Economics of National Automation of Libraries*

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APPROXIMATELY 0.1 PERCENT of our Gross National Product (GNP) is devoted to libraries, yet library operations are basically the same today as they were twenty years ago. And, while library operations continue unchanged, the cost pressures are intensifying. Across all libraries, personnel costs comprise about two-thirds of total expenditures. The excellent study by Mathematica (a research organization) performed for the National Advisory Commission on Libraries [1] shows that the increase in the cost of library operations must be *more rapid* than the increase in the cost of living because there has been no improvement in productivity per man-hour to offset the cost increases. This means that there is a higher rate of inflation in libraries than in the economy as a whole; that is, the cost of living reflects the net effects of both personnel costs and productivity in the economy as a whole. In our society the cost of living has not risen as rapidly as personnel cost because there have been increases in productivity. But there has been virtually no increase in productivity in library operations; therefore, the increase in library personnel costs must cause an increase in total library costs which is greater than that of the cost of living.

Those who are concerned with obtaining the funds to support library operations are justified in their feelings of crisis. In order to provide even the same level of service, total library costs will continue to increase as personnel costs increase year by year. Adding to this the increasing demand for library services in the form of a more literate population, more students, etc., it would not be surprising if

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some areas of library service were to suffer. Even though it is impressive that total library funding has doubled within a decade, it is not clear that this can continue.

Computer-based library automation is being cited by many as signaling a fundamental change in library operations which will radically alter the productivity of the individual librarian and thus, break the direct relationship between personnel costs and the costs of library services. While accepting this point of view as theoretically sound, we should question more closely why there has been so little change in library operations in the past and whether anything has occurred that will allow the rate of change to increase.

We are in the fortunate position of being able to obtain tentative answers to these questions. In recent years, economists have been improving our understanding of the processes of technological change. It is the purpose of this article to consider library automation in the light of this understanding and to interpret its implications. The economists' work indicates that the low rate of change in library operations can be attributed to structural features of libraries and also to improper models of technological change in libraries, both of which remain largely unchanged.

Given the present organization of the library field, it appears that by 1980 an increase in productivity of perhaps 30 percent will be possible, but this increase may be in effect in only half of the field due to the size of libraries and the problems in transmitting the necessary knowledge of the new techniques. Compared with the potential for change and the need for change, this rate does not seem high enough. Therefore, at the conclusion of this paper, some problems and possible solutions are sketched which should increase the rate of change in library operations in the coming decade.

The greatest need is for a program that combines the research, development and application of automated procedures. To obtain this, some research and development groups should be identified and charged with these responsibilities for the library community as a whole. Another need which will have to be met is the increasing shortage of qualified librarians. This shortage will be heightened by the new knowledge requirements for those organizing and operating automated library systems combined with the expanding demands for library services. This shortage can be met by establishing a program of supplemental education for present librarians and for those entering the field.

Status of Libraries and Library Automation

While it is not within the scope of this article to review extensively the current status of libraries and library automation, it is nonetheless necessary to provide a brief summary of that status in order to relate it to the economic influences on technological invention and application.

Let us begin by summarizing some of the cost and size characteristics of the targets of the automation efforts—the libraries: 1) they are small organizations (in relation to industry), 2) there are a large number of them, 3) personnel constitutes the major cost (two-thirds) of library operations, 4) taken together, libraries are a noticeable portion of the national economy (approximately 0.1 percent of the GNP), and 5) libraries are growing. Consider the following data.

Industrial organizations with annual sales of less than $50 million are usually considered small. By contrast, for 1965-66, only sixty-two college and university libraries were reported to have total operating expenditures of over $1 million, and the largest of these had a total of less than $7 million. Total operating expenditures for these sixty-two libraries were $122 million. However, a total of 2,207 college and university libraries reported total operating expenditures of only $320 million. Thus, after removing these sixty-two relative giants, the remaining libraries had an average annual operating expenditure of $92,000.[2] For the same period (from 1965-66), there were 1,178 public libraries serving communities with populations of 25,000 or more. The largest of these had expenditures of $16 million. The 270 libraries serving populations over 100,000 had total expenditures of $256 million (average, $950,000), while the remainder of the 1,114 reporting (not all of the 1,178 libraries reported expenditures) had expenditures of $88 million (average, $104,000).[3]

