CENTRALIZATION JR DECENTRALIZATION?
A STUDY OF THE DATA PROCESSING REQUIREMENTS OF THE
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ABSTRACT

This study investigates the question of whether the data processing requirements of the Research Department of the Federal Reserve Bank of Boston would be best satisfied by a centralized or decentralized organization.

An introduction to the organization within the Federal Reserve Bank is presented. It is followed by a summary of the literature dealing with the organizational question of the centralization or decentralization of data processing resources.

The specific situation within the Boston Federal Reserve Bank is then investigated. The needs of the organization are described. Three various alternative organizations are then presented and evaluated in light of the previously developed framework. These alternatives include complete centralization of all data processing resources; decentralization of the programming effort while retaining centralized operations; and decentralizing the equipment through the use of timesharing services and minicomputers.

The conclusions of this study are that the centralized organization is apparently the best choice as it provides the greatest benefits for the least costs.

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CHAPTER 1 - INTRODUCTION

1.1 Purpose of Study

The Research Department of the Federal Reserve Bank of Boston is responsible for producing various reports and analyses which necessitate the utilization of data processing resources. Currently the Research Department's data processing needs are met by a centralized staff which is responsible for handling almost all of the Boston Bank's data processing requirements. Various people within the Bank have expressed an interest in whether the current centralized organization is optimal for the Research Department and for the Bank, or whether another arrangement might be better.

This study investigates the question of whether the data processing requirements of the Research Department would be satisfied best by a centralized or decentralized organization. A general framework is developed which facilitates the consideration of the centralization-decentralization issue. This framework is used to analyze various options.
1.2 Organization of Study

The organization of the report is as follows. Chapter 2 presents background information concerning the organizational structures within the Federal Reserve System and particularly, the Federal Reserve Bank of Boston. Emphasis is placed on the organizational structure as it affects the data processing requirements of the Research Department. Chapter 3 reviews the literature related to the issues of centralization and decentralization of data processing resources. A framework is developed which will facilitate the evaluation of any particular proposed arrangement.

Chapter 4 includes a normative model of the Research Department's requirements. It describes the goals and constraints of senior management.

The next three chapters analyze three various alternatives. Chapter 5 evaluates a system characterized by centralized programming and computer equipment. It describes the current organization, evaluates it in light of the framework provided in Chapter 3, and then considers any possible improvements to the organization. Chapter 6 explores the effects of decentralizing the programming effort while retaining the centralized operational functions. Chapter 7 investigates the decentralization of computer equipment. Specifically the use of timesharing services and minicomputers are evaluated.
Chapter 9 summarizes the findings of the report and provides overall recommendations.
CHAPTER 2 - BACKGROUND INFORMATION: ORGANIZATIONAL STRUCTURES

2.1 Federal Reserve System

The Federal Reserve Bank of Boston is one of twelve regional Federal Reserve Banks which, along with the Board of Governors of the Federal Reserve System, constitute the Federal Reserve System. The Federal Reserve Bank of Boston (or the Boston Fed, as it is commonly called), like each of the 11 other regional Federal Reserve Banks, is a corporation which is owned by its member banks. Despite this status as a corporation, the individual Reserve Banks are not completely autonomous but are closely coordinated by the seven-member Board of Governors (or Board). Figure 2-1 represents the overall structure of the Federal Reserve System.
2.2 Organization of the Boston Federal Reserve Bank

The Boston Fed is organized into functional departments. Due to the specific problem being addressed in this report, the description of the internal organization of the Boston Federal Reserve Bank will be limited to those departments which in any way affect the data processing decisions of the Research Department. The following subsections summarize the general organizational structure and responsibilities of the relevant departments.

2.2.1 Research Department

The Research Department is headed by the Senior Vice President and Director of Research. The department is responsible for the performance and publication of economic research as well as for the collection, editing, and reporting of data from various banks, financial institutions, and utilities in District I of the Federal Reserve System.

The economic research is performed by a staff of economists who, supported by research assistants, report directly to the Director of Research. The Economic Research Section is further divided into smaller sections each of which is generally responsible for different areas. Thus there is a monetary section, an international section, a national business conditions section, and a regional
section. Each of these sections is directed by a Bank officer and includes one or more additional economists. In addition, there are also a few special staff members.

The rest of the department consists of the statistical and support areas and is under the direction of the Administrative Assistant to the Director of Research. This part of the department is also divided into functional sections.

The Statistical Section is responsible for collecting, editing, reporting, and releasing all financial data which the Boston Fed processes. The Computer Liaison Section is responsible for coordinating all of the departmental data processing activities.

Figure 2-2 illustrates an abbreviated organizational chart of the Research Department as it pertains to data processing.

2.2.2 Loan and Credit Department

The Loan and Credit Department includes among its many responsibilities the evaluation of all requests by member banks to borrow funds. In making a decision as to whether a bank qualifies for borrowing at the discount rate, the Loan and Credit Department utilizes many analytical tools and various data. Used in this analysis are some of the financial data collected by the Research Department as well
as a statistical package which is used by both departments.

Data collected by the Loan and Credit Department are used in reports made by the Statistical Section of the Research Department.

2.2.3 Accounting Department

The Accounting Department is responsible for informing all member banks of their required reserves (the amount of funds which must be kept on reserve at the Fed) for the coming period. These reserve requirements are based on individual bank deposit data which are collected and processed by the Research Department; they are generated by a computer program which accesses the deposit data.

2.2.4 Data Systems Support (DSS)

Under the supervision of an Assistant Vice President and department manager, the Data Systems Support Department is responsible for the design, development, implementation, maintenance, and documentation of most of the Bank's computer applications. The department was reorganized during 1973 and now is divided into three Task Forces, each of which is directed by an administrator. Each Task Force is responsible for providing full support to certain functional areas within the Bank.
Within each section, there is a variety of talent, ranging from programmer trainees to senior systems analysts. The objective of this organization is to provide management with flexibility in assigning personnel to tasks. Any individual project may be subdivided into specific modules to be performed by a section member of the appropriate level of expertise. In addition, possibilities exist for intersectional mobility, although this is less prevalent.

This structure is unlike the previous organization in which the department was divided into small groups which were assigned on a full-time basis to support specific departments or applications. The effect of the earlier organization was to provide each user with a fixed support staff; the user determined the priority of his outstanding projects and requested DSS personnel assigned to him to work on his projects in a particular order. Under the new organization, the user shares a larger pool of resources. Although on the average he should receive the same level of support, at any time he may have many more (or fewer) people assigned to his projects depending upon their priority in relation to all other outstanding Bank projects.

2.2.5 Computer Planning Department

The Computer Planning Department is headed by an Assistant Vice President and is organized into three
sections. The Computer Planning Section is primarily concerned with the planning of computer systems within the Bank and has minimal contact with the Research Department. The Systems Section is responsible for designing, developing, and supporting certain major systems which are used by other programs or programmers. Included in this category are such systems as data communications packages which support remote facilities and on-line text editors, which are used by programmers and other departments (including Research).

The ESS Section is responsible for the development and support of the Bank's Econometric Statistical System (ESS). This system was originally developed as an econometric tool to be used by Research economists and their research assistants in the analysis of data. Although this continues to be its primary use, the wide range of system capabilities has resulted in its being used by several other departments as well as by Research personnel for non-econometric applications.

2.2.6 Data Processing and Data Communications Department

The Data Processing and Data Communications Department, under the direction of an Assistant Vice President and department manager, is responsible for all of the Bank's data processing operations (exclusive of the check
collection and transit operation). The department operates two Burroughs 4700 computer systems as well as an IBM 2968 which is part of a Federal Reserve System network for transmitting data. In addition, the DPDC department also supervises all keypunching, job control work, and certain other functions which do not affect the Research Department.

Figures 2-3 and 2-4 present an abbreviated organizational chart of the Boston Fed and of the Computer Support Departments, respectively.
Figure 2-1: The Federal Reserve System

Board of Governors of the Federal Reserve System
Figure 2-2: Abbreviated Organization Chart of the Research Department
Figure 2-4: Organizational Chart of the Data Processing Departments
CHAPTER 3 - CENTRALIZATION OR DECENTRALIZATION?

3.1 Chapter Overview

This chapter presents a detailed analysis of the theoretical considerations related to the centralization or decentralization of electronic data processing (EDP) functions. The first section includes an overview of the key issues, presents the possible alternatives, and specifies certain criteria for consideration when analyzing a system.

The second section divides the centralization-decentralization issue into seven key factors and summarizes the conflicting ideas related to each of the factors.

The third section summarizes the major issues and provides a framework through which various proposed systems may be evaluated.

3.1.1 Definitions and Constraints

The issue of whether the EDP functions are best satisfied through a centralized or decentralized arrangement has been analyzed from various perspectives. Many different definitions and conclusions have resulted. There have been considerations from a geographic point of view as well as from an organizational perspective. As a result, certain
terms are now ambiguous and must be defined before any analysis of the controversy is begun.

Centralization is defined within this report as the placing of all responsibility for certain functions under one organizational unit. Thus as Solomon states, "Centralization is an organizational concept and holds no necessary implications for physical, geographic, or managerial restrictions" (1). Solomon's definition of centralization also includes the concept of teams on location (or resident analysts) which are assigned both geographically and functionally to one user but which remain under the administration of one central authority. However, the theory presented in this chapter will limit the analysis of centralization to the more conventional model; this broadened concept actually represents a variation of the two basic organizations.

Similarly, decentralization is defined by Kanter as the "delegation of decision making authority to the lowest point in the organization where the required information and capabilities can be brought together" (2).

This perspective of centralization-decentralization as an organizational problem seems appropriate given the current state of the EDP functions. The major problem is no longer one of technical developments; rather, advances must involve utilizing more effectively the resources currently available. As Dinter states: "Computer technology, if not
ahead of us, at least is capable of servicing our needs at whatever level we are capable of employing this technology" (3).

Dinter proceeds to stress that "in searching for more effective links between the computer and applications, we might thus concentrate on the human and organizational problems alone" (4).

The definitions of centralization-decentralization do not limit the scope of the function being controlled. Thus it may include all EDP functions, or merely certain aspects (such as programming, operations, or planning).

3.1.2 Basic Issues

On the surface, the question of centralization or decentralization seems to reduce to a tradeoff between economies of scale and the user's level of service. Proponents of centralization argue that economies of scale encourage specialization (of both managerial talent and staff members) and avoids the duplication of efforts offered by a decentralized authority. Advocates of a decentralized organization argue that the needs of the user are foremost, and that even if centralization might reduce costs, that it does so by neglecting the needs of the user. In effect this argument states that centralization provides false economy by minimizing cost through a reduction in service.
The question of centralization or decentralization is generally analyzed for two areas: operations (computer equipment, other hardware, and operators) and programming support. However, recent hardware advances and the cost of computers generally make the question of the centralization of equipment less controversial. Berman, a proponent of decentralization, contends that "the centralization of hardware and of staff are two separate questions... while I believe that both subjects should be viewed as controversial, the arguments for physical centralization of hardware seem much more valid" (5).

A key issue thus becomes the decentralization of the programming staff. Berman claims that "decentralized staffing provides for greater return in performance and benefits to the total organization for additional personnel costs that are at most only slightly higher" (6).

Decentralization of the programming staff does not imply that the operational activity can not be centralized. However, the converse does not generally hold. That is, a decentralized operations area almost prohibits a centralized programming staff. To have many different computer installations operated by different departments and under different operating systems but programmed by a central department fails to fully utilize the centralized software organization.
3.1.3 Possible Alternatives

Glaser suggests four possible organizational structures (7). The first of these would involve the centralization of the entire EDP function; both programming and operations are centralized. The other three alternatives all include decentralized programming.

Of the remaining three, one proposal is for centralized operations. The second of the remaining three calls for a decentralized operations and programming which are under some form of central control. Glaser proposes a central coordinator who would be responsible for controlling methods and processes but not the actual design and implementation of systems. Examples of his responsibilities include salary administration, career path planning, training programs, equipment compatibility, and standards for programs and documentation. The final proposed alternative is for a complete decentralization in which each department would have complete autonomy within the constraints of its accountability.

It should be emphasized that these four alternatives are not exhaustive. Many possible variations and combinations of the four basic plans exist. However, they do represent a good framework for subsequent analysis.

One potential organization – decentralized operations and centralized programming – has been dismissed as being unfeasible for reasons which were mentioned in the previous
subsection of this chapter.

3.1.4 Criteria for Viewing a System

The issue of centralization-decentralization is not a programmed decision. The analyst must consider the details of the situation (the environment) and the particular proposal and evaluate the latter in light of the former.

Glaser suggests seven key criteria which should be considered when deciding on the centralization-decentralization of EDP resources (8).

(1) Minimum total cost
(2) Sensitivity to user problems
(3) Effective utilization of personnel
(4) Ability to attract and retain good personnel
(5) Rational selection of projects for development
(6) Opportunities to share common systems
(7) Ability to adapt to changes in the technological or economic environment

The first of these considers the actual cost of the proposed system. The second factor, user satisfaction, is difficult to quantify but of extreme importance. One important subissue is the relationship between the user and the service group. Dolkas claims that "to be effective in communicating with the user, the installation must respond quickly to user needs. To gain the confidence of the user
there must exist within the facility a good relationship between the facility and the users."

The third factor is crucial for several reasons. It determines cost efficiency and effectiveness. However, it also affects the fourth factor, the ability to attract and retain good personnel. This factor is also important, for the costs of recruiting and training personnel are quite significant - both in monetary and time terms. The fifth factor includes the ability to commit resources to the project which is most important from a corporate viewpoint.

The sixth factor - the ability to share common systems - is important in that it allows for quicker project completion with less testing and debugging. Finally, the ability to adjust to technological or economic changes must be considered. New technology may be developed or the economic conditions may change. Included in the latter are both an internal budgetary change as well as potential changes in the external environment (for example, a shortage of programmers, a sudden rise in the cost of equipment).
3.2 Key Factors in the Evaluation of Centralized or Decentralized EDP Organizations

This section explores the seven key criteria related to the centralization or decentralization of EDP resources. The issues are presented in a framework which is a slight modification of that proposed by Glaser.

3.2.1 Minimum Total Cost

One key criterion in the evaluation of a system is the overall cost. Proponents of centralization maintain that there are economies of scale with centralized organizations and that therefore the same amount of EDP capability can be obtained for less cost through centralization (9). For example, Glaser mentions that it is often less expensive to have one large computer than several smaller ones which collectively provide the computing power of the larger one (10).

Blose and Carter claim that the centralization of equipment will result in more sophisticated hardware which will in turn lead to reduced processing costs (11).
3.2.2 Sensitivity and Responsiveness to User Needs and Problems

The centralization of EDP functions results in the formation of larger organizations than would occur with decentralization. Therefore, one key factor in the consideration of the centralization or decentralization question is whether the potential services available to the user of a large centralized organization will be better or worse than those available from a decentralized organization.

One of the major benefits of the larger centralized EDP department is that it makes feasible the possession of specialized resources which are not available in continuous quantities. Small organizations often can not afford to have specialized resources which are only used infrequently. However, larger organizations, by their very nature, can pool their needs and utilize these resources more extensively and thus justify their availability and cost.

Examples of these potential benefits exist for the centralization of both operations and programming. A small installation with only one job which needs a tape drive, or one job which requires a random access device, or one job which needs extensive core memory might find it difficult to justify purchasing any of them for its needs alone. However, if several departments were serviced together, their collective utilization of these resources could be
sufficient to justify their purchase.

Similar benefits may be available in the programming areas. Small staffs can not afford to have specialists; their personnel can not specialize in data communications, systems analysis, systems maintenance, etc. Typically there will just not be enough work of one type to keep a specialist busy. The result is that either he will not be retained, or that he will be underutilized for part of the time (this aspect is discussed subsequently). Under a centralized arrangement, the demand for a particular type of service is likely to increase and specialization is feasible. Thus larger staffs can provide the levels of talent required for specific problems.

It should be mentioned that these benefits will not always be attributable to a switch from a decentralized organization to a centralized organization. If the decentralized organization is large enough, it will be able to enjoy these benefits without having to centralize. For example, certain benefits may be experienced by a company which elects to centralize the EDP functions of departments which average 10 EDP employees; these same benefits and economies of scale might already be realized if the decentralized departments were large with an EDP staff numbering several hundred.

A second major advantage of the centralized organization is that resources, if available, will not be
underutilized or duplicated. Thus every department will not have to have its own tape drive, or programming specialist. It may well be that each activity needs that resource and would underutilize it in a decentralized environment, but could share it in a centralized environment.

Another benefit which results from the centralized organization is that the increased size helps make the organization more flexible and thus more responsive to particular events and needs. As an illustration, peak loads can be more easily met by shuffling people in large groups (where the impact of the move is dampened) than in smaller groups which are more likely to feel the full effect of a switch. This phenomenon is true in operations as well as programming areas. A smaller computer installation may not have the capacity to run a few extra jobs, or the personnel to schedule extensive overtime. The larger installation is more likely to provide that buffer. Similarly, centralization provides the opportunity for a more efficient utilization of personnel to meet peak work loads.

