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Library Cost Models: Owning Versus Borrowing Serial Publications.

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The costs of providing access to serial literature in four university research libraries were examined in this study, and a methodology was developed for comparing borrowing costs with the costs of acquisition, cataloging, maintenance, and circulation. Mathematical models are provided by which any library can determine at what frequency of use of a serial title it becomes less expensive to acquire a photocopy of an article from another library when needed than to subscribe to and maintain a file of the title. Cost data from the four libraries, when inserted into the models, indicate a strong case for borrowing low demand serial items. Study findings must be qualified because the four libraries are not a random sample of all research libraries, and no value was placed on having a collection available for browsing or on the shortened access time involved with local ownership. It is concluded that in order to give the research library a choice between borrowing and owning little used serials a national lending library system for serial literature needs to be developed. Appendixes include: details on the library surveys, mathematical analyses performed for the study, suggestions for a lending library system, and cost models for a specific serial title. (JB)

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by

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PREFACE

This study was made possible by a grant (GN 532) from the National Science Foundation, and its help is gratefully acknowledged. An Advisory Committee of Verner Clapp, Herman Fussler, Robert Hayes, Herman Henkle, Ferdinand Leimkuhler, and James Skipper assisted through all phases of the study. Their contributions were significant and their kindness is greatly appreciated. The analysis of data and all mathematical modeling was done by Westat Research, Inc., which also gathered the data from the sample libraries. Dr. Edward C. Bryant, president of Westat Research, Inc., was primarily responsible for these operations and was chiefly assisted by Robert R. V. Wiederkehr, Vernon E. Palmour, Cynthia J. Siehler and Vern Achtenmann. Samuel T. Waters and Albert M. Berkowitz of the National Library of Medicine and Dr. D. J. Urquhart of the National Lending Library for Science and Technology have been particularly helpful in providing data and reviewing drafts. The project staff are particularly grateful to the directors and staff of the four sampled libraries for their assistance in the data collecting phase of the project, although their names must be withheld to avoid disclosure of the identities of their libraries.

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Project Director

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SUMMARY

This study has examined the costs of providing access to serial literature in four university research libraries and provides mathematical models by which any library can determine at what frequency of use of a serial title it becomes less expensive for that library to acquire a photocopy of an article from another library when needed than to subscribe to and maintain its own file of the title. The methods of acquiring a photocopy when needed against which the costs of local ownership are compared in this study are somewhat more expensive than those presently used but are estimated to provide access within two or three days instead of the one to three weeks now normally required.

At the midrange of costs found in the four libraries studied, and for a serial title with an annual subscription price of $20 (the average price per title found in the study), unless the title is used more than about six times per year, it is less expensive for the library to acquire a photocopy of articles from it when needed than to maintain its own subscription and file. The available evidence from other studies indicates that a large proportion — perhaps half or more — of the serial titles now currently received in large research libraries are used less frequently than this.

The saving to the library under these conditions amounts to about $50 per title per year, or about $50,000 per year for 1000 titles. This

amount is the library's saving only and not the system saving to society as a whole since part of the costs the library saves would have to be borne by the institution from which the library borrower gets its photocopy. In order to estimate the net system savings to society as a whole the study has therefore estimated the loads and costs of a centralized national lending library for serials if libraries generally were to adopt these decision models. A substantial net saving would seem to be realizable.

Having thus very briefly summarized the results of the study, several qualifications must be noted if they were not to be misleading.

First, the critical frequency of use cited above is based on the midrange costs in the four libraries studied and while there is no reason to think their costs are not typical, actual costs vary from library to library. A library should base its decisions on the results of using its own costs in the mathematical models.

Second, the figures cited above do not include a factor for user cost because there may be a greater delay in access through borrowing or photocopying than through local ownership. But the report points out (see the Introduction) that if delays in access increase user cost and the aim is to minimize this cost, then what must be minimized is the average access time to all publications the patron uses — those locally owned as well as those borrowed or photocopied. Since there are now substantial

delays in access to what is locally owned but frequently used, it is suggested that minimum user cost will be achieved if the library's money is spent on providing more duplicate copies and faster access to titles frequently used rather than on local ownership for faster access to titles infrequently used.

Third, there are values not measured in the model in having even infrequently used titles locally available for browsing and for examination when indexes and abstracts are lacking or inadequate. In making a decision libraries must weigh these values against the values that might be realized from other uses of the money saved by relying on borrowing or photocopying for access to such titles.

Fourth, the savings estimated are for the most part only potential and not now actually realizable because there is not yet a source from which libraries can be assured of borrowing, or getting a photocopy, of what they do not own locally.

The establishment of such a source is a necessary pre-requisite and it is hoped this study will help bring it into existence.

1. INTRODUCTION

There are two fundamental ways in which a library makes a publication accessible to its patrons. It either acquires and maintains a copy in its own collection, or it borrows it, or acquires a photocopy, from another library. Neither way is free. It costs the library money in staff time to locate and borrow an item not in its own collection, for postage, and, if a photocopy is ordered, in most cases it must pay for that. For an item in its own collection it must process it and house it even if the publication itself is free, while in most cases, of course, it must be purchased. In the case of a borrowed or photocopied publication, the cost is essentially the same cost every time the same item is borrowed so the cost per use remains a constant. In the case of a title acquired and maintained in the library's own collection, the cost per use is a function of how frequently it is used. It is apparent that for every publication there is some frequency of use at which it becomes cheaper for the library to borrow, or photocopy, it from another institution than to acquire and maintain its own copy.

The primary purpose of the present study has been to provide mathematical models by which a library can determine at what frequency of use of any given serial title it becomes cheaper for that library to borrow or photocopy an item when needed than to maintain its own copy

of the title, and to give some indication of what the potential savings might be if libraries were to use such a decision-making policy more extensively.

The indications for the potential benefit to be derived from a critical study of the costs of providing access to the needed publications themselves come from the now several studies on patterns of use of library materials. The data from some of these studies are given in more detail in Chapter 3. Here it need be said only that these indicate that very substantial portions of research library collections of serial titles — in fact more than half of the titles in many cases — are used no oftener than once a year.

We are well aware, of course, that library cost only is not the major consideration; if it were the cheapest alternative of all would be to discontinue the library completely. In fact, the major consideration is user cost, and the basic purpose of library expenditures is to reduce the patron's cost for access to the point where all users have ready access to all of the information they need. A change in library operations that saves the library cost merely by passing it on to the user is therefore no saving at all.

The determination of user cost in getting access to information is extraordinarily difficult, but it is clear that it is directly related to the time the user must spend in getting such access. Since interlibrary

borrowing provides slower access than if the material is available locally, the user cost is therefore greater and a comparison of the costs of the two modes of access is valid only if it includes the user cost for the delay due to interlibrary borrowing, though it is valid only insofar as this comparison, by itself, is of concern and if there is no delay in access to what is locally owned. The mathematical models allow for the inclusion of a factor for user cost, if it is determined, and in order to give some idea of the magnitude of its effect on the critical frequency of use at which interlibrary borrowing, or photocopying, becomes cheaper than local ownership, we have calculated this for some arbitrarily assumed values of user cost (see p. 39).

We wish to emphasize, though, that when the object is the larger one of reducing total user cost for access to information, which we take it to be the real purpose of comparing library costs for these two modes of access, then to increase the cost of only interlibrary borrowing or photocopying by including the user's cost attributable to the longer delay is not valid. It is not valid because there are significant delays in access time to what is owned by the library as well as to what it must borrow, and if user cost is to be minimized it is the average access time to all the publications he needs that must be minimized, not merely to those which must be borrowed, or photocopied, on interlibrary loan.

The findings of several studies (16, 17, 18, 19) indicate that even when the publication needed by the patron is actually owned by the library,

only slightly better than half the time is it on the shelf and available for his use when he requests it. The most practicable way of reducing or avoiding these delays, which are caused by the items being in use by another patron, at the bindery, misshelved, or lost, is to provide more duplicate copies of them. (A discussion of this relationship is given in Appendix F.) Since delays in access to what the library actually owns will occur more frequently in connection with items that are most frequently used (those least frequently used are of course more likely to be on the shelf when wanted), money spent for providing a, or another, duplicate copy of what was frequently used will reduce the access time to that item for more users, and hence the average access time and user cost, more than if the same money were spent for a title that was very infrequently used, provided that the rapid and assured access by loan or photocopy assumed here was in fact available.

For this reason, comparison of the two modes of access (local ownership versus interlibrary borrowing or photocopying) that includes a factor for the greater user cost because of delay time in access to what is borrowed is misleading unless a similar factor is included to cover delay in access to what is owned. The simplest method would be to make the comparison first on the basis purely of library costs, with no component for user cost. For those titles whose frequency of use is below the point at which local ownership is cheaper for the library, then the question can

be asked, which will reduce the average access time more in that library — the acquisition of that title or the acquisition of a duplicate copy of a more frequently used one, and the decision made on that basis will provide the lowest user cost.

Two other factors that increase the value of having serials locally must also be mentioned. One of these is browsing, and the other is the non-existent or inadequate indexing of some serials. This latter factor, which seems to apply more frequently to serials in the humanities, means that a user cannot specify what he needs in a particular journal, if anything, without examining the full file himself. While such journals could be borrowed in their entirety if an adequate national lending system were in operation, the cost would be more per loan than that shown in the illustrations given below, and the critical frequency of use for which interlibrary borrowing, or photocopying, was more economical would be increased.

Borrowing, and its accompaniment of serendipitous discovery, is, partially at least, another matter. Browsing, in the sense of scanning a likely looking source to see if it contains anything of value, is essentially identical with the factor mentioned above, if one knows that the source exists. But unless the source is actually present where the user is, he will not find it while browsing through the library's collection and his discovery possibilities are reduced to citations and bibliographies. The importance of having material available for browsing should not be minimized, but

neither should it be over-emphasized. Too little is yet known about it to permit quantitative judgments of its extent, but the most serious investigation of it known to us is that of Fussler and Simon (5), who found that unrecorded use of publications in libraries, at least part of which can be assumed to be browsing use, was proportional to recorded use. This means, presumably, that those items with the least recorded use were also the least used as the result of, or for, browsing. At present, the value to put on having a serial available for browsing must be purely subjective, but if the relationship found by Fussler and Simon holds, little browsing use would be lost if very infrequently used serials were not in the stacks.

Unfortunately, there is not now a system within the United States that assures a library of access within a reasonable time to a serial publication not available in its own collection. There is such a system for medical literature operated by the National Library of Medicine, and a more limited one covering some titles in chemistry and biology operated by The Center for Research Libraries with the partial support of the National Science Foundation. But until there is a more comprehensive system covering all serial titles, most of the potential benefits of this alternate system of providing access will remain unavailable. One of the results it is hoped this study will help to promote is the establishment of such a national system of providing all libraries with ready access to serial literature (a national lending library system, in effect) by indicating its benefits in increasing the

access to information. Some estimates of loan loads and other characteristics of such a national system are provided in Appendix F.

This study considers the costs of the two systems in providing access to only a single major class of library materials, namely currently published serial titles. Although the general approach adopted here would be applicable to any class of library materials, limitations of time and money made some restriction necessary, and this class was chosen both because of its importance in library economy, and also because there has already been a partial implementation of the assumed system, as indicated above, that made possible a more complete cost analysis of the total system. It should be noted that although the analysis is limited to currently published serial titles, the costs are considered for providing access to all volumes of the title, from the current year back, and not merely the cost for access to the current volume. The analysis and mathematical models also consider several different possibilities with respect to local decisions: not subscribing to a title; subscription but retention of only the last few volumes; dropping an existing subscription but retaining all or part of the present files; and several others. For this study a serial was defined as any currently published title included in the library's serial record file.

It must be noted that the basic unit against which costs are compared in this study is the frequency of use of the serial title, i.e., of all

volumes of the title, and not merely of a single volume of the title. For example, frequency of use of two per year indicates that when all volumes of the title are considered, there are only two uses of all of these together, not that there are two uses of each volume. For a serial title with twenty volumes, two uses per year of each volume would be equivalent to forty uses per year of the title. This measure has been chosen in part because most of the available library data on use are recorded in this way rather than in use per volume, and in part because it is presumably more practical for libraries to keep volumes of serial titles in unbroken runs between whatever beginning and terminal dates are chosen than to keep only scattered volumes between those dates. This being true, the critical measure for them is total use of all volumes of the title within the time span considered.

As a final word with respect to the mathematical models themselves, they have been programmed for shared time computer use (in CAL, a language easily translated into FORTRAN) and the program listings are available upon application to The Center for Research Libraries for the cost of photocopying the listings (approximately $25.00).

2. COST MODELS FOR LOCAL LIBRARIES

2.1 Costs in Four Sample Libraries

The mathematical models developed in this study can be used by a library only when it knows its costs for the operations considered. Such costs vary from library to library, partly because of the different environments in which they operate and partly because of differing emphases and policies, but there are also similarities in that all libraries perform similar functions and in more or less similar ways.

For both of these reasons, four university libraries were studied in detail to develop methodologies that any library could use to determine its own individual costs, and to provide illustrative costs for this study. No attempt was made to draw a random sample of university libraries; a number of factors made this impossible. The actual selection was based partly by size, with some attempt to include a respectable range in this characteristic; partly by geographic dispersion; partly by convenience of location to the investigators, and partly by the ability of those considered to cooperate fully with the investigation and contribute their own staff time to the examination. Though the sample of libraries is not a random one, there is no reason to think these libraries or their costs atypical of other university research libraries since they provide a reasonable spectrum of size and geographic dispersion. Because comparisons, particularly cost comparisons without a full understanding of what causes the differences, can be invidious, the libraries are labeled here merely as A, B, C, and D.

Some characteristics of these libraries are given in Appendix A; enough so that another library can probably identify the one most like itself if it wishes to use the figures from this sample library as at least a rough approximation of what its own figures might be.

In this connection, it should be noted that while the actual costs will vary from library to library, and therefore the actual critical frequency of use at which it becomes cheaper to borrow than to maintain its own subscription will vary somewhat from library to library, even with fairly large differences in costs the critical frequency does not change greatly in absolute value at the low end of the scale where it is primarily of concern. For example, Figure 2.1 shows that for a serial with an annual subscription price of $20, at the midrange library costs of the four sample libraries it becomes cheaper to borrow if the frequency of use is less than 5.4 per year. A library's own costs would have to be significantly less -- by 100% or more -- than the midrange costs of the sample libraries to lower this critical frequency of use to three per year. Without more detailed records of use than most libraries can now easily provide, it would be difficult if not impossible for it to distinguish with much precision between titles with six uses per year and those with five. For this reason, plus the benefits of having titles used as frequently as four to six times a year more quickly available and accessible for browsing, most libraries are more likely to make their actual cut-off point fairly well below the actual critical point determined by their own costs -- say at uses not over once or twice a year when the actually determined point is four to six. As is shown below, a very

significant portion of research library serial collections are used no oftener than once or twice a year. Such a decision point therefore would in most cases be quite safe and yet provide very significant savings for any library that had no reason to expect its costs to vary wildly from the midrange costs of the four university libraries studied here. Such an approach is less accurate than for a library to determine its own costs and by using these in the mathematical models to determine its own critical points, but it may be preferred by some libraries.

In gathering the data, the principal cost factors in either owning or borrowing a serial title were first identified, and library operations were then studied to develop collecting techniques which might be expected to yield sufficient accuracy. An important consideration in the structuring of these techniques was the aggregative method to be used in comparing the available alternatives. A cost-per-title aggregation was chosen, rather than a cost per volume, since some important costs, such as cataloging, are attributable to the title rather than to individual volumes.