During that same period, there were 26,500 professional staff and 45,000 non-professional staff (both measured in full-time equivalents) in all of these university, college, and public libraries. The staff costs were $405 million, or 60 percent of the total expenditure. Staff costs are about evenly divided between the professional and non-professional categories.[4]

There are still more libraries to be accounted for, especially high school, elementary school, and special libraries. Though the statistics reported are uneven, the Bowker data indicate a total of nearly 28,000 libraries of all types (including university, college and public libraries).[5] For 1968, there were library expenditures of approximately

$1.5 billion, of which $1.0 billion were personnel costs. This means that about 0.1 percent of the Gross National Product is devoted to libraries.

Finally, the scientific and technical information activities of the federal government (STINFO) amounted to about $350 million.[6] While these activities are referred to as "transfer of information," they are very like library activities but are based upon technical documents and non-book materials. If they are included, the total expenditures for library-related activities in the U.S. in 1970 will probably exceed $2 billion.

The Mathematica study[1] has provided the necessary data to project the rate of change of these library costs, given a constant level of operation. Over the fifteen-year period from 1951 to 1966, salary scales were increasing at the rate of 4 to 5 percent per year. Because of this, the cost per unit of library operation has risen at the rate of 2.5 to 3 percent per year.[7] So long as the technology of library operations remains the same, costs are likely to increase in this manner, even without changes in volume of operation. However, there are also changes in volume of operations as a result of increases in purchasing levels in response to increasing publication and increasing demand. The rate of publication is said to be doubling every fifteen years. Library patrons are placing an increasing level of demand on the libraries, and by the end of the century there will be 100 million more people in the United States. The implications of this are enormous for libraries as well as for all public services.

With respect to the book collection, the public, college and university libraries discussed above were reported to have 465 million volumes at the end of 1965-66.[8] Of this total, 34 million volumes were added during the year. This represents an increase of 30 percent over the rate of additions in 1962-63.[9] Recent data continue to reflect this increase in the rate of addition.[10]

Unfortunately, however, we are not in a position to estimate or project total demand for library services because the statistics do not report the service aspects of these libraries. For example, none of the following is collected on a comprehensive basis: the amount of floor traffic, the number of circulations of various loan periods, the number of inquiries that are made, and the number of hours that the libraries are open and servicing their patrons. One conclusion, however, can be drawn immediately: since information about current services is not available, it will be extremely difficult to make a quantitative

assessment of the service benefits to be obtained from library automation.

In the early part of this decade, the view was that computer technology would have a substantial impact upon the operations of the nation's libraries in the 1960's. While there have been many individual accomplishments, the effect on operations has, by and large, not yet occurred.

With respect to the current status of automation, Hillis Griffin has said, "Library automation is an accomplished fact."[11] Without challenging the accuracy of the comment in the context in which it was given, it should be noted that the statement allows the reader to interpret library automation as a *state* of library operation rather than a *process* of changing library operations. Indeed, library automation exists as a process and some automated procedures have been developed. Computer programs have been developed to assist with the file maintenance chores associated with acquisitions, cataloging, and circulation. Also, Brown and Jones report on the plethora of first applications of specific computer-based techniques for information storage and retrieval and information center applications.[12] However, few libraries are using any of these techniques, and there are fewer than ten libraries of the more than 3,300 public, college, and university libraries which are using them all.

Even though little application of automated clerical procedures has occurred, such techniques at least have been developed. By contrast, scant work has been done on mechanized procedures to assist professional librarians. (In referring to procedures for professionals it is assumed that library tasks divide readily into the clerical and decision categories.) No such simple distinctions exist in practice. Tasks have a spectrum of routine and decision-making aspects; thus, nonprofessionals make some decisions and professionals perform some routine activities. For convenience, however, we assume that the total volume of decision-making activity is equal to the total professional man-effort.) It is not at all clear that any present system reduces the amount of professional effort required to provide library services. Thus, the selection decisions, the cataloging decisions and the reference-retrieval decisions are made largely unaided and mostly as they have been made for years. Indeed, those organizations using automated retrieval systems have found that skilled professionals are needed to formulate the retrieval requests and to evaluate the results. Thus, the demand for professional librarians is increased. At present, one half

of a library's manpower costs are for professional personnel. As a result, research in librarianship must be addressed to assisting or replacing the professional librarian in the performance of his decision tasks. This would allow for the reallocation of the professional librarian's tasks to meet the increasing demand for library services.