The increased flexibility and responsiveness also helps cushion the organization against problems with project continuity resulting from turnover. The loss of one person is more likely to be felt in the smaller organization than in the larger one.

Still another advantage which is attributed to the organization's size is mentioned by Blose and Carter who
claim that the installation of more advanced methods and equipment will result in faster processing (12).

Although all of the previously mentioned benefits can result from the centralized organization, it does not follow that they will. For example, if the centralized departments all have diverse needs, then the centralized organization will in no way contribute toward a more complete utilization of resources.

In addition, many of the alleged benefits attributable to centralization can exist in a decentralized environment - if the conditions are right. Specifically, the decentralized organization should be one which does not have varying needs, but rather one whose needs remain constant through time. Under these conditions, personnel may be trained to meet these specific needs and the problem of requiring various specialized talents will not exist.

Similarly, if the work load is fairly even and predictable, and the personnel is fairly stable, benefits resulting from the increased flexibility will not be important.

The size of an organization can be an argument for the decentralization of equipment in two additional ways. Blose and Carter claim that large scale facilities are not always adaptable in order to meet local service requirements. In addition, they feel that some local problems, because of their small volume and relative simplicity, are not
processed efficiently on large scale equipment.

Just as the factors related to size and specialized resources provide proponents of centralization with some most convincing arguments, so the ability to understand the user's needs is a major argument for decentralization.

The basic argument for decentralization is that the best service results when there is a good level of understanding and communication between the users and the service facility. As Dolkas says, "to be effective in communicating with the user, the installation must respond quickly to user needs" (13). Dolkas further adds that "to gain the confidence of the user there must exist within the facility a good relationship between the facility and the users" (14). Thus, the major contention for decentralization is that decentralized staffs are most sensitive to the user's needs and wants and are thus best able to provide responsive and satisfactory service.

The arguments for decentralization of EDP functions tend to concentrate on, but are not limited to, the decentralization of the programming efforts. Perhaps Glaser best expresses this view: "To apply the computer intelligently to the solution of complex problems in complex environments, systems analysts and programmers must be thoroughly familiar with the problems in detail. This level of familiarity can best be achieved by individuals who are
close (both physically and organizationally) to the problem to be solved and to those who want solutions" (15).

One of the reasons why Glaser feels that local analysts are more sensitive to the user's needs is their institutional knowledge of how things work in their department. As he says, "The local analyst often will be more successful (than the centralized analyst with more technical knowledge) because most of the tough problems are so defined for other than technical reasons" (16).

Glaser makes a similar argument for the decentralization of computer equipment. He feels that this will encourage a user-oriented organization and will, for any given configuration, facilitate a more rapid response to local processing needs and that faster turnaround will result (17).

Another advantage of decentralization cited by many authors is that it increases the involvement and participation of the user and analysts in design and development. Berman argues for decentralization by saying that it facilitates user involvement which is not true of a centralized organization (13). Another advantage is cited by Avots who states that: "Participation of the groups (of programmers) in the development of these detailed tasks is important. If programmers participate in the planning process, they gain a better understanding of the goals - and their commitments to the project become more meaningful"
Although it is generally recognized that decentralized staffs will usually better understand the user's needs and become more involved, it is possible for centralized staffs to provide this level of service. Solomon argues that a well-trained and managed centralized staff can involve the user and recognize his needs. Furthermore, because the centralized staff can afford to have specialists, the user's needs will not only be recognized but also served (20).

3.2.3 Effective Utilization of Personnel

The question of centralization or decentralization is further clouded by key issues concerning the efficient utilization of personnel. First of all, there is the issue of the type of management required for EDP personnel. Solomon contends that data processing personnel must be managed by professional EDP managers and that, like all other specialists, they can not be afforded by small decentralized organizations (21). Blose and Carter support this concept and add that when data processing personnel are managed by skilled specialists, other managers are thus freed to devote more time to their primary and more familiar responsibilities (22). Solomon further adds that if the manager is not an EDP expert, that he is then much more susceptible to being "snowed" by his personnel (23).
On the other hand, Glaser proposes that recent trends favor decentralization (24). He contends that today's managers are more knowledgeable and understanding of data processing areas and are therefore much better prepared to manage them. The consequence is that the need for centralization is not as great as it once was.

A second key issue is whether project control and evaluation are best performed under a centralized or decentralized organization. Advocates of centralization maintain that it improves managerial information and control. This is unquestionably true for integrated systems which cross departmental lines, involve the entire corporation, and require a team effort. These projects generally can not be standardized or coordinated easily with a decentralized organization.

The more interesting, and controversial, question involves the appropriate organizational structure for intradepartmental projects. The arguments for centralization are varied. It creates larger groups which can then afford to develop better standards for the accurate evaluation of personnel and the monitoring of projects. It encourages specialization and thus permits specialized EDP management who have the knowledge and experience to administer and control projects.

Proponents of decentralization argue that small groups can be more easily monitored and thus provide the
opportunity for better project control and performance evaluation. There is also the belief that system development will be less massive and prone to serious problems if it is broken into smaller pieces which can be handled by small decentralized groups.

Advocates of centralization refute these arguments by saying that "the user can influence staff selection when dissatisfied with the performance" (25) and that centralized organizations are not necessarily cumbersome bureaucracies.

To summarize, the decentralization arguments hold that it provides the users with more influence and facilitates better control of the project and performance evaluation. Proponents of centralization argue that decentralized organizations have no project control and that programmers consequently have an easy life. Furthermore, there is not necessarily justification for project approval and many needless applications result.

Another key issue of concern to management is the question of organizational synergy. There is some feeling that a single, large, centralized staff may be able to contribute more than several smaller groups would. Glaser, on the other hand, offers that a single staff is not necessarily more effective than several smaller ones (26). He contends that a large group may facilitate manpower management but that any economies of direct labor may be offset by additional expenses for the indirect labor
required to administer the larger staff.

Another key advantage of centralization is that it makes training programs feasible which would not be affordable with smaller groups. This is true for both initial training of new recruits as well as ongoing training for more senior employees. Larger organizations are better able to cover such costs because they represent a smaller percentage of their budget and are characteristic of any specialized resource (as discussed earlier).

Similar reasoning may be extended to the training and development of managerial personnel. Solomon contends that there is less opportunity within the decentralized staff to train, develop, and retain people with high management potential (27). Furthermore, he claims that specialized efforts within a centralized organization will result in more effective project management.

The training of personnel may not be a key factor against decentralization if opportunities for training exist elsewhere. Thus smaller groups do not have to train recruits if they can hire trained personnel or if there are educational opportunities available locally.

One additional argument for centralization is that it facilitates informal training and education. With large centralized staffs, the many members will generally be geographically located together and the resulting interaction will expose the staff to more new ideas and thus
provide additional training. The other side of this argument is that the interaction can occur even with decentralized staffs if the people are so inclined; and that if they are not, the communication will not occur even in a centralized organization.

The use of specialized management of EDP personnel often produces a bureaucratic organization. Proponents of decentralization argue that it is cumbersome and difficult to deal with. Furthermore, they add that any savings previously earned from centralization are lost due to the additional costs of communication. On the other hand, those who favor centralization argue that the centralized organization need not be gigantic or monolithic.

The issue of centralization or decentralization is affected by the internal organization of the corporation. If all the departments are organized as profit centers, and especially if the managers are strong, aggressive personalities, they will want to have as much control as possible over their performance. Consequently, the decentralized concept will be most appropriate. Much has been written about this issue and it is not the intent of the author to discuss the pros and cons of various control structures. Rather, the issue is merely being listed as one which must be considered in the choice of any EDP organization.

One other related advantage of centralization is that
it facilitates control and interaction by top management. Glaser suggests that top management can better control any EDP function when there is one individual center with one reporting system than when there are many nonuniform centers (28).

3.2.4 Ability to Attract and Retain Good Personnel

The difference in the size of groups resulting from a centralized or decentralized organization raises some key personnel issues concerning employee satisfaction, advancement, and other related matters.

One of the key issues involves employee satisfaction. Proponents of centralization argue that larger organizations (up to a certain undefined point) are more attractive to employees for the following reasons: they offer the opportunities for participation in more exciting and diverse projects; for more and better career paths; and for exposure to more sophisticated hardware and software systems. Advocates of decentralization contend that this undefined point is much lower than expected and that furthermore, job satisfaction is greater for employees working in small groups than in large groups. In addition, if big groups specialize, mobility among areas is more difficult and the opportunity for participation in diverse applications diminishes. If the groups do not specialize, then one of
the prime potential advantages of centralization is not realized.

Another key issue is employee turnover. It is generally recognized that turnover is greater (on a percentage basis) in larger organizations. Thus people who favor decentralization contend that their small groups will increase employee satisfaction and reduce the problems and costs associated with turnover. Proponents of centralization refute this argument. First of all, they contend that there is nothing about large organizations which inherently causes turnover; if the organizations are organized properly, the employee can feel as if he belongs to a small group and yet retain the benefits of a larger organization. Secondly, a centralized organization, because of its size, is less dependent on any one individual and thus minimizes the impact of untimely turnover.

A lack of career paths is generally recognized to be another cause of turnover. Small decentralized staffs do not require management specialists and thus can not provide upward career paths. Similarly, intradepartmental rotation and training programs are frequently less feasible in decentralized organizations. Interdepartmental rotation is more likely, but often includes a prerequisite of certain managerial responsibility, the opportunity for which is not available in smaller groups.

Another important issue is employee recruitment.
Because large groups often look more attractive to potential employees, recruitment is made easier with a centralized organization. In addition, the size and ability to specialize makes it better able to prepare and concentrate on recruitment.

3.2.5 Rational Selection of Projects for Development

Another key criterion on which any proposed system must be evaluated is its ability to provide the capability of allocating resources on the basis of corporate goals and priorities.

One major advantage of a centralized organization is that it facilitates management’s assignment of top talent to the high priority projects. Under a centralized arrangement, one central authority is in a better position to be informed of the overall corporate picture and to assign scarce resources accordingly. With a decentralized organization, the tendency is only to have a limited perspective and to see only that department’s needs and to thus assign resources accordingly — even if this means that more worthwhile projects (from the corporate point of view) are ignored.

Advocates of decentralization maintain that they have little control over their destiny under a centralized arrangement. They feel that they can not sufficiently
influence the levels of service which they will receive. They fear that important projects will not be pursued due to a misallocation of resources. Proponents of centralization argue that this is not necessarily true, and that under a well managed centralized organization, resources will be allocated on the correct basis of corporate profits. Furthermore, Solomon contends that the weak voice which a user might feel he has under centralization is not a problem if it means that projects must be cost justified and that departmental management can not automatically pursue any project (29). Berman reverses this argument and claims that centralization is not good if it means that a user can not automate an application which has sufficient justification (30).

3.2.6 Opportunities to Share Common Systems - Documentation and Standards.

Like apple pie and motherhood, documentation and standardization of EDP areas are considered to be ideal institutions. No one will refute that programs and operational procedures should be documented, and that the method of documentation should be standardized. In addition, there is almost unanimous agreement that this standardization should extend to most other EDP areas. Thus all programs written for a particular installation should
adhere to the same set of standards; similarly, the design
of data bases, the demands placed on the computer system,
and the purchase of equipment should all be subjected to a
set of standards.

The reasons for the need of good documentation and
standardization are varied. Basically, they are required in
order to avoid duplication of efforts in developing modules
which already exist; to ensure compatibility among existing
software systems and hardware configurations (where
necessary); to help develop integrated systems which cross
departmental lines; and, in the case of documentation, to
facilitate the use and modification of an existing system.
The intent of this paper is not to detail the reasons why
documentation and standardization are desirable, but rather
to consider them as desired objectives and evaluate whether
they are more readily accomplished with a centralized or
decentralized organization.

Proponents of centralization argue that documentation
and standardization just do not exist in decentralized
environments for a variety of reasons. In the case of
software documentation, the programming groups are small and
the programmers generally are familiar with the programs and
thus do not bother to document them. Secondly, small
decentralized groups are unable to specialize and therefore
are unable to justify the use of technical writers.

In the case of standardization, Blose and Carter argue
that policies can best be established to standardize forms and procedures in a centralized organization (31). Solomon adds that "small data processing groups are simply not staffed to develop, maintain, or enforce such standards" (32).

Proponents of decentralization contend that documentation and standards can exist in a decentralized organization. Their theory is that some authority will be responsible for the setting of standards. If the standards are not maintained, the resulting problems are not a consequence of the decentralized organization, but rather of the corporate structure (for example, the group or person responsible for standards).

Another advantage of decentralization is that centralized EDP often requires a sophisticated accounting system to distribute the costs among the users. The contention is that these costs in no way improve the quality of service but rather just represent additional overhead.

A potential disadvantage of the decentralized staff is that, because the analysts specialize in one area, they are limited in perspective and do not see the corporate picture. Conflicting efforts can result. An example of this is the design of data bases which often contain decentralized data that must be tied together in a centralized manner. Furthermore, since many departments may use the same data, any decisions made concerning it must consider all of the
departments and not just one user. Solomon and Fredericks both claim that this is most easily accomplished through a centralized organization (33).

To summarize, standards are needed and they must be set at the corporate level in order to eliminate undesirable redundancy in hardware, programming, and machine processing, as well as to facilitate efficient implementation of centralized, integrated file systems. A satisfactory level of standardization can be achieved with either a centralized or a decentralized organization. Centralization will facilitate standardization; however, good communication in a decentralized organization can offset the problems and produce the same results. In either case, there must be some central authority at the corporate level who has the responsibility to see that there is compliance with the standards. Fredericks adds that this authority must be able to enforce compliance with its standardized procedures if voluntary cooperation cannot be achieved" (34).

3.2.7 The Impact and Ability to Adapt to Changes in the Technological or Economic Environment

Recent technological and educational trends have influenced the question of centralization or decentralization. There is a need for an organization to be able to adapt to changes in the environment. Examples of
these current trends follow:

First of all, the cost of equipment has decreased considerably and consequently, many of the arguments for centralization of hardware based on economies of scale are no longer as important. Hardware no longer represents as significant of a part of the total EDP costs and thus offers less potential savings. The result has been a decrease in the importance of the issue of centralized hardware. As Glaser states, "Arguments based on staff - not equipment - considerations are the most important in nearly every case" (35).

Secondly, the reduction of equipment costs as well as the improvement of data communications software have facilitated the use of conversational programs, remote job entry techniques, and other telecommunication devices. The result is that geographic proximity to the computer facility is not currently important for the programmers or the actual users and that, accordingly, geographic decentralization is now more feasible.

A third trend has been the advent and rising popularity of inexpensive minicomputers. These provide moderate amounts of computing power at reasonable prices and are being used increasingly as dedicated devices both for specific user applications as well as for front ends to larger computers.

In short, many of the significant recent trends have
involved the cost of equipment. The availability of minicomputers has encouraged decentralization of the EDP operations areas. On the other hand, the availability of data communications and RJE have encouraged geographic decentralization of equipment out the retention of a centralized organization.

Another key advancement has been the development of timesharing systems. These take advantage of a distribution of software development costs to all users of the system and thus enable many people with similar needs to share a system, receive good response time, and pay less.

One trend which affects the programming issue is the recent improvement in the overall public knowledge of computers. The public in general, and management in particular, are now better informed about EDP issues. "Computer science" has made great inroads into the educational curriculum—from elementary school through graduate work. In particular, more and more business schools now require some form of formal course work in the EDP area.
3.3 Summary

The question of whether a centralized or decentralized organization is best for EDP operations is a controversial issue. It seems that there is no one correct answer, but rather that the choice depends on a variety of factors which have been presented in this chapter.

There are clearly tradeoffs with either organization. Therefore, the optimal choice will depend on the objectives of the user of EDP resources. Thus, in order to evaluate the merit of a proposed system, it is first necessary to establish the specific requirements and constraints of the organization. This necessitates looking at each of the seven broad areas covered in this chapter and specifying the relevant needs within each of them. Figure 3-1 summarizes the major requirements of any EDP system which must be considered before a particular proposal can be evaluated.

Having determined the specific requirements, it is then possible to consider the arguments for both centralization and decentralization and how they pertain to the proposed system. Figure 3-1 also summarizes the key questions which will serve as a guide in the evaluation of whether the user's needs will best be satisfied under centralization or decentralization.

Figure 3-2 provides a summary of the micro arguments for centralization and decentralization.
Figure 3-1: Major Requirements and Questions for Consideration in the Analysis of Centralization or Decentralization

MINIMUM TOTAL COST

COST

What is the cost of the system and is it within range?

Are there potential economies of scale to be realized or lost under the proposed system?

