0.01	0.02	0.01	-0.03	-0.12	0.00	-0.01	0.04	-0.11
-0.02	0.00	0.00	0.03	-0.02	-0.01	0.00	0.00	0.00
-0.02	-0.03	0.02	0.00	-0.01	0.00	0.00	-0.02	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	-0.01	-0.03	-0.06	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	-0.03	0.00	0.00	0.00	-0.05	0.00

The researcher discussed whether to use the deseasonalized data with Klopp[2], who used the windows technique with DEA. He felt that deseasonalizing the data would affect the validity of the envelopment surfaces generated in each window. The decision was made to use the original data.

Conclusion

The use of the survey data as a variable representing TQM is confirmed by the attainment of similar results with

[2] July 28 1992 telephone conversation between author and Klopp. Klopp conducted windows analysis with DEA on Army recruiting commands.

the QIP evaluation scores. The most flexible DEA model has been used in the analysis, and sensitivity analysis on this model shows little difference between it and the most likely alternative. Sensitivity analyses between deseasonalized and potentially seasonal data demonstrate that the use of potentially seasonal data is not inappropriate--particularly in view of the use of ratios to reduce seasonal effects. The use of deseasonalized data in windows analysis was appropriately avoided in order to maintain the distinctions among DMU quarters which was necessary for analysis.

CHAPTER IX

CONCLUSIONS

Overview

This chapter sets forth the study's conclusions and suggests how the study methodology may continue to be applied. The conclusions cover four areas: (1) governmental efficiency; (2) TQM expectation; (3) hypothesis evaluation; (4) applicability of DEA to enhance governmental efficiency programs. The first three areas where conclusions are reached accomplish the study's purpose to conduct an initial policy evaluation of TQM. The last conclusion area accomplishes the study's purpose to provide an efficiency oversight methodology and to demonstrate the use of DEA.

Governmental Efficiency

The review of the efficiency literature leads to the expectation that, in the absence of a great national challenge or struggle for governmental control, efficiency in government will continue to be a core consideration of American public administration. The great national problems concerning education, drugs, poverty and crime, together with scarce public resources, are forcing both politicians

and public administrators to find ways to obtain greater results in proportion to resources used.

It is possible that national crises such as war or economic recession will temporarily redirect the prevailing efficiency trend toward maximization of effectiveness for short periods of time. It is also possible that the polity will temporarily force politicians to focus in some areas on cost minimization and economy in order to gain greater control over governmental apparatus. However, world competition can only be engaged by efficiently meeting national challenges.

There is much current interest on the part of public administration writers concerning governmental efficiency. Privatization and governmental entrepreneurship are prevailing ideas on how government can be motivated to be more efficient. Motivation, however, is not enough. A management process that produces the desired results is critical. Successful private enterprises integrate efficiency and customer responsiveness. In order to be successful, government enterprises must do the same.

Total Quality Management Expectation

Total Quality Management requires organizations to focus on the customer, to continuously improve their processes and to involve people in management decisions.

Competition requires low-cost, high-quality products and services to satisfy customer expectations. The computer-driven Information Age provides the information with which to improve dramatically many governmental processes. Today, people expect to participate in decision-making as never before. These conditions, together with encouragement from the Federal Quality Institute, have induced many government agencies to adopt TQM. The adoptions require massive training of employees in order to engage them in process improvement efforts. TQM is a de facto public policy in many federal agencies, targeted at increasing effectiveness through satisfaction of customer needs. Yet it is not known whether TQM will bring the efficiency advances that the government also requires.

Hypothesis Evaluation

In view of the low or negative levels of association detected in the correlation examinations conducted with TQM and DEA efficiency measures, the hypothesis is rejected. This study has provided no support for the hypothesis that TQM improved DMU efficiency. This does not mean that TQM is not an appropriate goal; rather, it suggests that the consequences of TQM implementation are more likely to impact public satisfaction with government-delivered goods and services than improvement in the efficiency of that

delivery, at least in the early stages of TQM implementation.

The reader is cautioned that this was an initial and very limited examination of a hypothesis with four Defense Inventory Control Points (ICPs) as case studies. The ICPs should not be considered a representative example of all governmental activities. These ICPs are markedly different from, for example, Agriculture Laboratories or Internal Revenue Service Processing Centers. There may be significant early efficiencies to be gained from TQM in these other activities. Moreover, the three-year time span covered in this study is too short a period in which to make final observations concerning a transformation as comprehensive as the one described in the long-range TQM goals.