Returning to the application of existing techniques, what would be the benefits and costs on a national basis of the application of current automated techniques to libraries? Because of the nature of the supporting data, the answers must be in the form of conjectures only. First of all, let us assume that the level of application we want is a computerized system that will handle most of the current housekeeping chores associated with circulation, acquisitions, cataloging, serials and management records. (Because there is no quantitative characterization of present library services, we are not at this point going to attempt to discuss the benefits of automation resulting from the possible expansion of current services or the provision of new services. Thus, the analysis is restricted to the cost benefit of automation at current service levels.)

Estimates for a library system such as the one mentioned above generally predict a 40 to 60 percent reduction in clerical costs.[13] When considering application to thousands of libraries, this savings must inevitably be cut down because it is an estimate of the best that can be done. Such an estimate assumes that when the effort requirement is reduced, the man-cost is correspondingly reduced. Yet personnel assignments might not change because of a lack of alternative work compatible with the remaining tasks that still must be performed. Two tasks, each of which is cut in half, may still require the same number of people because the tasks may require that a person be in a particular place for a specified period of time. For example, the tasks at the reference desks in two branch libraries—one medicine and the other law—would be difficult to combine satisfactorily no matter how low the loads. Similarly, the timing of processing requirements will produce interference. Thus, if telephone calls decrease, their sequence of occurrence still might be such that the person answering them could not do other work effectively.

As a result of such limitations, my guess is that on an individual basis, the libraries of average size ($100,000) or less would not notice any reduction in man-effort, while the largest libraries will have a reduction of 33 percent in the non-professional man-effort. However, processing centers represent a possible method for making the benefits

of automation real for libraries with less than a $100,000 annual expenditure. Therefore, both individual installations and processing center installations should be considered.

Examining the distribution of sizes of the public, college and university libraries, it appears that approximately 1,000 installations of a computerized system (including processing centers) would make automated techniques available to those libraries whose cumulative personnel costs total $600 million of the library community's present $1 billion personnel costs. (This is based upon an assumption that there are a large number of libraries or branches with staffs of one or two people for which installation would not provide a cost benefit.) This leads to an estimate that these libraries would realize a $100 million savings per year in their non-professional staff costs (which are half of the $600 million personnel costs). Over the entire library community, this would represent a decrease in labor costs for a constant level of operation of approximately 10 percent.

On the basis of these benefits, we can now make a rough estimate of the costs for development and installation of our computerized system on a national basis. Let us assume that the development and first installation of this system is $2 million and that each subsequent installation costs $100,000. Further, assume that one system is developed for every 100 installations and that there are 1,000 installations, including processing centers. On this basis, ten systems would be developed at a total cost of $20 million. Subsequent installations of these systems would cost $100 million, and the total cost would be $120 million.

Economic Influences on Automation

It seems reasonably clear that the accomplishments of library automation during the decade of the 1960's were much less than was expected at its beginning. It would be easy to accept the current view, which might be paraphrased as follows: At the beginning of the 1960's the problems of library automation were not understood, and they turned out to be much more difficult than anticipated. However, most of the problems now have been identified and solved. As a result, substantial automation will be accomplished in the next few years.

In effect, this beguiling approach says: "I am wiser now, so trust me." I question whether we are wise enough. After all, some automation proposals made as recently as two or three years ago have been

found to be overly optimistic. Against this background, can the estimates made earlier in this paper be trusted? How can they be checked before they are tested by history? Is there any other experience that can be used as a cross-check on how wise we have become?

