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THESIS

THE EFFECT OF COMPUTERIZATION ON PRODUCTION
IN ADMINISTRATIVE OFFICES:
A COMPARATIVE ANALYSIS

by

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September 1990

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The Effect of Computerization on Production in Administrative Offices: A Comparative Analysis

by

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of the requirements for the degree of

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ABSTRACT

Using a one-group pretest/posttest pre-experimental research design and data collected by questionnaire and taken from archival sources, this study found that while an organization's outputs increased from 28% to 32% after computer support of clerical tasks, labor inputs declined 21%. The findings here support the notion that office automation and word processing in particular, enhanced productivity. These findings do not support a growing concern among investors in office automation that it is counterproductive.

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I. INTRODUCTION

Steve Crummey (1988), of Lotus Development Corporation, sized up the current white collar productivity dilemma:

> "In 1976, at the dawn of the personal computer age, corporations invested $100 million in PC (personal computer) technology. Ten years later in 1986, they spent $46 billion on PCs--and nobody really knows what those dollars are buying." (Crummey, 1988, pp. 1-6)

Office automation has arrived. The reality today is that office automation has largely been synonymous with word processing and personal computers. Word processing has often been viewed as the major application that motivated the introduction of computer-based equipment into the office. Office technology has changed and with it so has traditional office functions. Automation of traditional office functions is typically undertaken to reduce labor costs and to improve quality in communication and text preparation. With the computerization of office functions we have an added byproduct, in that automation is creating new tasks for the office: for example, there is now a new need for human resource planning via human resource information systems.

The goal of this study is to analyze, measure and answer the question as to whether the introduction of computerization has had any effect on productivity in the academic departmental offices at the Naval Postgraduate School (NPS).

> The mission of the Naval Postgraduate School is to conduct and direct the advanced education of commissioned officers and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval service. The mission establishes the continuing combined requirements of excellence in quality of academic programs and responsiveness to change in addition to innovation in technology and management in the Navy. (NPS CATALOG, 1989, pp. 6)

The administrative offices play ar integral role in the accomplishment of this mission.

The widespread introduction of personal computers into the academic departmental offices at NPS in the fall of 1985 boasts of increased productivity, efficiency and effectiveness. To be more specific, the goal is to empirically test these claims. In doing this, the industrial engineering definition of productivity will be used: the ratio of output divided by input. It can be seen from this definition that as a measure of output increases, or a measure of the input required decreases, or a combination of the two conditions occurs simultaneously, the productivity ratio becomes larger.

In this case, the inputs studied are the number of clerical people, civil service grade structure and the number of faculty. The outputs are the number of grades and the number of graduates. The number of courses taught for the academic year is used as a measure of effectiveness, an indicator of improvement in the quality of the degree requirement process. The effectiveness measurement is defined as the relationship between the number of courses taught and the number of graduates for the academic year.

The study does what few productivity studies have done, it looks at productivity from the industrial engineering model of productivity and it also looks at the organizational behavior issues of productivity. Archival data is used to capture empirical evidence of the affects of office automation before and after the implementation of personal computers in the departmental offices. The following is a summary of what we study:

- The use of pre-experimental design in data collection and hypothesis testing,
- The effect that the introduction of computers into the office workplace has on productivity,
- Empirical evidence of the social impact of computerization, using archival and current data,
- The affect that the changes in number of faculty and number of clerical staff has on the measurement of effectiveness.

II. LITERATURE REVIEW

After spending billions of dollars on automating the offices of white collar workers, organizations find that they must now analyze the computer companies' claims of increased productivity. Computer industry literature such as PC World, Computerworld and Byte reveal that no longer is computerization automatically synonymous with productivity. Organizations such as General Telephone and Electronics (GTE) and Westinghouse are questioning their definitions of productivity in an attempt to provide insight into its measurement.

A. WHAT IS NOT HERE

Several aspects of productivity measurement are not discussed here. First, little in the academic literature of the study of information systems that could be found dealt with productivity measurement. Secondly, the measurement of productivity of knowledge workers (professional, technical, managers and administrators) is not the subject of this study. Rather the focus here is on the productivity of clerical workers.

B. BASIC INPUT/OUTPUT MEASUREMENT

The definition of productivity embraced by this study is a ratio of output to input. This definition can be converted to output per worker per hour, output per unit of material or output per unit of any other physical, measurable or countable unit that describes what an organization does to achieve its goal. (Christopher,1986,pp.1-8) It is a definition under siege.

In defining productivity, Bain (1982) contends that productivity is not a measure of output produced.(Bain,1982, pp.16-27) He says instead that it is a measure of how well resources are combined to accomplish specific results. He explains that a concept of productivity must account for an interplay between factors such as quality, availability of materials, scale of operations, the rate of capacity, the rate of capacity utilization, the attitude and skill level of the work force, and the motivation and effectiveness of management. The way in which these factors interrelate has an important bearing on the resulting productivity.

C. IMMEASURABLE PRODUCTIVITY

Measuring white collar productivity resulting from automation is considered fruitless because it is believed to be difficult to quantify. Borko (1988) cites obstacles such as the difficulty of defining the value and the unit of measure to be used for the output. (Borko,1983, pp.202-212) Goldfield (1983) states that it is difficult to measure the increased speed, accuracy and completeness of reports. (Goldfield,1983,pp. 154-172) Cook (1988) sees difficulty in measuring improved customer service, work quality, timely information needed for decision mäking and improved employee morale as a result of office automation (OA). (Cook,1988,pp.31-32) In addition, they found it difficult to measure the increased productivity of repetitive and routine tasks such as manual recalculation, redrafting and editing, and filing and retrieving of information. Borko holds that the work done by white collar workers may not show results until several years later.

Perry Schwartz, president of Computer Research Associates, Inc., a software development and consulting firm, claims that with an absence of headcount reduction, there is no easy way to assess improvements in white collar productivity. (Schwartz,1987,47-52) He said that this does not mean that there is no payoff but that measuring the results requires more than just tracing improvements in white collar work to a bottom line. He stated that the output of white collar activity is frequently intangible, uncountable and not easily related to revenue. Therefore, the numbers to make the calculations and build a model to measure productivity are often unavailable.

D. SUBSTITUTING ATTITUDE SURVEYS FOR INPUT/OUTPUT

Another dissent from input/output quantification of productivity argues that quantifying productivity is unnecessary. Instead, Parsons (1987) implies that one method of gauging productivity is to substitute opinion surveys for input/output analysis. Parsons holds that if a worker feels like he is more productive using a computer, then he probably is. Weatherbe (1987) says that a common mistake made in measuring productivity is focusing solely on labor reduction and not value added to the work. He asserts that job satisfaction is a key indicator of productivity.

E. VARIETIES OF INPUT/OUTPUT ANALYSIS

Sink (1985) summarizes input/output definitions of productivity measurement. He gives the following ways in which productivity can be considered improved:

- Output increases while input decreases,
- Output increases while input remains constant,
- Output increases while input increases at a slower rate,
- Output remains constant while input decreases,
- Output decreases while input decreases at a more rapid rate.

Sink (1985) defines productivity measurement as "the selection of physical, temporal, and perceptual measures for both input variables and output variables and the development of a ratio of output measure(s) to input measure(s)." (Sink, 1985, p. 25)

Sink (1985) says there are two basic categories of pure productivity measures. The first are static productivity ratios in which measures of output are divided by measures of input for a given period of time. The second category are dynamic productivity indexes which give a static productivity ratio at some previous period in time. There are three types of productivity measures within each category:

- The partial factor measure which uses one class of input such as labor or capital,
- the multifactor measure which uses more than one class and,
- the total measure which uses all classes of inputs.

Each of the three types represents a ratio of output to input. However, they differ in terms of how much input is captured in the denominator of the equation.

Sink (1985) defined productivity as the relationship between quantities of outputs from a system and quantities of inputs into that same system. Dissecting this definition, it can be seen that the numerator contains an aspect of effective-ness in the way of quality and quantity. While on the other hand, the denominator contains an aspect of efficiency in the way the resources are actually consumed.

Sink (1985) states that a measurement system should primarily comprise ratios of output measures and input measures and indexes. The measures of output and input could be specific measures of quantities of any resource used and of quantities of any good or service produced as output.

F. API: LOCALIZED APPLICATION OF INPUT/OUTPUT

Bolte (1988), realized that there was very little practical information available on how to measure and improve administrative productivity and quantitatively control headcount growth. (Bolte,1988,pp.47-52) As a result, he created a continuous quantitative system for Intel Corporation that focused on reducing headcount and on improving administrative productivity. He wanted to dispel the myth that white collar productivity is immeasurable.