SENSITIVITY AND RESPONSIVENESS TO USER NEEDS

NEED FOR SPECIALIZED RESOURCES

If there is a need for specialized resources, are there opportunities for justifying them with a centralized organization?

NEED FOR FLEXIBILITY IN SCHEDULING

If there is a need for flexibility in scheduling, can it be met through a centralized or decentralized organization?

TURNAROUND TIME

Will the system provide the desired turnaround time?
LEVEL OF INVOLVEMENT AND UNDERSTANDING REQUIRED OF EDP PERSONNEL

Will the system provide the level of involvement and understanding of the user which are needed?

UTILIZATION OF PERSONNEL

NEED FOR EFFICIENT RESOURCE UTILIZATION

Will the system provide the level of EDP management needed to provide efficient utilization of personnel and other resources?

Will the system provide the necessary level of project control and performance evaluation to insure efficient personnel utilization?

Will the system operate efficiently or will it become an unworkable bureaucracy?

Is the organizational structure consistent with the corporate structure and personalities?

Are there opportunities for organizational synergy?

NEED FOR TRAINING

Will the system provide the necessary level of training (both initial and ongoing)?

ABILITY TO ATTRACT AND RETAIN GOOD PERSONNEL
IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

Can the system satisfy the turnover and recruitment problems?

IMPORTANCE OF EMPLOYEE SATISFACTION

Will the system provide adequate job satisfaction?

RATIONAL SELECTION OF PROJECTS FOR DEVELOPMENT

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

Will resources be allocated correctly from a corporate point of view as well as from a departmental point of view?

OPPORTUNITIES TO SHARE COMMON SYSTEMS: DOCUMENTATION AND STANDARDIZATION

NEED FOR STANDARDIZATION AND DOCUMENTATION

Can internal standards be enforced under the proposed organization?

Will the system permit the required level of documentation?

IMPACT AND ABILITY TO ADAPT TO CHANGES IN THE TECHNOLOGICAL OR ECONOMIC ENVIRONMENT?
ADAPTABILITY TO CHANGE

If recent technological advances in hardware, data communications, and minicomputers influence the decision, can the organization adapt?
Figure 3-2: Key arguments for centralization and decentralization

Arguments for Centralization:

Specialized resources made feasible through pooling of needs

Costs reduced through economies of scale

More complete utilization of specialized resources

More flexible and responsive organization; better able to handle peak loads, turnover problems

User involvement possible under centralization

Provides the corporate view of problems

Facilitates the development of documentation and standards

Facilitates informal training and education through better communication.

Allows for specialized EDP management

Provides for organizational synergy

More attractive to employees because of increased project diversity, more sophisticated projects, and better career paths

Recruitment easier due to specialization and desireability

Facilitates corporate control of top priority projects

Better managerial control over ongoing projects

Better able to develop standards for performance evaluation

Top management better informed if only interacting with one user who is responsible for all EDP

Availability of data communications, RJE
Arguments for Decentralization

Small organizations can better adapt to certain local service requirements

Small organizations process certain problems more efficiently

Training not a factor if external opportunities exist

Local analysts more sensitive to user needs

Decentralized equipment provides better turnaround time

Increased user involvement

Standards and documentation can exist in a decentralized environment

A sophisticated accounting system is not required to distribute charges to users

Specialized EDP managers are not as necessary due to better general education

Lack of administrative overhead which makes centralization more costly

Increased job satisfaction

Turnover less severe in smaller groups

Provides for better user control over ongoing projects

No communication problems and costs due to massive bureaucracies

Better monitoring of small projects

Better and more personal performance evaluation

Decreased costs of equipment (especially minicomputers)

Availability of timesharing systems
CHAPTER 4 - GOALS OF THE RESEARCH DEPARTMENT

This chapter presents a normative model of the data processing needs of the Research Department (36). Issues related to the quantity and quality of service, the timing of these needs, the amount of control required by the department, as well as an approximation of allowable costs are described for each of the two major Research activities. In addition, these two areas are subclassified into software and hardware needs.

Section 4.1 provides an overview of the general needs of the Research Department. Emphasis is placed on the relationship of the department to the rest of the Federal Reserve Bank of Boston and to the Board of Governors.

Section 4.2 details the specific requirements and allowable cost figures for the functions related to the Statistical Section. Section 4.3 presents a similar normative model for the Economic Research Section.
4.1 General Data Processing Needs of the Research Department

In order to understand the data processing needs of the Research Department, it is necessary to understand the department's responsibilities. The Research Department is responsible for activities which may be either support services or required functions. The result is that departmental personnel are involved in both high priority projects with relatively immediate deadlines, as well as the more traditional long-run activities often associated with a research organization.

As mentioned earlier, most of the department's responsibilities may be broadly classified as involving either the processing of statistical and financial data (also called statistical series) or the performance of economic research. The nature of both of these functions is that they frequently are data intensive, repetitive, or both. Over the last six years, the departmental management has seen the potential (and subsequent realization) for reducing personnel costs as well as improving the quality of the work by automating many of the manual operations. In addition, many other activities have been initiated which would not have been undertaken if computer resources were not available. The result has been a significant commitment to automation and a dependence on EDP resources.

It is important to realize that this commitment has
been voluntary and not obligatory. The final measure of the department's accomplishments is its output. Computers merely provide a means for efficiently achieving the desired levels of output; if the department could be as effective and efficient without using computer technology then it would be expected to do so. In short, the department is not a data processing department; it is only a data processing user.

The Research Department is organized as a cost center. Its output is not explicitly measured. Rather, the department is expected to accomplish certain required functions as well as many more self-initiated ones. Each year, the departmental management constructs a budget which includes expected costs for all of the planned activities.

The department is expected to stay within the budgeted amounts. However, since the department, like much of the Federal Reserve System, exists to serve the public and the banking community, variances are permitted if they are justifiable. Thus in all decision making, the ultimate criterion is not the expenditure and whether or not it had been budgeted, but whether the result will be beneficial.

It should be mentioned that this study is limited to the data processing needs for the two major departmental activities. Recently EDP resources have been used for word processing and for automating many of the functions performed by the Research Library staff. However, as these
areas are relatively minor and undefined, they will not be included in this analysis.
4.2 Specific Requirements of the Statistical Section

The Statistical Section is responsible for processing almost all of the current financial and economic data collected by the Federal Reserve Bank of Boston. These data are quite varied. Each particular series is characterized by a specific survey form which is completed by a designated group of reporters (or participants) at regular intervals.

For example, the Statistical Section currently processes different series. The information contained on these reports varies with each series. The participants also vary with each series. Thus some reports are completed by all member banks; others may be completed by only certain member banks, or by nonmember banks, savings banks, life insurance companies, or public utilities. Furthermore, the frequency of each report also varies. Some data are collected daily; other data are collected weekly, monthly, quarterly, semi-annually, annually, and even bi-annually.

Although the specific processing varies with each report, there are certain common procedures. The surveys are collected and edited to see that the figures reported are accurate. This editing process may be either simple or complex, depending upon the importance of the data and guidelines which have been established by the Board. At the minimum, the editing involves verifying that the reported total figures actually equal the sum of the reported...
microitems. At the other extreme, more complicated editing involves verifying that the reported figures are reasonable and consistent with that which was reported previously on either earlier reports of the same series (these are known as prior periods) or on other reports which request some of the same information (these are known as interseries data).

After all of the data for a particular series have been collected and edited, some form of final output is generated and distributed. Depending upon the specific series, the output may be one or more of the following: printed reports, magnetic tapes, graphs, or reports for transmission over a communications network.

The information processed by the Statistical Section may be classified according to its use as either regulatory or statistical. The former include information which must be reported in order for the Federal Reserve Bank to regulate banking activities. Perhaps the best known illustration of this is the weekly report of deposit data which all member banks are required to provide in order for the Fed to calculate their required reserve positions. The latter includes all other information which is not used for regulatory purposes, but instead is used by economists within the Federal Reserve System for statistical purposes (such as determining an appropriate monetary policy).

Much of this information is processed under tight, rigid deadlines. The regulatory data are needed by other
departments (such as the Accounting Department who must inform the member banks of their required reserves for the upcoming period). The statistical data also must be processed rapidly because its timeliness is a major factor in its value in determining monetary policy.

Because of the tight deadlines, the large volume of information, the required editing, and the repetitive nature of each series which is processed, most of the series have been automated. The result is that the Statistical System relies heavily on the use of computers and has accordingly generated a minimum level of required service.

4.2.1 Equipment requirements of the Statistical Section

COST REQUIREMENTS:

The Research Department's primary objective is to satisfy the demands placed on it by the Board of Governors and the President of the Bank. Costs are considered to be an important, but secondary, effect. Therefore, almost any absolute costs are acceptable as long as they are reasonable for the level of services required.

As the present system does satisfy most of the department's data processing needs, the recent budgets provide the best estimates of what will qualify as acceptable expenditures for this function.
Table 4-1 presents the best estimates of the value of the EDP resources used by the Research Department.

NEED FOR SPECIALIZED RESOURCES

As mentioned earlier, the editing of series often involves comparing current data with prior period data or with interseries data. Because of this frequent use of other data, and the need to receive fairly rapid response time, storage of data on tape is not sufficient. There is a need to have certain amounts of data stored on fast access devices, such as disk or drum.

Table 4-2 illustrates the current demands for mass data storage. In addition, significant amounts of disk storage are needed daily as scratch storage for production programs.

The Statistical Section also requires the capability of producing output on magnetic tapes, at a plotter, and on printed pages.

The Statistical Section must have data security. Most of the data are confidential and can not be released to the general public.

Secondly, because data are used for both editing and statistical purposes, they must be retained indefinitely. The consequence of this is that many millions of bytes must
be accessible (not all on-line; see Table 4-2 for specific figures).

NEED FOR FLEXIBILITY IN SCHEDULING

The Statistical Section requires the capability of processing each of its automated series. Although very few series must be processed on any given day, the capability of processing the critical reports must exist. Quantification of this capability is both difficult and arbitrary because of the many factors which influence the processing. For example, some reports are due on certain dates of the month while others are due on specified days. If these two coincide, processing requirements for that day will increase. Furthermore, typically processing is distributed over a period of time between when the surveys are received and when the final reports are due. However, personnel absences, holidays, mail delays, computer problems all may result in a shorter time frame and a compressed processing schedule. Thus, it is within the realm of possibility that on any given day, 10 different series would have to be processed and that this would require 15 different computer runs.

Table 4-3 describes the actual processing requirements of the Current Reporting Series.
TURNAROUND TIME

The system must be available to process the high priority projects. Delays of one or two hours are occasionally permissible; however, delays of one day or more are not usually tolerable.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

Most of the Statistical Section's work is repetitive and similar and thus does not require a detailed knowledge of the specific applications on the part of the EDP operations personnel. However, an understanding of the importance of particular jobs (especially as their deadlines approach) and a familiarity with the general procedures is helpful.

NEED FOR EFFICIENT RESOURCE UTILIZATION

It is desired that all resources be used as efficiently as possible in order to eliminate unnecessary expenses. This is particularly true of personnel resources because it is felt that idle employees will become bored and dissatisfied with their job.

On the other hand, the resources must be available to meet the specific Bank requirements. Thus, slack time is
acceptable if it is absolutely needed in order to insure meeting deadlines.

NEED FOR TRAINING

Because of the importance of the EDP work, it is necessary that the personnel be trained in order to satisfy the user's needs. However, within the operations area, most of the training involves initial training on the system being used. Once the indoctrination period is over, ongoing training is minimal.

Initial training in areas not unique to the installation are available from external sources such as schools and training programs. Therefore the key requirement is to provide that training which is characteristic of the facility.

IMPORTANT OF TURNOVER AND RECRUITMENT PROBLEMS

The major concerns are the problems which result from a lack of trained personnel who can operate the EDP equipment and the associated time and monetary costs of recruiting and training replacements.

Although there are no specific requirements, the costs and potential problems necessitate that the chances for disruptive action be minimized.
IMPORTANCE OF EMPLOYEE SATISFACTION

Both officially and unofficially, there is an attempt within the Bank to provide as much employee satisfaction as possible.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

There is a need for ED operations personnel to be aware of the high priority jobs within the Bank and to commit resources to those with imminent deadlines.

NEED FOR STANDARDIZATION AND DOCUMENTATION

Because some of the data processed by the Research Department is used by other departments, it is necessary that there be compatibility between the data storage of the Research Department and the rest of the Bank. In addition, there are constraints within the Federal Reserve System which require that the Boston Fed be able to produce magnetic tapes which are compatible with IBM equipment.

Documentation of the operations area itself is not an issue.
ADAPTABILITY TO CHANGE

The Research Department is not concerned with having the latest technical advances. It is, however, concerned with not being bypassed technologically, especially with regards to efficient and effective task accomplishment.

4.2.2 Software requirements of the Statistical Section

COST

Details of the allowable costs for software development are included in Table 4-1.

NEED FOR SPECIALIZED RESOURCES

The need for specialized resources is not great. The needs of the department are fairly homogenous over time. Most of the work involves programming data input, editing, storage, and reporting. Currently, the needs are quite similar to those of other departments within the Bank.

The Statistical Section may require software support for any of six possible reasons. First of all, the Board of Governors may initiate a new series which necessitates the development of a new system. Secondly, the Board may revise the survey format, the editing criteria, or the format of
the final report of an existing series. Thirdly, an existing system may have to be updated due to external events. An examples of this would include the changing of the numbering system used to identify banks. A fourth cause of software support is the need to correct existing operational programs when programming bugs are discovered. A fifth reason is the modification of existing programs for non-essential but convenience reasons. Examples of this include the desire for format changes, procedural changes, or different information. Similarly, a sixth possibility includes the development of new programs for convenience reasons.

Table 4-4 provides a breakdown of the type of requests which must be fulfilled.

NEED FOR FLEXIBILITY IN SCHEDULING

It should be noted that the third, fifth, and sixth causes can generally be controlled and scheduled through careful planning. The other three types tend to be much less predictable and controllable. Programming bugs crop up at any time. Board requests can generally be anticipated, but they too can come with either little notice or at most inopportune times.

Some Board requests result from changes in regulatory policy. These are definite mandates which must be
implemented within the specified time frame; no excuses are accepted. Other Board requests involve data used for statistical purposes. Generally, the individual Reserve Banks know of these in advance and are asked for comment on their potential costs and effects. However, once the Board receives all of this input, it reaches a final decision; this may or may not be consistent with the individual Reserve Banks's recommendations. At this point, the decision is considered to be a mandate. The Board rarely states that the processing must be automated; that decision is left to the discretion of the individual Banks.

TURNAROUND TIME

Precise quantification of the frequency of these areas is difficult. One reason is that there is no such thing as a representative time period. Total demands by the Board and the by users do not follow any set patterns. In addition, for the fourth class of causes for software assistance (bugs), many of the requests are never formally documented but instead are corrected immediately. Table 4-4 presents a breakdown of all formal requests for programming support for the Statistical Section between March, 1972 and December, 1973 and is therefore indicative of the level of software support needed.

The consequence of this situation is that the
Statistical Section requires programming support which is capable of developing a new system or modifying an existing system within relatively short time frames. In addition, because ongoing systems are used extensively and with tight deadlines, it is essential that they remain operational. Since the Research users are not computer experts, it is therefore necessary that they have quick access and response from programming personnel in case of emergencies due to system failures.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

The major requirement of the software development staff is that it be able to analyze particular processing requests and determine the feasibility and subsequently, the optimal method of automating them. Because of the similarity and interrelationship of many of the series, this necessitates a good understanding of the overall processing done by the Research Department.

In addition, it is important that the EDP staff understand the nature of the users so that the systems can be designed for their use. Furthermore, because of the lack of EDP expertise among the general Research user, it is necessary for the EDP staff to be involved in both the initial planning and the subsequent usage and modification.
NEED FOR EFFICIENT RESOURCE UTILIZATION

The desire for efficiency and the acceptance of slack time expressed in the previous discussion of hardware requirements are true for software resources also.

The need to monitor and control projects is of particular importance. The Research Department has all final responsibility for meeting deadlines. Delays due to data processing problems are not accepted. Therefore, if it is decided to meet new requests by using data processing resources, the departmental management must insure that these ventures are successful.

NEED FOR TRAINING

Initial training consists mostly of an indoctrination to the procedures and software which are unique to the installation. Ongoing training is needed mainly to aid career development and to meet specific needs. Because of the abundance of EDP personnel and course opportunities in the Boston area, the need to be able to train internally is restricted mainly to those procedures which are unique to the Bank.
IMPORTANCE OF TURNOVER AND RECRUITMENT

Because of the tight deadlines imposed on data processing work, the loss of any trained personnel could be troublesome. The difficulty would be manifested in the completion of ongoing projects as well as the support of existing systems.

The availability of competent recruits, although a problem, is at least somewhat alleviated by the current Boston labor market situation. Although no long run predictions can be made with certainty, it does seem that the variety of educational institutions in Boston will make recruiting talent less of a problem than in most other areas.