There is one cross-check that can be applied: the economics of changing technology in general. Over the last decade there has been a growing interest in this field. Mansfield has produced an excellent text which brings together the diverse work that has been done in this area.[14] I have extracted liberally from this text and the interested reader is referred to it, both for extension and for qualification of the generalizations. All readers should be aware that only very small amounts of data exist to support the general assertions set out by Mansfield. Also, there is no data that indicates the degree to which these assertions apply specifically to library automation (although the effects of the assertions should be the same). Extensive data collection and analysis remains to be done to make our knowledge of technological change more precise.

In the development and use of a new technology, Mansfield defines three stages: technological change, innovation, and the diffusion of the new technique. In the first stage, the new technology must be invented or discovered. "Technological change" does not refer to a change in the use of techniques; it refers to an increase in our fund of knowledge about possible goods and services that can be produced or about possible methods and equipment that can be used for the production of goods and services. Thus, technological change, as Mansfield uses it, represents an invention or a new technique that has been developed, whether or not it is applied.

The second stage, innovation, refers to the first use of the new technique on an operational basis. Though this may be closely related to the technological change, it may also be a separate step performed at a later time in a different organization. The third and final stage, diffusion, refers to the increased use of the technique until it reaches an equilibrium with competing techniques and thus becomes an established one. Ultimately, it may be replaced by newer techniques. Later in this article, I combine Mansfield's two stages of innovation and diffusion into a single stage: application.

The rate of the first stage, technological change or invention, is increased by:

1) increases in the demand for the product(s) affected by the change;

2) decreases in the availability, or increases in the prices of the resource inputs;

3) increases in the number of people working in the field, or related fields, in a position to make the changes;

4) increases in the amount of effort devoted to making modest improvements in operations;

5) increases in the amount of resources devoted to improvements in the capital goods and other resource inputs from supplying industries;

6) increases in cumulated research and development expenditures made by the firm or industry; and

7) increases in firm size in the range of less than 1,000 employees to more than 5,000. That is, the percent of sales which is devoted to research and development increases and thus, technological change is stimulated.[15]

Libraries appear to be prime candidates for technological change insofar as the criteria given are concerned: there have been increases in demand for library services, there have been increases in the prices of the resource inputs (in the form of increasing salary and wage costs), and there have been increasing numbers of people working to make changes in the field. Why, then, has there not been more discovery of new knowledge or more invention of new techniques or equipment?

One reason is that until recently the expenditures for research and development continued at a low level in spite of the increasing demand for library service. In general, individual libraries cannot afford research; that is, the pay-off from research is usually a function of the size of the organization. Therefore, in small organizations such as libraries, the research is thought to be too risky and the pay-off too limited to be worth the portion of the library's budget that would be required. The recent expansion in federal funding of library research and development is thus extremely important to the stimulation of technological changes.

However, there are further problems in stimulating technological change, and these have to do with attitudes about the nature of the change required and the resulting allocation of these research and development funds. Technological change is characterized either as capital-embodied or disembodied change. Capital-embodied change requires new equipment (thus, capital investment) for its use, while disembodied change, in the form of changed methods and/or organi-

zation, can be applied with either existing or new equipment. Of course, many changes are mixtures of these two types of change.

The problem with library automation is that it was improperly classified as a capital-embodied change. While the computer per se is a capital-embodied change, library automation requires much more than a computer; thus, library automation is disembodied change. Setting up a computerized system requires a performance program which specifies in minute and exhaustive detail the conditions to be expected and the actions to be performed for each condition. To develop these programs and the data to be processed by them, research is required, i.e., the study and understanding of the fundamental processes of the library. Even then, the use of these programs is not necessarily evident. Education and training may be needed to make the system user aware of the workings and the possibilities of the programs.

By contrast, the bulk of the library automation expenditure has been for the application of a knowledge *that was assumed to exist.* The functions of library acquisitions, cataloging, circulation, etc., were felt to be conceptually simple, and the tasks chosen for computer applications were referred to as "clerical processes." Library automation was conceived to be a direct and single application of existing computer techniques to well-defined processes. Even now, the emphasis of the field remains upon application or demonstration and not on research. This is a reasonable strategy to promote the use of existing techniques, but it does not make a strong contribution to the development of new techniques. The changing of technology in a library (as with any other field), requires a continuing effort, one which incorporates research, development, and application.