Bolte's fi--st step was to define the products of white collar workers by working with administrative organizations. He used the classic definition of productivity by dividing physical units of work output by the number of employee hours required to produce it. He did not use dollars of sales, revenues, cost of payroll, or other financial measures of output or input because he says that his straightforward definition is "understandable, controllable, and workable at the first-time management level, which is where productivity improvements must take place." (Bolte, 1988, p.47)

Bolte next identified those indicators that directly affected inputs and outputs. First he had each department establish its own quantity and quality goals. Second, the quantity and quality indicators were compared to other units that do the same work. Third, he determined the ratio of direct labor to indirect labor (supervisors) within an administrative organization.

Bolte viewed administrative areas as 'paper processing factories' with specific inputs and required outputs so that production line techniques could be used to measure productivity and a base-line index could be calculated. (Bolte, 1988, p. 48) He developed an Administrative Productivity Indicator (AP1) which can be used where a single output can be defined as the measure of the performance by an organization. The API is simply work output divided by labor hours input and is expressed in hours per unit (HPU). Its output units must be a physical, countable entity which shows that an organization does what it was organized to do. The input is the hours of work paid for by the organization, minus vacation, absenteeism, and sick leave, during the time in which the output was produced.

The API provides a measure of changes in productivity over time. A beginning HPU is used to determine future productivity trends. After establishing an API, and, in an effort to reduce the base HPU, the next step is to simplify work tasks, apply workload management techniques, and to monitor the API. This will eventually lead to a reduction in headcount, and thus, indicating an improvement in productivity.

G. MOPI: MULTIPLE OUTPUT PRODUCTIVITY INDICATOR

Christopher (1986) includes the Multiple Output Productivity Indicator (MOPI) as a general measure of productivity. This measure, like the API, has been applied in administrative organizations to monitor and improve productivity performance. Unlike an API, a MOPI is used when a single output measure is not considered adequate and several outputs are defined as representing the purpose of a unit. Some of these outputs may be quantifiable while others require subjective appraisal. In general, to calculate the MOPI, an organization identifies outputs that identify their successful achievement purpose and at the same time can be measured. They then establish a rating scale technique that will ultimately be used to produce a single overall MOPI.

H. CONSENSUS MODEL: LOCALIZED ADAPTATION OF INPUT/OUTPUT

Schwartz (1987) discusses several models that have been used to analyze cost-benefit and measure productivity when direct output models cannot be developed or are infeasible. The Consensus Model was used by General Telephone and Electronics. It projects benefits by seeking agreement among managers on the range of the payoff expected from the introduction of a specific computer technology. Managers are asked to estimate the value of a task and share their estimates and reasoning. After repeated estimates and sharing, a consensus is formed on the dollar value of the production task. The assumption is that an increase in output yields an increase in profit, and an increase in profit is an indicator of increased productivity. It should be noted that these estimates are basically subjective and that this model is used in situations where there is limited quantitative basis for making estimates of value.

I. COST DISPLACEMENT MODEL

In the Cost Displacement Model, inputs can be exactly determined but outputs cannot be measured. (Schwartz, 1987) This model assumes that outputs remain at the current level. Schwartz explains that if outputs actually do remain the same, and inputs such as head counts are cut, then it can be inferred that productivity (output divided by input) has increased, although the absolute amount of the increase cannot be determined.

The Cost Displacement Model requires only that real labor cuts be made or actual equipment savings be achieved. One drawback is that without a real cut in head count or equipment costs, Cost Displacement Models are inappropriate.

J. INFERRED INPUT MODEL

Inferred input models (Schwartz, 1987) are the most frequently used cost-benefit analysis models for information systems. They use projected increases in efficiency and effectiveness among workers rather than actual, verified cuts in labor or head count. In general, these projections are based on the development of a task/time matrix that jointly reflects an amount of time workers devote to activities and the time-saving impact of computer technology. IBM has the most common model of a task/time matrix developed by Booz, Allen, Hamilton (1977). Office professionals were asked to estimate the time they spent in specific activities, such as reading, typing and talking on the phone. The benefits were then quantified by multiplying the time savings by salary.

This attempt by Booz, Allen, Hamilton in the 1970's was the earliest attempt to develop a method of quantifying the benefits of information technology. Their time-savings/time-salary (TSTS) model is simple to use but flawed, says Schwartz (1987). Poppel (1982) holds that the flaw in the TSTS model is that it counts time saved on lower value activities as being equivalent to savings on higher value activities. A TSTS cannot distinguish between making a white collar worker a better manager or making him or her a better clerk.

K. WORK VALUE ANALYSIS

Schwartz (1987) and his colleagues have developed a hybrid model called the Work Value Analysis (WVA). WVA evaluates the payoff from computer technology as it affects the effectiveness and efficiency of white collar workers. Schwartz defines efficiency not as input/output but rather as doing things right. He argues that efficiency refers to an additional amount of work accomplished in the same amount of time. He refers to effectiveness as doing the right things. He says that it relates to the amount of time workers spend doing principal activities rather than support activities.

WVA recognizes that not all activities performed by workers directly advance the purpose of an organization. Therefore, the model accounts for two types of white collar productivity improvements: - Technology can shorten the amount of time required to complete a given task or it can allow more of the task to be completed in the same amount of time, Technology can be the basis for a shift in a work pattern that allows more time to be spent on primary activities and less on lower valued activities such as support, clerical, and lost time. (Schwartz, 1987)

Schwartz identifies the second type of productivity improvement as effectiveness. It is this shift in the work profile that he says produces the most valuable productivity improvement. Using wages as a benchmark, WVA determines the dollar worth of changes in a work pattern. The full model is based on a linear system of constraints requiring a set of simultaneous equations, one for each job level.

Schwartz asserts that a strength of WVA is that it permits objective determination of the productivity payoff when external dollar criteria, relating to profit or value of work, other than salary, <u>cannot</u> be measured or inferred. However, WVA requires considerable effort, such as time logging, to objectively determine work activity profiles.

L. NPMM: NORMATIVE PRODUCTIVITY MEASUREMENT METHODOLOGY

The normative productivity measurement methodology is a result of a two year study of Administrative Computing and Information Services. (Morris and Smith, 1976) It uses a ratio of output to input and a nominal group technique (NGT). Sink (1985) describes NPMM as, "a process by which measures (surrogates), ratios, and/or indexes of productivity can be participatively identified and developed into a measurement, evaluation, control, planning and improvement system." (Sink, 1985, p. 139).

NPMM uses consensus measures of productivity. It involves the execution of NGT to generate a prioritized list of measures for each specified unit of analysis. From this information, a workable productivity measurement system is drafted based on the goals of the organization. The results of this draft are then briefed, reviewed, and discussed with the participants to obtain feedback prior to implementation of the final productivity measurement system. Once the draft has been approved by the organization, a productivity measurement system is integrated into the organizations already existing performance measurements. The final stage requires continuous monitoring and feedback based on the initial calculated ratios.

M. MFPMM: MULTIFACTOR PRODUCTIVITY MEASUREMENT

Multifactor Productivity Measurement is called a total factor productivity model. It is used by the American Productivity Center. MFPMM is a consultative, data base/ accounting system-oriented method. Its primary source of data is not people but system documentation. Sink (1985) states that it is diagnostic in a passive, absolute, and objective sense as opposed to an active, relative, and subjective sense. (Sink, 1985, pp.145) It is a self-contained decision support system that operates with organizational system data on prices/costs and quantities of output and input resources. MFPP is a complicated model based on Weighted Performance Indexes and their effects on bottom line profit.

MFPP is used because it:

- Obtains an overall, integrated measure of productivity for the firm,
- Accesses and evaluates bottom-line impacts on profitability as a result of productivity shifts,
- Tracks the results of specific productivity improvement efforts.
- Assists with setting productivity objectives and general strategic planning marketing efforts, cost management, and staffing.

Sink (1985) also calls MFPMM an objective matrix because it provides a mechanism for developing an aggregate productivity index. It allows for the aggregation and analysis of performance against a variety of criteria.

This methodology can be seen in Felix and Riggs (1988) description of the Oregon Productivity Center's Objective Matrix and Rowe's (1981) description of the Westinghouse technique of measuring white collar productivity. (Felix, 1983, pp.386-392) Employees of a department participate in a brainstorming exercise. They develop a list of priorities. (Rowe, 1981, pp.42-47) A composite index is calculated for a department by weighting it according to criteria set by management and combining the values into a composite value.