The following functions were identified and the average cost per title of performing each was obtained from each of the four libraries:

Acquisition, excluding subscription costs

Subscription costs

Cataloging

Check-in

Claiming

Binding, excluding contract costs

Bindery (contract costs)

Marking

Administration

Training

Other

In addition, costs were obtained for interlibrary borrowing activities to arrive at a total cost per item borrowed, including photocopy, mailing and labor.

Costs were generally classified as "contract costs", such as subscription costs and bindery costs, and "labor costs". The former costs are not subject to overhead, but the latter are. In the cost comparisons of alternatives shown subsequently in this section an overhead cost was added to all direct labor costs, including that identified as "Administration" and "Training", categories of costs which themselves might have been considered as overhead under a different formulation of the cost models.

An analysis of the cost data by function shows substantial comparability in the proportion of manpower effort expended by each of the libraries. Summaries are shown in Tables 2.1 to 2.3. Note that labor costs are shown in these tables with an arbitrary overhead of 50 percent. Appendix A provides details on the data collection techniques used in the survey and provides profile data on the libraries surveyed.

The total holdings of the libraries surveyed varied between 648,000 and 1,732,000 volumes. Between 30% and 35% of gross library manpower effort was devoted to serials at costs, respectively, of $206,000 and

$352,000 without overhead. The three functions accounting for the majority of the serial labor effort were circulation and reference, acquisitions, and check-in. The percentage of total serial labor range from 23% to 49% for circulation and reference, from 9% to 19% for acquisitions, and from 6% to 20% for check-in. The initial cost of acquiring a serial title, namely the costs of acquisition and cataloging, varied (with estimated overhead) from $53 to $72. These costs include such activities as bibliographic checking of requests, preparing orders, answering inquiries, other communications with requesters, typing and bookkeeping activities. The magnitude of these costs has stimulated queries from librarians who have seen the data, but a review of the data collection processes does not reveal any reason to doubt the figures. Note that the reported costs are for the acquisition function rather than the Acquisitions Department, if any. It was found that a number of acquisition tasks were performed by other departments, and that this activity was particularly heavy in branch libraries.

The continuing costs of subscriptions and maintenance labor over the period of one year (with estimated overhead) ranged between $29 and $46. These costs do not include the one time costs of acquisition and cataloging incurred in the first year. Also excluded are storage costs, which depend upon the number of volumes stored, and circulation costs, which depend upon the number of times circulated. Costs of borrowing an article from an issue of a serial varied between $3.18 and $9.79, including photoduplication, postage and overhead. Lending cost per request filled ranged between $1.26 and $3.62.

Table 2.1. Cost per Title of Acquiring a Purchased Serial from Four Sample Libraries

	Without Overhead			With 50 percent Overhead		
Library	Acquisition*	Cataloging	Total	Acquisition*	Cataloging	Total
A	$29.20	$ 9.62	$38.82	$43.80	$14.43	$58.23
B	23.03	12.37	35.40	34.55	18.55	53.10
C	34.41	13.74	48.15	51.62	20.61	72.23
D	32.38	12.73	45.11	48.57	19.10	67.67

*Excluding subscription costs.

Certain cost figures required for the models came from sources other than the survey. They are shown in Table 2.4. Storage and disposition costs derived by Fussler and Simon[5] were used. Overhead costs of 50% of direct labor were based on a study by the National Science Foundation[14]. NSF reported the average indirect cost rate for small and large colleges as 28.2% and 32.0%, respectively. These percentages did not include employee benefits which were considered to be about 15% for this study. The two percentages were combined into one figure of 50%. Note that library administrative labor was considered to be direct cost rather than overhead. An attempt to obtain photoduplication costs for items loaned by the sample libraries was unsuccessful because the photoduplication service was used widely for cataloging and other functions within the typical library. An intensive cost accounting study would have

Table 2.2 Estimated Cost per Title per Year of Maintaining a Purchased Serial, from Four Sampled Libraries, Excluding Storage and Circulation Costs*

Function or item	Costs without overhead				Costs with 50 percent overhead			
	Library A	Library B	Library C	Library D	Library A	Library B	Library C	Library D
Subscription (contract item	$12.62	$22.62	$21.55	$17.06	$12.62	$22.62	$21.55	$17.06
Check-in (labor)	1.94	2.93	2.28	3.20	2.91	4.40	3.42	4.80
Claiming (labor)	0.84	0.17	0.52	0.36	1.26	0.26	0.78	0.54
Binding (labor)	1.74	2.99	1.44	2.33	2.61	4.48	2.16	3.50
Marking (labor)	0.19	0.13	1.07	0.76	0.28	0.20	1.60	1.14
Administration (labor)	1.18	3.06	2.24	3.22	1.77	4.59	3.36	4.83
Training (labor)	0.59	0.80	1.05	0.29	0.88	1.20	1.58	0.44
Other (labor)	0.09	0.44	0.48	0.00	0.14	0.66	0.72	0.00
Bindry (contract item)	6.22	7.79	6.36	4.29	6.22	7.79	6.36	4.29
Total labor items	6.57	10.52	9.08	10.16	9.85	15.79	13.62	15.25
Total contract items	18.84	30.41	27.91	21.35	18.84	30.41	27.91	21.35
Grand total	25.41	40.93	36.99	31.51	28.69	46.20	41.53	36.60

*See Table 2.4 for storage and circulation costs.

Table 2.3 Interlibrary Loan Costs for Serials from Four Sample Libraries

Library	Without Overhead							
	Cost per item loaned	Cost per item borrowed			Cost per item loaned	Cost per item borrowed		
		Labor	Photo copy*	Total		Labor	Photo copy*	Total
A	$2.17	$1.45	$1.00	$2.45	$3.26	$2.18	$1.00	$3.18
B	1.11	2.31	1.00	3.31	1.66	3.46	1.00	4.46
C	2.41	1.61	1.00	2.61	3.62	2.42	1.00	3.42
D	0.84	5.86	1.00	6.86	1.26	8.79	1.00	9.79

*See text for method of determination.

been required to obtain that portion of costs attributable to servicing borrowing requests. A consensus among informed persons with whom the problem was discussed was that such costs should amount to about ten cents per page for a nine page article so $1.00 was used arbitrarily for photocopying and postage.

Data obtained later from a library photocopy laboratory doing a large volume of business showed the average pages per article to be 8.2 with the following costs per article:

Locating item, obtaining item, marking, etc.	$1.10
Labor, materials, machine rental for photo-copying and preparation of invoice	0.75
Wrapping and postage	0.10
	$1.95

The costs do not include overhead costs on labor or equipment. However, in the present study the costs of locating, obtaining and marking the item for copying ($1.10, above) are included in the costs for servicing inter-library loan requests. Therefore, one can conclude that the arbitrarily selected cost of $1.00 for photocopy costs is reasonably in accord with the experience of one large lending library.

Table 2.4 Miscellaneous Cost Figures

Item	Cost	Comments
Storage costs	$0.135 per volume per year	Fussler and Simon[5]
Circulation costs	$0.58 per volume circulated	Estimated from one library in the survey. Compares with $0.43 found by Lister[13] at Purdue.
Overhead	50% of direct labor costs	
Disposition costs	$0.60 per volume (high)	Lister[13] and interview with one of the surveyed libraries.
	$0.10 per volume (low)	Fussler and Simon[5], representing a cost of transfer to compact storage.
Photocopying and postage costs	$1.00 per item	Arbitrary assignment of $0.10 per page in a nine page article plus $0.10 for postage

Shisko[15] conducted a study of "program budget" costs at the MIT library. His categorization of cost elements does not coincide with that of Tables 2.1 to 2.3, but some of his costs are reasonably comparable. His figures include a 28.5 percent overhead charge on actual salaries and are listed as follows:

Selection for acquisition	$ 1.54
Ordering	3.35
Cataloging with L. C. Card	9.47
Cataloging without L. C. Card	14.70
Cost per item of purchasing serials	8.53
Cost per item of purchasing journals	17.40
Cost per volume per year for storage	0.12
Cost per item for non-reserve circulation	1.10
Cost per item for bibliographic aid	2.20
Cost per fulfilled requests for interlibrary loan (both borrowing and lending costs)	7.35
Binding	8.08

Shisko's cataloging costs (corrected for overhead) range from $7.37 for cataloging with L. C. copy to $11.44 for cataloging without L. C. copy, while cataloging costs from the four sample libraries ranged from $9.62 to $13.74 without overhead. The proportion of his item representing serials is unknown. His storage costs of $0.12 per volume per year compare with $0.135 reported by Fussler and Simon, the figure used in this study. His binding costs of $8.08 compare favorably with our bindery and binding (combined) costs which range from $7.79 to $12.27, with

overhead. His combined borrowing and lending costs per fulfilled request adjusted for overhead is $5.72 compared with costs found in this study that range from $6.63 to $11.94 (the latter from Table VIIIb in Appendix A).

The major difference in costs reported by Shisko and those found in the present study are acquisition costs. The source of the difference is unknown, although there is considerable evidence in the present study that a relatively high level of library personnel devote substantial portions of their time to acquisition activities. Perhaps they could have appeared under "administration" in Shisko's classification. Also, while the present study attempted to charge to acquisitions the costs of bookkeeping and other record keeping associated with ordering, such costs might easily have been charged elsewhere by another researcher.

2.2 Cost Comparisons with Example Data

2.2.1 Borrowing Costs

Typically, interlibrary borrowing now involves a delay of two to three weeks, and this kind of service is detrimental to research effort.

Present interlibrary borrowing service of articles from serials normally utilizes surface mail for sending the request, and return of the photocopy by surface mail. The photocopying itself is usually dammed to even the flow and economize costs, but at the expense of greater speed. The delay time of two to three weeks now normally encountered is excessive and a handicap to more extensive use of this mode of access in place of local ownership. A shorter delay time is not only desirable to provide better access to information, but practically it is essential to more

widespread acceptance of borrowing in place of local ownership. Since faster access than at present can be obtained only at a higher cost, it was therefore essential that we make some determination of what these additional costs might be, and their effect on the frequency of use at which borrowing becomes cheaper than local ownership.

The fastest present method of access to a copy not in the library's own collection is via facsimile transmission, but at a relatively high cost. A slower but still very significantly shorter access time than is now normal can be provided by more conventional and now universally available methods. These methods are simply the sending of requests via telephone or TWX, speeding photocopy time by paying a premium to avoid queueing, and returning the photocopies by airmail.

It is sometimes overlooked that the time advantage of facsimile transmission over other methods lies solely in the delivery time of the completed photocopy and that this is not the function in which the major portion of present delays occurs. The time for transmission of the request by telephone or TWX is the same in both methods; since present facsimile transmission equipment will accept only single sheets rather than pages in journals, whether in single issues or bound volumes of several issues, a photocopy needs to be made for either method; and finally, the same time is required by the lending institution to locate the material in its stacks and bring it to the camera. The time difference therefore lies only in the time required to transmit the finished photocopy. Since present facsimile transmission time over voice telephone lines is about

six minutes per page, or one hour for a ten page article, practically facsimile transmission can be considered as delivery sometime the same day as compared with the next day, or day after, for air mail delivery of the photocopy. The operating cost of transmitting a ten page article [20] via Xerox-Magnavox Telecopier is about $4.60, to which a one hour long distance telephone line charge must be added. This charge varies with the distance and type of service, but over several hundred miles and at the cheapest rate will run close to $10.00. Since airmail costs for a ten page article are about $0.30, independent of distance, in round numbers same-day service would be about $12-$15 more per article than one- or two-day service. (We have assumed that as a matter of course a national lending system would be organized to provide quick, i.e. same day, response time in locating and getting material to the camera.) Whether the gain is worth this cost others must decide, but we have assumed here that the significant acceleration of access time achievable at moderate cost by other methods would be more generally acceptable.

The additional costs for such accelerated delivery above those paid for present normal delivery are:

Additional photocopy cost	$0.20
Telephone (or TWX) of request	1.10
Additional clerical costs due to telephone or TWX	.50
Additional mailing photocopy by air	.20
	$2.00

Adding these costs to the now normal-service midrange costs of $6.49 and rounding gives a cost of $8.50 per request fulfilled by such accelerated-service (see Table 2.5). Facsimile transmission costs would include all of the above costs but substitute about twelve to fifteen dollars for the additional mailing cost of twenty cents. The difference in costs between the normal and accelerated services at low frequencies of use -- the only condition at which the decision to discontinue the subscription is economically sound -- is quite small. Because of this small difference for the substantial decrease in access time, principal cost curve comparisons are made against borrowing costs with this accelerated service. Appendix F of this report includes some discussion of a possible national lending system capable of providing accelerated service.

2.2.2 Owning Costs

The basic model developed for the comparison of costs assumes that one wishes to compare cumulative expenditures over a period of years called the planning period. Since the value of the dollar changes over time, the model provides for insertion of an expected inflation rate. Also, since money invested in services is deprived of the opportunity to earn at the normal rate of interest, provision is made for insertion of an interest rate. These are options which may be selected in exercising the model.

Costs during any time period in the future are considered to be the sum of the following cost elements:

1. Initial cost - cost of selection, ordering cost, cataloging cost, and so on. Applicable only if the serial is ordered in the given period.

2. Annual recurring cost - subscription, check-in, claiming, binding, marking and bindery. Independent of number of years in file or annual demand.

3. Storage (maintenance) cost - depends on number of volumes in the file in the given period.

4. Disposition (weeding) cost - depends on number of volumes being removed from the file in the given period.

5. Internal use cost - circulation, reshelving and shelf maintenance. Depends on number of volumes in the file and on annual demand.

6. Borrowing cost - personal services, photoduplication and mailing cost associated with borrowing an item not held by the library. Critically dependent on volume of demand.

7. Salvage value - the value (negative cost) of the collection at the end of the planning period. In the cost curves shown in this report this is assumed to be zero.

The model is expressed algebraically in Section 2.3 and described in detail in Appendix G.

The cost comparisons displayed in this section are based upon the actual library cost data summarized in Section 2.1 and presented in greater detail in Appendix A. The costs used in the comparisons are given in Table 2.5. These are midrange costs, that is, the aggregate of the average between the highest and lowest costs observed for each function in each of the four surveyed libraries. For example, the midrange cost of an acquisition is the average of $34.55 and $51.62 (Table 2.1) which is $43.08, and the midrange cost for cataloging is $17.52, the average between $14.43 and $20.61. Hence, the midrange initial cost is the aggregate of $43.08 and $17.52 or $60.60.

Two critical quantities in the cost comparisons are annual demand per title and subscription cost per title. Since these variables are identifiable with each title they have been parametrized, that is, results have been expressed in terms of these two variables, so that the library decision maker can select the values of these variables which most nearly represent a title about which a decision is being made. The following annual subscription costs have been considered: zero, $10, $15, $20, $30.