A more important consideration is the ability to screen and select potential employees. Because of the reluctance of the Bank to discharge people, it is important to recruit good people. In addition, because the Research Department is a user department and not an EDP department, its management does not want to become involved in problems of recruiting a staff - unless it is absolutely necessary.

IMPORTANCE OF EMPLOYEE SATISFACTION

As in the discussion of hardware requirements, employee satisfaction is a stated goal. This is particularly true due to the potential problems of project discontinuity from
personnel turnover. In addition, the professional status of EDP software personnel makes the issue of career opportunities particularly important.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

Most of the programming needs of the Statistical Section result from requests beyond the control of the Boston Fed. Consequently, there is not a need for constant interaction between top management and the EDP staff to insure that internal EDP resources are not misutilized. However, at the same time, care must be taken so that there are not "convenience" programming requests being fulfilled at the expense of higher priority corporate projects.

NEED FOR STANDARDIZATION AND DOCUMENTATION

There is a need for both software standardization and documentation within the department and within the Bank. Not only must systems be compatible for operational reasons, they must also be designed so that common data bases and systems are available and not altered without sufficient documentation.

In addition, the availability of good documentation will help eliminate redundant efforts and the resultant misutilization of personnel.
Finally, user documentation is mandatory in order to insure efficient and effective system usage.

ADAPTABILITY TO CHANGE

Research has little concern for adapting to technological advances in software except as they would affect programming efficiency and effectiveness. This area is not a significant factor due to significant time lags between the introduction of new languages and their widespread usage.
4.3 Specific Requirements of the Economic Research Section

The Economic Research Section is responsible for researching and analyzing various economic issues which are of interest to the President or Directors of the Bank, other senior management, and on occasion, members of the Board of Governors. Although the staff of economists may get involved in a diverse range of topics, most of them may be broadly classified as belonging to one of the following disciplines: monetary policy, national business conditions, international economics, regional economics, or banking and banking structures.

The impetus behind and subsequent utilization of the individual research projects are varied. Many of the studies are initiated in order to be included in a bi-monthly journal published by the Federal Reserve Bank of Boston for the general interest of the public and banking community. Still other studies are performed for the general interest of the departmental staff. However, a large number of research efforts are performed in order to provide information on topical issues which are of concern to the Bank's President, Directors, or to the Board.

Many of the research projects involve the collection and analysis of data. The specific types of analyses and statistical methods used vary considerably. Some economists are extensive users of econometric tools; others rely less heavily on quantitative analysis. The consequence of this
is that the analytical needs of the Economic Research Section will vary over long periods of time depending upon the nature of the economists who comprise the staff and their particular projects at that time. Since most of the analytical work requires the use of EDP resources, this means that the specific EDP resources used will also vary considerably.

The deadlines under which the research is performed are also varied. Most of the studies initiated for publication in the Bank's journal or for internal use are long-range, and may in fact, represent several years of work. Nonetheless, even these studies encounter time pressures as they become scheduled for publication and are not as advanced as expected when the scheduled deadlines approach. On the other hand, most of the research on topical issues for senior management are of much shorter duration and face much more severe deadlines. It is not unusual for someone within the Bank to need particular information on notice of one or two days, and for this to require some nontrivial amount of data collection and analysis.

The data processing needs of economists may be broadly classified according to the following factors. First of all, there is the availability of data. Secondly, there is the need to be able to manipulate and analyze data samples of various sizes. Thirdly, there is the type of econometric tools needed. Finally, there is the turnaround for
response) time needed to facilitate successful research.

With the exception of part of the Regional Section, which analyzes the competitive effects of proposed changes in banking structures, most of the research performed is of a similar nature to that performed by most other economists. The significance of this is that the data processing needs of the Economic Research Section are diverse from those of the rest of the Bank, but homogenous with those of other economists.

4.3.1 Equipment Requirements of the Economic Research Section

COST

Details of the allowable costs for computer usage are included in Table 4-1.

NEED FOR SPECIALIZED RESOURCES

Data analysis requires the capability of performing many numerical calculations on samples of data which may range from a few variables and observations to 100 or more variables and 50,000 or more observations. The result is that the computer must be able to handle large arrays efficiently, and to perform scientific processing with
sufficient precision. The latter is particularly important as many of the projects use regression analyses. This technique requires calculating the inverse of large matrices. In order to receive meaningful results, precision is mandatory.

Secondly, there is a need to be able to accept data from or produce output onto, a variety of media. At the minimum this includes cards, magnetic tape, and printed pages.

NEED FOR FLEXIBILITY IN SCHEDULING

The demands placed on an econometric system are not constant. Typically, economists in the analytical stage of a study will not have even loads from day to day but rather will have peaks and valleys. When this individual variance is compounded by the number of ongoing projects for each economist and by the number of economists, it is clear that there is a potential for highly variable and unpredictable system demands.

It is true that this may overstate the case, and that in fact, all of these jobs are not absolutely needed at once. Although this too is true, it just tends to reduce the magnitude of the variances.
TURNAROUND TIME

Most of the economists questioned felt that they could generally operate well with turnaround time of about two hours. Some felt that this would be the best service which they might ever need; others could foresee the need for almost instantaneous response time.

This survey was taken on the current staff of economists. At the present time, it does not include an economist who is developing his own models and who thus requires the immediate response and feedback of an interactive system. When such work is performed, the needs are much different.

The potential problem is felt when one considers whether this optimal turnaround time should be available to all projects or just for the high priority ones. Currently, it is the opinion of the Director of Research that only high priority projects require rapid turnaround time.

On the other hand, the worst acceptable turnaround time seems to be about one day. The economic staff were near agreement that turnaround of greater than that would be unbearable.

The relevance of turnaround time is seen when one considers how economists process information. Almost all analyses are made sequentially; it is rare when two jobs from one project can be submitted together. The results of the first job usually determine what will be analyzed in the
second job.

Table 4-5 summarizes the sentiments of the economists questioned concerning the level of service required.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

As with the Statistical Section, the only requirement in the operations area is that the personnel be informed of which jobs must receive immediate attention.

NEED FOR EFFICIENT RESOURCE UTILIZATION

The same conditions specified for the Statistical Section hold here.

NEED FOR TRAINING

Likewise, the conditions specified for the Statistical Section hold here.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

These requirements also follow the same conditions as mentioned in the discussion on the equipment requirements of the Statistical Section.
IMPORTANCE OF EMPLOYEE SATISFACTION

Likewise, this is the same as for the Statistical Section.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

EDP operations personnel must be aware of the priority of the econometric jobs in relation to other Bank projects. However, there is currently no central source who can make this decision. As a result, the requirement is purely academic.

NEED FOR STANDARDIZATION AND DOCUMENTATION

The major requirements concerning equipment is that the system be able to process most commonly used media. Thus data generated on other installations, as well as internal data maintained by the Statistical Section, must be accessible.

ADAPTABILITY TO CHANGE

This requirement is the same as for the Statistical Section.
4.3.2 Software Requirements of the Economic Research Section

COST

Allowable costs for software development are presented in Table 4-1.

NEED FOR SPECIALIZED RESOURCES

Two of the most important features required of an econometric system involve specialized resources. Certain economists (those who use regularly published, standard data series) feel that their work would be considerably expedited by the availability of this data. Other economists, who collect particular data not widely used, find this feature to be of little importance.

The second major specialized resource is the availability of a full range of econometric tools. Economists want to be able to use that econometric technique which they feel is optimal. Thus, whereas certain basic features will satisfy almost all of their econometric needs, the staff will occasionally need a new technique. Typically, this need is absolute and can not be circumvented.

In addition, knowledge of statistics and efficient programming techniques are both key requirements. Unlike
the Statistical Section's work, this area tends to be data intensive and lengthy. Thus, the effect of any programming inefficiencies are magnified.

Table 4-6 presents a breakdown of the needed features and their frequency.

NEED FOR FLEXIBILITY IN SCHEDULING

The requests for new econometric techniques are rare and are usually well known in advance and thus present little potential for scheduling problems.

TURNAROUND TIME

Most of the requests for new techniques can be foreseen from one to six months in advance. In addition, because at this point in most projects, final deadlines have not been established, turnaround time is not an essential feature.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

Involvement and understanding of the projects are not necessary.
NEED FOR EFFICIENT RESOURCE UTILIZATION

This factor is the same as for the software requirements of the Statistical Section.

NEED FOR TRAINING

Training requirements could consist of three different types. There is a knowledge of statistics, a knowledge of the econometric system, and a knowledge of programming.

The first of these can not efficiently be developed internally and thus must be recruited. The second can only be recruited if a standard system is used; otherwise, it must be developed internally within the group responsible for the system. Finally, the third requirement can either be recruited or developed through internal training.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

Turnover is important because of the difficulty in recruiting personnel with all of the abilities needed. On the other hand, the longer time frames make the issue of project continuity less critical.
IMPORTANCE OF EMPLOYEE SATISFACTION

This is the same as in the Statistical Section.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

Because so few system changes are needed at any one time, the need to be aware of corporate priorities is not as essential.

NEED FOR STANDARDIZATION AND DOCUMENTATION

The software must clearly conform to the standards applied to other programs within the same installation. In addition, the statistical techniques used must follow the standard definitions.

However, the key issue is user documentation. One of the major requirements of an econometric system expressed by the economists was the need for good and complete documentation. One of the biggest concerns is to have the problem of poor turnaround time compounded with the frustration of having a job not run as expected due to inadequate documentation.
ADAPTABILITY TO CHANGE

These requirements are also the same as for the Statistical Section.
Table 4-1: Allowable EDP Costs

<table>
<thead>
<tr>
<th>Section</th>
<th>1973 Actual</th>
<th>1974 Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATISTICAL SECTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer runs</td>
<td>$146,000</td>
<td>$144,000</td>
</tr>
<tr>
<td>Program development*</td>
<td>146,000</td>
<td>47,000</td>
</tr>
<tr>
<td>System development*</td>
<td>26,000</td>
<td>75,000</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>$318,000</strong></td>
<td><strong>$266,000</strong></td>
</tr>
<tr>
<td><strong>ECONOMIC RESEARCH SECTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer runs</td>
<td>$75,000</td>
<td>$83,000</td>
</tr>
<tr>
<td>System development*</td>
<td>117,000</td>
<td>95,000</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>$192,000</strong></td>
<td><strong>$178,000</strong></td>
</tr>
</tbody>
</table>

**TOTALS - CENTRALIZED FACILITY**  
$510,000  $444,000

*Development costs include salary, benefits, and program test time
Table 4-2: Storage Requirements for the Statistical Section

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Bytes on Mass Storage (as of December, 1973)</td>
<td>90 million</td>
</tr>
<tr>
<td>Number of Bytes Added to Mass Storage per Year</td>
<td>13 million</td>
</tr>
<tr>
<td>Number of Bytes on Fast Access Storage</td>
<td>13 million</td>
</tr>
</tbody>
</table>
Table 4-3: Number of Statistical Section Jobs per Reporting Period

<table>
<thead>
<tr>
<th>Reporting Period</th>
<th>1-2</th>
<th>3-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
<th>21-25</th>
<th>26-40</th>
<th>41-50</th>
<th>51-75</th>
<th>76-100</th>
<th>101-150</th>
<th>151-200</th>
<th>sub-total</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEEKLY</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>R*</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>MONTHLY</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>R</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>QUARTERLY</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>R</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>SEMI-ANNUALLY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ANUALLY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>R</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>25</td>
<td>55</td>
</tr>
<tr>
<td>R</td>
<td>13</td>
<td>13</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

*(P = Posting, R = Reporting)*
Table 4-4: Programming Requests of the Statistical Section*

<table>
<thead>
<tr>
<th>Reason for Request</th>
<th>0-2 weeks</th>
<th>2 wks-1 month</th>
<th>1-2 months</th>
<th>2-3 months</th>
<th>over 3 months</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>New programs initiated by Board requests</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Modifications to existing programs</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>resulting from Board requests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modifications to existing programs</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>due to external factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correction of programming bugs</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Convenience changes to existing programs</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Development of convenience programs</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>13</strong></td>
<td><strong>13</strong></td>
<td><strong>13</strong></td>
<td><strong>5</strong></td>
<td><strong>14</strong></td>
<td><strong>58</strong></td>
</tr>
</tbody>
</table>

*Data collected over a period from March 1972 to December 1973
Table 4-5: Sample Responses to Survey Concerning the Desired Levels of Service Requested by Economists

Number of jobs from a study which would generally be submitted during one day

<table>
<thead>
<tr>
<th>Number of jobs</th>
<th>Frequency of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 or more</td>
<td>4</td>
</tr>
</tbody>
</table>

Maximum number of jobs which might realistically be submitted and needed on one day

<table>
<thead>
<tr>
<th>Number of jobs</th>
<th>Frequency of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2-3</td>
<td>3</td>
</tr>
<tr>
<td>4-5</td>
<td>3</td>
</tr>
<tr>
<td>6-7</td>
<td>0</td>
</tr>
<tr>
<td>8 or more</td>
<td>2</td>
</tr>
</tbody>
</table>

Can these jobs be submitted all at once or must they be submitted sequentially?

<table>
<thead>
<tr>
<th>Option</th>
<th>Frequency of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>All at once</td>
<td>1.5</td>
</tr>
<tr>
<td>Sequentially</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Turnaround time required

<table>
<thead>
<tr>
<th>Time</th>
<th>On the average</th>
<th>Fastest</th>
<th>Maximum that could live with</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 1/2 hr.</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1/2 - 1 hr.</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1 - 2 hours</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 - 4 hours</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4 - 7 hours</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>overnight</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>more than 1 day</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 4-6: Econometric and Other Techniques Used by the Research Department in a Sample of 120 ESS Jobs

<table>
<thead>
<tr>
<th>Technique used</th>
<th># jobs using the technique</th>
<th>% jobs using the technique</th>
<th>average for all jobs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input files</td>
<td>120</td>
<td>100.0%</td>
<td>1.9</td>
</tr>
<tr>
<td>Card files</td>
<td>68</td>
<td>56.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Disk files</td>
<td>35</td>
<td>29.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Tape files</td>
<td>17</td>
<td>14.2</td>
<td>0.5</td>
</tr>
<tr>
<td>History system</td>
<td>48</td>
<td>40.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Observations</td>
<td>120</td>
<td>100.0</td>
<td>308.2</td>
</tr>
<tr>
<td>Input variables</td>
<td>120</td>
<td>100.0</td>
<td>26.2</td>
</tr>
<tr>
<td>Total variables</td>
<td>120</td>
<td>100.0</td>
<td>49.9</td>
</tr>
<tr>
<td>File selecting</td>
<td>46</td>
<td>38.3</td>
<td>na</td>
</tr>
<tr>
<td>Data sorting</td>
<td>70</td>
<td>58.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Data &amp; file merging</td>
<td>41</td>
<td>34.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Transformations</td>
<td>90</td>
<td>75.0</td>
<td>41.7</td>
</tr>
<tr>
<td>Estimations</td>
<td>2</td>
<td>1.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Grouping</td>
<td>22</td>
<td>18.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Statistical summaries</td>
<td>27</td>
<td>22.5</td>
<td>8.9</td>
</tr>
<tr>
<td>Correlation matrices</td>
<td>13</td>
<td>10.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Variables/matrix</td>
<td>na</td>
<td>na</td>
<td>31.4</td>
</tr>
<tr>
<td>Minimum output regressions</td>
<td>7</td>
<td>5.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Average number of IVs</td>
<td>7</td>
<td>5.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Regular regression eqs.</td>
<td>10</td>
<td>8.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Average number of IVs</td>
<td>10</td>
<td>8.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Stepwise equations</td>
<td>14</td>
<td>11.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Average number of IVs</td>
<td>14</td>
<td>11.7</td>
<td>1.2</td>
</tr>
<tr>
<td>PDLs</td>
<td>3</td>
<td>2.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Plotter output</td>
<td>18</td>
<td>15.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Card output</td>
<td>14</td>
<td>11.7</td>
<td>0.1</td>
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<tr>
<td>Disk output</td>
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<td>0.0</td>
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<tr>
<td>Tape output</td>
<td>12</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

* The average is for all jobs, not just those using this particular technique. Thus to know the average for only those jobs using the technique, multiply the third column by 120 and divide by the number of jobs using the technique (column 1).
CHAPTER 5 - CENTRALIZED EQUIPMENT AND SOFTWARE

One potential approach to satisfying the data processing requirements of the Research Department is a centralized organization in which all Bank data processing resources (both equipment and software) are centralized under one service organization and shared by the various user departments. This method is the one currently followed within the Federal Reserve Bank of Boston.