This composite index is used as a basis for measuring the productivity of a specific unit against itself over time. Once established, management has a system for monitoring white collar productivity. The MFPMM technique is relatively simple and useful for quantifying what has heretofore been regarded as unquantifiable.

N. PRODUCTIVITY MAP

Pacesetter Software has developed a program, called Productivity Map, that purports to measure productivity goals. (Hierl, 1988) Defining productivity as the ratio of goods produced to resources consumed, the program works with measures of productivity such as quantity, quality, timeliness and cost.

Productivity Map uses a survey technique to assess the efficiency of office workers in fulfilling the organizational objectives. It begins by asking managers to define the department's mission. Then it asks workers to rate the importance of the products, services and delivery performance of their departments. Lastly, customers are asked similar questions. When all data are collected the results are displayed on graphs that emphasize quality and timeliness rather than quantitative measures.

O. BOSTI

Buffalo Organization for Social and Technological Innovation (BOSTl) measures the effects of work environment on productivity and quality of work life. (Brill, 1988) They show how certain facets of the office environment affect job satisfaction and performance. BOSTI believes that productivity can be improved and measured as a result of improvements in office surroundings.

P. WHAT WAS FOUND

Having surveyed the literature, the following was found:

- An assumption that computerization of office work always leads to productivity improvement,
- No record of documented measurement of productivity improvement resulting from computerization of office work,
- The beginnings of questioning of the Productivity Assumption that justifies spending on computerization,
- A movement to supplant input/output efficiency definition of productivity with a survey questionnaire assessment of job satisfaction,

- A view of productivity measurement as an adjunct of productivity improvement programs,
- No before/after experimental or quasi-experimental research designs in the study of office automation productivity.

Q. THE GOAL

The aim is to:

- Establish an empirical benchmark for productivity gains from the introduction of computers in the departmental offices,
- Base that benchmark on a before/after experimental design,
- Base a study on hard data measures of an input/output definition of productivity,
- Conduct an office automation productivity study independent of the ameliorative enthusiasms and biasing politics of productivity improvement programs,
- Provide a framework for examining comparative studies of office automation productivity.

III. METHODOLOGY

A. CONDUCT OF THE STUDY

1. Prelude to the Sample

The primary investigator originally intended to sample data from all offices located at NPS. The preliminary data gathering effort was insurmountable. The selection of the academic offices resulted from the search for an organization or part thereof, which would enable us to address the question, "how does the introduction of computer-supported automation affect productivity?"

At the start of this study, in the summer of 1989, data was in the process of being collected to substantiate the premise that productivity is indeed improved with the introduction of computers when it was realized that bias would be introduced and taint the output. The collected data was discarded and a new slant on data gathering and collection was introduced.

During discussions, interviews and the administering of the questionnaires, employees were observed to be satisfied with their jobs. There were many helpful comments and the most common request was to have the required registrar reports be standardized. This was a good starting point for this study.

Prior to the widespread proliferation of personal computers in the offices in 1985, office personnel handled their reporting manually or used the mainframe which was too slow and time-consuming.

Separate meetings were held preceding the collection of data, between the investigator and the personnel in the administrative offices. The purpose of this initial meeting was twofold. First, to build a relationship that would reassure the personnel that the data collection would be done in a manner to have little or no impact on their operations. Second, to begin evaluating the measures of performance that could be used in a study of productivity. Additionally, personnel were assured that information collected was in support of a thesis study.

2. **Environment Described**

Campus-wide usage made of micro-computers as stand-alone development tools or as processing elements imbedded in more complex systems is encouraged at NPS.

NPS has incorporated the use of computers in its curricula consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The effect spans a wide spectrum of influence in that it could be the subtle difference of the better appearance and more timely submission of reports and projects over the now antiquated typewriter, the replacement of office equipment with new, updated state of the art automated machines or it may be even more significant, such as the installation of a new mainframe or another novel computer system.

The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. This is substantiated by the fact that all NPS graduate students take at least one course involved with the use of computers. The only curriculum at NPS that did not have a computer course requirement in its typical course of study was that of National Security Affairs (NSA), as verified in the NPS course catalog, however the volume of reports, projects and presentations that are required for degree completion in the NSA curriculum makes it advantageous and mandatory for the candidate to acquire this knowledge. Graduate students are introduced to the computer early in their curriculum at NPS, normally in the refresher or first quarter of studies as outlined in the course catalog and are encouraged to use the computer in subsequent course work and research.

3. Scope of Study

The scope of the thesis refers to the units of analysis developed by the measurement system of productivity. The scope can range from the macroscopic (national, industry) to the very microscopic, (for example, workgroup). The scope here will be the academic departmental offices.

This analysis is being conducted with some degree of prejudice aided by limited exposure in the Management Information System (MIS) curricula. The addition of personal computers to the activities of the departmental offices is a fait accompli. By observation, inquiry and interviews, the deduction is made that most personnel within the offices today do not have the wherewithal to produce a report manually or to accomplish assigned tasks in any other mode of operation than with the use of a personal computer. It is with great conviction that the data collected will be analyzed to determine the answers posed by this thesis. Research in the area of automation in the office work-place has pointed out that there is both an increasing annual cost of paper and far too numerous occurrences of report duplication which ultimately lead to distribution problems, lateness and loss of revenue. Late reports contain late data which usually are of no value to the user and as a consequence subsequently has to be discarded.

4. The Questionnaire

The questionnaire consists of thirty five questions. There are no questions that will identify the respondent. The raw data is being held by the investigator. The purpose of the survey was explained to all interviewees before the questionnaire was administered and the investigator was available to provide assistance with its completion. The questionnaire requested data on the respondent's title in the office,the department and the telephone extension for statistical purposes only. Questions were asked to determine the amount and type of automated equipment present in the offices, the usage and preference of products when given a choice. The last question was provided for the respondent to give any additional comments, suggestions and /or opinions, to aid in and add to, in deriving the answers to the thesis. A sample questionnaire is provided as Appendix A.

5. **Analysis**

The analysis used was one of comparison, using the data collected of the pre and post periods of computerization at NPS departmental offices.

6. **Collection of data**

The faculty at NPS performs its graduate education functions in an organizational arrangement that includes eleven academic departments and three interdisciplinary academic groups, each headed by a designated chairman. Departmental offices make the integral connection between the student and academia. Reports, administrative functions such as orientation schedules, registration, liaison activities and numerous other activities must be accomplished for the school organization to continue smoothly. A statement of desired outcomes is most critical in the formulation of the plan that will be used to validate the research questions posed. Vision exercised through clear thought as to what is to be accomplished was addressed early in the quest for data. The benefits seen to arise from this measurement of productivity was the assistance in efficient conduct of operations as provided through programs that enhance productivity along with the improvement of internal company climate and assistance in coping with the external environment using forecasting, trends and industry comparison.

The collection of data began in Herrmann Hall with initial visits to the Registrar, Scheduler, Personal Property, Civilian Personnel and the Mezzanine offices. Additional data were collected from the eleven academic departmental offices which are listed in Appendix B.

Currently the departmental offices are staffed with thirty people. The staff consists predominately of civilian women.

B. THE SAMPLE

The hypothesis under consideration is whether the implementation of the personal computer and other automated tools in the eleven academic offices at NPS has an effect on productivity/efficiency. The sample population is limited to the staff of the academic offices. The belief is that there should be a significant increase in productivity/efficiency in the offices. Personal computers were introduced en masse at NPS in the curricular offices in the summer of 1985 and to the administrative offices in the fall of 1985. To measure the change of productivity/efficiency in the departmental offices, the periods 1984 and 1988 are examined and compared.

C. DATA COLLECTION DESIGN

Archival data were gathered for both 1984 and 1988 from the records maintained within the boundaries of the NPS campus. With the introduction of FOCUS as the campus software program, records prior to 1986 were not currently converted to fit the program and pertinent and vital information had to be manually retrieved.