It is significant in the study results that both efficiency, in some measure, and the survey scores decreased at the ICPs between 1990 and 1991. As explained in Chapter VII, it is possible that the unlearning of old habits and relearning of TQM methodology reduces efficiency for several years. Also, the reduced survey scores may reflect the disappointment of unfulfilled expectations for TQM. These phenomena make it difficult to measure efficiency gains attributable to TQM. An argument can be made that despite the use of work-load ratios in this study, the ICPs manage

different commodities and are therefore too different to be effectively compared. If TQM implementation levels begin to increase, future studies will be able to compare the rate of relative efficiency changes to changes in levels of TQM implementation among the ICPs. This approach would facilitate the comparison of changes in efficiency for each ICP instead of ICP to ICP efficiency. Each ICP would be compared to its own performance, thereby obviating the effects of commodity changes.

The results may also be attributable to the choice of inputs and outputs for the measurement of efficiency. As indicated in Chapter VI, the inputs and outputs used in this study reflect the largest portion of ICP activity. But other studies should be conducted using alternative ideas about what inputs and outputs are most important.

These results are not attributable to the way TQM was measured. The survey results were validated by the QIP results.

Application of Data Envelopment Analysis

Another important contribution of this study is the development of a foundation for a continuing evaluation of efficiency within government operations. At least in the logistics business area of DoD, performance is measured through effectiveness measures such as stock availability and through measures of economy such as operating costs.

The author does not know of any use of measures which integrate effectiveness and economy measures into a single measure of efficiency, such as is achieved with DEA. Data Envelopment Analysis and its 'windows' extension in particular has proven to be an excellent way to measure efficiency for this study. Use of such efficiency measures would facilitate evaluation of the efficiency impacts of management improvement activities such as TQM.

Decision tools such as DEA should be used for more than intermittent decision studies. DEA provides summary measures of efficiency which reflect the combination of effectiveness (outputs) and economy (inputs). Such measures should be used to monitor continuously such important public matters as efficiency and budget expenditures so that government enterprises can change investment programs such as TQM as early as necessary to optimize results.

DEA is one opportunity for the application of the study methodology. The quarterly data used in this study of the ICPs and other performance data for other DLA field activities is available monthly. Those measures could be evaluated through DEA and correlated with survey data collected through a monthly mailing. Changes in TQM implementation strategy could be evaluated against gains or losses in efficiency. Where efficiency gains are achieved, the budget could be adjusted downward and appropriate

rewards made. Efficient activities could act as benchmarks for other activities which have lagged in efficiency improvements. This methodology could be applied in any organization, public or private, which has measurable outputs, is concerned about efficiency and is implementing efficiency improvement programs.

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Appendix

TQM SURVEY

CIRCLE THE NUMBER THAT BEST DESCRIBES YOU/YOUR JOB:

1. What most closely describes your personal function within the organization? Choices are listed in code numerical order by occupational groups (for Wage Grade employees) respectively.

1 - Miscellaneous Occupations (GS-0XX)
2 - Social Science, Psychology, and Welfare (GS-1XX)
3 - Personnel Management & Industrial Relations (GS-3XX)
4 - General Administration, Clerical, & Office Services (GS-3XX)
5 - Accounting & Budget (GS-5XX)
6 - Medical, Hospital, Dental, & Public Health (GS-6XX)
7 - Engineering & Architecture (GS-8XX)
8 - Legal & Kindred (GS-9XX)
9 - Information & Arts (GS-10XX)
10 - Business & Industry (GS-11XX)
11 - Physical Sciences (GS-13XX)
12 - Library & Archives (GS-14XX)
13 - Mathematics & Statistics (GS-15XX)
14 - Education (GS-17XX)
15 - Investigation (GS-18XX)
16 - Quality Assurance, Inspection, & Grading (GS-19XX)
17 - Supply (GS-20XX)
18 - Transportation (GS-21XX)
19 - Wire Communications Equipment Installation & Maintenance (WG-25XX)
20 - Electronic Equipment Installation & Maintenance (WG-26XX)
21 - Electrical Installation & Maintenance (WG-28XX)
22 - Fabric & Leather Work (WG-31XX)
23 - Instrument Work (WG-33XX)
24 - Machine Tool Work (WG-34XX)
25 - General Services & Support (WG-35XX)
26 - Structural & Finishing Work (WG-36XX)
27 - Metal Processing (WG-37XX)
28 - Metal Work (WG-38XX)
29 - Motion Picture, Radio, Television, & Sound Equipment (WG-39XX)
30 - Painting & Paper Hanging (WG-41XX)
31 - Plumbing & Pipefitting (WG-42XX)
32 - Pliable Materials Work (WG-43XX)
33 - Printing (WG-44XX)
34 - Wood Work (WG-46XX)
35 - General Maintenance & Operations Work (WG-47XX)
36 - General Equipment Maintenance (WG-48XX)