Let us now consider the application of existing techniques (which Mansfield refers to as innovation and diffusion). The following are the determinants of the rate of application:

1) the greater the economic advantage of the innovation over older methods, the greater the rate,

2) the lower the uncertainty associated with using the innovation, the greater the rate,

3) the lower the commitment required to try out the technique, the greater the rate,

4) the greater the rate of reduction of initial uncertainty, the greater the rate,

5) as the number of firms using the technique increases, the probability of adoption by non-users increases,

6) the greater the expected profitability, the greater the rate,

7) for the same expected profit, the lower investment alternative will be preferred,

8) the lower the knowledge and coordination required, the greater the rate,

9) the less the "new behavior or social organization," the greater the rate,

10) the fewer the changes in socio-cultural values and behavior, the greater the rate,

11) the fewer the restrictive policies of relevant labor unions, the higher the rate, and

12) industry characteristics that increase the rate:

a) inclination to experiment and risk,
b) keenly competitive,
c) financially healthy,
d) durable equipment,
e) growing industry output,
f) unconcentrated industries,
g) adequate advertising.[16]

Let us apply this general information to library automation. The determinants of the rate of application show that it is reasonable to expect very few libraries to be using existing computer techniques and programs. First, the economic advantages have been unclear. There has been considerable uncertainty with respect to most aspects of the use of computers—their development and operating costs, the period to develop the operations, the stability of the computer operations developed, etc. Furthermore, because the patrons of the library do not pay directly for the services performed, increasing utilization of the library (though desirable in many ways) increases the financial problems of the library. Because libraries operate as components of some other agency which controls their budget, the use of computers does not offer any prospect of profit because the money saved is not likely to be available to the library for other uses. Indeed, the library administrator may see the threat of increasing difficulties in winning the funds needed for the library as a result of the existence of the computer operations.

Second, given the average library budget of $100,000, the relative

size of the commitment to try out these techniques has been huge. This commitment is large compared with the budgets of even the largest libraries. Third, where the attempt has been made, the usual result (after some effort and delay) has been that the existing computer programs embodying these techniques could not be used or were unavailable. Where computer programs already exist, their operation must be understood and perhaps modified, arrangements must be made for their operation on a specific computer, and the personnel must be trained to provide the needed data and to use the results. To date this has led to a slight reduction of the initial uncertainty about the advantages of computer operations.

Whether or not the library administrator is inclined toward experiment and risk, libraries are in a position in which the penalties for failure for both the library and the administrator are far greater than have been the possible rewards from the successful application of computers to library operations. Here again, federal funding has been a most important factor in stimulating application because it provides the development capital and thereby reduces the risk to the library. However, this risk capital in general has been provided only for the initial development and first use of a system. Thus, unless the uncertainty with respect to the costs and benefits of the methods is reduced, it can be expected that there will be a low rate of subsequent application in other libraries.

Problems and Prospects

In looking forward to the decade of the 1970's, there seems little question that automation will indeed have an impact on the operation of the nation's libraries. It is also likely that the rate of change of these library operations will be greater than it has been over the last decade. The reason is that there is an increasing understanding of the problems of library automation, and some of the useful techniques that have been developed will be generally applied. Even so, most of the economic factors which contribute to a slow rate of change are still very much present as a result of the structure of the library community. Before we can predict their precise influence, the quantitative data on current performance must be collected, and quantitative analysis must be made to identify effects of each of the factors. This will require both time and effort, and, for the present, the question is whether our current approaches to library automation can be improved. My view is that there are several solvable problems which

would improve the rate of library automation, but they require regional or national coordination. I will discuss the problems and the possible solutions, but not the mechanisms for achieving the needed coordination.

When library automation moves into an area that is clearly new, such as the mechanization of professional processes, support for research and education must be corollary parts of the program, with corresponding increases in the funding. For example, in *Technology and Libraries*[17] the costs of a library improvement program are projected, and the allocation to research, education, and training is half of the amount allocated to hardware (i.e., computer equipment) and software (i.e., computer programs) specification and development. This sort of estimation is most welcome since it signals recognition of problems peculiar to librarianship which will have to be addressed as a part of the continuing program of library automation.