1. Before Computer Installation

Productivity is not synonymous with performance. Productivity is of vital importance to the organization system performance and it is appropriate to measure it. However productivity measurement alone is not sufficient to measure , evaluate, control and improve performance. NPS curricula departments have adopted an adequate amount of innovation in the office workplace to warrant an examination of the possible change in productivity. They have incorporated such items as personal microcomputers, facsimile machines, photocopiers and multifaceted telephone systems. Managers, supervisors, people in authority must measure in order to manage and improve productivity. Productivity measurement and evaluation can tell when the system, department, division is ineffective, inefficient and when there is a quality problem. Productivity measurement in some cases can point the right direction in terms of control and improvement. The data collected were limited to the following categories for academic year 1984 are as follows:

- Courses taught
- Faculty
- Grades awarded
- Graduate degrees awarded
- Clerical staff

2. **After Computer Installation**

Selection of data for 1988 were of the same general categories as collected in 1984.

3. **Additional Measures**

Figure 1 represents the interaction of inputs and outputs, both before and after the installation of computers at the offices. Testing null hypotheses represents a method in which to determine if data sampled from the before/after periods are statistically the same. If the data are statistically indistinguishable, then the null hypothesis is confirmed. If the null hypothesis is rejected, acceptance of the alternative hypothesis means that the before/after difference in the means is greater than a merely chance occurrence. No statistical testing is provided within this thesis.

	BEFORE AUTOMATION	AFTER AUTOMATION
ACADEMIC YEAR	1984	1988
INPUTS	STAFF SIZE FACULTY SIZE	STAFF SIZE FACULTY SIZE
OUTPUTS	GRADES AWARDED GRADUATES	GRADES AWARDED GRADUATES

Figure 1. Productivity Matrix

D. INSTRUMENTATION

1. Inputs

Several inputs were considered appropriate to study the effect of computerization on productivity in administrative offices. They included :

- the percentage change in clerical staff with the introduction of computers
- the percentage change in faculty with the introduction of computers

A common way in which a change in productivity can be measured is by analysis of the ratio of inputs to outputs. Various inputs into a system or process are required to produce a given output. If the system or process is changed so as to require fewer input resources, or to produce a greater quantity of output, productivity is enhanced. Changes in input or output occur singly or in combination, frequently producing a synergistic increase in productivity.

2. Output

a. Quality

Outputs of the study were measured in two different ways:

- The before/after number of grades awarded or volume of work performed, and
- The before/after number of graduates or quality of work performed.

b. Quantity

The volume of work is represented by the number of courses taught, graduate degrees awarded and grades submitted. This production of work is inclusive of all courses regardless of course level.

E. ANALYSIS STRATEGY

- The pool of employees of the academic offices was not identical one-for-one, between the before and after periods. There was normal turnover of personnel as well as a restructuring of job descriptions across the time periods studied. Associated changes in GS structure between the two periods also took place.
- Employees were not matched one-for-one between the before/after periods. Information on employees regarding age, sex, educational level, and experience level was not collected.

F. BARRIERS TO MOST RECENT DATA COLLECTION EFFORT

The effort to gather data for this thesis did not go without its fair share of hurdles. In an effort to help anyone conducting a similar venture the following is provided.

- Information is scattered throughout various offices on the NPS campus
- Difficult to coordinate convenient times to meet knowledgeable personnel
- Information is difficult to access
- Information was out of date
- Information did not exist
- Information available, but too much effort would be expended in retrieving it from the responsible party
- Personnel responsible for maintaining the information was not doing so
- NO information is available before 1987 because of the conversion effort to FOCUS
- People had been contacted before and were not responsive to being contacted again.

IV FINDINGS

The findings are provided in the following tables for the academic years 1984 and 1988. Also, graphs are presented throughout this discussion in an attempt to visually show the changes that transpired between the periods. Based on the results of data collected in this thesis, the investigator concludes that productivity has improved.

The following data totals and percentage changes are summarized in Table I from the data collected before and after the installation of computers.

TABLE I

PRODUCTIVITY MATRIX WITH CHANGES

CATEGORY	BEFORE COMPUTERIZATION	AFTER COMPUTERIZATION	CHANGE
COURSES TAUGHT	1376	2038	+32%
FACULTY	351	313	-11%
GRADES AWARDED	24238	24109	-01%
GRADUATES	759	1059	+28%
CLERICAL WORKERS	43	34	-21%

As depicted from the data gathered, Table 1 reflects that outputs have increased greater than inputs. Figure 2 is provided giving a graphical representation of the relationship between the periods for the five statistics.

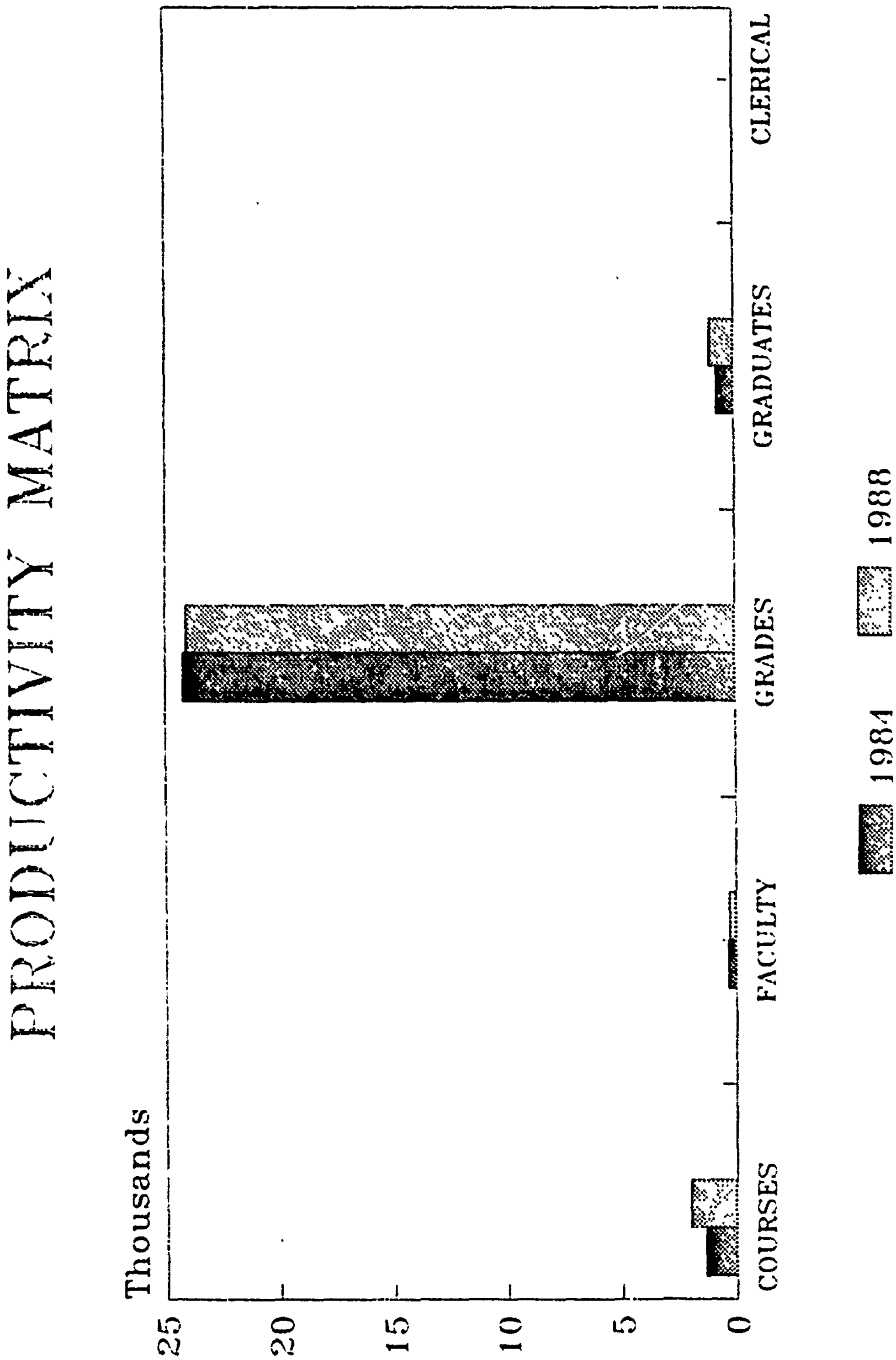

Figure 2. Productivity Matrix with Data Totals

It is difficult to measure productivity in an office environment. One cannot simply count the number of products produced daily or determine quality by simple observation. One can measure , for example, how many letters documents or reports of a certain quality are produced in a certain time period. Observation and inquiries have shown that the number of documents produced increases only slightly because more iterations are made and routine office correspondence typically does show better turnaround times after word processing systems are introduced.