Table 2.5. Annual costs used in comparative models, including fifty percent overhead

Cost category	Midrange costs, including overhead
Initial cost	$60.60
Annual recurring cost, excluding subscription	19.54
Storage cost*	0.194
Disposition cost**	0.52
Internal use cost ***	1.48
Borrowing cost, without cost of faster service	6.49
Borrowing cost with faster service	8.50

*$0.135 per volume times 1.44 volumes per year. No overhead cost is applicable

**Average of $0.10 and $0.60 (see Table 2.4) plus 50 percent overhead.

***Average of circulation and interlibrary loan costs, weighted by proportion of serial lending in each.

A range of average annual demands per title from zero to 20 was considered. A digression is necessary to explain what is meant by average annual demand. Studies reported in Section 3 showed that, on the average, the demand for each annual volume* of a serial title declines by seven percent each year. That is, an annual volume with a demand of 100 this year would be expected to have a demand of 93 next year and of 86.5 the following year.** Obsolescence must therefore be taken into account in equating the demands for serial titles with different lengths of back issues. Some titles under consideration for subscription or termination will be new titles and some will be old. A demand of, say, 10 per year for a new title may indicate a much higher level of demand than a demand of 20 for an old title because of the portion of the demand generated by the back issues. Clearly, some normalization procedure is necessary.

All annual demands were therefore normalized to the demand expected of a serial title having 10 years of back issues, that is, the demand in the eleventh year of publication. Thus, in applying the models to specific titles one should adjust observed (or anticipated) demand upward or downward depending on the back issues. Table 2.6 provides some adjustment factors.

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* An annual volume is defined to be all of the issues for a calendar year, regardless of their labeling or binding.

**Demand in the first years of publication of an issue does not follow this pattern closely, tending to decline more rapidly than seven percent. However, the simplification does little harm in the cost comparisons which follow.

For example, one would multiply the observed demand with five years of back issues in the file by 1.56 to arrive at a 10 year normalized demand. If there were 20 years of back issues, he would multiply the observed demand by 0.70 to arrive at a ten year normalized demand.

Costs were compared on the basis of expected expenditures over a 25 year planning period, considering an inflation rate of three percent per year. The effect of the planning period and inflation rate on the decision point in terms of frequency of use of a title is discussed below, and a further discussion of these adjustments appears in Appendix G.

It is important to note that annual demand takes into account unrecorded use within the stacks. The extent of such use in general is unknown, but Fussler and Simon [5] estimated, partly on speculative grounds, that in some collections it may equal from 3 to 9 times recorded use, if one counts number of times the item was "touched." Their conclusions cover both serials and monographs and many of the "touches" would be the equivalent of checking a title, something that could perhaps have been done in other ways. They found that unrecorded use is proportional to recorded use, so that, whatever the factor one chooses to compensate for unrecorded use, one can apply it generally to the collection. We make no recommendations here for accounting for unrecorded use, but simply warn the reader that our annual demand refers to uses which are the equivalent of all uses, and that this will be higher than recorded use by some factor, such as that estimated by Fussler and Simon.

Table 2.6. Adjustment Factors for Normalizing Annual Demand to Ten Years of Back Issues

Years of back issues	Adjustment factor
1	4.07
2	2.81
3	2.18
4	1.81
5	1.56
6	1.38
7	1.25
8	1.15
9	1.07
10	1.00
12	0.90
15	0.80
20	0.70
25	0.65
30	0.61
40	0.58
50	0.56
100	0.55

2.2.3 Cost Comparisons

The following cases were distinguished:

A. Decision to continue or to discontinue a subscription now being received

   1. Discontinue and throw away back issues

   2. Discontinue and keep back issues

   3. Continue in normal manner

B. Decision to subscribe or not to subscribe to a title not now held

   1. New title (no back issues)

      a. Borrow everything

b. Subscribe in normal manner

2. Old title (10 years of back issues available)

a. Borrow everything

b. Subscribe in normal manner and buy back issues

Other alternatives than these are obviously possible; e.g., for a subscription now being received, to continue but discard all issues more than one or two years old. Basically, for all three classes (titles now being received, beginning titles, and old titles not previously subscribed to) one might consider subscribing but not checking in or claiming, not binding, and not keeping more than a year or two of back issues. These possibilities were also examined and the critical frequencies of use at the low end of the scale were found to be not greatly sensitive to them, though obviously they do provide some savings over retention of infrequently used files while providing current browsing advantages. The mathematical models provide for considering these alternatives if a library wishes to consider them and their effect. The effect, while not large per title, might be significant for an institution that wished to treat a good many in this way.

Figure 2.1 shows cost comparisons with respect to decisions concerning subscriptions now being received. The costs are those summarized in Table 2.5 with the addition of a $2.01 premium for accelerated borrowing service, and a three percent inflation rate. The numbers on which Figure 2.1 is based are shown in Table 2.7. The cost curves can be expressed mathematically as follows:

Discontinue and throw away back issues

Normal borrowing costs

$$c = 5 + 347.0\,d \qquad \text{(A.1.n)}$$

Accelerated service borrowing costs

$$c = 5 + 454.4\,d \qquad \text{(A.1.a)}$$

Discontinue and keep back issues

Normal borrowing costs

$$c = 71 + 283.9\,d \qquad \text{(A.2.n)}$$

Accelerated service borrowing costs

$$c = 71 + 364.0\,d \qquad \text{(A.2.a)}$$

Continue subscription

$$c = 886 + 36.5\,s + 79.1\,d \qquad \text{(A.3)}$$

where c = 25-year costs, with 3% inflation

d = normalized annual demand

s = subscription costs.

Only accelerated service borrowing costs have been shown in Figure 2.1 as alternatives to continuing subscriptions, because it is felt that some improvement in present interlibrary loan service will be required to make borrowing an acceptable alternative. The above equations and Table 2.7 give normal borrowing costs for those who are interested.

To discontinue a subscription and dispose of all back issues is equivalent to the decision to borrow everything. Figure 2.1 shows that a lower cost alternative (except for demands near zero) is to discontinue

Table 2.7. Sample Cost Data for Decision to Continue or to Discontinue a Subscription, Midrange Costs, Complete Ten Years of Back Issues assumed to be in the Stacks, Three Percent Inflation per Year, Twenty-five Year Planning Period

Decision	Normalized Annual Demand							
	0	0.1	0.2	0.5	1.0	5.0	10.0	20.0
Discontinue and throw away back issues								
Normal borrowing costs	$5	$40	$74	$179	$352	$1,740	$3,475	$6,945
Accelerated service borrowing costs	5	50	96	232	459	2,277	4,549	9,093
Discontinue and keep back issues								
Normal borrowing costs	71	99	128	213	355	1,490	2,910	5,750
Accelerated service borrowing costs	71	107	144	253	435	1,891	3,711	7,351
Continue subscription								
Free subscription	886	894	902	925	965	1,282	1,678	2,469
$10 subscription	1,250	1,258	1,266	1,290	1,330	1,646	2,042	2,834
$15 subscription	1,433	1,441	1,448	1,472	1,512	1,828	2,224	3,016
$20 subscription	1,615	1,623	1,631	1,655	1,694	2,011	2,407	3,198
$30 subscription	1,980	1,987	1,995	2,019	2,059	2,375	2,771	3,563

Expenditures during
25 year planning period (with 3% inflation)

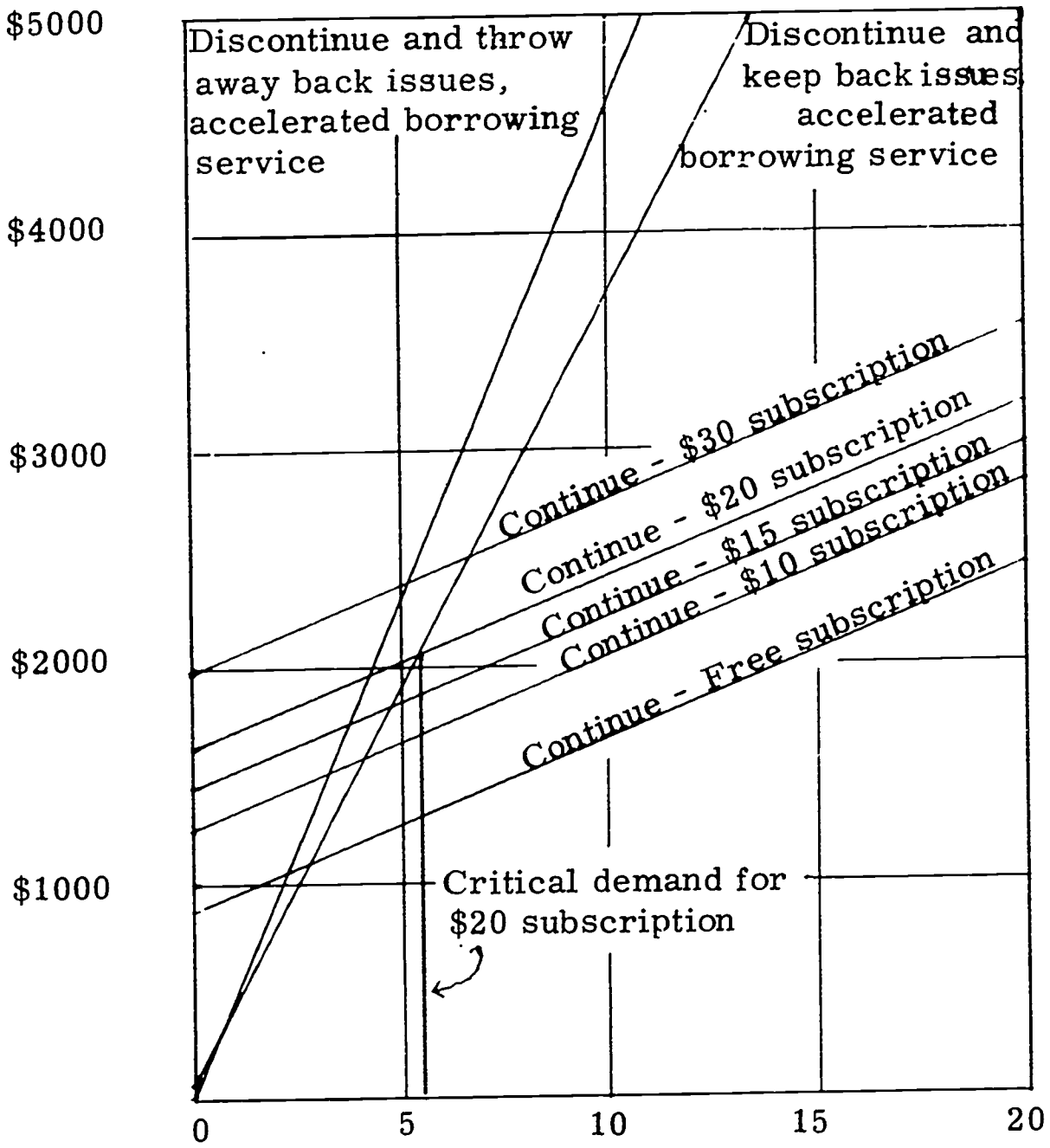

Figure 2.1. Sample cost curves for decision to continue or to discontinue a subscription - 10 years of back issues in the stacks - midrange costs of the sample libraries.

the subscription and retain all back issues. For example, with a normalized annual demand of two, the expected expenditures over a 25 year planning period under the various alternatives are approximately as follows:

Discontinue and keep back issues (accelerated service)	$ 800
Discontinue and throw away back issues (accelerated borrowing service)	910
Continue subscription in normal manner	
Free subscription	1,040
$10 subscription	1,410
$15 subscription	1,590
$20 subscription	1,770
$30 subscription	2,140

For the costs used in the comparisons, it may be seen that accelerated-service borrowing is a lower cost alternative than continuing a subscription, even though the subscription is free, when the normalized annual demand is two*. Since a $20 subscription is quite typical (see Table 2.2) one may consider the demand at which the $20 subscription line intersects the accelerated-service borrowing line to be a critical value. This point is seen to be about 5.4 demands per year, and is marked on the graph.

Note that annual demand has been normalized (see above) and that for purposes of the computations it has been assumed that the decision is being made with respect to a title which is 10 years old with all of the back issues in the library. The intersection points are not very sensitive to other assumptions about age of the serial publication.

*Solution of equations A.2.a and A.3 for s = 0 shows that the indifference point between continuing a free subscription and discontinuing the subscription is a normalized demand of about 2.9.

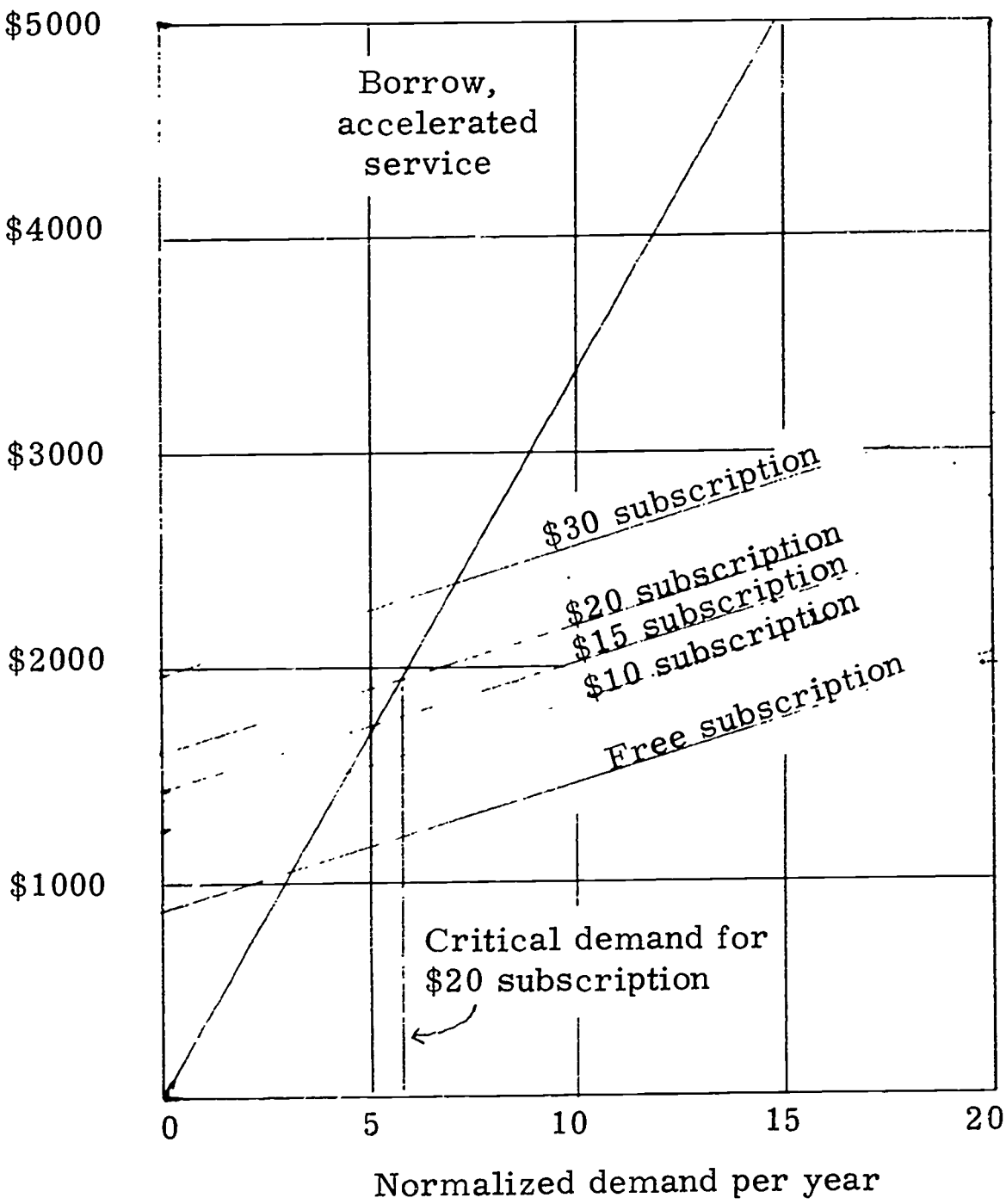

Figure 2.2 Sample cost curves for decision to subscribe to a new serial -- midrange costs of the sample libraries.