The first section of this chapter presents a descriptive model of the organization. The second section evaluates the results in light of the needs of the Research Department (as specified in Chapter 4) and those issues relevant to the question of centralization. The third section considers modifying the current system while retaining the centralized structure (37).
5.1 Descriptive Model of the Current Centralized Organization

Almost all of the operational requirements of the Research Department are run on the Bank's central computer facility which is the responsibility of the Data Processing and Data Communications Department. This work includes all of the automated processing of the Statistical Section and almost all of the Economic Research Section's work; the only exception to the latter is that a small amount of work is performed on external timesharing services.

The programming requirements of the Research Department are handled by two separate departments. The development and maintenance of the internal Econometric Statistical System is the responsibility of the ESS Section of the Computer Planning Department. ESS is a general purpose statistical package which is used for all econometric analyses performed by the Economic Research Section (other than those done with timesharing). In addition, because of its versatility and "programmability", ESS is also used by the Statistical Section for certain jobs which require data retrieval, manipulation, analyses, or formatted output.

The ESS Section consists of a project leader, a programmer/analyst, a statistician and programmer, and a person responsible for documenting the system and assisting the users.

All of the programming support required by the
Statistical Section is provided by one of the three Task Forces of the Data Systems Support Department. Currently the Research Department is in the process of converting the processing of many of the individual Statistical Series from single purpose stand-alone applications to a general purpose program. This General Purpose Series Processor (or GPSP) is a major system which is functionally to the Statistical Section what ESS is to the Economic Research Section. It allows its users to define series; valid reporters, items, and editing procedures; as well as desired reports. Consequently, programmers are freed from having to make many minor changes.

Because of limitations within GPSP, not all of the Statistical Series can be processed with it; those remaining series are processed as stand alone applications. The consequence is that DSS is responsible for both developing and maintaining GPSP as well as all other special purpose programs which are needed.

Currently DSS assigns about three programmers to support the stand-alone applications. An additional staff of about two programmers is responsible for GPSP. However, the Research Department is also supported indirectly by other DSS efforts. The Task Force Manager, the department manager, and the Assistant Vice President all contribute various amounts of supervision and coordination of programming efforts. In addition, DSS retains a technical
writer who is responsible for developing and insuring conformance to documentation standards. There is also a training coordinator who is responsible for both initial and ongoing training of departmental personnel.

All of the Research Department's data processing is coordinated by the Computer Liaison Section. All operational work - from keypunching to computer jobs - are funneled through the Computer Liaison Section which is responsible for submitting all work to the DPDC Department. Because of limited resources, not all of the Research work can be run during the day. Therefore, the Liaison Section submits only those jobs of highest priority and leaves the others for overnight processing. Day time work is submitted from and received at a remote job entry terminal; all evening work is run in a purely batch mode.

All of the requests for software development and maintenance are also coordinated by the Computer Liaison Section. The impetus behind these requests may be observations made by the Liaison Section or they may result from users' questions to the Liaison Section. In either case, once a need for programming support is established, the Liaison Section documents the specific details of the request and forwards it to the appropriate programming group. In addition, the Liaison Section will inform the programming management of the priority of that request relative to all other outstanding departmental requests.
The Computer Liaison Section was created in order to establish one departmental authority which would be responsible for all data processing activity and communication. This eliminates otherwise potential problems of having different users within one department make conflicting requests from the service areas.
5.2 An Evaluation of the Centralized Organization

This section evaluates the centralized organization as it pertains to the needs of both the Statistical Section and the Economic Research Section. As the equipment requirements of these sections are serviced by the same centralized facility, a joint evaluation is presented in the first subsection. Because there is a difference in the programming organization, this evaluation is presented in the second and third subsections.

5.2.1 Equipment Requirements of the Statistical Section and the Economic Research Section

COST

As the allowable costs were based upon the current expenditures, they are considered to be within reason.

NEED FOR SPECIALIZED RESOURCES

A pooling of needs among user departments has helped to justify and make possible a reasonable utilization of equipment resources which might not otherwise be possible.

First of all, both the Statistical and Economic Research Sections require the capability of using cards, magnetic tape, plotter, and printed page input/output. However, as they are not utilized constantly, a centralized
organization makes these resources available to all users and thus increases their utilization.

Secondly, because there is one central facility serving all users, a much larger machine can be justified than would be possible with the limited needs of the Research Department. Consequently, more core and mass storage are available from economies of scale. This means that the need for sufficient core for processing econometric routines and the need for mass storage of statistical data can be more easily satisfied at a lower cost.

Similarly, because a bigger, more versatile system is feasible, the need for a scientific machine can also be satisfied.

Finally, the internal housing of the facility provides for the data confidentiality needed by the Statistical Section.

NEED FOR FLEXIBILITY IN SCHEDULING

The use of a large centralized facility provides a cushion against variances in demand. If necessary, one or two additional Research jobs can be run at the expense of less urgent jobs from other departments. This ability to shuffle jobs is attributed to the increased organizational size.
TURNAROUND TIME

Generally, the centralized facility provides the turnaround required for all of the Statistical Section's work and most of the high priority work of the Economic Research Section. Most shortcomings are in the latter area. Due to a variety of factors, ESS processing is limited to one job at a time. This means that the system currently can not process many high priority jobs at once. In addition, big jobs may not be run during the day. Fortunately, the needs for such service are infrequent. In addition, scheduled software changes will remedy the former situation and reduce the importance of this factor.

Of course, the advantages of a centralized facility, which permits other department's jobs to be sacrificed for higher priority Research jobs, can also work against Research and increase turnaround.

LEVEL OF INVOLVEMENT AND UNDERSTANDING REQUIRED OF EDP PERSONNEL

The major need in this area is the knowledge of high priority work that may require special attention. Because the Statistical Section's work is fairly regular, many of the deadlines are known by the operations personnel, who in turn make every effort to see that those jobs are completed on time.
For those statistical series which are less frequent, or for the important econometric runs, the operations personnel must be informed of the relative urgency. This is easily communicated verbally during the day and with written priority sheets at night. Furthermore, as the Computer Liaison Section controls the day time work, it is able to insure that most important jobs are completed.

The system seems to be successful. There have been few instances in which important jobs were not completed on time.

NEED FOR EFFICIENT RESOURCE UTILIZATION

The pooling of needs and resources has created a larger facility which is less susceptible to inefficiencies attributable to scheduling variances. Peaks in one area may be offset by valleys within another area. Consequently, it is easier to retain a particular level of resources which are efficiently used.

Secondly, because there is enough work to utilize a full staff of operations personnel, specialized EDP management can be retained who are able to guide and evaluate the personnel.
NEED FOR TRAINING

The major requirement involves initial training. This is particularly easy with a centralized organization because good candidates can be selected from other areas of the DPDC department. These people will already have some understanding of the internal system. Additional training can be provided by other operations personnel and management. In addition, new recruits can be trained gradually. These opportunities might not exist with smaller decentralized staffs.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

The increased size of the operations area makes it better able to absorb losses due to turnover. Recruitment also is facilitated by intradepartmental promotion and the availability of experienced management who are able to select good candidates.

Research efforts have not been hurt by problems in these areas.

IMPORTANCE OF EMPLOYEE SATISFACTION

The DPDC department is small enough so that morale problems due to large staffs are not a factor. On the other hand, there are enough people (approximately eight operators
on two shifts) to require two shift supervisors. This therefore creates supervisory positions, and along with other departmental positions, provides the operations personnel with attractive career opportunities.

Interdepartmental rotation is also feasible.

**NEED FOR COMMUNICATION WITH TOP MANAGEMENT**

The placing of all data processing under one organization permits the DPDC management to inform its operational personnel of critical jobs within the Bank. Thus the Research Department may inform DPDC management of its high priority requests, and a central management can then place them in their proper perspective relative to other Bank projects.

**NEED FOR STANDARDIZATION AND DOCUMENTATION**

The use of a centralized facility means that there is no problem with compatibility of interdepartmental and intradepartmental data. Secondly, the system is compatible with IBM equipment (as far as I/O) and thus meets the specific Research requirements.
ADAPTABILITY TO CHANGE

The availability of an experienced, specialized computer planning department frees Research from all responsibilities concerning the selection and evaluation of computer equipment. In addition, the centralized organization allows this group to become better informed and better utilized due to the variety of projects available. In addition, the group is better able to place the data processing needs of the Research Department into an appropriate corporate priority.

5.2.2 Software Requirements of the Statistical Section

COST

The software costs are within the acceptable limits.

NEED FOR SPECIALIZED RESOURCES

DSS, because of its size and diverse range of talents, has generally been able to satisfy the variety of programming requests submitted by the Research Department. DSS has been most successful in completing major systems development and maintenance. In addition, Research benefits from other Bank systems (such as the data base and data
inquiry programs) developed by DSS.

Another potential advantage to Research involves interactive programming. Currently, there is no need for this within the Statistical Section's applications. However, it is likely that there will be a need in the future. At that time, Research will be able to benefit from DSS expertise in this field which is now being accumulated by work on other projects.

The major failures of DSS are its inability to provide system analysis and minor maintenance. The former is discussed subsequently. The latter is a result of the department's orientation toward major applications which are planned for and staffed well in advance. Consequently, when minor efforts are needed, there is often a shortage of trained personnel available.

NEED FOR FLEXIBILITY IN SCHEDULING

The size and resultant flexibility in moving personnel from project to project enables DSS to adjust quite well and satisfy the sporadic demand for long range system development.

DSS has not been as successful in servicing minor projects of a shorter duration. Because it is geared toward handling larger systems and has developed appropriate review and control systems, it is much less flexible and responsive
to shorter term requests.

TURNAROUND TIME

DSS has been able to satisfy most of the important programming requests within the required time frames, although this has often been accomplished under last minute "crisis" situations. Some projects have not been completed successfully; these have generally either been at least useable or not absolutely necessary.

Because the orientation is toward larger systems, there has been an increased effort by the the Statistical Section to avoid making minor requests. This is particularly evident with GPSP, which allows the Statistical Section to process many of the minor requests without DSS support.

The support and maintenance of existing systems has been satisfactory but not outstanding. Problems are usually solved. However, as each system is often known by almost one programmer (who may or may not be available), turnaround on emergency problems is not ideal.

LEVEL OF INVOLVEMENT AND UNDERSTANDING REQUIRED OF EDP PERSONNEL

Much of the required involvement and understanding is provided by the Computer Liaison Section. All programming
requests are reviewed and analyzed for feasibility and importance by the section. In addition, its members occasionally pinpoint specific portions of code which require modification. The result is that, for many systems, the Liaison Section performs most of the analysis and even parts of the design process.

This effort is necessitated by a lack of DSS understanding of both the nature of the Research problems and the relationship among the data processing systems. DSS personnel have been reluctant to become involved in the procedures within the Statistical Section. Accordingly, they do not understand the problems and must rely on the Liaison Section to communicate them. When requests do come, DSS often does not appreciate the urgency and tends to question the requests. Although this questioning is good in that it prevents allocating resources to unimportant projects, it does prevent or delay worthwhile projects from being attended to.

The second problem is that DSS personnel do not know the entire data processing area of the Statistical Section. Each person knows his area, but cannot solve a problem which involves or interfaces with another area. This is particularly troublesome due to the interrelationship of certain major programs.

In short, this lack of understanding makes DSS reluctant to handle some programming requests. An overall
defensive attitude restricts the support available to Research.

NEED OF EFFICIENT RESOURCE UTILIZATION

The existence of a centralized staff has led to an overall scheduling system which allocates personnel to the high priority projects. However, the centralized organization has not benefited from an accurate system for monitoring ongoing projects. Most of this control still results from the interaction between the project leader and the analysts assigned to the task. No formal system is used and status reports are often just crude estimates by the programmers. This lack of control is at least partially due to the training requirements placed on the supervisory personnel.

Another problem is the level of effort contributed by the programming staff. The programmers are responsible and accountable to DSS. However, their performance affects the Statistical Section, which has no direct authority over them and thus no ability to motivate them. Accordingly, Research is often at the mercy of the programmers and analysts - at least in the short run.

One advantage of the centralized arrangement is that the programmers are reviewed by EDP management who, because
of specialized knowledge and responsibility for a larger staff, are better able to appraise and compare individual performances.

NEED FOR TRAINING

To date, most of the formal training efforts provided by the centralized department have involved programming languages. A more general program was initiated but has not been particularly successful.

Informal training of recruits by experienced staff members has been more successful. It may be at least partially attributed to the physical proximity of the EDP staff. Unfortunately, this has been limited to programming aids or to knowledge of particular systems. There has been little effort to provide an indoctrination to the entire data processing installation.

Ongoing training has been successfully accomplished by rotating people from project to project and by permitting enrollment in courses offered in the Boston area.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

The Research Department has benefited from the centralized organization. Because personnel are assigned to segments of a task and are also moved from project to
project, there are many people with at least some exposure
to parts of a major system. In addition, many of the
applications use Bank-wide routines with which most analysts
are familiar. Consequently, project continuity problems due
to turnover are partially avoided by the availability of
experienced personnel.

Problems of recruiting are also facilitated by a
specialized EDP management which is experienced in
interviewing and selecting personnel.

IMPORTANCE OF EMPLOYEE SATISFACTION

Employee satisfaction is provided by several factors.
The existence of large, challenging systems is one factor.
Another factor is the variety of projects and mobility among
them. Thirdly, the current size of the DSS Department seems
to be advantageous. It is big enough (about 50) to require
supervisory and managerial positions. Yet it is not so
large as to cause problems with loss of identity or
recognition.

Interdepartmental mobility, although not common, is
possible and thus offers another avenue of career
advancement.
NEED FOR COMMUNICATION WITH TOP MANAGEMENT

The centralized arrangement has facilitated the possibility of communication between top management and the EDP management. However, because the Research Department reports directly to the President of the Bank, the importance of its projects are not always known by the EDP area which organizationally reports to the First Vice President. This communication gap causes the EDP management to rely on Research input in order to position its requests with regard to other Bank requests.

In addition, the centralized system has not taken advantage of its increased ability to assign priorities for all projects on a Bank basis. Resources are currently allocated largely on a basis of who demands the most and who is willing to fund support. Current efforts to provide guidance to EDP management should remedy this situation.

NEED FOR STANDARDIZATION AND DOCUMENTATION

Programming standards for the installation have not been established. An effort has been made to establish programming guidelines; however, this is an interdepartmental effort and cannot be attributed to centralization. Furthermore, despite the centralized arrangement, there is currently no method of enforcement.

Documentation of systems has traditionally been poor.
Recent efforts have generally improved user documentation, due in part to increased managerial emphasis and the help of a technical writer. However, program documentation - both internal and external - is poor and user documentation of older systems is also substandard.

The result of this situation is that much training and information is informal and by word of mouth. People with problems go to the person originally assigned to the project - or to the user. On many occasions DSS personnel have come to the Research Department to learn details of a system developed by (and even for) DSS.

Despite these problems, there has not been any significant redundancy of efforts.

ADAPTABILITY TO CHANGE

This area is relatively unimportant due to the infrequent nature of changes. If they should occur, their analysis would be facilitated by the specialized talents of a centralized department.

5.2.3 Software Requirements of the Economic Research Section

The ESS Section is a small group which is organizationally separate from all other programming and user departments. As a result, it is not typical of
centralized organizations. On the other hand, the section does not serve just one user but does provide a Bank-wide system. For this reason, it offers an interesting illustration of how a small centralized facility is able to serve its users.

COST

The software costs of this organization are within the allowable range.

NEED FOR SPECIALIZED RESOURCES

There is no intention for the programming staff to satisfy the data collection requirement of the Economic Research Section.

The second major need, that of providing a full range of econometric tools, has been satisfied. ESS has evolved from a series of requests by users for specific techniques and features. In most cases, they have been implemented. The major exceptions involve techniques which are not compatible with the current system design.

The staff has sufficient knowledge of econometrics to handle Research requests.
NEED FOR FLEXIBILITY IN SCHEDULING

This need is currently minimal and is therefore easily met with the current organization.

TURNAROUND TIME

Because there are few requests for new features and these are generally presented with sufficient lead time, this requirement has also been well satisfied. If there were many simultaneous requests for new features, the small group would be unable to meet the needs.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

This is not a major requirement.

NEED FOR EFFICIENT RESOURCE UTILIZATION

The small size of the section makes it unfeasible to develop systems for controlling individual performances. However, this is partially overcome by the small size which permits constant interaction with the section leader. In addition, the section is part of a computer oriented department which has management with an understanding of computer problems and is thus able to control and appraise
personnel.

As in DSS, there is no formal system for evaluating ongoing projects and insuring efficiency. Much is left to the discretion of the individuals involved.

NEED FOR TRAINING

As ESS is not a standard system, internal training of new personnel must be provided. The small size of the section necessitates that this be done on an informal basis. To date, it has been successful; however, there has not been a major turnover problem.