A. GRADES AWARDED

Academic years 1984 and 1988 grades awarded by course level within departments, cumulative departmental grades awarded and the designation for the curricula which are included in the respective departments are provided in support of the output: workload. Grades awarded by course level for 1984 and 1988 are presented in Appendix C. Figure 3 is presented to show the relationship between total grades awarded by department between observed periods.

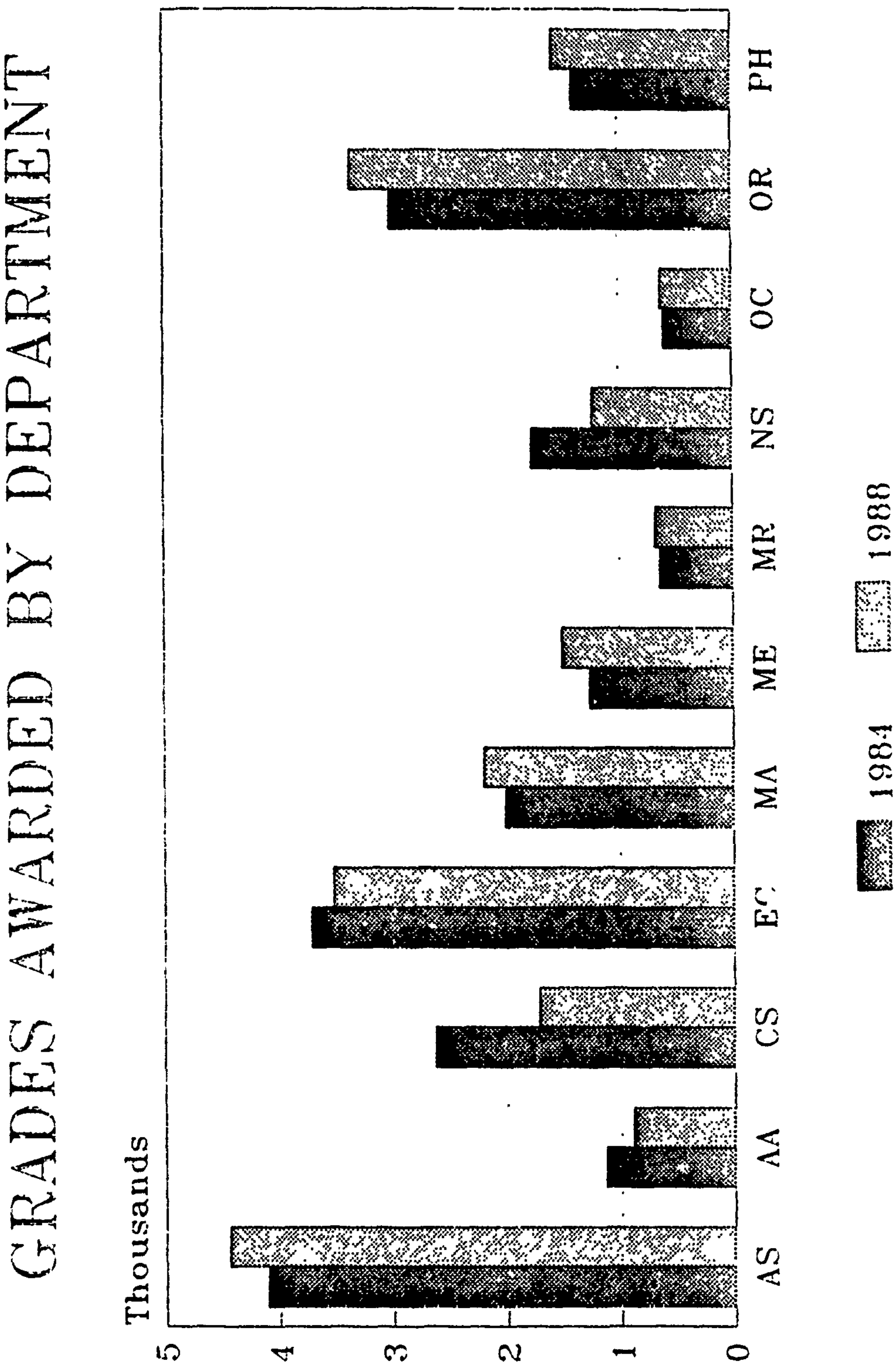

Figure 3. Grades awarded by department

The school total grades shown in table 2 are reflective of the total number of courses given during the academic years of 1984 and 1988. As is readily apparent, the academic year of 1984 had more grades awarded than that of 1988. However, it is important to note all course grades are incorporated in the totals given. When only the totals for the eleven departments are tabulated there is only a two percentage point change in the periods observed.

Course levels as explained in any NPS course catalog are as follows:

0001-0999	No credit
1000-1999	Lower division credit
2000-2999	Upper division credit
3000-3999	Upper division/graduate credit
4000-4999	Graduate credit

TABLE 2

SCHOOL TOTAL GRADE DISTRIBUTION BY COURSE LEVEL

LEVEL	1984	1988	CHANGE
1000	796	904	+12%
2000	6715	5967	-13%
3000	11419	11672	+2%
4000	5308	5566	+5%
TOTAL	24238	24109	-.01%

1. **Faculty**

The number of faculty for each of the academic department for years 1984 and 1988 is provided in the comparison Table 3 and Figure 4 below.

TABLE 3

FACULTY DISTRIBUTION BY ACADEMIC DEPARTMENT

DEPARTMENT	CODE	1984	1988	CHANGE
ADMINISTRATIVE SCIENCES :	AS	52	53	+2%
AERONAUTICS:	AA	20	21	+5%
COMPUTER SCIENCE:	CS	22	22	0%

ELECTRICAL AND : COMPUTER ENGINEERING	EC	51	39	-24%
MATHEMATICS:	MA	28	23	-18%
MECHANICAL ENGINEERING:	ME	27	27	0%
METEOROLOGY:	MR	27	16	-41%
NATIONAL SECURITY AFFAIRS:	NS	24	25	+4%
OCEANOGRAPHY:	OC	29	22	-24%
OPERATIONS RESEARCH:	OR	35	39	+11%
PHYSICS:	PH	36	26	-17%
TOTAL		351	313	-11%

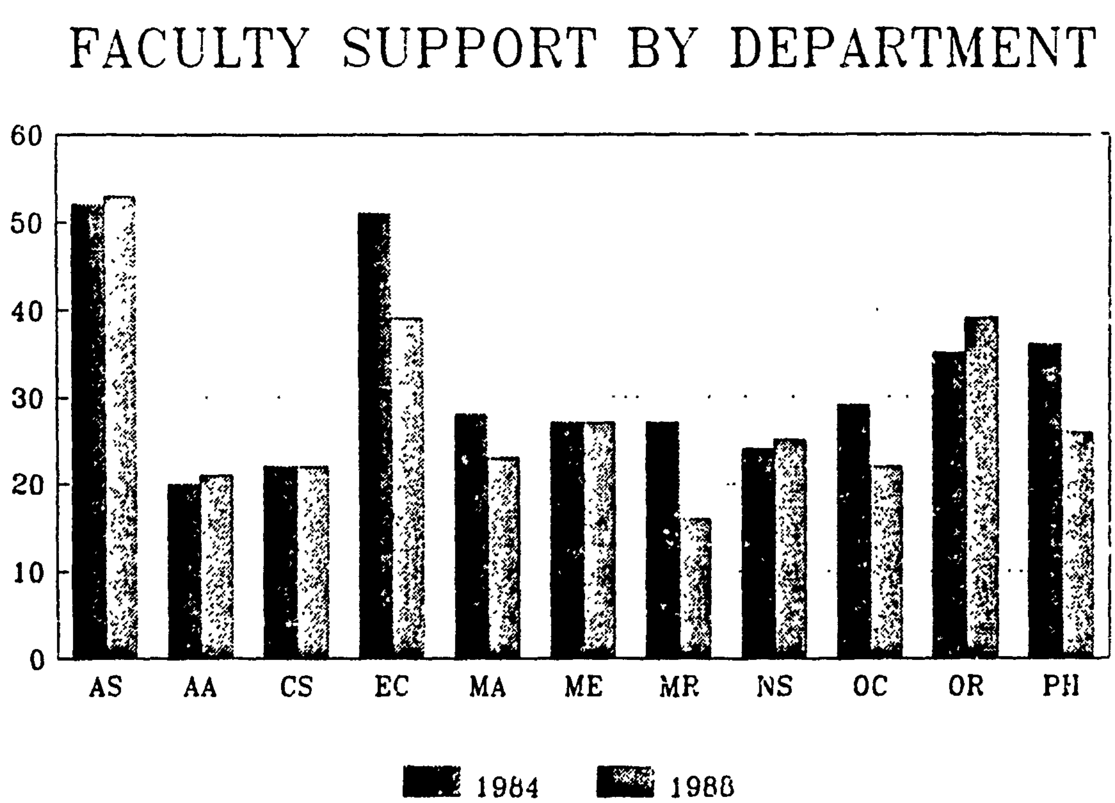

Figure 4. Faculty Support by Department

2. Clerical Staff

The number of clerical staff for each of the academic department for years 1984 and 1988 is provided in the comparison Table 4 and Figure 5 below.