Table 2.8. Sample Cost Data for Decision to Subscribe to a New Serial, Midrange Costs, Three Percent Inflation per Year, Twenty-five Year Planning Period

Decision	Normalized Annual Demand							
	0	0.1	0.2	0.5	1.0	5.0	10.0	20.0
Borrow everything, accelerated service	0	$34	$68	$169	$338	$1,690	$3,380	$6,760
Subscribe and keep in normal fashion								
Free subscription	876	882	887	905	935	1,170	1,465	2,055
$10 subscription	1,240	1,246	1,252	1,270	1,299	1,535	1,830	2,419
$15 subscription	1,423	1,428	1,434	1,452	1,481	1,717	2,012	2,602
$20 subscription	1,605	1,611	1,617	1,634	1,664	1,900	2,195	2,784
$30 subscription	1,969	1,975	1,981	1,999	2,028	2,264	2,559	3,149

Also keep in mind that the costs serving as the basis for the comparison are not presumed to be national average costs. They are illustrative only, even though derived from surveys of four real libraries. Also, note that no time-related cost of borrowing service has been included. That is, no penalty has been attached to borrowing because the item is not immediately available in the local library.

Figure 2.2 compares illustrative cost of subscribing to a newly published serial publication with accelerated-service borrowing costs. The lines on Figure 2.2 are graphs of the following cost equations:

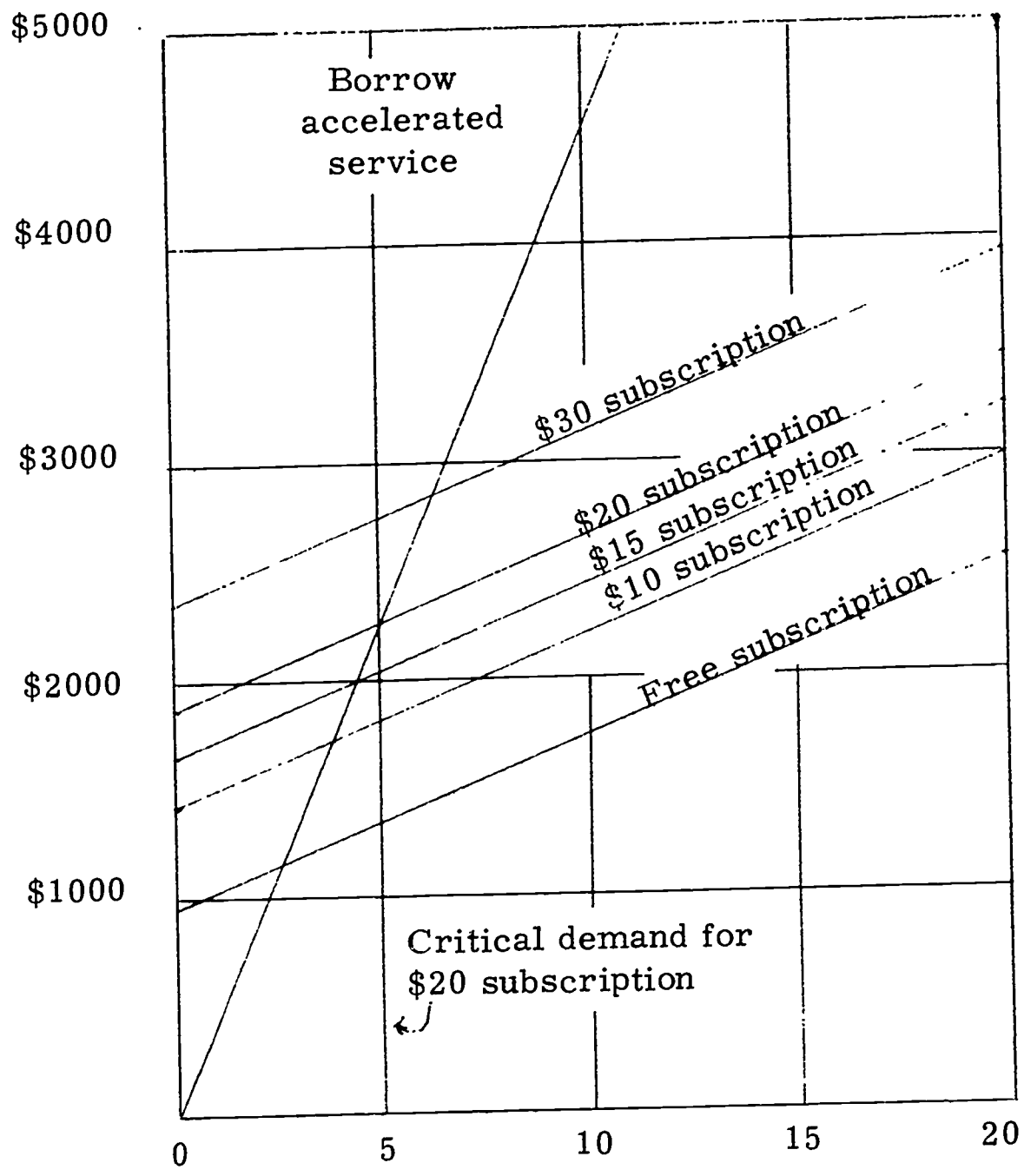

Figure 2.3 Sample cost curves for decision to subscribe to 10 year old serial, none in the stacks -- midrange costs of the sample libraries - assume all back issues to be ordered.

New serial - borrow everything - accelerated service

$$c = 338\ d \qquad \text{(B.1.a)}$$

New serial - subscribe in normal manner

$$c = 876 + 36.5\ s + 58.9\ d \qquad \text{(B.1.b)}$$

Some values are shown in Table 2.8. In terms of the cost data used it is cheaper to borrow when normalized demand is less than 3.1 per year even if the subscription is free. For typical $20 subscriptions the critical normalized demand is about 5.8 per year.

Figure 2.3 makes the same comparison for subscriptions to an old serial (assumed to be ten years old at time of the decision and also assumed that back issues will be purchased at time of subscription*). The costs are described by the following equations and are shown in Table 2.9:

Ten year old title - borrow everything - accelerated service

$$c = 454\ d \qquad \text{(B.2.a)}$$

Ten year old title - subscribe in normal manner - all back issues to be purchased

$$c = 947 + 46.4\ s + 79.2\ d \qquad \text{(B.2.b)}$$

*It was assumed that back issues could be purchased at current subscription prices.

Table 2.9 Sample Cost Data for Decision to Subscribe to Ten Year Old Serial and Acquire Back Issues, Midrange Costs, Three Percent Inflation per Year, Twenty-five Year Planning Period

Decision	Normalized Annual Demand							
	0	0.1	0.2	0.5	1.0	5.0	10.0	20.0
Borrow everything, accelerated service	0	$45	$91	$227	$454	$2,270	$4,540	$9,080
Subscribe, acquire back issues and keep in normal manner								
Free subscription	947	955	963	987	1,026	1,343	1,739	2,529
$10 subscription	1,411	1,419	1,427	1,451	1,490	1,807	2,203	2,994
$15 subscription	1,643	1,651	1,659	1,683	1,722	2,039	2,435	3,227
$20 subscription	1,876	1,883	1,891	1,915	1,955	2,271	2,667	3,459
$30 subscription	2,340	2,348	2,356	2,380	2,419	2,736	3,132	3,924

The critical demand for a $20 subscription is 5, rather than 5.8 as above, indicating that costs of decisions to subscribe are not very sensitive to age of the serial at time of purchase.

From Figure 2.2 it is clear that expensive subscriptions, say $100 or $200, would require a high demand to justify their purchase on economic grounds alone (about 16.2 per year for a $100 publication and about 29.5 per year for a $200 publication).

What effect does the 3% inflation factor have? For a newly begun serial costing $20 per year for the subscription, if the inflation factor is included in the model the critical point at which it becomes cheaper to acquire a photocopy on demand than to maintain a local subscription is 5.8 uses per year; if it is not included this is raised only slightly to 6.3, indicating relatively little effect*. Whether it is sound in any case to include a factor for inflation is debatable, and even if its inclusion is sound the rate is at best a guess on the future of the economy. But since it leads to a more conservative decision, i.e. if included it tends slightly to lower the rate of use at which local subscription is economically cheaper, a 3% inflation factor has been included in the illustrative cost curves shown here.

What effect does the 25 year planning period have? For the same case, that is, a new serial publication and a $20 subscription, but with a 3% inflation, changing from a 25 year planning period to a 10 year planning period raises the critical point from 5.8 to 11. The reason, of course, is that one is investing during the first 10 years in volumes some of whose use will not come until later. For a publication with several volumes already published when the subscription was entered, the change would be smaller. Thus, using a 25 year planning period is more conservative than a 10 year planning period, and it has been used throughout this report. For a 50 year planning period the critical point changes from the 5.8 uses per year of the 25 year planning period to 6.2 uses, and for 100 years is 6.0. A 25 year planning period is probably a more realistic fiscal planning period than 50 years, and in addition 25 years is probably closer to the average

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*The cost equation for subscribing in the normal manner is
$c = 619 + 25\,s + 37.4\,d.$

life span of serials titles than is 50 years, so it is this period that has been used in this study. The models permit a library to use a longer or a shorter period if it wishes.

In the above comparisons no account has been taken of the possible delay costs due to borrowing an item rather than obtaining it from the local collection. Consider again the decision whether to subscribe to a new title. Let D be the delay cost per item borrowed. Then, a revised cost formula for borrowing is

$$c = (338 + 36.44\,D)d \qquad (C.1)$$

Comparing with Equation (B.1.b), cost of subscribing in the normal manner, yields

$$d = \frac{876 + 36.5\,s}{279 + 36.44\,D}$$

for the critical point for any subscribtion price (s) and any delay cost (D). The following critical values have been computed as test points:

	Subscription cost	
Delay Cost	Free	$20
0	3.1	5.8
$2	2.5	4.6
$10	1.4	2.5

Thus, it may be seen that the comparison can withstand a moderate delay cost and still remain economically favorable to borrowing. Again, the reader is cautioned that both recorded and unrecorded use are included.

It has been pointed out by a reviewer of this manuscript that unrecorded use may take on special significance where there are long time lags between publication of a paper and its appearance in indexing

or abstracting publications. Thus, one may actually have to see the publication before deciding whether to use it. This requirement is particularly acute in the humanities.

One might inquire whether the number of titles with low demands is substantial enough to make any economic difference. Nothiesen[3] reported that during a twelve month study period at the John Crerar Library only 3,988 out of approximately 10,000 current titles were used at all, that is, about 60 percent had not been requested at all during a year. At the National Library of Medicine[4] about 88 percent of the titles had not been borrowed in a twelve month study period. The percentage of these titles which were "closed" is unknown, however. Fussler and Simon[5] reported that the average use of a sample of titles in biology at the University of Chicago for a five year period was about 2.3 for titles up to about 10 years of age (corresponding roughly to our normalization period). Since this is an average of a highly skewed population one can safely assume that a large number of titles did not circulate at all.

Also, it may be seen from Table 3.1 (presented later in Section 3) that most of the titles demanded have only one demand. So, if one focuses his attention on those titles which, on the average, have only one use per year, or less, he has indeed identified a major portion of the serial titles in the research library.

Table 2.7 shows the potential saving to the research library in expenditures per title over a twenty-five year planning period which might be effected by borrowing rather than owning serial publications whose

average normalized annual demand is one request per title. We have shown above that the number of such titles is substantial in the typical research library. The data in Table 2.10 are subject to all of the qualifications previously given. In particular, they may not represent population average costs, but do represent costs observed in four operating research libraries. Also, they do not take into account delay costs or unrecorded use.

Table 2.10. Twenty-Five Year Savings per Title to the Research Library (from illustrative data) Due to Borrowing instead of Subscribing to Serial Titles Having an Average of One Request (normalized demand) per Year, for Various Subscription Prices.

Case	Subscription price				
	Free	$10	$15	$20	$30
Current subscription - 10 year old title	$500	$900	$1,080	$1,260	$1,625
New subscription - 10 year old title	570	1,040	1,270	1,500	1,960
New subscription - new title	600	960	1,140	1,330	1,690

It may be seen that even with free subscriptions one might expect to save over $500 of expenditures per title over a 25 year planning period (about $20 per title per year). For $20 subscriptions, a typical subscription cost, one can expect to save in the neighborhood of $50 per title per year. Note that the three percent inflation rate has been assumed to apply to subscription costs as well as labor and other costs, so that the average difference over 25 years between a $20 subscription and a free subscription

is greater than $20. Estimated savings have been computed on the basis of average costs rather than marginal costs, since no data are available on the latter. There is no question that some average costs per title of acquiring serials could be expected to increase with a reduced number of titles, but these costs might also be partially offset by potential reductions in cost per title of borrowing with a larger volume and less searching for the holder of a given title. Inadequate data are available to make a judgment at this time. Note also that these are presumed savings to research libraries, not to society as a whole, since the cost of establishing and maintaining a satisfactory lending service would have to be borne by someone. This aspect is discussed in Appendix F. Also, no credit against cost has been allowed for "browsing availability" or for shortened request-fulfillment time due to having the title in the research collection. The intention of the above gross cost comparison is to provide some indication of what such availability may be costing the local library.

2.3 Cost models

The primary motivation for this study was to derive models for comparing alternative kinds of library service and to develop methodology for obtaining costs. When the derived models were applied to actual costs obtained to test the methodology they produced the cost comparisons which have been presented above.

One basic model has been derived. By inserting different parameters it can be used to derive planning period costs under a wide range of assumptions.

Let C_t denote costs incurred in year t and let C denote the "present value" of all costs incurred over the planning period (of T years) discounted at the annual interest rate of i and adjusted for inflation at the annual rate of j. Then

$$C = \sum_{t=o}^{T-1} C_t \left(\frac{1+j}{1+i}\right)^t \qquad (2.1)$$

$$C = I_o\, \delta(a_o - t) + A_t + S_t + W_t + U_t + B_t - R_T\, \delta(t - T) \qquad (2.2)$$

where

I_o = the initial cost of acquiring and cataloging a new title. This cost is incurred only during the first year of the planning period when t = 0.

$\delta(x)$ = the Kronecker delta function which assumes the value of 1 when x equals zero and a value of 0 otherwise, x being the year in which the title was ordered $(a_o - t)$ or "salvaged" $(t - T)$.

a_o = the age of the oldest annual volume of a particular title at the beginning of the planning period (t = 0).

A_t = the costs incurred in year t which are independent of how many annual volumes of the title are held by the library and include the subscription costs, the overhead and administrative costs, and the maintenance costs, (viz., check-in, claiming, binding, marking, and bindery costs).

$A_t = M_t + P_t$ (defined below).

M_t = maintenance cost in year t.

P_t = subscription cost (purchase cost) in year t.

S_t = the storage cost in year t.

W_t = the weeding cost in year t. This includes the cost of catalog revisions indicating the new status of the remaining annual volumes of the title held by the library in year t.