37 -	Plant & Animal Work	(WG-50XX)
38 -	Miscellaneous Occupations	(WG-52XX)
39 -	Industrial Equipment Maintenance	(WG-53XX)
40 -	Industrial Equipment Operating	(WG-54XX)
41 -	Transportation/Mobile Equipment Operation	(WG-57XX)
42 -	Transportation/Mobile Equipment Maintenance	(WG-58XX)
43 -	Warehousing & Stock Handling	(WG-69XX)
44 -	Packing & Processing	(WG-70XX)
45 -	Laundry, Dry Cleaning & Pressing	(WG-73XX)
46 -	Other	(GS or WG)

2. What type position do you presently occupy?
   1. Executive (The Agency Director/Deputy Directors/Chief of Staff, PLFA commanders/deputy commanders, PSE heads or deputy, all chiefs-of-staff.)
   2. Supervisor (Controls/directs work of others and provides appraisals of the work of others. Not already counted as an executive. Can be any rank/grade.)
   3. Non-supervisor (Are not executives or supervisors as noted above. Can be any rank/grade.)

NOT TRUE AT ALL	SOMEWHAT TRUE	HALF & HALF	MORE TRUE THAN NOT	THE TRUTH	I DON'T KNOW

TOP MANAGEMENT LEADERSHIP AND SUPPORT

This category examines how all levels of senior management create and sustain a clear and visible quality value system along with a supporting management system to guide all activities of the organization.

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3. I can tell that our top executive is very involved in quality improvement type activities - he/she acts like quality improvement is a personal crusade.

   1 2 3 4 5 X

4. Top executives have done a good job in communicating the organization's vision, goals and values to me - I know what the goals are and understand what they mean to me in my job.

   1 2 3 4 5 X

5. I know, or can tell from what I read and hear, that Total Quality Management (TQM) is the organization's number one priority for success in the future.
1 2 3 4 5 X

6. "Continuous improvement" is something I hear all the time where I work.
1 2 3 4 5 X

7. I am aware of actions being taken, or plans that are in place, to really involve all managers and supervisors in the TQM effort.
1 2 3 4 5 X

8. Management provides us with enough resources (time, training, dollars) in order to improve the quality of our services or products.
1 2 3 4 5 X

9. Innovation, pride in work, continuous improvement in what we do, open communication and information sharing, and cooperation are all encouraged where I work. (We may not have achieved all of these but they are encouraged or supported.)
1 2 3 4 5 X

10. I feel a personal responsibility for success of the organization's overall quality improvement effort.
1 2 3 4 5 X

11. My feeling of responsibility is supported by my supervisor.
1 2 3 4 5 X

12. Our top executive does not make compromises that may satisfy short-term needs but at the same time would hurt the organization's long-term plans and objectives. He/she sticks to his guns when the future of the organization is in question.
1 2 3 4 5 X

13. You can easily get to see/visit with our top executive.
1 2 3 4 5 X

14. Top management has regular contact with people in my organizational element.
1 2 3 4 5 X

15. Our outside customers and suppliers can easily get to visit with top management.
1 2 3 4 5 X

16. Top management has regular contact with those customers and suppliers.
1 2 3 4 5 X

17. Top management holds organization members responsible for continuous improvement of the processes they use and the products they provide.
1 2 3 4 5 X

18. Top management provides various kinds of rewards for efforts that result in progress toward achieving the organization's quality improvement goals.
1 2 3 4 5 X

STRATEGIC PLANNING

This category examines the extent to which quality consideration are taken into account in the planning process.