TABLE 4

CLERICAL STAFF DISTRIBUTION BY ACADEMIC DEPARTMENT

DEPARTMENT	CODE	ACADEMIC YEAR 1984	1988	CHANGE
ADMINISTRATIVE SCIENCES:	AS	7	5	-28%
AERONAUTICS:	AA	5	3	-40%
COMPUTER SCIENCE:	CS	2	3	+50%
ELECTRICAL AND COMPUTER ENGINEERING:	EC	3	3	0%
MATHEMATICS:	MA	2	2	0%
MECHANICAL ENGINEERING:	ME	4	2	-50%
METEOROLOGY:	MR	2	3	+50%
NATIONAL SECURITY AFFAIRS:	NS	3	3	0%
OCEANOGRAPHY:	OC	5	3	-40%
OPERATIONS RESEARCH:	OR	6	4	-35%
PHYSICS:	PH	4	3	-25%
TOTAL:		43	34	-21%

Figure 5. Clerical Staff Distribution by Academic Department

3. Graduates

The number of graduate degrees awarded for each of the academic department for years 1984 and 1988 is provided in the comparison table 5 below.

TABLE 5

NAVAL POSTGRADUATE SCHOOL STATISTICS: GRADUATE DEGREES

Degree	1984	1988	Change
MA in National Security Affairs	95	80	+19%
MS in Aeronautical Engineering	44	45	+2%
MS in Applied Mathematics	0	5	+500%
MS in Applied Science	1	0	-100%
MS in Chemistry	0	0	0%
MS in Computer Science	48	53	+9%
MS in Computer Systems Management	0	0	0%
MS in Electrical Engineering	62	97	+36%
MS in Engineering Acoustics	10	79	+87%
MS in Engineering Science	23	19	-17%
MS in Hydrographic Sciences	5	2	-150%
MS in Information Systems	66	51	-29%
MS in Management	163	150	-9%
MS in Material Science	0	1	+100%
MS in Mechanical Engineering	45	57	+21%
MS in Meteorology	6	4	-50%

MS in Meteorology and Oceanography	28	29	+3%
MS in National Security Affairs	0	12	+1200%
MS in Oceanography	3	2	-50%
MS in Operations Research	62	81	+23%
MS in Physics	16	24	+33%
MS in Systems Engineering	21	105	+80%
MS in Systems Technology	4	133	+97%
MS in Telecommunications Systems Management	17	30	+43%
Total Master's Degrees	759	1059	+28%

There was a 28% percentage increase in the total number of graduates from 759 in 1984 to 1059 in 1988. Hence, the deduction that outputs increased between the observed time period.

4. Courses Taught

The number of courses taught for each of the academic department for years 1984 and 1988 is provided in the comparison Table 6 and Figure 6 below.

TABLE 6

COURSES TAUGHT BY ACADEMIC DEPARTMENT

DEPARTMENT	CODE	1984	1988	CHANGE
ADMINISTRATIVE SCIENCES :	AS	207	246	+16%
AERONAUTICS:	AA	87	137	+26
COMPUTER SCIENCE:	CS	104	146	+29%
ELECTRICAL AND COMPUTER ENGINEERING	EC	176	293	+40%
MATHEMATICS:	MA	133	201	+34%
MECHANICAL ENGINEERING:	ME	95	181	+48%
METEOROLOGY:	MR	57	81	+30%
NATIONAL SECURITY AFFAIRS:	NS	163	170	+4%
OCEANOGRAPHY:	OC	68	97	+30%
OPERATIONS RESEARCH:	OR	171	280	+39%
PHYSICS:	PH	115	206	+44%
TOTAL		1376	2038	+32%

COURSES TAUGHT BY DEPARTMENT

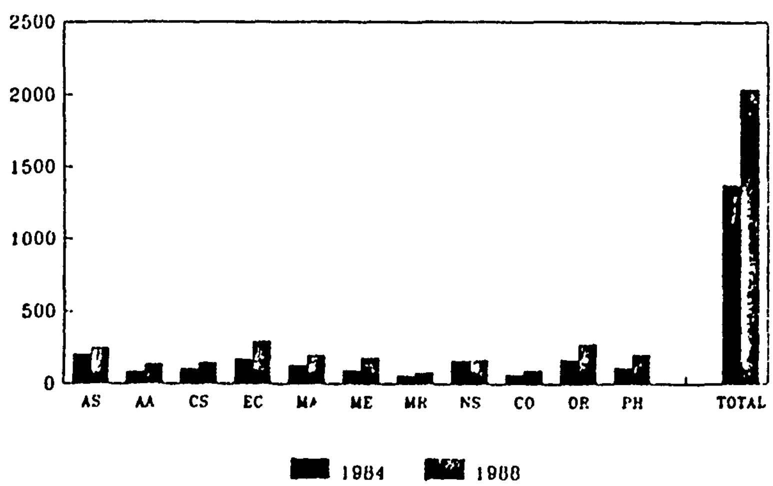

Figure 6. COURSES TAUGHT BY ACADEMIC DEPARTMENT

5. Overall Findings

Table 7 is provided to aid in the presentation of the percentage change in the data before and after the introduction of computers.

TABLE 7

PRODUCTION MATRIX WITH PERCENTAGE CHANGES

CATEGORY	BEFORE COMPUTERIZATION	AFTER COMPUTERIZATION	CHANGE
COURSES TAUGHT	1376	2038	+32%
FACULTY	351	313	-11%
GRADES AWARDED	24238	24109	-01%
GRADUATES	759	1059	+28%
CLERICAL WORKERS	43	34	-21%

Please observe the totals given for grades are inclusive for the entire school. When only the eleven departments are considered, there is a three percentage point decrease which matches with the decrease in table 8.

Table 8 is a cumulative table with all percentage changes in the data for the academic departments.

The data presented has shown that productivity has increased because of the relationship between the inputs and outputs that has been considered in this thesis. The workload, comprising of the output of grades and graduates have increased more significantly than the inputs which comprised of both clerical staff and faculty. The inputs have shown a decrease over the periods.

TABLE 8

CUMULATIVE STATISTICS BETWEEN 1984 AND 1988

DEPARTMENT	CLERICAL STAFF	FACULTY	GRADES AWARDED	COURSES TAUGHT
ADMINISTRATIVE SCIENCES :	-28%	+2%	+8%	+16%
AERONAUTICS:	-40%	+5%	-20%	+36%
COMPUTER SCIENCE:	+50%	0%	-35%	+29%
ELECTRICAL AND COMPUTER ENGINEERING	0%	-24%	-5%	+40%
MATHEMATICS:	0%	-18%	+9%	+34%
MECHANICAL ENGINEERING:	-50%	0%	19%	+48%
METEOROLOGY:	+50%	-41%	+6%	+30%
NATIONAL SECURITY AFFAIRS:	0%	+4%	-31%	+4%
OCEANOGRAPHY:	-40%	-24%	+5%	+30%
OPERATIONS RESEARCH:	-35%	+11%	+12%	+39%
PHYSICS:	-25%	-17%	+12%	+44%
TOTAL	-21%	-11%	-2%	+32%