U_t = the cost of using volumes of the title held at the library in year t. This includes the cost of circulating, reshelving, and shelf maintenance due not only to inhouse use but interlibrary loan usage as well.

B_t = the cost of borrowing from an external source volumes of the title not held by the library in year t. This cost may include a penalty cost for the delay in request fulfillment.

R_t = the residual value or salvage value of volumes of the title held by the library at the end of the planning period. This cost is incurred only in the last year of the planning period and is assumed to be zero in the cost curves shown here. This is true for infrequently used titles, but not for frequently used ones so the curves are in error by this amount for such titles. This is not significant here, though, where our interest is in costs for relatively infrequently used titles. See Appendix G.

Equation (2.2) accounts for all cost components and therefore may be used to consider any number of alternatives. When an alternative is considered where some of the components are missing, then the corresponding cost is zero. For example, if (2.2) is applied to a title presently held by the library, the I_o, the cost of acquiring and cataloging the title in t = 0, the first year of the planning period, is zero. If (2.2) is applied to a title not presently held by the library, and the library considers the cost of not acquiring the title, the only non-vanishing terms would be B_t, the cost of borrowing volumes of the title from an external source.

Details to be considered in the assignment of values to the terms in (2.2) are given in Appendix G and should be examined carefully before application of the model. A computer program, suitable for use on a time-sharing computer network has been developed and can be made available, at cost, to interested readers.

The complete model permits one to insert values for years since first publication of serial, years in collection, number of years to be stored before weeding, years in planning period, variable costs and variable demands.

3. ESTIMATION OF THE NATIONAL BORROWING DEMAND FOR SERIALS

As a prelude to the development of decision models for the operation of research library systems it has been necessary to study the characteristics of interlibrary borrowing demand. The aggregate demand and the distribution of demand over titles and over age of serials are of interest.

3.1 Aggregate demand

Since the focus of this study is on serials literature it would be desirable to have a measure of total interlibrary demand for serials publications. Unfortunately, there are no data on overall interlibrary borrowing of serials. However, one can develop an approximate lower bound on such borrowing in the following manner.

The total number of interlibrary loan (ILL) transactions for college libraries in the year 1963-64 was 796,000 [1]. Since approximately 50 percent of all ILL transactions are for serials (see Appendix A), and since approximately half of the reported transactions are borrowing (as contrasted to lending) transactions, one can assume that these libraries fill about 2000,000 requests for serial literature.

Other major lending sources in the United States are The National Library of Medicine, the John Crerar Library, The National Agricultural Library, the Center for Research Libraries and the Library of Congress. These libraries collectively lend something like 300,000 serials per year, so it seems safe to assume that at least a half million serials items are

currently requested each year. The proportion of these that are in the fields of science and technology is not known, but common observation would suggest that these constitute a majority of requests.

Much of this demand is reflected in intercollegiate interlibrary loan transactions in which the borrower must depend upon the good will of the lending library to provide him with the item desired. Also, he often must wait excessively long for receipt of the item borrowed. The result is to discourage the interlibrary lending of materials.

It is pointless to talk about interlibrary borrowing as a less expensive mode of service than acquiring and holding the item in the local collection when, in fact, interlibrary borrowing may provide service which is unacceptable to the research community.

It has been necessary, therefore, to postulate the existence of improvements to the interlibrary lending system in the United States such that dependable and expeditious service is given. More is said in Appendix F about the postulated characteristics of such a system.

Assuming the existence of such a system, what would be the total demand on it? The best clue seems to be the experience of the United Kingdom's National Lending Library for Science and Technology (N. L. L.). The total loan requests received by the National Lending Library in 1967 were 591,000* of which it is estimated 90 percent (or 532,000) were serials requests.

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*Some of these requests were for social science literature, since the National Lending Library has recently begun serving this part of the research community.

There are approximately 654 thousand scientists and technologists in the United States and 142 thousand in the United Kingdom, a ratio of 4.61 to 1. Therefore, one might assume that something like 2.4 million demands could be made on a similarly constituted lending service in the United States. The National Lending Library became fully operational in 1962 with a collection previously held in part by the Science Museum Library and partly acquired directly by N. L. L. If one could assume a similar initial collection in the United States and a parallel rate of growth to that experienced by the National Lending Library, the following would be the expected demands on an augmented lending service in the United States:

Year of operation	Demand (millions)
1	0.5
2	0.9
3	1.2
4	1.6
5	2.0
6	2.4

Note that the first year corresponds roughly to what is being currently lent by the existing system. Part of this demand, particularly in the college and university segment, might be replaced by the augmented system.

The actual structure of such a system with regard to location, ownership, administration, and separation into subject matter specialties is not discussed in this report. We have only postulated the existence of a reliable lending system with a turn-around time and other service characteristics which roughly parallel that of the National Lending Library.

3.2 Distribution of demand by title

It is well known that most of the requests for serial publications are for a relatively small percentage of the total titles held in the typical library. Thus, if a library wished to minimize its cost for a fixed level of requests it would acquire relatively fewer titles and would borrow the titles more rarely demanded. This approach presumes that a satisfactory lending service exists. It also assumes that it is possible for a library to predict its demand for serial titles, at least relative to each other. It is, of course, impossible to make precise predictions, but "order-of-magnitude" predictions, on the basis of experience of other libraries and modified by some local observation should be possible. For example, it might be possible for the librarian to select between those used more than two or three times a year and those used less than this. Such approximations are sufficient to increase materially the fulfillment-cost ratio for a given library.

Figure 3.1 shows demand curves for two lending libraries giving national service. The serial titles are arranged in descending order of demand, so the curves show that a relatively small percentage of titles account for a large percentage of total demand per year. Curve A corresponds approximately to the early experience of the National Lending Library and Curve B to the approximate experience of the National Library of Medicine, although both curves have been smoothed. Note that the base of the per-cent of titles is total titles held in the collection, not just those which circulated.

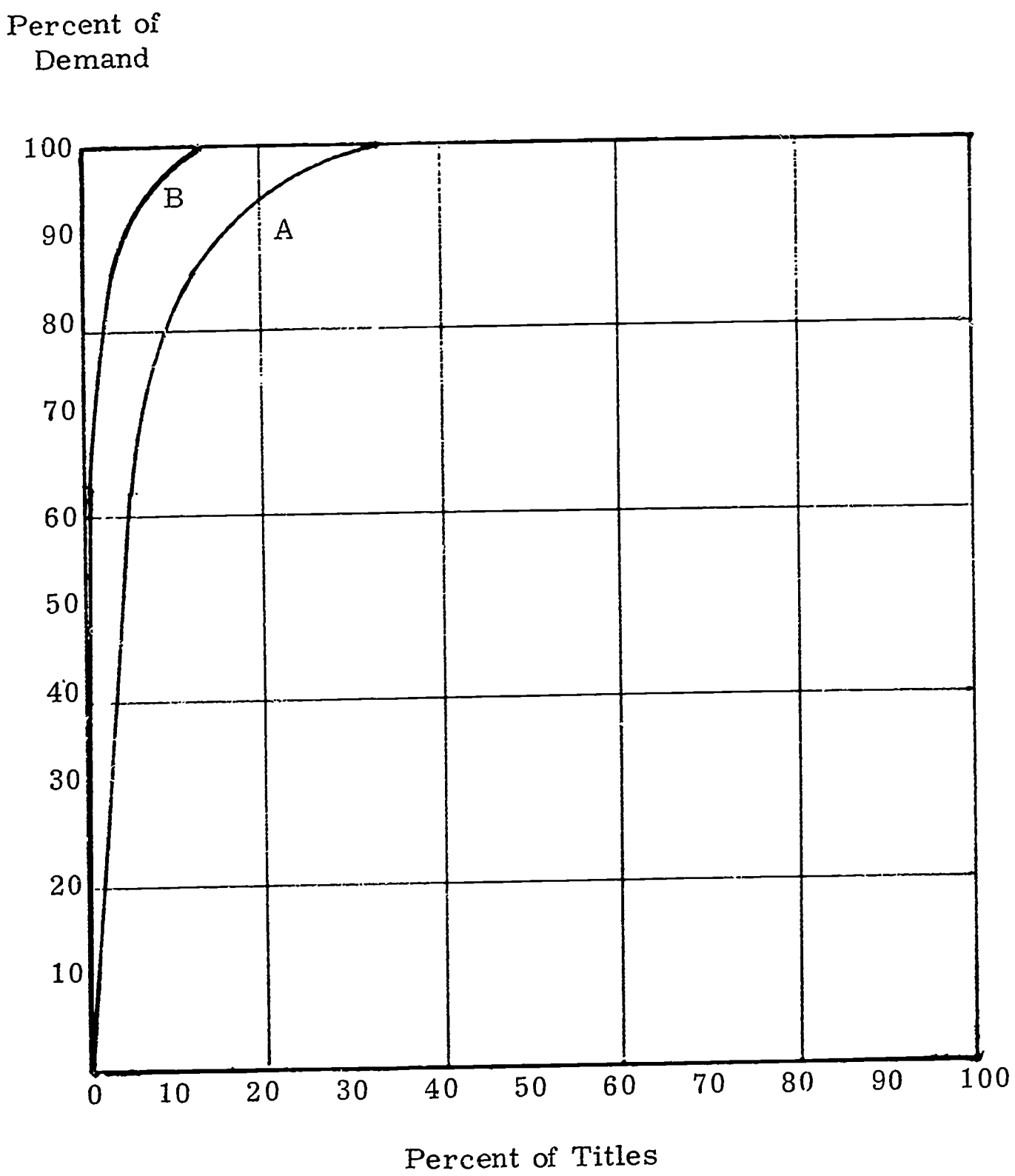

Figure 3.1 Demand distributions for two lending libraries.

In Curve A, 5 percent of titles account for about 60 percent of demand, while in Curve B, 5 percent of titles account for about 90 percent of demand. Obviously, the collections are different (among other differences the National Library of Medicine has more, and longer, back files than the National Lending Library), and possibly the philosophy of the two represented libraries may be different.

Data for the distribution of demand per title are available from a number of sources. Notheison [3], studied the use of serial titles at the John Crerar Library by analyzing all of the call slips collected during two six month periods, January through June 1958 and January through June 1959. Distribution of use by title, by age and by language was determined. Kurth [4], studied the use of serial titl· s at the National Library of Medicine. By analyzing completed interlibrary loan forms for the calendar year 1959, distribution of use by title, by age, and by other factors was determined. Schilling [10], also studied the use of serial titles at the National Library of Medicine by analyzing 20 percent of the loan forms completed during calendar year 1967. Hoisington and co-workers [9], analyzed requests received at the National Agricultural Library during a three month period in 1962. The distributions of demand per serial title obtained from these sources are presented in Table 3.1.

The numbers are to be interpreted as follows: In the 1963-64 National Lending Library study (Col. 1), 68.8 percent of requests were for titles having no more than 5 requests each. There were no more than 100 requests for any title. In Appendix D it is shown that these demand data follow a log-

Table 3.1. Cumulative Percent of Titles With Nonzero Demand Having a Demand per Title Less Than or Equal to D for Several Central Libraries.

Demand per title (D)	National Lending Library (1963-4)	National Library of Medicine (1959)	National Library of Medicine (1968)	John Crerar Library (scientific and technical) (1958-59)	John Crerar Library (medicine) (1958-59)	National Agricultural Library (1962)
1	37.8	28.4	36.3			68.8
2	51.5		50.5			83.2
3	59.6		59.7			88.9
4	64.8		65.8			92.5
5	68.8	57.2	70.7	62.7	68.6	94.2
6	71.5					95.5
7	73.9					96.5
8	75.8					97.1
9	77.4					97.7
10		69.0	84.6	75.3	80.2	98.1
19	85.7					
20		74.9	93.9	84.6	88.5	99.6
29	89.9					
30			97.0			
39	92.1					
40		88.5	98.3	91.1	94.2	
49	93.7					
50			99.0			
59	94.8					
60		92.3		94.3	97.1	
69	95.9					
70						
79	96.4					
80		94.3		95.7	98.2	
89	96.9					

Table 3.1 cont.

Demand per title (D)	National Lending Library (1963-4)	National Library of Medicine (1959)	National Library of Medicine (1968)	John Crerar Library (scientific and technical) (1958-59)	John Crerar Library (medicine) (1958-59)	National Agricultural Library (1962)
90						
99	97.4					
100	100.0	95.6		97.2		
120				97.8		
140				98.1		
200		98.3				
300		98.9				
Total Demand		77,698				13,066
Total Titles	13,627*	4,347	4,051	2,745	1,179	6,626
Source of Data		Kurth (4)	Schilling (10)	Notheison (3)	Notheison (3)	Hoisington (9)
Remarks:	Full sample of 12 month period	Full sample of 12 month period	1/5 sample of 12 month period	Full sample of two 6 month periods	Full sample of two 6 month periods	Full three month sample

*Includes a few titles requested but not held.

normal pattern, making it possible to project demands per title for various levels of total borrowing demand.

Using the log-normal assumption and making some adjustments which are explained in Appendix F, one can project the total demand for the lending system by years to be that shown in Figure 3.2. Referring to the scale at the bottom of Figure 3.2, it may be seen that in the fifth year it is estimated that 90 percent of the demand will be for titles requested 2 or more times, 50 percent of the demand for titles requested 21 or more times, and so on, thus providing the basis for judgments about the number of duplicated titles required.

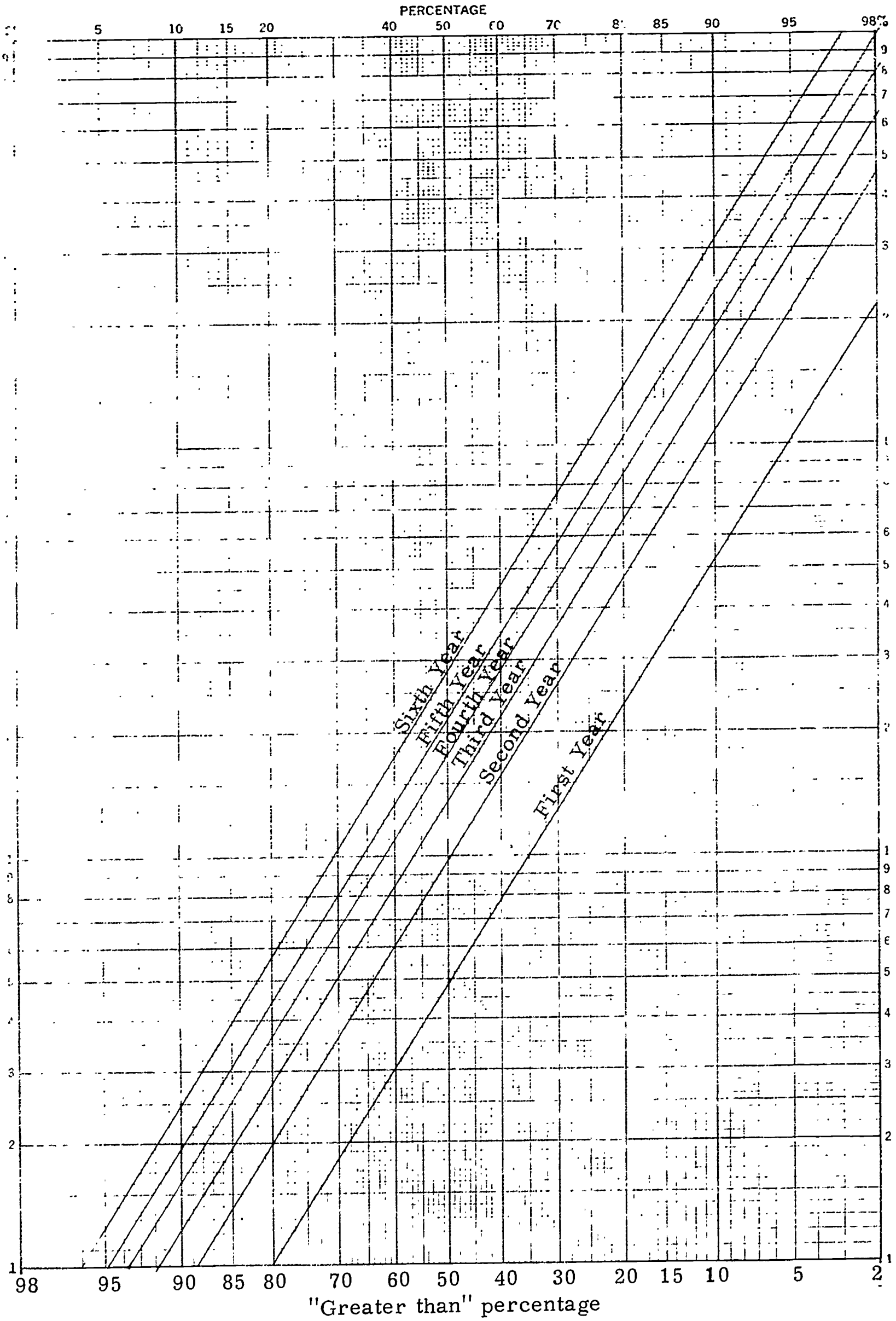

Figure 3.2 Distribution of Demand Per Title at a U. S. Lending Library System

4. CONCLUSIONS

In this report we have developed a general methodology for comparing the costs of providing access to serials literature in alternative ways. In particular, we have been concerned with the comparison of borrowing costs with the costs of acquisition, cataloging, maintenance and circulation.