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19. My supervisor is actively engaged in removing barriers that keep us from making improvements.
1 2 3 4 5 X

20. Management regularly evaluates the degree to which TQM has been adopted throughout the organization.
1 2 3 4 5 X

21. My organizational element has both short and long-term goals for quality improvement.
1 2 3 4 5 X

22. Our quality improvement goals are designed to help the organization as a whole achieve its goals.
1 2 3 4 5 X

23. Our long-term quality improvement goals require us to make a fairly big improvement in order to attain those goals.
1 2 3 4 5 X

24. I personally participate in some part of the development of long-range or short-range plans.
1 2 3 4 5 X

25. Plans we make at my level are done with the goals of the organization's "big picture" plan in mind.
1 2 3 4 5 X

26. We use a formal process (it doesn't just happen by chance) to develop quality improvement goals.
1 2 3 4 5 X

27. Goals in our quality improvement plans are updated periodically based on the improvement results we have achieved so far.
1 2 3 4 5 X

28. Quality data and quality type information and analyses (such as customer requirements, process capabilities, supplier data, comparisons with leaders in the same field are used when we develop our plans.
1 2 3 4 5 X

29. Customers' needs and expectations are used quite a bit in our quality improvement planning. (You don't have to ask for something you "expect." Needs you make known.)
1 2 3 4 5 X

30. Improved relationships with our suppliers is a part of our quality improvement planning.
1 2 3 4 5 X

31. We compare ourselves with the best organizations (commercial or government) in a number of ways to determine what quality improvements are possible. How do we measure up to the best?
1 2 3 4 5 X

32. My organization strives to be better than the best organizations we compare ourselves to.
1 2 3 4 5 X

33. Resources we need (for example: new equipment, additional training, improvements in supplier quality) are first determined during our planning, and then these resources are made available to us to accomplish the plan.
1 2 3 4 5 X

34. The formal planning process we use is checked on a regular basis and corrective actions are taken to improve it.
1 2 3 4 5 X

FOCUS ON THE CUSTOMER

This category examines the organization's overall customer service systems, knowledge of the customer, responsiveness and ability to meet requirements and expectations.

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35. We have a way for our customers, both internal and external customers, to let us know what they think of our services or products.
1 2 3 4 5 X

36. Our customer feedback systems get information about what we consider to be the important characteristics of our services or products.
1 2 3 4 5 X

37. We can tell from those feedback systems which of our service/product characteristics the customer ranks as most important.
1 2 3 4 5 X

38. We have a system in place which gets the customer feedback we receive to groups or individuals that can do something about that feedback.
1 2 3 4 5 X

39. Processes (how we do things) that require improvement based on feedback from our customers are given priority for the improvement needed.
1 2 3 4 5 X

40. Customers can easily find out about all of the services or products we provide.
1 2 3 4 5 X

41. Customers have easy access to our people who are responsible for ensuring that the customer's concern or complaint is resolved.
1 2 3 4 5 X

42. My supervisor works hard to ensure that all of us are aware of our customer's needs and expectations.
1 2 3 4 5 X

43. My supervisor ensures that I understand and fulfill the customer service standards (courtesy and prompt action for example) established for dealing with our customers.
1 2 3 4 5 X

44. Those of us whose primary responsibility is contact with our customers are given the power to resolve customer problems without unnecessary coordination with others, supervisory approval, or other "red tape" type activities.
1 2 3 4 5 X

45. Employees that are responsible for customer contact are hired only if they display the type of attitude and behavior which should ensure good relations with our customers.
1 2 3 4 5 X

46. Employees that are responsible for customer contact are given training that helps them work well with our customers.
1 2 3 4 5 X

47. Goals for every service we provide are aimed at exceeding our customer's expectations.
1 2 3 4 5 X

48. We track progress toward those goals and use the information that shows how we are doing in our planning for the future.
1 2 3 4 5 X

49. In the past we have made changes in how we get customer feedback because those customers changed the way they think about our service/product.
1 2 3 4 5 X

50. The methods we use to monitor customer concerns and complaints are regularly reviewed to ensure that they give an accurate picture of those concerns and complaints.
1 2 3 4 5 X

EMPLOYEE TRAINING AND RECOGNITION

This category examines the organization's efforts to develop and utilize the full potential of the workforce for quality improvement and personal and organizational growth, as well as its efforts to use rewards and incentives to recognize employees who improve quality and productivity.