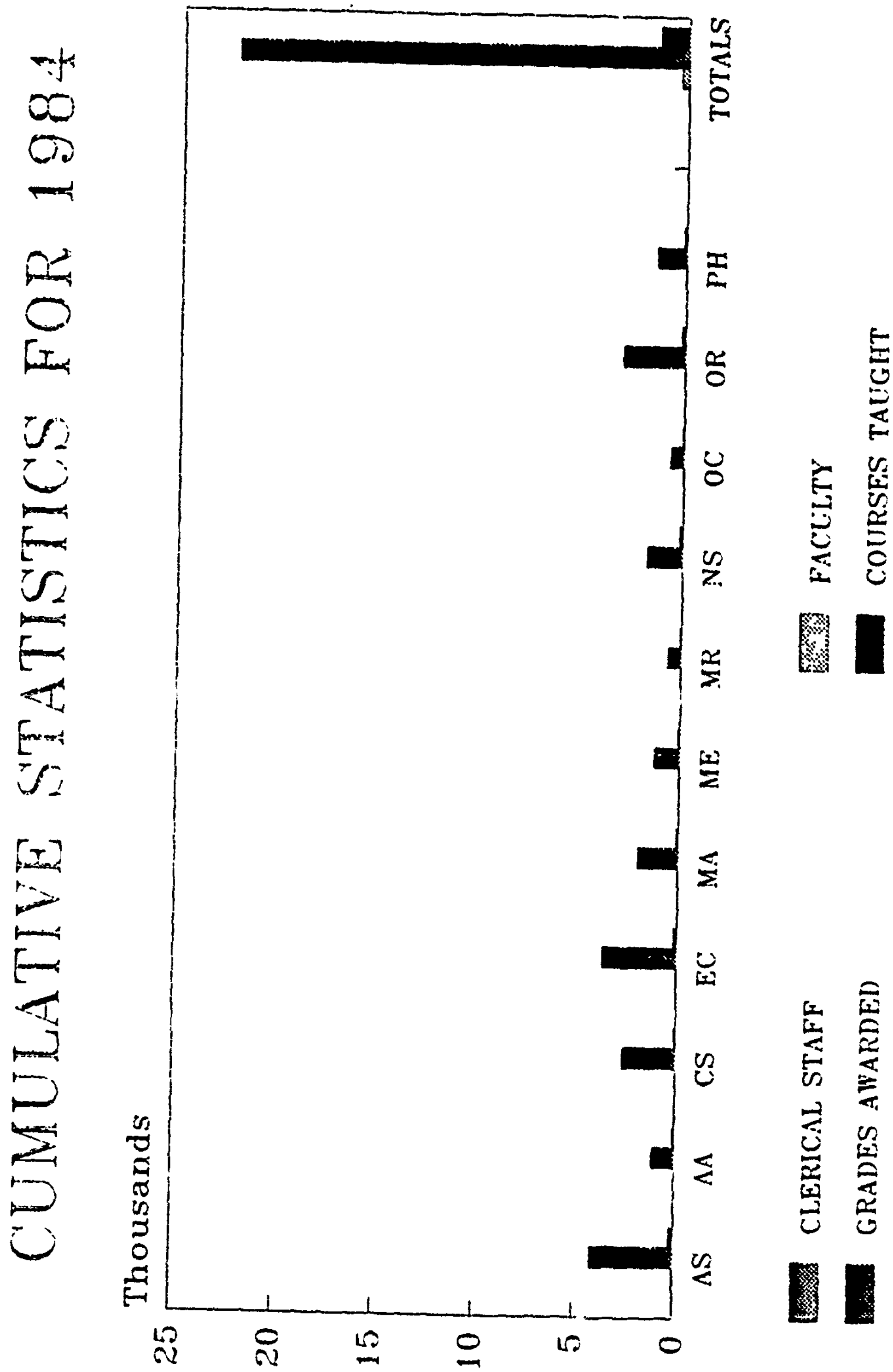

Figure 7A. DATA CUMULATIVE STATISTICS FOR 1984

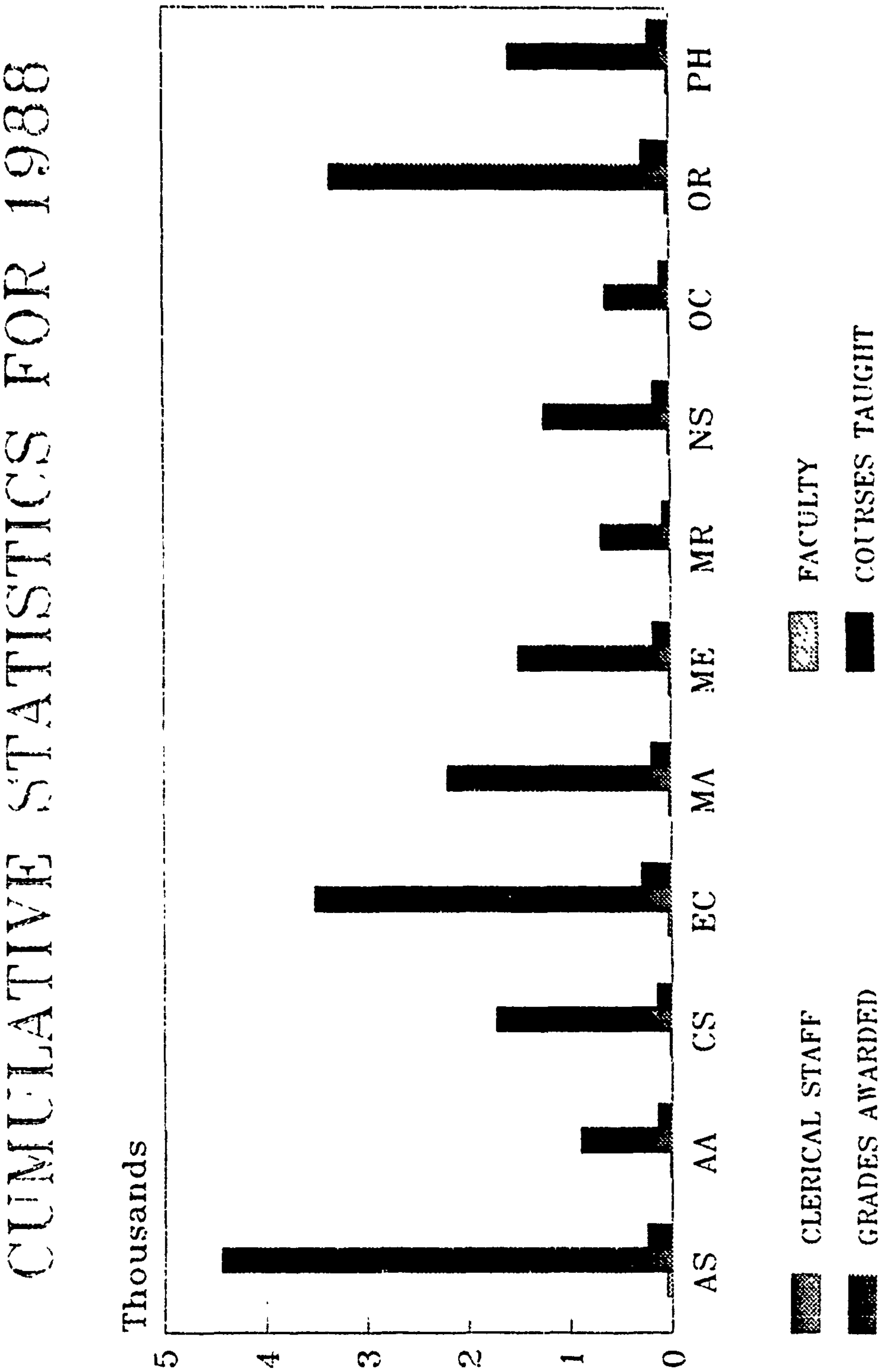

Figure 7B. DATA CUMULATIVE STATISTICS FOR 1988

V. CONCLUSION

The primary focus of this thesis was to determine the productivity/efficiency comparison before and after implementation of computers in departmental offices at NPS. This task was accomplished through the following measures:

- the usage of documented data on departmental clerical employees for the periods 1984 and 1988
- the usage of documented data on the number of graduating students for the periods 1984 and 1988
- the usage of documented data on the number of faculty for the periods 1984 and 1988
- the usage of the number of grades awarded for the periods of 1984 and 1988
- the usage of the number of courses taught for the periods of 1984 and 1988
- administering the questionnaire to the eleven departmental offices at the NPS campus
- evaluation of the collected data to deduce an answer to the thesis primary and secondary questions.

Specifically, classrooms stayed constant but the clerical workers, faculty, student attendance and graduates, computers, number of courses and class-size experienced a significant change over the span of the time period examined. Using 1984 as the base for comparison, when computers were not widely distributed, it can be deduced that there is a rise in productivity.