Programmers have been both recruited and internally trained. Statistical expertise has been recruited rather than developed.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

The major effect of the small group has been a delay of projects resulting from project continuity problems attributable to turnover. However, as most of the projects have not been of an urgent nature, the problems have generally been negligible.
IMPORTANCE OF EMPLOYEE SATISFACTION

Few of the normal benefits attributable to a centralized organization are experience due to the size of the group. However, because it operates within a centralized facility, it has the opportunity to use advanced features and techniques.

Career paths are limited within the group and may be a cause of some turnover. However, there is mobility possible within the department, as well as to other EDP areas or to user departments.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

This also is not an important need due to the small number of requests.

NEED FOR STANDARDIZATION AND DOCUMENTATION

Conformation to statistical conventions is greatly facilitated by the presence of a statistician.

Conformation to installation standards is not a major issue. Currently, this is achieved by distributed memoranda and informal communication.

User documentation has been provided. It has been rewritten by a documentation specialist and should satisfy all requirements.
ADAPTABILITY TO CHANGE

This small centralized organization benefits from informal interaction with the major programming unit as well as from affiliation with the Computer Planning Department.
5.3 Possible Changes

On the whole, the current centralized system seems to have satisfied the major needs of the Research Department. The two major problems which have developed are the long turnaround for ESS jobs and the programming service received for requests to correct bugs and to develop some major systems.

The problem of ESS turnaround time can not be solved through a modification to the centralized organization. This problem could be solved if the Research Department maintained its own equipment; however, this would not be efficient. The most likely solution involves programming changes to ESS which are already in process. When completed, ESS should process much faster. If it does not, then the desired turnaround for econometric work could only be achieved with a centralized organization if additional resources (for example, core memory) were obtained.

The centralized programming facility has met most of the department's needs, but has not lived up to its potential. Failure to take advantage of specialized resources in developing programming standards, documentation, and training are key elements. On the other hand, these deficiencies seem to be largely a result of individual performances and departmental priorities, and may not be a fault of centralization.

What seems to be a fault of the centralized
organization is the lack of understanding and sensitivity to the Research area. However, this can be obtained with centralization if a determined effort were made to bridge the gap between the two departments.

Currently, Research is reluctant to utilize DSS because it anticipates poor service. On the other hand, DSS does not know the Research area and is reluctant to get involved. If DSS personnel had better exposure to the Research area (through seminars, written documentation, and even spending time in the department) their knowledge of the area would increase and they would be able to provide better service. In addition, if DSS had better system documentation, their understanding would be increased and they would be less defensive in handling Research requests. In either case, the Research Department and DSS would still have to rely on the Computer Liaison Section for much of the system analysis unless DSS greatly increases its level of involvement.

Other minor failures of the centralized organization could be remedied. Delays in correcting minor bugs could be reduced by a variety of efforts. Better documentation would enable anyone to become involved instead of just the person originally responsible. DSS could also increase its allocation of man-hours for maintenance and unexpected tasks.

Another problem - Research's lack of control over DSS personnel - could be alleviated if Research were to
participate in the evaluation of DSS personnel. This could be done with varying degrees of formality. However, if it is to work, DSS management must use the evaluations and DSS personnel must be aware of the system.
A second possible alternative for satisfying the data processing requirements of the Research Department is to retain the centralized organization of equipment but to decentralize the software development effort. This approach seems logical in light of the analysis of Chapter 5 in which it is shown that the major deficiency of the centralized organization is in the software support area. Similarly, the analysis within this chapter is limited to the decentralization of the software effort for the Statistical Section, as this seems to be where the largest potential improvement exists.

The first section of this chapter briefly describes the proposed organization. The second section includes an evaluation of this alternative (38).
6.1 Descriptive Model of a Decentralized Software Support Organization

The proposed decentralization of software would involve a programming staff being organizationally assigned to the Research Department. This staff would most likely be fused into the Computer Liaison Section which would then be responsible for providing all programming support for the Statistical Section as well as coordinating all other departmental EDP work with the DPDC and Computer Planning Departments.

Even if the Computer Liaison Section were to assume responsibility for all Research applications, it is not likely that it would require as many additional programmers as it now supports in DSS. Best estimates indicate that the Statistical Section's needs could be met by three additional people. This reduction in personnel would be accomplished mainly by providing for better control and efficient personnel utilization, as well as by freeing the time of members of the Computer Liaison Section which currently has two people who principally are involved in coordinating and monitoring programming efforts.
6.2 An Evaluation of the Decentralized Software Organization

COST

The expected annual cost of retaining an additional programmer is $15000 for salary and benefits and $5000 for computer test time. Therefore, the cost of adding three programmers to the Research Department would be $60,000. To this must be added the cost of test time used by current members of the Computer Liaison Section who would also be programming. Thus the total cost of this proposed organization would be about $70,000.

NEED FOR SPECIALIZED RESOURCES

The addition of three programmers to the Computer Liaison Section would provide it with the capacity of meeting the varying needs of the Statistical Section. The major systems development and modification of high priority systems would necessitate two senior level people. However, the less urgent and less complex tasks could be handled by three trainee and junior level programmers. Some of this talent currently exists within the Computer Liaison Section; the remaining would be recruited.
NEED FOR FLEXIBILITY IN SCHEDULING

The proposed staff would provide the talent and capacity to meet all of the current requirements. However, by its very nature, it does not provide the flexibility for processing extremely large projects or many simultaneous efforts.

These obstacles can be largely overcome. In the short run, overtime and priority shuffling may be used. In the long run, full-time or part-time personnel could be added. Of course, if the work load were to subsequently decrease, Research would then be overstuffed. Neither solution provides the flexibility offered with a centralized organization.

TURNAROUND TIME

Turnaround time on minor programming efforts should improve. The time consuming process of dealing with another organization and its bureaucracy would be eliminated. Memoranda would not be required and thus all intermediary management would not become involved. The leader of the Computer Liaison Section would recognize a need and assign it directly to a programmer. A similar procedure would handle emergency program bugs.

Turnaround on longer projects would not be affected as greatly. The bureaucratic "paper-shuffling" is a relative
constant whose significance diminishes the longer the project's duration. Another factor in turnaround is the efficiency of employee utilization which is discussed subsequently.

Turnaround time would also improve due to the elimination of the need to inform the programming staff about matters characteristic of the application or the Research Department.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

The greatest gains of the decentralized organization would exist in this area. Because the programmers would be assigned to the Research Department, they would accumulate a much better understanding of the nature of the work and personnel within the department. This would help them to design and document systems which are better suited for the level of work and employee involved.

Another gain would result from the increased knowledge of the departmental data processing. The increased understanding of the interrelationship among the series would provide a better overall perspective. Accordingly, the analysts would be able to become involved more quickly and effectively.

The net effect of this change should be that better
The exception to this would be if specialized skills were required which were not available within the Liaison Section. Currently, the nature of the Statistical Section's needs are such that departmental understanding is more crucial than specialized EDP talent.

NEED FOR EFFICIENT RESOURCE UTILIZATION

Under the proposed organization, employees would most likely be more efficiently utilized for several reasons. First of all, they would be under the direct control and supervision of the department responsible for the results of their work; poor performance would be more quickly noticed and acted upon. Secondly, the employees would be more motivated as they would be part of a team and not just an external service organization. Thirdly, Computer Liaison members would be freed from many of their current liaison responsibilities which are time consuming but represent administrative overhead. It could be argued that the group now would be responsible for controlling ongoing projects and that this would take time. Although this is true, it would not be that much more than the section now does in insuring that projects are completed on time.

On the other hand, the specialized EDP management needed to control and evaluate programmers would not be
available. This could be a major factor on large projects, especially if the techniques within the centralized organization improve.

Another consideration is the potential misutilization of experienced senior personnel when there is not an outstanding major project which would utilize their expertise.

Finally, there is the issue of EDP expertise within the Research Department. Currently it is fortunate to have two people with sufficient knowledge to administer programming. However, the department is not inherently an EDP department and thus would not always be able to develop such talent.

NEED FOR TRAINING

The required training could be accomplished in a small decentralized organization in a manner directly analogous to that currently used in DSS. Much training could be provided from a combination of external sources and informal communication.

Even at its best, training would not be as good as with centralization. Informal communication, although possible, would be restricted by geographic separation. In addition, Research could not afford to develop a formal training program for such a small staff.

It is possible that the latter could be circumvented by
permitting Research to utilize any DSS training program. However, this would no longer represent a pure decentralization.

IMPORTANCE OF TURNOVER AND RECRUITMENT

Because it would have a small staff, the Research Department would be particularly vulnerable to problems of project continuity resulting from unscheduled turnover. These problems would be magnified if the turnover involved either experienced talent or several people simultaneously. This potential vulnerability would put Research in the position of not being able to fulfill the Board's requests.

Recruitment would also pose potential problems. The Research Department does not have the experience or specialized knowledge for effectively recruiting EDP personnel, and thus would not likely be as effective as the centralized organization.

IMPORTANCE OF EMPLOYEE SATISFACTION

Employee satisfaction would most likely be reduced in the decentralized organization. Fewer avenues for advancement exist within the department's data processing area. Furthermore, as the department is research-oriented and not an EDP department, other senior positions within the
department would not be readily accessible.

Another consideration is the type of programming. Much of Research's work is maintenance. Although this would be challenging to junior personnel, it would not interest the more senior people. Thus, boredom might result if there were not work available on major systems.

Partially offsetting these arguments would be the increased satisfaction of being more involved in the analysis, design, and usage of the systems; the programmers would be more than coders.

In addition, opportunities for interdepartmental mobility do exist.

**NEED FOR COMMUNICATION WITH TOP MANAGEMENT**

No mechanism would exist to insure that programmers were not assigned to projects of less importance than other Bank projects for which personnel were not available.

**NEED FOR STANDARDIZATION AND DOCUMENTATION**

Conformation to the present informal standards would present no problems. If standards were adopted, they would most likely follow the current effort which consists of members from various EDP sections. Merely adding one member from Research to this group would alleviate any potential
difficulties.

Intradepartmental user documentation would likely be as good or better than that of the centralized organization. Some quality may be lost due to the specialized talents of a technical writer. On the other hand, the decentralized section would know the department personnel better and would therefore be better able to develop documentation for their needs.

Interdepartmental documentation could be a problem. A mechanism would be required to insure interdepartmental communication in order to eliminate any possibility of a duplication of effort or changes resulting in data incompatibility.

ADAPTABILITY TO CHANGE

Research would be hurt slightly if changes should be required due to technological changes. The lack of specialized expertise would hinder analyses of technological advances.
CHAPTER 7 - DECENTRALIZED EQUIPMENT FACILITY

A third alternative for satisfying the Research Department's data processing needs is to decentralize the computer facility. Under this alternative, the Research Department would not utilize the Bank's centralized facility but would be free to secure the resources necessary to meet its requirements.

Advances within the past five years have created a range of potential solutions to the Research Department's data processing problem. Possibilities include the traditional decentralization with the use of a medium size system, as well as other approaches, such as the use of timesharing services, service bureaus, minicomputers, and packaged software; all of which are becomingly increasingly in vogue.

The intent in this report is not to investigate all of the possibilities. Instead, the emphasis is on two of the methods: minicomputers and timesharing services.

The study of these methods has two immediate implications. First of all, their services are specialized and thus tend to be more appropriate for a particular activity within the Research Department than for the entire department. This is largely due to the diverse data processing requirements between the Statistical and Economic...
Research Sections.

Secondly, the decentralization of hardware is also likely to result in the decentralization of software support. Although this is not a necessary result, many of the potential benefits of centralized software would not be realized and the arguments for centralization would thus be less convincing. This chapter ignores this issue and investigates the decentralization of hardware on its own merits. If the alternatives are viable, then a second order analysis would be appropriate.

The first section of this chapter explores the use of minicomputers. The second section investigates the feasibility of using timesharing services.
7.1 Feasibility of Using Minicomputers

The minicomputer has evolved during the past few years so that it now closely resembles small business computers that it is quite difficult to draw a line of demarcation. Minis no longer are limited to small machines with 4K words of memory, a teletypewriter, paper tape I/O, and a price of under $20,000. Instead, they now can be purchased with 128K words of memory and are capable of supporting magnetic tape and disk devices, medium speed printers, and CRT displays for over $100,000. Even at these prices, the minis still provide much computing power per dollar. For this reason, their applicability to the Research Department is explored in this section.

Minicomputers are marketed by a variety of vendors. Each company is offering a machine which is a little different from the others. However, in general, there are many similarities and few major functional differences among minicomputers. What does tend to differ is the way operations are done or the software and service provided. As much as possible, this analysis of minicomputers deals with minis in general. When there are issues which are vendor dependent, the Data General 840 is used as a benchmark (39).

The selection of the Data General 840 is justified because of the importance of service and reliability. These necessitate that a company with a good local service network
be selected. Of the two major minicomputer manufacturers in the Boston area, Data General provides the better software support, which is an important concern to the Research Department.

The use of minicomputers for satisfying the needs of the Economic Research Section has been considered and rejected. Although there are several managerially related issues why minis would not be appropriate, these are similar to the issues presented in the subsequent subsection. Rather, minis have been rejected for the econometric area on purely technical reasons.

Although minis can support up to 128K words (256K bytes) of memory, the largest single address space for a program is 32K words. This simply is not large enough to support an elaborate econometrical system. The Bank's ESS system was designed and developed for a small computer and accordingly has a complex overlay structure; nonetheless, its large programs would not fit into the allowable program space. There is some question as to whether it would be possible to rewrite programs for a mini. Even if it were possible, the program swapping would surely increase the already marginally acceptable execution time to unacceptable limits. This turnaround problem would be further compounded by the generally slower processing which results when converting from medium sized machines to minis. The hardware is simply not as fast, but most importantly, the
less sophisticated system just cannot provide as efficient resource utilization. In addition, the accuracy provided with a minicomputer would not meet the rigid precision requirements of econometric work. Normal precision on a mini is six places; double precision is 14 places and much slower (40). Even the latter would not provide sufficient precision for the matrix inversion routines used in regression analysis; these currently involve 16 and 32 place accuracy.

The use of minicomputers for the Statistical Section is technically feasible. That is, mini's are capable of doing any processing a maxicomputer could do (except for basic limitations of program size). Furthermore, expected technical advances will make these issues even less urgent.

It should be noted that there is currently a major bias within the Bank's senior management against an internal proliferation of computer installations. This proliferation is acceptable only if there are significant potential advantages.

7.1.1 Descriptive Model of a Minicomputer System

The proposed minicomputer system which would satisfy the data processing requirements of the Statistical Section would include the following equipment: 80K words of memory; a card reader; a 600 line per minute printer; a tape drive;
and 50 million bytes of disk storage.

Under the proposed system, all job flow would be through the Computer Liaison Section. Econometric work would be handled on the centralized facility or through timesharing services. It would be the responsibility of the Computer Liaison Section to operate the minicomputer system and to insure the completion of the Statistical Section's work flow. This would require the services of at least one additional person during the day; however, evening work as well as holdover would require either a second shift (of one person) or else significant overtime.

In addition, there would have to be a mechanism for making these data available to the centralized facility so that other Bank departments could access them. This could be accomplished by creating tapes which would be read and posted to the Bank's centralized database by special programs.

The urgency of much of the Statistical Section's work necessitates that service not be suspended for periods of more than one or two hours. As this level of service cannot be guaranteed, the department would have to provide its own backup. This would necessitate the purchase of one additional reader, printer, and tape drive, as well as a second processor.
7.1.2 An Evaluation of the Minicomputer System

COST

The purchase cost (41) of a system which satisfies the data processing requirements of the Statistical Section (without backup) is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>80K core memory</td>
<td>$45000</td>
</tr>
<tr>
<td>50 mil bytes disk</td>
<td>$35000</td>
</tr>
<tr>
<td>Printer</td>
<td>$20000</td>
</tr>
<tr>
<td>Tape Drive</td>
<td>$10000</td>
</tr>
<tr>
<td>Card Reader</td>
<td>$ 5000</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$ 5000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$120000</strong></td>
</tr>
</tbody>
</table>

To this total must be added the cost of necessary backup equipment. Based on a minimal requirement base, this would approximate $60000 and thus bring the total purchase cost to $180000. Assuming a technological life of four years, the annual cost would be $45,000. To this must be added a minimal service cost of $5000; therefore, the expected annual cost of equipment would be $50,000.

There would still be other additional costs. The costs of at least one full-time operator (plus overtime) would be about $20,000 (including benefits and cost of hiring). The
cost of converting Research data to the centralized facility and the Loan and Credit Department's data to the minicomputer facility must also be included. Programs would have to be developed and run on a regular basis which would increase the department's processing costs. The best estimates of these costs are around $20,000.

To conclude, the minimal expected annual costs of this system would be $90,000. Although this represents a savings from the current processing costs, there are several important observations. First of all, the current costs are "funny money" in that they represent an internal accounting system. The purchase of external services would not necessarily save the Bank anything, but would just mean additional expenditures. If this decentralization would enable the Bank not to incur additional expenses from expansion, then the savings would be real. However, even in this case, the savings would not be as great as expected. Many facilities would still be duplicated. For example, much of the disk storage (both scratch disk and data storage) would be required on both installations.