Cost data obtained from four research libraries in the United States, when inserted into the models, indicate a strong case for borrowing rather than owning the low demand serial items. Some cautions are in order, however. First, the four libraries chosen cannot be considered a random sample of all research libraries. They were not chosen to be atypical, however. Second, no value has been assigned to having a collection available for browsing and other nonrecorded use, nor has any value been placed on the shortened access time which can be accomplished when the item is in the local collection.

It is clear that in order to give the research library a choice between borrowing and owning little used serials an improved lending library system needs to be developed. If such a system were available, the research librarian would have the opportunity to put resources into improvement of service rather than into building a collection. The alternative could be vitally important to the research library faced with serious budgetary and space restrictions.

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APPENDICES

Appendix A - Survey of four university libraries

Appendix B - The fraction of proper requests fulfilled as a function of the fraction of titles available with nonzero demand

Appendix C - The coverage of a sample where demands are log-normally distributed

Appendix D - Characteristics of demand for serials

Appendix E - A queueing model for delays due to outages

Appendix F - Notes on specifications for a lending library system

Appendix G - Cost models for policies concerning a particular serial title

APPENDIX A

SURVEY OF FOUR UNIVERSITY LIBRARIES

A-1. Introduction

Field surveys were conducted at four university libraries to collect data on the cost of acquiring and maintaining a serial title, and lending and borrowing a serial title by Interlibrary Loan. Costs were collected on a library function basis, e.g., acquisitions, cataloging, circulation, and so on; and later were combined into aggregates to yield the total costs per serial title.

The universe of literature surveyed by this report is that of currently purchased serial publications. Difficulty was encountered at each of the libraries in defining a "serial." For example, Library A maintains a serial list for journals, i.e., those titles which arrive at regular intervals with a

frequency greater than once a year, and two standing order lists, one for titles which arrive irregularly or annually, and another for selected university publications, excluding journals. In both of the standing order files monographic series are indicated by "class separate" rather than by a call number. At this library the university publications were excluded from the survey as being primarily monographic in character. The labor effort on the monographic series was not identifiable in each of the functional classifications, however, and it was not possible to isolate the cost of these series. Library C maintains two serial lists on the basis of regular frequency greater than once a year, and irregular frequency or regular frequency of once a year or less. Libraries B and D maintain one serial list which includes both regular and irregular frequencies. Both of these files include monographic series, but one file excludes annual titles.

These differences in definitions seem to be typical, and have some influence on costs presented later in this appendix. The reader should be aware of such differences in comparing the reported costs with each other and with costs of any other library with which he is familiar.

A-2. Data Collection Techniques

2.1 General Facts

Four university libraries, A, B, C, and D (ranked highest to lowest by the number of serial titles owned), were surveyed for the study. The survey was conducted by Westat Research, Inc. in its offices in Denver and Bethesda.

The duration of the survey was March through August, 1967. Pretesting was performed at Library D over a period of one month. One and one-half weeks were spent in surveying each library, and one month was allowed per library for summarization of data, follow-up correspondence and phone calls.

2.2 Survey Organization and Procedures

2.2.1 Introductory Consultation with Heads of Libraries and Use of Organization Questionnaire

For the most part, interviewing was done by two-person teams. An initial meeting was set up with the director or assistant director of the participating library. The purpose of the meeting was twofold: first, to acquaint the library with the survey methods and objectives; second, to familiarize the interviewers with the organization and procedures of the library. It was found that involving as many department heads as possible in this initial meeting was the best way to avoid needless repetition during subsequent interviews. Survey forms are shown in Section 9 of this appendix.

"Form 1, General Organization" was used at the meetings to outline the basic organization and the serial operations of each library. It consists of five sections. Section I through IV call for locations and administrative names, e.g., a list of departments and department heads.

Section V elicits specific operational information about the library and locates the concentration of work on serials. It also locates records which may supply library statistics and cost data. Finally, Section V supplies the necessary background for the Serials List Survey.

2.2.2 General Use of Labor Questionnaire

"Form 2, Allocation of Employee Time" was designed to separate the amount of library employee time spent on serials from the amount of time spent on other library materials, e.g., monographs, theses, and pamphlets. It requires that an employee's time be divided among eleven library "functions", which include the following categories:

1. Acquisitions
2. Check-in
3. Cataloging
4. Binding
5. Marking
6. Claiming
7. Training
8. Gifts - Exchanges
9. Circulation - Reference
10. Administration
11. Other

The use of "function" rather than "department" for the allocation of employee time came about as the result of two factors: (1) the overlapping activities among various departments within a library, and (2) the difference in nomenclature in departments and related activities among libraries.

Example of (1): At Library A, the Acquisitions "department" spends over 99% of its time on the acquisition "function". Yet a significant amount of time is also spent on the acquisition "function" in other departments,

for example 30% in Serials, 29% in Reference, and 23% in Circulation.

Example of (2): Library C handles its binding through the cataloging department, while Libraries A, B, and D all maintain separate binding departments.

Technically, Form 2 is not a questionnaire, but rather a checklist accompanied by a data sheet. After some experimentation, this design was found to be most effective. The actual time estimate is recorded on the data sheet, but the checklist is of primary importance because it serves as an aid to the person making the estimate. The checklist was carefully designed with the help of librarians during the pretest at Library D. It subdivides each function into related activities, using conventional library terminology. Because a subjective time-estimate technique was employed, very precise definitions were required for the generalization of functions among several universities. The use of such a checklist helped to assume the validity of the numbers recorded on the data sheets.

The following information was recorded on the data sheet for an individual for each function: the total hours spent per week and the number of hours spent specifically on serials. The supplemental background required for the individual is his salary rate per hour. From this it is possible to calculate the cost per week or per year of the individual's total labor and his labor on serials. Data on individual employees are summarized to arrive at departmental totals.

2.2.3. Administering Form 2 in Library Departments

The normal procedure for administering Form 2 in a library department was to interview the department head and obtain from him as much information as possible about the organization of the department and the various responsibilities of the individual employees. From this the interviewer was able to form some idea of the number of persons he had to interview in order to get time data for all employees. The department head was familiarized with the questionnaire and the information that was required. He was then asked to estimate, for each function, the total number of hours he spent on each. (The total number of hours for all functions is equal to the normal working week for a full time employee. This number ranged from 35-40 among the four libraries surveyed.) Next the department head was asked to estimate, for each function, how many of the hours devoted to that function were spent on serials. This process was repeated for each employee in the department, preferably by the department head, or by other key individuals in the department who were familiar with the activities of other employees.

The task of estimating the amount of time spent on serials, particularly for those persons who deal indiscriminantly with serials, books, theses, etc., was rarely easy. More often than not, the interviewer's first reaction was one of bewilderment. The interviewer's task was to be both patient and persistent until a reasonable estimate was determined.

There were several exceptions to the above procedure and the use of Form 2. For example, in Library A the cataloging of serials

was mainly undertaken in the Serials Department. The Cataloging Department, however, was responsible for the cataloging of analytics, which were classified as serials for the purposes of this survey. No distinction was made between analytics and monographs in the Cataloging Department, and the department head felt that it would be impossible to estimate the amount of time spent on analytics by each of the 27 catalogers. An alternate method for estimating the amount of time spent on analytics was devised, using the ratio of analytic volumes cataloged to the total number of volumes cataloged.

2.2.4. Administering Form 2 in Dependent Branch Libraries

In addition to the data collected for the departments of the main library, it was also necessary to obtain data on employee time for those branch libraries whose collections were centrally processed (i.e., centrally acquired, cataloged, bound, and marked). This was necessary in order to balance the central processing costs against the work performed on the same materials within the branch libraries (i.e., check-in, claiming, training, circulation-reference). The typical branch library surveyed was supervised by one head librarian and the staff sizes ranged from 1 to 12.2 full-time equivalent employees.

The number of branch libraries in each case exceeded the number that the interviewers were capable of covering in the amount of time allotted. A sample of representative libraries was therefore taken, and the data later extrapolated to include all dependent branch libraries. The method of administering Form 2 in the dependent branch libraries was the same as in the departments. Frequently the staff sizes were smaller.

2.3 Sampling for Special Information

Form 2 was used exclusively for gathering labor costs. For some departments there were additional costs which had to be taken into consideration.

2.3.1 Binding

Three of the libraries surveyed used commercial binderies for binding needs. Obtaining a total fiscal year cost for bindery charges was not difficult, but file sampling was necessary for determining the amount spent on serials. The bindery cost survey for Library A is explained later.

2.3.2 Serials List Survey

"Form 3, Serials List Survey" was used to extract pertinent information concerning serials from the central Kardex file. For each library, an employee who was familiar with the Kardex was hired to complete the Serials List Survey.

2.3.3 Interlibrary Loan Data

Each of the libraries maintain a separate interlibrary loan department. A modified version of the Form 2 Data Sheet was used for the purpose of separating the time spent on "lending" activities from the time spent on "borrowing" activities. Flow charts were helpful in determining the separation. All items pass through the hands of the employees and no effort was made by the libraries to distinguish serial "lends" and "borrows" from other "lends" and "borrows". Therefore the separation of time spent on serials from the time spent on other library materials was sometimes done by multiplying the total time spent on lending and borrowing by the ratio of

serial items to total items lent or borrowed. This ratio was obtained by sampling for serials in the interlibrary loan "borrow" and "lend" files. Interlibrary loan labor costs are discussed further in Section 6. A summary of the interlibrary loan data appears in Tables Xa and Xb.

2.4 Summarizing the Data

A summary sheet was prepared for each university library, based on the information obtained on the data sheet of Form 2. Section 10 contains an explanation of this summary sheet.

A-3. A Profile of the Surveyed Libraries

Tables I through V give a summary picture of the four libraries studied. In arriving at a total cost to acquire and maintain a serial title at each library, costs were aggregated for each central library unit and its dependent branches. The combination of a central unit and its branches is defined as a gross library. Table I presents the organization of each gross library, the serial title holdings and the total volume holdings of both the gross and central libraries. Also indicated is a relative measure of the serial title holdings and two parameters indicating decentralization of the gross library between the central unit and the branches. Tables II and III present a profile of total and serial labor effort in numbers of full time equivalent employees and labor dollars. Each of these labor effort measures is divided into professional and nonprofessional staff, as defined at each of the libraries. An indication of concentrated serial labor is given by a count of the number of employees devoting more than 75% of their time to serial labor. Tables IV and V present the distribution of serial labor effort by function in the central and gross libraries, respectively.

A-4. The Costs of Acquiring and Maintaining a Serial Title

Tables VI and VII present the costs of acquiring and maintaining a serial title for each library. The acquisition costs may be thought of as the initial, or onetime, costs involved in opening a serial title. In general, these initial costs include the costs of performing the activities defined in this report as the acquisition and cataloging functions (see Checklist, Section 8). Both paid titles and gift and exchange titles incur the costs of acquisition. To obtain the cost of acquiring any new title, the sum of the acquisition costs and the gift and exchange costs may be divided by the sum of new purchased titles and new gift and exchange titles. This combined acquisition cost has been rejected in favor of the cost of acquisition for purchased titles, since the aim of the study is to provide a decision tool when the purchase of a title is under consideration. This decision is further justified by the fact that, after acquisition, gift and exchange titles become indistinguishable from purchased titles in the library process. The cost used is the quotient of the acquisition cost, exclusive of gifts and exchanges, and the number of new purchased titles. When the cataloging cost per title is added to it, one obtains the cost of acquiring a purchased serial title, exclusive of the subscription cost.

In order to separate out the cost of acquiring gifts and exchanges, a category was created among the functions on Form 2. Time spent on acquisition of gifts and exchange titles is therefore distinguished from time spent on acquisition of purchased titles. Such a measure was necessary, particularly since the method of handling gifts and exchanges varied greatly

among the libraries surveyed. Libraries A and C maintained no separate gift and exchange department. Library C was in the process of setting one up and Library B maintained a highly organized gift and exchange department. The variance in organization is revealed in the percent of full-time equivalents for gifts and exchanges (Table V.) Library A, with no organized department, spent only 1% of labor time on gift and exchange serials, while Library C, whose gift and exchange activity is in process of being organized, spent almost 4% of labor time on that activity.

The costs of maintaining a serial title, whether purchased, donated or exchanged, are the costs which continue during the life of a serial subscription. (See Table VII). They are obtained by dividing the respective functional costs by the number of current titles. The average subscription price is calculated from the Serials List Survey. Table VIII summarizes the respective costs at each library.

A-5. Storage Costs

Storage costs were not available for all of the universities surveyed. An estimate of storage cost for conventional book stack space is given in a study by Fussler and Simon.[1]

According to this study, the assumed values for Conventional Book Space are the following:[*2]

Assumed vols/sq. ft.	15
Assumed site cost/sq. ft.	$ 2.00
Number of stack levels	four
Assumed construction cost/sq. ft.	$20.00
Current operation expense	$ 0.60

At 15 volumes/sq. ft., the storage cost per volume per year is $0.135. The details are as follows:

Site cost/sq. foot of book space, assuming 5% imputed interest over an indefinite period	= ($2.00/4 levels) (.05)	= $0.025
Construction cost of space/sq. ft., assuming 5% imputed interest over an indefinite period	= ($20.00) (.05)	= $1.00
Maintenance fund at 2% of construction cost	= ($20.00) (.02)	= $0.40
Current operation expense		= $0.60
	Total	$2.025
Direct cost per volume per year or Required capital fund per volume	= $2.025/15	= $0.135

[1] Fussler, Herman H. and Julian L. Simon. Patterns of the Use of Books in Large Research Libraries. University of Chicago, 1961.