51. The training plan which supports our training needs for the quality improvement effort was well thought out before it was published.
1 2 3 4 5 X

52. That training plan is based on a very thorough analysis of our real training needs (ensures that training is provided for what is really needed.)
1 2 3 4 5 X

53. The organization regularly checks to see whether the quality training provided to us is really helping and improvements to that training are made when they need to be.
1 2 3 4 5 X

54. Training plans we use are a part of the organization's "big picture" plan to improve quality in the coming years.
1 2 3 4 5 X

55. There are plans in place to increase the effectiveness and productivity of the employees within my organizational element.
1 2 3 4 5 X

56. I have been given training in the "continuous improvement" philosophy.
1 2 3 4 5 X

57. Training is given to ensure that my technical job skills are continuously improved.
1 2 3 4 5 X

58. My organizational element ensures that all employees are provided with frequent updates on new developments in quality improvement techniques, methods and tools.
1 2 3 4 5 X

59. The organization says that human resource development is one of its top priorities.
1 2 3 4 5 X

[Delete #59]

60. The amount of time and other resources devoted to training clearly shows me that human resource development is a high priority.
1 2 3 4 5 X

[Delete #60]

61. We follow established guidelines and procedures within my part of the organization to evaluate and recognize employee contributions.
1 2 3 4 5 X

62. My supervisor personally and regularly recognizes individuals and teams that have made measurable contributions to the quality of our service/product.
1 2 3 4 5 X

63. We use what I consider to be an innovative (different but it works well) method of employee reward and recognition within my organizational element.
1 2 3 4 5 X

64. We celebrate small successes as much or more than we recognize grand accomplishments.
1 2 3 4 5 X

65. I have noticed that there has been an increase in the amount of recognition given to teams, as compared to individual recognition, in the past six months or so.
1 2 3 4 5 X

66. An important part of the recognition we get in my organizational element is the recognition that comes from fellow employees - pat on the back from a fellow worker or something similar.
1 2 3 4 5 X

EMPLOYEE EMPOWERMENT AND TEAMWORK

This category examines the effectiveness and thoroughness of employee involvement in Total Quality Management.

67. There are several ways in which I can get involved in quality improvement efforts within my organizational element - like participation in Quality Circles, on Process Action Teams, through the suggestion program, etc.

1 2 3 4 5 X

68. Management supports employee involvement, contribution and teamwork.

1 2 3 4 5 X

69. A feeling of trust and respect exists between managers/supervisors and other employees where I work.

1 2 3 4 5 X

70. People from other work areas participate in team quality improvement efforts within my area and we participate on teams they lead.

1 2 3 4 5 X

71. Internal "customer and suppliers" participate in our team activities.

1 2 3 4 5 X

72. Customers and suppliers from outside the organization participate in our team activities.

1 2 3 4 5 X

73. Various things that make my job site a nice place to work have shown a steady improvement over the past six months or so.

1 2 3 4 5 X

74. Management has given me more authority to make decisions and act on those decisions with regard to needed improvements in the processes I'm responsible for.

1 2 3 4 5 X

[Delete #74]

75. If my authority to act has increased, this has led to a greater feeling of responsibility for that process and a sense of ownership for quality improvement on my part.
1 2 3 4 5 X

[Delete #75]

76. Management and the union work together to promote quality improvement practices.
1 2 3 4 5 X

[Delete #76]

77. There has been a reduction in the layers of management (bosses with more bosses) within my organizational element.
1 2 3 4 5 X

[Delete #77]

78. Power, rewards, information, and knowledge are being moved downward in the organization - from top to middle managers and from middle managers to employees.
1 2 3 4 5 X

79. If you have been given more power to take what you believe to be the best action, the quality of services/products has also improved as a direct result of that increased power to act.
1 2 3 4 5 X

[Delete #79]

80. The organization uses a formal survey process (similar to the survey you're taking now) to determine employee satisfaction with various aspects of their jobs.
1 2 3 4 5 X

81. I can tell that action is taken to improve the organizational environment and human resources practices based on responses to the employee satisfaction surveys we take.
1 2 3 4 5 X

MEASUREMENT AND ANALYSIS

This category examines the scope, validity, use, and management of data and information that underlie the organization's TQM system and how the data are used to improve processes, products and services.