Because even the largest libraries are still in the category of small industrial organizations, the funding for research and development will have to continue to be external, presumably from the federal government. Therefore, some number of organizations should be selected to receive the funding for library research and development efforts on a continuing basis for periods of not less than five years. In return for the external funding, arrangements must be made to make the results generally applicable and available to the libraries. This is discussed later.

I suggest further that the funding go to a number of organizations, rather than just one, because parallel research and development efforts have been shown to be effective where there is uncertainty about the best technical alternative to be developed.[18] In library automation, there are many situations in which the "best" alternative will be unclear. If there were only one research and development group, chances are that we would not be given any alternatives to the work of this group. However, if there are several organizations doing parallel work, we can pick and choose from a variety of proffered alternatives.

With respect to the kind of research to be performed, the next stage of technological change (i.e., the one following the mechanizing of clerical operations) in libraries must assist or replace the present activities of the professional librarian. Only in this way will we be able to expand library services to meet the sharply increasing demands. Therefore, this funding must support research on the fundamental problems of librarianship, such as the intellectual organization

of information, as well as the more technically oriented problems directly related to computer operations. Indeed, the richness of these problems being worked upon as an integrated set gives the promise of significant technological change for libraries during the coming decade.

While the establishment of a set of stable research and development groups should provide for continuing discovery and invention, it does not address the problems in the application of these techniques to operating libraries. The most important problem here is that of uncertainty with respect to the *merits* of the application and to the *methods* for introducing it. In approaching this problem, the research groups should investigate the economic aspects of their work on a continuing basis. To support this work however, cost accounting data must be available from the libraries. The availability of this data would allow study of the economics of current techniques in relation to new techniques. In contrast to the many speculations in this paper, this data would provide solid information on which to base the research, development, and application of new techniques.

The research and development groups should be organized so that they provide continuing support to the library community in the application of the techniques developed. In addition to providing programs and written materials, they should train library personnel and consult with them on problems of implementing and operating library systems. Such contact is vital to insure the application of developed techniques in many libraries. Because most libraries are quite small, they can automate their operations only if they are given this kind of support. For those libraries that elect to use processing centers (instead of buying and installing their own equipment), the research and development groups should train and consult with the processing center personnel and provide support for training the library personnel.

One problem we should anticipate in trying to accelerate the rate of technological change is the potential negative reaction from library personnel. Even though total demand for library services continues to increase, there is a possibility of dislocations and/or instability of employment. As indicated before, the next series of technological changes must be addressed to assisting or replacing the activities of the professional librarian. As such it has the potential of partially obsoleting the education and experience of present librarians, while it creates demands for different education and experience.

It should be possible to establish security of employment within

the profession as a whole because of the increasing total demand for library services and because the librarian's education and experience will be only partially obsolete with national automation of libraries. A promising approach would be to establish a fellowship program to support any and all librarians for re-education in computer-based library systems. In addition to classroom work, such a program should also have an internship devoted to working with automated procedures related to the individual's particular specialties. This program would consist of many different aspects and courses of study, and it is not expected that everyone would take the same set of studies.

What are the possible dimensions of such a program? We might assume that one year is the longest time that people would take in the program, while the shortest would be two months. Now, it is not likely that all librarians would elect such a program; therefore, let us assume that over the next decade 30,000 people (out of an estimated 50,000, including those entering the field during the decade) undertook such a program. Further, let us assume that one-half of them took a three-month program, one-quarter a six-month program, and the remaining one-quarter took a full-year program. This would total 15,000 man-years of student time. Thus if the program were set up to accommodate 2,000 man-years of student time per year, this program could be accomplished in seven and a half years. If the cost were $40,000 per man-year for the support of all aspects of the program, the annual costs would be $80 million.

While this is a significant amount of money, it represents less than 10 percent of current library manpower costs or less than the amount that these costs can be expected to increase over the next two years. Since total annual costs for library services can be expected to exceed $2 billion, it would be reasonable to invest this much in library personnel training in order to get on with the tasks of technological change.

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