[*2] Op. cit. Table 45, p. 260, and Chapter X, pp. 245-262.

A-6. Interlibrary Lending and Borrowing Costs

The results of the interlibrary loan department survey are presented in Table VIII a and b. Again the libraries are ranked A, B, C and D by serial collection size. The abbreviation F.T.E. represents the full-time equivalent employees required to staff the department. The cost per serial item borrowed includes labor costs and $1.00 per item for photocopying and postal charges. It has been assumed that most serial lending is done by photocopy. The photocopy charges were established by a sampling at Library C, where the average cost of photocopying an article is $0.87. An assumed average of $0.12 for postage brings the total to approximately $1.00.

Despite the assistance of the pretest, obtaining the labor time expended on over-all lending and borrowing, serial lending and borrowing, and on fulfilled loans and borrows presented some unique problems which required flow charting of tasks and sampling of Interlibrary Loan records.

The lending information is most conveniently characterized by a consideration of the serial title holdings of each library. Libraries A and B, having the largest and second largest serial collections, received the largest and second largest number of requests. Excluding considerations of demand, it is reasonable to assume that libraries possessing the largest serial collection will show the greatest number of entries in the Union List of Serials or in New Serial Titles, and hence one should expect that the largest collection will receive the greatest number of Interlibrary Loan requests. However, the smallest library, D, received more requests than the next largest library, C. But Library C has a low total loan-borrow ratio.

If in addition to the availability code of the union listings, librarians also have a "feel" for the availability of material from other libraries, the low number of serial requests to C may be explained. It is also reasonable to assume that serial collection size will have some effect on the percentage of requests filled. A relationship is seen in libraries B, C and D, each filling respectively 86%, 84% and 78% of requests. The largest library, however, filled only 67% of its requests.

The borrowing data is more difficult to characterize, since the demand at each library is probably a function of both serial collection size and the extent of the research activity which relies upon that library. Such research activity depends mostly upon the character of the university maintaining the library, and no data has been collected on this character. No relationship can be established between collection size and requests. On the contrary, the largest and smallest collections display nearly equal numbers of requests. Given the unique labor involved in verifying each request, one cannot expect to find an economy of scale in borrowing. A comparison of the serial loan-borrow ratio and the cost per item requested establishes that this cost is not related to the proportion of serial borrowing at the library.

A-7. Tabular Results

Table I - Library Sample Profile

Table II - Gross Labor Effort Profile

Table III - Gross Labor Dollar Profile--Excluding Overhead

Table IV - Distribution of Serial Labor in Central Libraries: Percent FTE's by Function

Table V - Distribution of Serial Labor in Gross Libraries; Percent FTE's by Function

Table VI - Cost per Title of Acquiring a Purchased Serial--Excluding Overhead

Table VII - Cost per Title of Maintaining a Purchased Serial--Excluding Overhead

Table VIIIa - Interlibrary Loan Department Profile

Table VIIIb - Interlibrary Loan Summary: Cost per Item Filled--Excluding Overhead

Table I. Library Sample Profile.

Library	Organization	Current gross holdings		Current central holdings		Serial titles / 1000 total vols.	% Serial labor decentralization**	% Serial collection decentralization**
		Serial titles	Volumes	Serial titles	Volumes			
A	Main library and 16 branch libs*	16,450	1,731,690	8,850	1,130,838	9	63.3%	46.2%
B	Main library and 28 branch libs*	11,718	736,000	5,259	441,000	16	40.5%	55.1%
C	Main library, 2 branch libs* and numerous small collections	10,371	647,614	6,864	574,360	16	9.8%	43.8%
D	Main library and 10 branch libs*	9,207	1,020,000	3,708	711,500	9	37.3%	59.7%

*All branch libraries are dependent
**Percent at branch libraries

Table II. Gross Labor Effort Profile.

LABOR EFFORT (Number of Full Time Equivalent Employees)

	Number of full time equivalent employees						Percent serial of total labor			Percent of total devoting 75% or more of their time to serials			Total serial labor excluding Circ-Ref
	Total labor			Serial labor									
Library	Prof	Non prof	Total	Prof	Non prof	Total	Prof	Non prof	Total	Prof	Non prof	Total	
A	63.4	115.1	178.5	17.0	43.9	60.9	26.8%	38.1%	34.1%	7.0%	14.8%	21.8%	35.5
B	62.7	150.5	213.2	17.5	57.8	75.3	27.8%	38.4%	35.3%	5.0%	12.0%	17.0%	38.1
C	37.3	132.5	169.8	13.1	45.4	58.3	35.2%	34.3%	34.5%	6.0%	14.8%	20.8%	39.8
D	24.8	119.6	144.4	9.7	34.0	43.7	39.1%	26.9%	30.2%	7.3%	15.7%	23.0%	33.4

Table III. Gross Labor Dollar Profile--Excluding Overhead.

Library	Total labor dollars			Serial labor dollars			% Serial dollars		
	Prof	Non prof	Total	Prof	Non prof	Total	Prof	Non prof	Total
A	520, 130	529, 665	1, 049, 641	134, 475	155, 320	289, 795	25. 9%	29. 3%	27. 6%
B	566, 140	557, 091	1, 123, 231	160, 205	191, 627	351, 832	28. 2%	34. 4%	31. 3%
C	301, 909	593, 609	895, 518	112, 150	179, 943	291, 582	37. 2%	30. 3%	32. 6%
D	233, 835	536, 145	769, 980	86, 134	119, 470	205, 612	36. 8%	22. 3%	26. 7%

Table IV. Distribution of Serial Labor in Central Libraries: Percent FTE's by Function.

Library	Central serial title Holdings	Central volume Holdings	Percent of total FTE's										
			Gifts & exchange	Cata-loging	Acqui-sitions	Check-in	Circ-ref	Adminis-tration	Bindings	Marking	Claiming	Training	Other
A	8,850	1,130,838	.13	19.85	19.25	12.50	14.52	9.74	12.86	1.83	6.98	1.98	.36
B	5,259	441,000	1.42	4.65	14.00	16.40	46.70	5.30	6.95	.45	.32	1.00	2.75
C	6,864	574,360	3.82	17.29	19.65	5.98	31.35	4.45	2.89	6.95	.92	3.12	3.52
D	3,708	711,500	2.19	20.00	17.60	15.20	16.10	10.03	10.02	7.50	included in check-in	1.02	0

Table V. Distribution of Serial Labor in Gross Libraries: Percent FTE's by Function.

Library	Gross serial title Holdings	Gross volume Holdings	Percent of total FTE's										
			Gifts & exchange	Cata-loging	Acqui-sitions	Check-in	Circ-ref	Adminis-tration	Bindings	Marking	Claiming	Training	Other
A	16,450	1,731,690	.21*	8.74	10.86	11.33	41.05	3.48	14.58	1.13	4.43	2.34	1.49
B	11,718	736,000	2.23	5.37	9.46	13.44	49.36	6.39	9.71	.56	.49	1.53	1.63
C	10,371	647,614	3.86	16.13	19.06	6.15	32.06	4.27	4.15	6.96	1.21	2.94	3.20
D	9,207	1,020,000	1.54	13.77	13.20	19.62	23.45	8.66	12.26	4.74	1.49	1.25	0

*A letter received from Library A after the data was collected indicates that this figure may be as high as one percent. See text for organization of Gift and Exchange departments.

Table VI. Cost per Title of Acquiring a Purchased Serial--Excluding Overhead.

Library	Acquisition*	Cataloging	Total
A	$29.20	$ 9.62	$38.82
B	$23.03	$12.37	$35.40
C	$34.41	$13.74	$48.15
D	$32.38	$12.73	$45.11

*Excluding subscription costs.

Table VII. Cost per Title of Maintaining a Purchased Serial--Excluding Overhead.

Library	Subscription	Check-in	Claiming	Binding	Marking	Administration	Training	Other	Bindery	Total
A	$12.62	$1.94	$0.84	$1.74	$0.19	$1.18	$0.59	$0.09	$6.22	$25.37
B	$22.62	$2.93	$0.17	$2.99	$0.13	$3.06	$0.80	$0.44	$7.79	$40.93
C	$21.55	$2.28	$0.52	$1.44	$1.07	$2.24	$1.05	$0.48	$6.36	$36.99
D	$17.06	$3.20	$0.36	$2.33	$0.76	$3.22	$0.29	$0.00	$4.29	$31.51

Table VIIIa. Interlibrary Loan Department Profile.

Library	Number of FTE's	Labor cost excluding overhead	Total loan / Total borrow	Serial loan / Serial borrow
A	3.00	$15,015	$\frac{5660}{1885} = 3.00$	$\frac{4540}{942} = 4.82$
B	1.75	$ 8,320	$\frac{3331}{1792} = 1.86$	$\frac{2334}{644} = 3.62$
C	1.47	$ 6,533	$\frac{1365}{1377} = .99$	$\frac{629}{371} = 1.70$
D	3.33	$15,240	$\frac{4216}{1930} = 2.18$	$\frac{1487}{896} = 1.66$

Table VIIIb. Interlibrary Loan Summary: Cost per Item Filled--Excluding Overhead.

Serial Lending

Library	Number of FTE's	Labor dollars	Items requested	Items filled	Cost per item requested	Cost per item filled
A	1.78	$9874	6768	4540	$1.46	$2.17
B	0.65	$2590	2718	2334	$0.95	$1.11
C	0.42	$1856	752	629	$2.02	$2.41
D	0.40	$1243	1889	1487	$0.66	$0.84

Serial Borrowing

A	0.17	$1370	1150	942	$1.19	$2.45*
B	0.28	$1487	798	644	$1.86	$3.31*
C	0.13	$ 596	440	371	$1.35	$2.61*
D	1.02	$5253	1164	896	$4.51	$6.86*

*Total Cost includes $1.00 for photoduplication and postage.

A-8 Special Surveys

8.1 Bindery Cost Survey-Library A

A file of 12,500 Serial and Pamphlet Titles bound over a period of years was sampled for those Serial Titles bound in the fiscal year 1965/66. The first stage sample size, including pamphlets, serials bound in 1965/66 and serials bound in other years, was 500. Of those, 225 Serial Titles were bound in 1956/66. The total number of volumes for 225 titles was 325. The total cost of binding 225 titles was $1404.39.

The average binding cost per title, therefore, was $6.25, and the cost per volume $4.20. Number of volumes per title was 1.44. This figure was used to arrive at a bindery cost per title at the other three universities, where only cost per volume information was available.

8.2 Serials List Survey Summary - Library A

I.	1/3 KARDEX COUNT		
	(a) Ordered (Purchase and Other)*	3,865	70.5%
	(b) Gifts and Exchanges	1,128	20.6%
	(c) Other (Depository Items)	490	8.9%
	TOTAL	5,483	100.0%
II.	SAMPLE BLOW-UP		
	(a) Ordered (Purchase and Other)* X3	11,595	70.5%
	(b) Gifts and Exchanges X3	3,384	20.6%
	(c) Other (Depository Items) X3	1,470	8.9%
	TOTAL	16,449	100.0%
III	2 CARDS PER TRAY		
	(a) Ordered - Publisher	155	19.8%
	(b) Ordered - Agent	387	49.7%
	(c) Ordered - Other	0	
	(d) Gifts and Exchanges	171	22.0%
	(e) Depository Items	66	8.5%
	(f) Public Law 480	0	
	TOTAL	779	100.0%
	SUMMARY		
	(a) Ordered (Purchase* and Other)	542	69.5%
	(b) Gifts and Exchanges	171	22.0%
	(c) Other (Depository Items)	66	8.5%
	TOTAL	779	100.0%

*Not all items ordered from publisher or agent were accompanied by a purchase price. Only those accompanied by a price could be used in calculating a subscription cost.

Serials List Survey Summary - Library A - (Continued)

IV SUBSCRIPTION COSTS

$$\frac{\text{Total Cost of Purchased* Titles}}{\text{Number of Purchased* Titles}} = \frac{\$5,819.05}{461} = \$12.62$$

V FREQUENCY AND COST (Excludes G & E and Depository Items)

(a) Annual	189	40.99%	$10.56
(b) Semi-annual	35	7.59%	8.41
(c) Three times/year	16	3.47%	9.99
(d) Quarterly	94	20.39%	7.89
(e) Biennial	-	-	-
(f) Six times/year	35	7.59%	15.87
(g) Monthly	65	14.09%	15.55
(h) Weekly	13	2.81%	71.70
(i) Daily	-	-	-
(j) Irregular	9	1.95%	6.11
(k) Bi-weekly	4	.86%	17.33
(l) Semi-monthly	1	.21%	4.50
TOTAL	461	99.95%	$11.43

VI NUMBER COPIES RECEIVED PER TITLE

(a) Publisher and Agent	Titles	542
	Copies	607
	Copies/Title	1.13

*Not all items ordered from publisher or agent were accompanied by a purchase price. Only those accompanied by a price could be used in calculating a subscription cost.

Serials List Survey Summary - Library A - (Continued)

(b)	Gifts and Exchanges	Titles	171
		Copies	181
		Copies/Title	1.06
(c)	Other (Depository Items)	Titles	66
		Copies	88
		Copies/Title	1.33
	TOTAL	Titles	779
		Copies	876
		Copies/Title	1.13

A-9. - SURVEY FORMS

INDEX

WESTAT RESEARCH, INC.
Form 1
General Organization

DATE _____

INTERVIEWER _____

I. NAME OF UNIVERSITY _____

LIBRARY NAME _____

MAILING ADDRESS _____

II. LIBRARY DIRECTOR _____ PHONE NO. _____

LIBRARY ASS'T DIRECTOR _____ PHONE NO. _____

OTHER: _____ PHONE NO. _____

OTHER: _____ PHONE NO. _____

OTHER: _____ PHONE NO. _____

III. PROCESSING UNITS AND DEPARTMENTS INVOLVED WITH SERIAL ACTIVITIES

	DEPARTMENT NAME	DEPARTMENT HEAD
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		

V. BRANCH / DEPARTMENTAL LIBRARIES

LIBRARY NAME

1. _____ _____
2. _____ _____
3. _____ _____
4. _____ _____
5. _____ _____
6. _____ _____
7. _____ _____
8. _____ _____
9. _____ _____
10. _____ _____
11. _____ _____
12. _____ _____
13. _____ _____
14. _____ _____
15. _____ _____
16. _____ _____
17. _____ _____
18. _____ _____
19. _____ _____
20. _____ _____
21. _____ _____
22. _____ _____
23. _____ _____
24. _____ _____
25. _____ _____

V. GENERAL LIBRARY POLICIES

A. CIRCULATION

1. Stacks are open to _____ Faculty

   _____ Grad Students

   _____ Undergrad Students

   Other rules _____

2. Policy on Out-of-Building Circulation for Serials:

   Current Issues _____

   Bound Volumes _____

B. ACQUISITION

1. Are Monograph Orders and Serial Orders handled or placed by separate departments?

   Yes _____ No _____ Notes _____

2. What type of Screening Process is followed in handling requests for new serial titles? _____

3. Does the Library issue the payment check? _____

   Or is this handled by the University Accounting Office? _____

   Other procedures _____

C. SERIALS RECORD FILE

1. What type of Record System is used? _____ Kardex Trays

   _____ Punch Cards

   _____ Other

2. Does this Record File only show "Current" subscriptions, gifts, and exchanges? _____

3. Does this Record File contain only "Cataloged" entries? _____

4. Are records or reports available which would show Serial Distributions by Frequency, Subscription Cost, No. of Copies Received, Location where Title is Housed, Source of Purchase (direct, dealer, gift, exchange), Binding Status (received bound, received unbound--bound, received unbound--not bound) etc. (If not, briefly discuss Sampling Procedure of Serials File)

_____

5. Does the Serials Record File also contain an entry for the payment? _____ or is a separate payments file maintained? _____
6. Is claiming for missing issues done during the check-in operation? _____ during the binding preparation operation? _____ does your library follow a systematic claiming procedure? _____

D. GIFTS AND EXCHANGES

1. Is there a separate department or unit to handle gifts and exchanges? _____
2. Once a gift or exchange is received does it become a part of the regular "flow" of serial processing and therefore is its identity as such is lost? _____
3. Does the Serial Record File indicate which titles are being received by gift and exchanges? _____

E. CATALOGING

1. Do you have both Serial Catalogers _____ and Monograph Catalogers___ Are some catalogers involved with both Serials and Monographs? _____
2. For serials, is Dewey Decimal _____ or Library Congress _____ system used, or both _____
3. Do you utilize the LC Proof Slips _____. Are these received automatically _____ or ordered as needed _____
4. What system of reproduction is used to create the necessary number of Catalog Cards _____

_____

F. BINDING

1. University bindery _____, Commercial bindery _____, Other _____
2. Location of bindery _____
3. Who pays the transportation charges? _____
4. Is each Departmental Library responsible for its own binding preparation?