The costs also ignore the increased programming costs. Programming a minicomputer is recognized to be a more difficult and longer process. Care must be given to program size. In addition, limitations of the higher level languages often necessitate the use of the less efficient (for coding) assembler language. Another consideration is
that the current programs would all have to be rewritten in order to fit into a minicomputer as well to incorporate the new database routines. This reprogramming would be nontrivial since most systems do not support COBOL. Thus there would be significant conversion costs. Finally, many programs would have to be duplicated on the minicomputer system (such as data storage routines).

The overwhelming conclusion is that minicomputers will offer at best minimal cost savings due to the need for expensive system backup and the increased programming costs resulting from the department's diverse range of applications.

NEED FOR SPECIALIZED RESOURCES

The minicomputer would be able to process the Statistical Section's normal daily workload. The normal load averages 10 jobs which typically are of a short nature and could be met by a minicomputer. In addition, the minicomputer would provide the required I/O peripheral devices.

One problem which would develop would be the issue of data confidentiality. The problem of other users would not exist. The problem of security from external sources is much greater. The Research Department is not located within the main building and thus does not receive the same
security as does the central facility. Consequently, it would be extremely difficult to secure the minicomputer and data from determined external sources.

The core limitations would not likely present major problems. Most of the Statistical Section's programs would fit into 32K of memory; the large ones would require modification.

NEED FOR FLEXIBILITY IN SCHEDULING

The use of minicomputers provide little flexibility against demands from peak loads. Only two jobs can be multiprogrammed; thus the ability to process many jobs simultaneously is limited. The availability of a backup processor would somewhat alleviate this problem; however, there would still be times when the limited capacity would be unable to meet peak loads.

TURNAROUND TIME

The actual turnaround to be expected is not known without running benchmarks. This action is only appropriate if it appears that minicomputers are otherwise satisfactory. However, even the most optimistic estimates expect that turnaround time would increase by 25% (42). First of all, the lack of decimal arithmetic would be a problem in many
applications. The only solution to this problem involves the use of multiple integers; however, this is quite slow. Secondly, minis are particularly good for dedicated applications which are processor bound. They are not designed for I/O bound programs, which typify the Statistical Section's work. For example, every I/O operation involving two bytes steals one memory cycle. Furthermore, since all I/O is spooled, and spooling also causes central processor interrupts, processing would be further slowed down. Thus, although minis could do the work, they would not be processing efficiently and would surely increase turnaround time.

One other key factor involves maintenance. The major mini manufacturers claim to provide service within 24 hours. However, this pertains solely to hardware and still is not as good as the larger companies. In fact, the 24 hour service would be unacceptable to the Research Department and thus necessitates the costs of a skeleton backup system. This problem is avoided in the centralized organization because the large scale of the operation justifies the retention of on-site maintenance engineers.

The minicomputer companies also do not provide guaranteed fast software support. Thus, should there be difficulties with any system software, the bug might last for several days; this too would be an unacceptable condition. The support that is provided is of a very
technical level. Data General assumes that it is supporting systems people with computer science backgrounds; this would thus place an additional burden on departmental staffing.

In short, the service level would decrease, especially in peak times.

LEVEL OF INVOLVEMENT AND UNDERSTANDING NEEDED OF EDP PERSONNEL

The major benefit from decentralization would be in this area. Research personnel could completely control their work and thus be able to insure that the most important jobs received top priority.

NEED OR EFFICIENT RESOURCE UTILIZATION

From the Research Department's viewpoint, resource efficiency might increase. The same work would probably be done for fewer dollars. This is true despite the underutilization of the resources. Equipment such as the tape drives would only be used infrequently. In addition, the entire system would only be used for part of the day. However, although this is not necessarily bad, as Gruenberger and Babcock point out, it is not maximum efficiency (43).
NEED FOR TRAINING

By decentralizing, Research would become responsible for training its operators. Although this is not a major problem, due to the relative simplicity of the minicomputer system and the training provided by most manufacturers, it would be an additional responsibility.

IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

As with the training, these problems are minimized due to the relative simplicity of minicomputers. Nonetheless, Research would have a small operations staff which would be affected by turnover. Other people would have to fill in (thus ignoring their normal responsibilities). In addition, recruitment would be a minor problem due to the lack of attractive career opportunities within the department.

Because "systems level" knowledge is required to fully utilize the minicomputer, Research would have to recruit or train more sophisticated analysts than is now needed under centralization.

IMPORTANCE OF EMPLOYEE SATISFACTION

One major drawback of the decentralized organization is the lack of job satisfaction which would result. The simplicity of operations would provide fewer challenges and
thus lead to boredom and less satisfaction. In addition, the small scale operations would not encourage career development within the EDP area and could well lead to stagnation and disenchantment.

**NEED FOR COMMUNICATION WITH TOP MANAGEMENT**

The decentralization would not affect Bank priorities.

**NEED FOR STANDARDIZATION AND DOCUMENTATION**

Establishing programming standards and enforcing them would not be a problem. Programmers would have to be informed of the system's limitations; however, this could be easily done as only a few people would be programming on the system.

System documentation would be provided by the vendor. Specific operational procedures unique to the installation would become the responsibility of Research to document.

As mentioned previously, compatibility of Research data with other departments would be a problem. The problem is further compounded by the internal representation of characters within minis by the ASCII convention; both IBM and Burroughs use EBCDIC. Although this problem could be overcome with translation tables, it would further add processing time and inefficiencies.
ADAPTABILITY TO CHANGE

This function would be significant as Research would now become responsible for periodically monitoring the minicomputer system to see how it compares with other available products. In addition, the Department would be extremely vulnerable to major technological changes which made their system obsolete or to business changes which resulted in their not being serviced.
7.2 Feasibility of Using Timesharing Services

Timesharing services are characterized by their capability of providing many independent users with slices of time on a centralized computer and thus enabling them to interact with the software as if each user had the entire system to himself. Although there has been a proliferation of timesharing companies, very few actually are marketing the same product.

The result of this situation is that there are few companies which can satisfy the diverse needs of the Research Department. Some can meet the needs of one activity but are weak in the other. Still others would do a fair job in each area, but would not completely meet the needs.

For these reasons this paper is limited to the use of timesharing services in the Economic Research Section. This limitation is justified on several counts. First of all, timesharing services do not appear to solve the Statistical Section's basic needs. Data confidentiality from external sources is a potential problem. In addition, the statistical data are used by other departments and thus the use of timesharing services would require that two other departments, much less sophisticated in data processing, also become at least partially decentralized. Finally, the rigid report formats preclude the use of "typical reports" and thus would require the development of reporting
programs. This would eliminate any potential savings from a sharing among many users of software development costs.

The limiting of this issue to the Economic Research Section is also justified by the apparent savings from a duplication of effort. Unlike the Statistical Section, whose needs are not similar to that of other known organizations, the Economic Research Section performs analyses which are similar to that performed by other research economists. This convergence of needs makes much more likely a sharing of the same resources and thus of development costs.

Even with this limitation, there are still several possible avenues. Timesharing services for research applications may be positioned along many different dimensions. One dimension is the computing capability. Some firms provide excellent computing resources but very little else in the way of software or application packages. Another dimension is the availability of data. Some companies maintain current data series; others either offer no data bank or maintain it with less emphasis. A third dimension is the quality of the software packages. Some companies have specialized econometric routines; others are less specialized and sophisticated. Other key factors include reliability, accessibility, and special services.

In evaluating the feasibility of using timesharing services, this paper limits the analysis to one company —
Data Resources Incorporated (DRI). DRI has been selected for several reasons. First of all, it is designed principally for econometric work. Secondly, in a survey of staff economists, DRI was consistently named as the service which best satisfies an econometrician's needs. Thirdly, DRI provides certain unique features (such as the DRI model and memos) which the Federal Reserve Bank of Boston needs. A choice of another company would still require that DRI be retained for these services.

Although it is not the intent of this report to compare various services, certain factors should be considered. DRI is unlike most other timesharing companies in that it offers more than just timesharing services. It also offers an economic consulting service. Included in its rates are provisions for use of this expertise. Another firm with the same applications and data, but less economic consulting expertise, would probably be less expensive and thus an even better comparison. Unfortunately, no such service exists.

7.2.1 Descriptive Model of the DRI Timesharing Service

DRI (44) is a complete service in that it provides its subscribers with accessibility to certain financial, monetary, national, and regional data, as well as a complete range of econometric tools. All programming, system development, data maintenance are the responsibility of DRI.
The user is just that; he has no overhead except to use the system.

Thus, in analyzing DRI, it is important to realize that it serves both the hardware and software needs of its users. Furthermore, these services are interrelated and thus difficult to differentiate. For this reason, the analysis of how DRI satisfies the needs of the Economic Research Section considers both the equipment and software support needs simultaneously.

7.2.2 An Evaluation of the DRI Timesharing Service

COST

The cost of running all of the Economic Research Section's work on the DRI timesharing service can not be predicted accurately for several reasons. First of all, the cost will depend on the number of Research users, the intensity of their use, and the type of work being done. Even if these factors were known, translating them into dollar costs would be difficult without performing extensive benchmarks under DRI to determine the specific cost of running various features. As these costs themselves depend on several factors (such as number of variables, number of observations, etc.), the problem is compounded further.
Secondly, the cost is affected by the time of day during which the work is done. One of the components of the cost is the elapsed time during which the user is connected to the system (also called connect time). As this varies with the number of other users on the DRI system, the actual charge to a user will depend on who else is using the system.

Even allowing for these future unknowns, it was desired to estimate future costs based on current usage. However, this effort was confronted with a third difficulty. Currently neither the Research Department nor the EDP departments have specific figures as to which ESS runs are made by the Research Department or the Economic Research Section. Consequently, it is difficult to determine the number of ESS econometric jobs now run by the Economic Research Section.

Despite these difficulties, the author has derived a crude estimate of the expected cost of running the econometric work on the DRI timesharing system. It is anticipated that all work now run under ESS could be run on DRI for an annual cost of $50,000. It can not be overstressed that this figure is a "best guess" and is susceptible to error of 25% in either direction. Details and assumptions behind this estimate are provided in Appendix I.
NEED FOR SPECIALIZED RESOURCES

DRI has the capability of providing all of the specialized resources needed by the Economic Research Section. Because it caters to many similar users, it can maintain a computer system which is designed for their specific needs. Thus DRI offers access to a large system capable of providing precise scientific calculations on small or large data matrices. Secondly, the system is designed for economists and offers a full range of econometric tools. Thirdly, by taking advantage of the similar needs of economists, DRI can afford to maintain an accurate and up-to-date data base which any one user might not be able to justify. This data availability would mainly benefit the economists within the monetary and national business conditions in which between 10 and 20% of the research assistant time is spent collecting data which would be available on DRI. On the other hand, this service would be of no or little value to the regional and international sections.

Another advantage of DRI is that is responsible for providing the technical expertise required to develop statistical systems. Thus both EDP and econometric expertise are needed. By distributing these costs among all users, many people benefit from a single effort.

There are two potential drawbacks with a complete use of DRI. One involves I/O other than from a terminal. DRI
does have both plotter and capabilities and the ability to accept or produce large quantities of I/O in a batch mode. However, this is not convenient due to its remote location and would require either physically traveling to DRI or relying on slower mail service.

The second problem involves the development of specific econometric techniques. If an economist needs a specific statistic, he can not be completely sure that DRI will have it or be able to develop it. DRI does have a staff which it claims is available, either as a free service or at a marginal cost, for doing such work.

NEED FOR FLEXIBILITY IN SCHEDULING

The use of any timesharing service should resolve any potential problems resulting from uneven schedules. Peak loads can be run by merely increasing the number of simultaneous users. Processing of software development is not an issue due to its relative infrequent nature.

TURNAROUND TIME

The major benefit of a timesharing service is that it provides instantaneous turnaround time. This level of service is needed by econometricians who are actively building a complex model which is of high priority.
However, currently it is not needed by the Bank economists in general and thus actually exceeds the minimum requirements.

The fast turnaround time is interrupted by two possible events. Occasionally, DRI, like most systems, will have interrupted service and will not be accessible. Although these interruptions are for short durations and still allow for faster turnaround than with a batch system, they can provide problems. Users can "lose work" and have to reenter or redo their previous session. In addition, experience at the Boston Fed shows that the user becomes accustomed to fast service and thus becomes intolerant of delays which would have sufficed under the batch mode.

The second potential problem with turnaround involves batch runs made overnight at a reduced cost or because of excessive I/O. These jobs would be delayed by mail service or would require special courier service.

There is no empirical evidence concerning the turnaround time for programming requests. However, the support service advertised by DRI would satisfy the specific requirements outlined in Chapter 4.

LEVEL OF INVOLVEMENT AND UNDERSTANDING REQUIRED OF EDP PERSONNEL

The issue here is a knowledge of high priority
departmental requests. There is no mechanism for guaranteeing that important requests will be fulfilled. However, DRI depends on customer satisfaction and thus, although the Research Department would have no direct influence, there is no reason to suspect that this would not be a problem.

NEE) FOR EFFICIENT RESOURCE UTILIZATION

The problem of efficient resource utilization is completely delegated to the timesharing service and thus relieves the Research Department from becoming involved with this issue. However, there is one related benefit. Currently Research economists submit jobs with every possible combination of factors in anticipation of slow service. The faster turnaround time would enable them to submit just what they needed and thus would reduce the overall wasting of computing resources.

NEE) FOR TRAINING

User training is provided by DRI. Seminars, consulting service, and other guides are available. The issue of training EDP staff is no longer important to the Boston Bank as it also would be delegated to DRI.
IMPORTANCE OF TURNOVER AND RECRUITMENT PROBLEMS

There would be no potential problems to the Research Department as they would be completely delegated to DRI.

IMPORTANCE OF EMPLOYEE SATISFACTION

Problems related to EDP personnel would not be an issue as they would be the complete responsibility of DRI.

NEED FOR COMMUNICATION WITH TOP MANAGEMENT

The lack of a centralized facility would make it more difficult to position departmental projects among overall Bank projects. However, this need is slight due to the independence of the Research function and the operational activities.

NEED FOR STANDARDIZATION AND DOCUMENTATION

Access to the Statistical Section's data would not be accomplished easily. The only two possibilities would be to convert the needed data to the timesharing facility or to retain ESS for just this work. Neither of these is efficient.

Issues related to the standardization and documentation of programs within the installation are of no concern to
Research as they are completely delegated to DRI.

The only key consideration is user documentation. Currently DRI provides adequate documentation. The major drawback is that the Research Department would become a minor customer and thus have little influence over the quality and content of the documentation.

ADAPTABILITY TO CHANGE

Research would be freed from all responsibility concerning technological changes. DRI would assume these concerns and be forced to adapt as necessary in order to remain competitive.

The only involvement required of Research would be to periodically monitor the service to see that it remained competitive. As this involves a statistical and economic background as much as an EDP knowledge, the department would be as qualified for this responsibility as anyone.
CHAPTER 8 - SUMMARY AND RECOMMENDATIONS

This report has studied the data processing requirements of the Research Department of the Federal Reserve Bank of Boston and analyzed how these needs would be satisfied under centralized and decentralized organizations. The first two chapters introduced the problem of the study and the organizational structure of the Boston Fed. Chapter 3 reviewed the literature concerning the advantages and disadvantages of centralized and decentralized structures.

Chapter 4 provided a normative description of the Research Department's data processing needs. Chapter 5 analyzed the extent to which these needs have been satisfied with centralized hardware and software facilities. Chapter 6 investigated the ramifications of a decentralized programming staff. Chapter 7 analyzed the decentralization of equipment through the use of timesharing services and minicomputer facilities.

Tables 8-1, 8-2, 8-3, and 8-4 summarize the analyses of the different organizational structures.

Certain conclusions may be drawn from these tables. First of all, the equipment requirements of the Statistical Section are best met by the current centralized facility. An organizational change resulting in the use of minicomputers would provide one major benefit: it would improve the involvement and understanding of the jobs being run. However, this increase would surpass the actual
requirements which are satisfactorily met with centralization. The costs of this gain are great. Research would encounter problems in handling peak loads; receiving adequate turnaround; providing training, recruitment, employee satisfaction; providing data compatibility among systems; and adapting to technological change.

Surprisingly, the expected advantage - that of reduced costs - is minimal and may in fact be non-existent once all the start-up costs and conversion costs are included.

A second issue involves the software support for the Statistical Section. The current centralized organization is not achieving its potential. Both Research and DSS management agree to this. However, at its theoretical best, the centralized facility would be better than the proposed decentralized organization.