TABLE 9 PRODUCTIVITY MATRIX WITH TOTALS

	BEFORE AUTOMATION	AFTER AUTOMATION
ACADEMIC YEAR	1984	1988
INPUTS	STAFF SIZE=43 FACULTY SIZE=351	STAFF SIZE=34 FACULTY SIZE=313
OUTPUTS	GRADES AWARDED=24238 GRADUATES=759	GRADES AWARDED=24109 GRADUATES=1059

There is a definite increase in reports, added paperwork and responsibilities, with the respective departmental heads and supervisors spending an inordinate amount of each day verifying, editing, perusing and deriving information from these reports. Please note that the recommendations are based on opinions and professional background of the investigator and others may of course reach different conclusions or disagree with the recommendations.

The recommendations are not listed in any particular order and no inference should be drawn about their position on the list.

A. RECOMMENDATIONS.

1. Consider Alternatives and Common Obstacle

Productivity improvement in NPS departmental offices should be promoted with enthusiasm and confidence. The curricula department community should be convincing and confident in their quest to produce a better way of improving the various tasks to be performed.

Many problems arise that present obstacles to retard the progress of productivity in the workplace and those that are common and exist at the NPS campus are listed:

- resistance to change
- lack of proper planning
- lack of appropriate data base
- resentment to criticism
- conflicting compromise of objectives
- complacency resulting from current status
- inadequate sharing of productivity and quality improvement gains
- starting off too big.

The findings of this study do not invalidate the findings of other completed studies but rather add support to supplement the analysis for future research. The successful response to the questionnaire noted in the study and the opinions of the respondents indicate that there is opportunity to enhance the relationship between supervisors and subordinates thus leading to the improvement in office productivity.

2. Further Study

Further study related to productivity measurement in the department offices at NPS is recommended. The study reported in this thesis centered on departmental offices, yet was not necessarily broad in its coverage due to a lack of available data. Therefore, further gains and benefits can be derived by focussing on particular aspects of the data gathered in the study in addition to future data gathering efforts. Also, further study is needed to determine precisely what aspect did the impact of personal computers and other automated tools have on the job and its contribution to higher user satisfaction and productivity improvement in the departmental offices at NPS.

APPENDIX A

ACADEMIC OFFICE DEPARTMENT SURVEY

The following survey was conducted by administering a questionnaire to the eleven curricula offices at NPS. All the offices responded to the survey.

The spiraling cost of automated office equipment, the increase in student class sizes and the increasing student population resulted in the increase in student to staff ratios and can logically be labeled as prime detractables of productivity at the departmental offices. The decrease in the office personnel between the observed periods has not matched the huge increase in the student body as a whole and the sizeable increase in the payroll costs involved. The investigator adds that the introduction of novel automated office equipment coupled with the change in office duties, responsibilities and requirements may indeed overshadow the gains that were made in raising productivity. more detailed survey with a different focus specifically analyzing items such as training, costing and pricing relationships may in fact give a more poignant deduction. In all surveys of this nature one cannot discard the cost that is always present, that is, the cost of switching.

The questions are:

1. Date
   Position
   Curriculum Department
   Telephone

2. Please circle any of the following equipment in this office ?

   personal computers

   terminals(mainframe)

   graphics terminals

   word processors(other than PC's)

   local area networks

   work stations

   typewriter

   copiers

3. How are the following functions in the office performed now?

a. Drafting of papers, memos or other word processing functions

typewriter	word processor
personal computer	other

b. Intra department communication

typewriter word processor

personal computer other

c. External communication to the department

typewriter word processor

personal computer other

4. If you had the choice of computer to use in your office what make will you choose?

IBM

APPLE CLONE

COMMODORE OTHER (PLEASE SPECIFY)

EPSON

ZENITH

5. Circle any of the following devices in your office

printer:

(dot matrix) (daisy wheel) (laser)

hard disk size:

10MB 20MB 30MB

40MB+

modem color/RGB monitor

graphics capability

6. What word processing programs do you use?

wordperfect 5.0/5.1 wordstar

multimate script

other

7. Is the primary use of office automation for word processing?

yes no

8. If you have a printer, approximately how many pages do you print a week?

less than 10 10 to 50

50 to 100 over 100

9. How often do you use a modem in a week?

never sometimes often

10. Does this office connect up to a school-wide system?

yes no

11. Does this office connect up to the Registrar's office via computer?

yes no

12. Do you make regular use of the department support staff?

yes no

13. Has the support staff been able to handle all of your requirements within a reasonable amount of time?

yes no

14. How much time is spent a week on paperwork that could be completed by the support staff?

less than 1 hour between 1 and 4 hours

between 4 and 7 hours greater than 7 hours

15. How many boxes of computer paper are ordered per order-period?

1 2 3 4 5 6 7 8 9 10

16. How many boxes of computer paper is actually used per order-period?

17. Approximately how many times are documents/correspondence changed prior to final draft?

0 1 2 more than 3

18. Do you believe that it now takes more time to get the job done than before automation?

yes no

19. What is the manning allowance of personnel for this office and the actual staffing presently?

allowance...

actual...

20. Do you have an organizational chart/chain of command in the office?

yes no

21. Approximately how much time do you spend with the computer daily?

less than 1 hour

more than 1 hour but less than 3 hours

more than 3 hours

22. How long have you worked here?

less than 1 year 1--3 years more than 3 years

23. Do you enjoy working in this office?

yes no

24. What would you like to see changed with regards to office automation?

25. The process of acquiring a computer for this office is....

simple too hard

there is no process

26. Do you know who on campus to call if your personal computer fail?

yes no

27. Is there an office property security officer?

yes no

28. Do you have to register your computer with anyone on campus?

yes no

29. What functions in your office are still being done manually that could be computerized?

word processing spreadsheets

database other

30. Are there any standardized or formatted reports and/or listings required of this office?

yes no

31. How often are they required?

daily weekly monthly

semiannually

32. How many are there?

less than 3 3 to 5 more than 5

33. Whom are these reports for?

personal students

supervisor outside office

34. How often do you dispose of them?

daily weekly monthly

semiannually

35. Where do you store these reports before disposal?

on/in close proximity of your desk

designated storage cupboard within the office

storage area outside the office

other

APPENDIX B

ACADEMIC DEPARTMENT OFFICES

The following is a listing of the eleven academic departmental offices at the Naval Postgraduate School, Monterey.

- Administrative Science
- Aeronautical Engineering
- Computer Science
- Electrical and Computer Engineering
- Mathematics
- Mechanical Engineering
- Meteorology
- National Security Affairs
- Oceeaography
- Operations Research
- Physics

APPENDIX C

GRADE DISTRIBUTION BY COURSE LEVELS

Academic Year	1984	1988
Administrative Sciences: CM, CO, IS, MN		
Levels:		
1000	67	70
2000	533	565
3000	1991	2181
4000	1509	1623
Total	4100	4439
Aeronautics: AE		
Levels:		
1000	0	0
2000	356	224
3000	251	322
4000	525	350
Total	1132	896
Aviation Safety: AO		
Levels:		
1000	0	0
2000	652	715
3000	1275	1430
4000	0	0
Total	1927	2145
Command Control and Communications: CC		
Levels:		
1000	0	0
2000	0	0
3000	0	2
4000	0	34
Total	1132	896
Computer Science: CS		
Levels:		
1000	0	0
2000	911	243
3000	1249	957
4000	465	520
Total	2625	1720

Electrical and Computer Engineering: EC		
Levels:		
1000	0	0
2000	2064	1716
3000	962	991
4000	685	808
Total	3711	3515
Mathematics: MA		
Levels:		
1000	510	619
2000	988	924
3000	465	624
4000	42	33
Total	2005	2200
Mechanical Engineering: ME, MS		
Levels:		
1000	16	0
2000	429	468
3000	578	796
4000	239	241
Total	1262	1505
Meteorlogy: MR		
Levels:		
1000	0	0
2000	97	200
3000	346	288
4000	198	194
Total	641	682
National Security Affairs: NS		
Levels:		
1000	43	0
2000	0	6
3000	1289	889
4000	435	341
Total	1767	1236
Oceanography: OC, GH		
Levels:		
1000	3	0
2000	65	49
3000	338	343
4000	195	239
Total	601	631

Operations Research: OA, OS

Levels:		
1000	0	0
2000	311	324
3000	1937	2156
4000	758	873
Total	3006	3353

Physics: PH, CH, SE

Levels:		
1000	157	215
2000	309	483
3000	706	632
4000	230	246
Total	1402	1576

Space Systems: SS

Levels:		
1000	0	0
2000	0	50
3000	0	61
4000	0	64
Total	0	175

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