82. Within my organizational element we collect quality and timeliness information on all our services/products from our external customers and suppliers.
1 2 3 4 5 X

83. We also collect the same type of information from internal customers for all the important services/products we provide them.
1 2 3 4 5 X

84. I have access to a large amount of quality, timeliness, efficiency and effectiveness information/data on the processes and services/products for which I'm responsible or work with.
1 2 3 4 5 X

85. The data with which I work regarding our processes and services/products is complete, timely, and accurate and can be used to really tell how we're doing.
1 2 3 4 5 X

86. I, or someone else, routinely checks to make sure the data being used is correct (it fairly represents the process/service/product characteristic being measured).
1 2 3 4 5 X

87. I often use measurement of various kinds to identify problems.
1 2 3 4 5 X

88. I often use some type of quantitative analysis to identify solutions to problems I work on. (For example, I track the number of actions or tasks accomplished correctly to determine if the process is working well rather than making the same judgement because other employees have not complained about it - a qualitative method).
1 2 3 4 5 X

89. When a process or procedure is modified or a new one started we perform an assessment of the process to see if the change or new procedure is producing the results we expected.
1 2 3 4 5 X

90. Work processes used within my area use what I consider to be advanced technology and modern analysis tools.
1 2 3 4 5 X

QUALITY ASSURANCE

This category examines the systematic approaches used by the organization for total quality control of products and services, and the integration of quality control with continuous quality improvement.

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91. Services/products and processes for which my organizational element is responsible are designed, reviewed, verified, and controlled to meet or exceed our customer's needs or expectations.
1 2 3 4 5 X

92. We routinely use analytical tools (for example, design of experiments or some other form of trial and error experimentation) to make the processes with which we work the best they can be.
1 2 3 4 5 X

93. The methods we use to improve the quality of our services/products are designed to prevent errors rather than detect errors after they have happened.
1 2 3 4 5 X

94. We not only look at the quality of our services/products but we regularly take a hard look at the systems and procedures that help us maintain the quality of our services/products and use what we find to improve those same quality assurance systems.
1 2 3 4 5 X

95. The procedures we use to maintain the quality of our services or products are changed to keep up with changes in technology, new quality assurance practices, and the improved quality of our services/products and processes.
1 2 3 4 5 X

96. Within my organizational element we use established methods/procedures to verify that our quality requirements are met by all our external suppliers.
1 2 3 4 5 X

97. If we have a choice when selecting a supplier of products or services, we use quality as the key factor in choosing a supplier.
1 2 3 4 5 X

98. We have established and use measures of quality for all the services/products we provide to others within the organization - doesn't get out the door unless it measures up.
1 2 3 4 5 X

QUALITY AND PRODUCTIVITY IMPROVEMENT RESULTS

This category examines the measurable and verifiable results of the organization's TQM practices.

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99. I know what the most important indicators are for my organization's mission accomplishment - how we know we're getting the job done.
1 2 3 4 5 X

100. The most significant indicators of my organizational element's mission accomplishment have shown exceptionally good results over the past couple of years.
1 2 3 4 5 X

101. Our customers have noted the improvement in our services/products during each of the last couple of years.
1 2 3 4 5 X

102. I am aware of the results we have achieved regarding the quality of our services/products.
1 2 3 4 5 X

103. The results we have achieved with regard to the quality and timeliness of our services/products have been excellent across the board.
1 2 3 4 5 X

104. The results we have achieved have been primarily due to our overall quality improvement (TQM) efforts.
1 2 3 4 5 X

105. The quality improvement and productivity results we have achieved have contributed significantly to our ability to accomplish our mission very well.
1 2 3 4 5 X

106. The quality performance of the external suppliers who provide my organization with services or products has continuously improved over the past several years.
1 2 3 4 5 X

107. The quality performance of our internal suppliers (someone in another organizational element) has continuously improved over the past several years.
1 2 3 4 5 X

THAT'S IT. THANK YOU AGAIN.

Vita

Marshall Bailey was born on July 20, 1944 in Alexandria, Virginia, and is an American citizen. He graduated from Groveton High School in Fairfax County, Virginia, in 1962. Subsequently he received his Bachelor of Science Degree in Business from American University in Washington, D.C., in 1968 and has been employed in various logistics positions in the Defense Logistics Agency for 25 years. He received a Master of Business Administration Degree in 1972 and a Master in Public Administration Degree in 1988 from George Washington University and is a 1988 graduate of the Industrial College of the Armed Forces. In the fall of 1990, he was a senior executive fellow at Harvard University's John F. Kennedy School of Government. Mr. Bailey currently serves as Chief of the Planning Division, DLA Headquarters, and is an adjunct professor at George Mason University.