Even in its current state, the centralized organization is not bad. Its major deficiency, vis a vis decentralization, is in the area of involvement and understanding of Research applications. Because personnel within the centralized facility do not understand Research projects and programs, they provide poor systems analysis and response to short-term programming requests.

There are several recommendations presented in section 5.3 which would help to improve the service provided by the centralized facility. First of all, it is suggested that DSS personnel receive better training and indoctrination in
the Research Department. Secondly, improved system
documentation must be provided. Thirdly, additional
man-power should be allocated to supporting the Research
Department, especially for short-term maintenance. Finally,
Research should be given direct input into the evaluations
of personnel working on departmental projects. This last
suggestion might take the form of an informal periodic
review, or of a formal review, or could even go as far as to
approach a matrix organization.

A switch to decentralization would be possible if
problems were to continue or get worse. Such a switch would
present no major problems concerning standards within the
Bank. In fact, it is anticipated that the overall benefits
to the Bank would increase due to the net reductions in
personnel costs. However, these savings are slight and
would be largely outweighed by the extra inconvenience to
the Research Department. Its management would now become
responsible for a whole new area - EDP administration.
Consequently, it would be burdened with problems relating to
flexibility of personnel scheduling (peak loads),
controlling ongoing projects, training, recruitment,
employee advancement, and adapting to technological changes.

Thus it is the author’s feeling that the potential
advantages of centralized software support outweigh the
advantages of decentralization and that the current
organization should be continued. If over time, these
potential advantages are not realized, the Research Department could then consider decentralization and determine whether its management were willing to accept the additional responsibilities in order to gain better service.

A third alternative which was investigated was the decentralization of the computer hardware and software support for the Economic Research Section to the DRI timesharing service. This area is the most difficult one to evaluate for several different factors.

First of all, the cost tradeoffs are hard to measure. It seems that the cost of running as much of the Research Department's work as possible on DRI would not likely surpass the current cost of running the same work on the in-house ESS system. However, this argument has several "holes." The internal costs are crude estimates and are subject to large error. Similarly, the estimated DRI costs are also crude and susceptible to large error. Finally, the internal costs represent "funny money." Switching to DRI would not necessarily save the Bank anything; in fact, it would mean additional expenses unless it resulted in system contraction (which is not likely due to a long-term lease) or prevented subsequent system expansion. The question of cost swings completely in the favor of decentralization when software costs are included. Presumably, the use of DRI would also mean that the Research Department would not be charged for ESS systems development work. These savings are
significant, but are susceptible to the same "funny money" arguments as the hardware savings.

A second factor involves the actual services provided by DRI. DRI offers the Research Department several advantages. Turnaround time for jobs would be faster than with the current centralized environment (in fact, it would surpass the department's stated goals). The user would be able to process larger data arrays than are currently possible on an econometric system which was designed for a smaller system. Finally, the Bank would be able to delegate responsibility and concern over problems involving efficient personnel utilization, control of projects, and turnover and recruitment problems. In short, timesharing makes a lot of sense. It allows the Research Department and the Bank not to get involved in data processing areas which can be provided by other companies. This approach is feasible because, unlike all other departments within the Bank, the Economic Research Section is the one whose needs are most dissimilar to other departments and most similar to the needs of other users outside of the Bank.

Nonetheless, it is not clear timesharing services are the way to go. They have several distinct disadvantages. First of all, they do not provide easy access to data collected by the Statistical Section. While this is not an insurmountable problem, it would be cumbersome and require advance planning before the data were to be used. Secondly,
DRI is not convenient for processing jobs which require I/O from devices other than remote terminals. While this too can be circumvented, it is not without its problems.

Thirdly, the use of any external service automatically reduces the amount of control which the Research Department would have over its jobs. The department would be particularly vulnerable to any external changes, such as major price increases, the company going out of business, or the like. Finally, there is the question of getting service when problems arise; this is much more difficult when the services are external.

To summarize, the advantages and potential drawbacks of using a timesharing service are numerous. It would seem that using timesharing would definitely be the best approach if the Bank did not already have its own system and had to develop (or rewrite) its own. The minor inconveniences would be outweighed by the lower cost and better service. On the other hand, the Bank currently has a system which should not require substantial maintenance costs in the future. Thus it costs relatively little to retain the current system. For these reasons, it is the recommendation that the centralized ESS system be retained. DRI should be used for certain jobs which require either fast turnaround or the use of data maintained by DRI. This usage will pay for itself, but will also help to provide additional input into the likely cost of switching to DRI. If the costs seem
reasonable, or if the Bank finds that ESS will require a major rewrite, then timesharing services provide a good alternative.
Rating System Used in Tables 8-1, 8-2, 8-3, and 8-4

4 = exceeds normal requirements
3 = satisfactory in all respects
2 = marginally satisfactory or satisfactory with large effort
1 = unacceptable performance

Note: Parenthesized ( ) numbers represent values which are theoretically obtainable but have not been achieved under the actual centralized organization.
Table 8-1: A Comparison of the Relative Benefits of the Centralized Facility and Minicomputers (Meeting the Equipment Requirements of the Statistical Section)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Centralization</th>
<th>Minicomputer</th>
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<tbody>
<tr>
<td><strong>COST</strong></td>
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</tr>
<tr>
<td>Approximately $150,000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR SPECIALIZED RESOURCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass storage capability</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Tape, plotter, printer output</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>External security for data</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR FLEXIBILITY IN SCHEDULING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-10 jobs/day</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Handle peak loads</td>
<td>3</td>
<td>2 to 1</td>
</tr>
<tr>
<td><strong>TURNAROUND TIME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process high priority projects</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Avoid delays of 2 hours</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>LEVEL OF INVOLVEMENT &amp; UNDERSTANDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recognize important jobs</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>NEED FOR EFFICIENT RESOURCE UTILIZATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of resource utilization</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial training – installation</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF TURNOVER &amp; RECRUITMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal disruption</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Time &amp; costs of turnover</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF EMPLOYEE SATISFACTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction as a goal</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR COMMUNICATION WITH TOP MANAGEMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDP personnel aware of Bank priorities</td>
<td>3</td>
<td>na</td>
</tr>
<tr>
<td><strong>NEED FOR STANDARDIZATION &amp; DOCUMENTATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interdepartmental data compatibility</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Compatibility with IBM I/O</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>ADAPTABILITY TO CHANGE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid technical obsolescence</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 8-2: A Comparison of the Relative Benefits of Centralized and Decentralized Staffs (in Meeting the Software Requirements of the Statistical Section)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Centralized Staff</th>
<th>Decentralized Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximately $125,000</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>NEED FOR SPECIALIZED RESOURCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General data processing</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>System analysis</td>
<td>1 (3)</td>
<td>3</td>
</tr>
<tr>
<td>System development</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>System maintenance</td>
<td>2 (3)</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR FLEXIBILITY IN SCHEDULING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handle uneven project loads</td>
<td>2 (3)</td>
<td>2</td>
</tr>
<tr>
<td><strong>TURNAROUND TIME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tight deadlines</td>
<td>2 (3)</td>
<td>3</td>
</tr>
<tr>
<td>Long lead times</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Short lead times</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>LEVEL OF INVOLVEMENT &amp; UNDERSTANDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding of overall system</td>
<td>1 (2)</td>
<td>3</td>
</tr>
<tr>
<td>System analysis responsibility</td>
<td>1 (3)</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR EFFICIENT RESOURCE UTILIZATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of resource utilization</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Monitor and control projects</td>
<td>2 (3)</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial training of installation</td>
<td>2 (3)</td>
<td>2</td>
</tr>
<tr>
<td>Ongoing training &amp; development</td>
<td>2 (3)</td>
<td>2</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF TURNOVER &amp; RECRUITMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimize impact of turnover</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Ability to recruit &amp; select new hires</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF EMPLOYEE SATISFACTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction as a goal</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR COMMUNICATION WITH TOP MANAGEMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>View requests in Bank priorities</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR STANDARDIZATION &amp; DOCUMENTATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatible &amp; standardized programs</td>
<td>2 (3)</td>
<td>2</td>
</tr>
<tr>
<td>Program documentation</td>
<td>1 (3)</td>
<td>2</td>
</tr>
<tr>
<td>User documentation</td>
<td>2 to 3</td>
<td>3</td>
</tr>
<tr>
<td><strong>ADAPTABILITY TO CHANGE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid technical obsolescence</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 8-3: A Comparison of the Relative Benefits of the Centralized Facility and a Timesharing Service (in Meeting the Equipment Requirements of the Economic Research Section)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Centralized Facility</th>
<th>Timesharing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximately $80,000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR SPECIALIZED RESOURCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific processing on large arrays</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Various I/O media</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR FLEXIBILITY IN SCHEDULING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable and unpredictable demands</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>TURNAROUND</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapid turnaround on high priority jobs</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Guaranteed 24 hour on all jobs</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>LEVEL OF INVOLVEMENT &amp; UNDERSTANDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of important jobs</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>NEED FOR EFFICIENT RESOURCE UTILIZATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of resource utilization</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial training on installation</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF TURNOVER &amp; RECRUITMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal disruption</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Time &amp; costs of recruitment</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF EMPLOYEE SATISFACTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction as a goal</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR COMMUNICATION WITH TOP MANAGEMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of Bank priorities</td>
<td>3</td>
<td>na</td>
</tr>
<tr>
<td><strong>NEED FOR STANDARDIZATION &amp; DOCUMENTATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility to Statistical Section data</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>ADAPTABILITY TO CHANGE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid technical obsolescence</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 8-4: A Comparison of the Relative Benefits of the Centralized Staff and a Timesharing Service (in Meeting the Software Requirements of the Economic Research Section)

<table>
<thead>
<tr>
<th>Issue</th>
<th>Centralized Staff</th>
<th>Timesharing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximately $100,000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR SPECIALIZED RESOURCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data availability</td>
<td>na</td>
<td>3</td>
</tr>
<tr>
<td>Full range of econometric tools</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Knowledge of econometrics</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR FLEXIBILITY IN SCHEDULING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to process infrequent requests</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>TURNAROUND TIME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally involves long lead times</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>LEVEL OF INVOLVEMENT &amp; UNDERSTANDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not essential</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NEED FOR EFFICIENT RESOURCE UTILIZATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of resource utilization</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ability to monitor &amp; control projects</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistical training</td>
<td>na</td>
<td>3</td>
</tr>
<tr>
<td>System training</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF TURNOVER &amp; RECRUITMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimize disruption</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>IMPORTANCE OF EMPLOYEE SATISFACTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction as a goal</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>NEED FOR COMMUNICATION WITH TOP MANAGEMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not essential</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NEED FOR STANDARDIZATION &amp; DOCUMENTATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conforming to programming standards</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Conforming to statistical standards</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>User documentation</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>ADAPTABILITY TO CHANGE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid technical obsolescence</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
(1) Solomon - 21, page 293.
(2) Kanter - 17, page 20.
(3) Dinter - 7, page 32.
(4) Dinter - 7, page 32.
(5) Berman - 3, page 290.
(6) Berman - 3, page 290.
(9) Solomon - 20.
(11) Blose and Carter - 5.
(12) Blose and Carter - 5.
(18) Berman - 3.
(19) Avots - 2, page 43.
(20) Solomon - 21.
(21) Solomon - 21.
(22) Blose and Carter - 5.
(23) Solomon - 21.
(27) Solomon - 21.
(29) Solomon - 21.
(30) Berman - 4.
(31) Blose and Carter - 5.
(33) Solomon - 20, 21; Fredericks - 12.
(34) Fredericks - 12, page 12).

(36) The specific requirements are based on discussions with Research Department personnel.

(37) These observations are based on first hand observations by the author as well as interviews with key personnel in the Research, DSS, DPDC, and Computer Planning Departments.

(38) This section is largely speculative in that it is based on the author's best estimates of what is likely to happen. These assumptions are a result of the author's experiences as well as general principles presented in the literature.

(39) Information on the Data General 840 was provided by sales and technical representatives of the company as well as from the Auerbach Reports.

(40) These figures are based on figures for the Data General 840 but are typical of most minicomputers.

(41) The cost figures are based on prices quoted by a Data General sales person in February, 1974.

(42) The 25% figure is based on benchmarks run by Data General against an IBM 360/40. These tests, which even Data General admits were arranged to take advantage of their
system, show that the IBM system is 16% faster than the Data General system. Thus, when one considers that the 360/40 is not as powerful as the current Burroughs 4700 and that the benchmarks were processor bound and not I/O bound, the 25% figure is probably quite conservative.

(43) Gruenberger and Babcock - 15.

(44) Information on DRI was provided from the author's experience with the system and its users, as well as from discussions with DRI sales and support staff.
BIBLIOGRAPHY

1 Auerbach Computer Technology Reports, Auerbach Publishers Inc., 1973 to date.


3 Berman, Peter, "A Vote Against Centralized Staff", Datamation, May 1970.


7 Dinter, Heinz, "Criteria for the Organizational Effectiveness of Data Processing", Data Management, July 1971.


APPENDIX I

In estimating the expected costs of using DRI for all econometric work, several assumptions were made initially. Some of these were subsequently relaxed when cruder but more complete figures were generated. Nonetheless, the following were initially assumed:

1. 308 ESS jobs are run on the Bank's centralized facility each month. This figure represents an average of monthly totals for those months in 1972 in which the figures appeared reliable. Due to "system failures", this information was not available for the entire year, but only for scattered months.

2. 75% of all ESS jobs are run by the Research Department. This figure represents good guesses by several people; it must suffice as no exact records exist.

3. The major costs in using DRI involve the use of regression and correlation analyses and data input. This is supported by information provided by the DRI technical staff who ran certain test jobs for the author. Data transformations were attempted but proved to be inconsequential.

4. The sampled period, which included 120 ESS jobs, is typical of Research activity.

From these assumptions it follows that the expected annual cost of running all regression and correlation analyses work on DRI would be about $30,000. These figures were derived as follows:

1. All ESS jobs included in the sample which involved regression or correlation analyses were
classified according to their size. The two factors which were measured were the number of observations and the number of variables used; these were selected as they determine the cost of a DRI job. These figures are included in Table I-1.

(2) The costs of running a regression or correlation of a particular size is given in Table I-1. These figures were provided by DRI. It should be noted that the cost of running regressions with more than 15 independent variables had to be estimated, for all attempts to run such did not compute due to multicollinearity among the variables.

(3) The costs were multiplied by the sampled frequency to get an expected sample cost. This came to $1300.

(4) A blowup factor was created to convert this sample cost into an expected annual cost. Using the assumptions listed previously, it was determined that the normal monthly amount of ESS jobs run by the Research Department was 231 (75% of 308). This figure was divided by 120 to get a monthly conversion factor of 1.9, which in turn was multiplied by 12 to get an annual blowup factor of 22.8.

(5) The annual blowup factor was multiplied by the sample cost of $1300 to yield approximately $30,000.

The $30,000 figure is quite conservative for it fails to consider several factors. First of all, only data input, regressions, and correlations were included. Transformations, file merging, and other special features were excluded from the estimates. Although individually these are negligible, collectively they represent
significant costs. The author estimated that this could be as much as 50%. Furthermore, this sample was assumed to represent a typical period. However, in comparing these jobs to what has been run in the past, it appears that this period was less active than usual - both in the number of regressions and correlations run as well as in the size of these jobs (number of observations and variables). Thus the new $45,000 figure could easily increase by 33%, which represents the author's best estimate of $60,000.

Even this last figure is low if one considers that, in the past, an active model builder has regularly run up monthly costs of $1500. However, such a person would have to use DRI anyway and thus would not really add to the cost of converting from the centralized facility to DRI.

Slightly offsetting these estimates is the fact that they represent all Research ESS jobs, and not just those run by the Economic Research Section. Although these Statistical Section jobs are significant in number, the size and complexity of these jobs are relatively minor.
Table I-1: Price and Frequency of Regression and Correlation Analyses

<table>
<thead>
<tr>
<th>Number of Observations</th>
<th>Correlations</th>
<th>Number of Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>300</td>
<td>$4.50*</td>
<td>$9.30</td>
</tr>
<tr>
<td></td>
<td>0*</td>
<td>0</td>
</tr>
<tr>
<td>150</td>
<td>$2.40</td>
<td>$6.50</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>$1.70</td>
<td>$4.40</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>$3.30</td>
<td>$4.95</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Observations</th>
<th>Regressions</th>
<th>1</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>$1.00</td>
<td>$1.35</td>
<td>$2.50</td>
<td>$4.25(est.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>40</td>
<td>12</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>$1.00</td>
<td>$1.20</td>
<td>$2.60</td>
<td>$4.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>$.90</td>
<td>$1.30</td>
<td>$1.70</td>
<td>$2.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>181</td>
<td>141</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>$1.05</td>
<td>$1.30</td>
<td>$1.60</td>
<td>$2.50(est.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>167</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The top figure ($) in each block represents the estimated DRI price for that type of run. The bottom number represents the sample frequency.