_____

5. Are materials going to and being returned from the Bindery routed through the Main Library? _____

G. LIBRARY BUDGETS, YEAR END REPORTS, SALARY REPORTS, ETC.

1. Collect any reports which may have a bearing on the study.
2. Salaries: Before leaving the university secure a list of employee names and salary rates.

H. INTERLIBRARY LOAN DEPARTMENT

1. Does the Library both loan and borrow Monographs _____ and Serials _____
2. Is the loaning of Serials in the form of photocopy rather than the original issue? _____
3. Are the loaning and borrowing activities handled by the same department? _____
4. Loaning Policies (Time, photo costs, etc.) _____

_____

I. COMMENTS

1. Student and part time help seems to be a sizeable proportion of overall time in certain processing areas. Be sure to include them on "Form 2, Allocation of Employee Time" for each department.
2. Other: _____

_____

_____

CHECKLIST FOR LIBRARY FUNCTIONS

Acquisitions

1. Bibliographic checking of requests (searching)
2. Assign dealer and fund
3. Prepare order form (multiple-order record)
4. Type requisition or purchase order
5. Revise, sign and mail request to dealer
6. Check reports from dealers (cancellations etc.)
7. Inquiries (status of order in process, bib. info. etc.)
8. Bookkeeping (invoices checked and processed for payment)
9. Clear order files (when notif. rec'd from cat. that title is processed)
10. Nofity requestor (that title is ready for circulation)
11. Typing general (general letters to dealers, claims, etc.)
12. Filing (correspondence, order forms, etc.)
13. Other acquisitions work specify: _____
14. "Snags"

Check-in

15. Receiving routine (sorting alpha, outstanding order slips pulled)
16. Sort serials for check-in
17. Record receipt of titles in serials record file (Kardex)
18. "Snags"

Cataloging and Catalog Cards

19. Order LC cards
20. Receive and arrange LC cards
21. File LC proof copy
22. Match LC cards or proof copy with serials
23. Accession numbering

24. Catalog and classify with LC cards/copy
25. Type call number, added entries on LC sets. Prepare shelf list cards.
26. Revise LC card sets
27. Original cataloging and classifying
28. Type master card
29. Revise master card
30. Reproduce catalog card sets from master card
31. Sort catalog cards and shelf list cards
32. File catalog cards and shelf list cards
33. Catalog maintenance (other than filing) - replacing worn cards etc.
34. Other cataloging work. Specify: _____
35. "Snags"

Binding

36. Gathering titles, collating records (Branch Libraries)
37. Gathering titles, collating records (Main Library)
38. Preparing binding spec. card
39. Preparing binding charge card
40. Transportation to/from bindery
41. Bindery costs
42. Receiving and handling bound vol. from bindery
43. Mending
44. "Snags"

Marking

45. Titles received bound
46. Bound volumes from bindery
47. General stack maintenance (mending)
48. "Snags"

Claiming

49. During check-in
50. Systematic claiming
51. During bindery preparation
52. "Snags"

Training

53. Specify: _____
_____
_____

Gifts-Exchanges

54. Acquisition procedures

Circulation-Reference

55. Check-out
56. Returns
57. Reshelving
58. Assistance to patrons
59. Other service

Administration

Other

Lib
Dept
Name

WESTAT RESEARCH, INC.
Form 2, Data Sheet
Allocation of Employee Time

									Total per week	Total per year
Title										
Grade										
Rate										
I. Total hrs/wk										
II. Hrs/wk on Serials										
III. % Time on Serials										
IV. Cost of Serial hrs.										
Acquisitions	I.									
	II.									
	III.									
	IV.									
Check In	I.									
	II.									
	III.									
	IV.									
Cataloging	I.									
	II.									
	III.									
	IV.									
Binding	I.									
	II.									
	III.									
	IV.									
Marking	I.									
	II.									
	III.									
	IV.									
Claiming	I.									
	II.									
	III.									
	IV.									
Training	I.									
	II.									
	III.									
	IV.									
Gifts and Exchanges	I.									
	II.									
	III.									
	IV.									
Circulation-Reference	I.									
	II.									
	III.									
	IV.									
Administration	I.									
	II.									
	III.									
	IV.									
Other	I.									
	II.									
	III.									
	IV.									

FORM 3, SERIALS LIST SURVEY

The Serials List Survey draws a sample as follows: for every tray, full information (abbreviated title, call number, etc.) is recorded for two titles, whose locations are tenth from the bottom and tenth from the top. Every third try, an entry is made of the number of cards in the tray. Information is extracted from the survey and presented in the manner shown on page B-15.

WESTAT RESEARCH, INC.
Form 3
Serials List Survey

Library _____ Date _____

Cardex Tray	Abbreviated Title	Call Number (1st 2 lines)	Freq. co e	Cost per year	No. of copies	Location code	Ordered from	Binding code	No. cards in tray		
									Purchases	Gifts, exch.	Other
X									X	X	X
X											
X											
X											
X											
X											

WESTAT RESEARCH, INC.
Form 3
Serials List Survey

INSTRUCTIONS FOR SERIALS LIST SURVEY

Kardex tray--Enter tray number. Select tenth non-blank card from beginning for first line and tenth non-blank card from end for second line.

Ignore information type cards in counting

Abbreviated title -- Can be very brief.

Call Number - First 2 lines only Ex HC 107

Frequency Code --

1 = annual	7 = monthly
2 = semiannual	8 = weekly
3 = 3 times per year	9 = daily
4 = quarterly	10 = irregular
5 = biennial	11 = bi-weekly
6 = 6 times per year	12 = semi-monthly

If code 10, indicate no. received and time period, for example, 10

3/2 yrs. for 3 items in 2 yrs.

Cost per year per copy -- Enter actual cost. Handle special cases as follows:

a. Subscriptions to library services (ex., Moody's) --Enter total subscription price for service and number of line items received (ex., 385.00/19).

b. Irregulars--Enter cost of last item (if available).

No. of copies--Enter no. of copies received, even though they may be separate line items.

Location Code--

1 = Main library	11 =
2 =	12 =
3 =	13 =
4 =	14 =
5 =	15 =
6 =	16 =
7 =	17 =
8 =	18 =
9 =	19 =
10 =	20 =

Ordered from--

1 = direct
2 = dealer
3 = gift
4 = exchange
5 = other

Binding code--

1 = received unbound, not being bound
2 = received unbound, being bound
3 = received bound
4 = looseleaf
5 = other (indicate)

No. cards in tray-- Entered only for every third tray. Use color code, if available. Exclude information-type cards, such as cost cards for subscription services, etc.

If requested information is not available, enter an asterisk. In case particular items don't seem to fit the form, leave the line blank (except for information which is clearly applicable) and prepare a note concerning the problem.

A-10. - DATA SUMMARY SHEETS

INDEX

I=Hrs/Wk on Serials II=FTE III=Total Cost for Serials		Serials	Gifts and Exchanges	Card Preparation	Catalog Unit	Circulation
Acquisitions	I	79.00				
	II	1.98				
	III	7,405.00				
Check In	I	210.00				
	II	5.92				
	III	16,904.00				
Cataloging	I	75.00		4.60	2.50	
	II	1.88		.12	.06	
	III	8,217.00		518.00	641.00	
Binding	I	60.00				
	II	1.50				
	III	5,346.00				
Marking	I			8.00		
	II			.20		
	III			645.00		
Claiming	I					
	II					
	III					
Training	I					
	II					
	III					
Gifts and Exchanges	I	5.00	20.00			
	II	.13	.50			
	III	570.00	3,560.00			
Circulation-Reference	I	126.00				472.00
	II	3.15				11.80
	III	24,004.00				42,429.00
Administration	I	45.00				
	II	1.13				
	III	3,819.00				
Other	I					
	II					
	III					
FTE Total		17.00	2.00	20.25	6.00	32.88
FTE Serials		15.00	.50	.32	.06	11.80
$ Serials		66,265.00	3,560.00	1,193.00	641.00	42,429.00
$ Total		72,467.00	15,974.00	93,212.00	50,500.00	121,895.00

Table 1. Labor Data Summary Sheet for Library B

	Administration	Systems Development	Order	Reference	Department Totals
			168.00 4.20 18,546.00	4.00 .10 626.00	251.00 6.28 26,577.00
			30.00 .75 3,276.00	26.00 .65 3,067.00	266.00 7.32 23,247.00
				1.00 .03 183.00	83.10 2.08 9,588.00
	2.00 .05 312.00			62.50 1.56 7,849.00	124.50 3.11 13,507.00
					8.00 .20 645.00
	2.00 .05 495.00		5.00 .13 455.00	.50 .01 51.00	7.50 .14 1,001.00
		5.00 .13 810.00	10.00 .25 1,300.00	3.00 .08 617.00	18.00 .45 2,727.00
				.50 .01 98.00	25.50 .64 4,228.00
				239.00 5.98 33,042.00	837.00 20.93 99,475.00
	24.70 .62 7,556.00	14.00 .35 3,664.00	10.00 .25 1,092.00	1.25 .03 332.00	94.95 2.37 16,463.00
		21.00 .53 1,898.00	28.00 .70 3,245.00		49.00 1.23 5,143.00
	13.63	6.00	24.00	21.68	143.44
	.72	1.00	6.28	8.44	44.75
	8,363.00	6,373.00	27,914.00	45,864.00	202,600.00
	130,594.00	35,520.00	109,324.00	127,993.00	757,479.00

I=Hrs/Wk on Serials II=FTE III=Total Cost for Serials		Electrical Engineering	Forestry-Horticulture	Veterinarian Science	Branch Average	Branch Total
Acquisitions	I		.08	4.00	1.36	38.00
	II		.00	.10	.03	.84
	III		7.80	602.00	203.00	5,688.00
Check In	I	1.00	2.00	9.00	4.00	112.00
	II	.03	.05	.23	.10	2.80
	III	96.00	198.00	892.00	395.00	11,064.00
Cataloging	I	7.00		1.00	2.67	75.00
	II	.18		.03	.07	1.96
	III	478.00		300.00	259.00	7,262.00
Binding	I	8.00	1.50	8.00	5.83	163.00
	II	.20	.04	.20	.15	4.20
	III	894.00	385.00	1,025.00	768.00	21,511.00
Marking	I			1.00	.33	9.24
	II			.03	.01	.22
	III			96.20	32.07	898.00
Claiming	I			1.00	.33	9.24
	II			.03	.01	.22
	III			109.00	36.00	1,019.00
Training	I			3.00	1.00	28.00
	II			.08	.03	.70
	III			709.00	236.00	6,620.00
Gifts and Exchanges	I			4.50	1.50	42.00
	II			.11	.04	1.04
	III			647.00	216.00	6,042.00
Circulation-Reference	I	30.00	20.00	19.00	23.00	644.00
	II	.75	.50	.48	.58	16.24
	III	3,284.00	1,976.00	2,209.00	2,490.00	69,715.00
Administration	I	4.00		6.50	3.50	98.00
	II	.10		.16	.09	2.44
	III	728.00		1,352.00	693.00	19,413.00
Other	I					
	II					
	III					
FTE Total		3.23	1.00	3.25	2.49	69.72
FTE Serials		1.25	.59	1.42	1.09	30.52
$ Serials		5,480.00	2,567.00	7,942.00	5,330.00	149,232.00
$ Total		14,360.00	3,952.00	20,876.00	13,063.00	365,752.00

Table 1. Labor Data Summary Sheet for Library B (Contd)

Department Totals	Branch Total	Grand Total
251.00	38.00	289.00
6.28	.84	7.12
26,577.00	5,688.00	32,265.00
266.00	112.00	378.00
7.32	2.80	10.12
23,247.00	11,064.00	34,311.00
83.10	75.00	158.10
2.08	1.96	4.04
9,588.00	7,262.00	16,850.00
124.50	163.00	287.50
3.11	4.20	7.31
13,507.00	21,511.00	35,018.00
8.00	9.24	17.24
.20	.22	.42
645.00	898.00	1,543.00
7.50	9.24	16.74
.14	.22	.37
1,001.00	1,019.00	2,020.00
18.00	28.00	46.00
.45	.70	1.15
2,727.00	6,620.00	9,347.00
25.50	42.00	67.50
.64	1.04	1.68
4,228.00	6,042.00	10,270.00
837.00	644.00	1,481.00
20.93	16.24	37.17
99,475.00	69,715.00	169,190.00
94.95	98.00	192.95
2.37	2.44	4.81
16,463.00	19,413.00	35,876.00
49.00		49.00
1.23		1.23
5,143.00		5,143.00
143.44	69.72	213.16
44.75	30.52	75.27
202,600.00	149,232.00	351,832.00
757,479.00	365,752.00	1,123,231.00

APPENDIX B

THE FRACTION OF PROPER REQUESTS FULFILLED AS A FUNCTION OF THE FRACTION OF TITLES AVAILABLE WITH NONZERO DEMAND

The purpose of this appendix is to derive a relationship between the fraction of proper requests filfilled and the fraction of titles with nonzero demand. The relationship is based on the assumption that the demand per title is log normally distributed with $\sigma = 1.94$.

Since the demand per title is log normally distributed with parameters μ and σ, the fraction of titles with a demand per title between x and dx is given by:

$$f(x)dx = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{(\ell n X - \mu)^2}{2\sigma^2}} \frac{dx}{x} \qquad \text{(B1)}$$

The fraction of titles which have a demand greater than or equal to d is given by:

$$F_T(d) = \frac{1}{\sqrt{2\pi}\,\sigma} \int_{x=d}^{\infty} e^{-\frac{(\ell n\, x - \mu)^2}{2\sigma^2}} d(\ell n\, x) \qquad \text{(B2)}$$

If we let $y = \frac{\ell n\, x - \mu}{\sigma}$, then (B2) becomes

$$F_T(d) = \frac{1}{\sqrt{2\pi}} \int_{y=\frac{\ell n\, d - \mu}{\sigma}}^{\infty} e^{-1/2\, y^2} dy = 1 - \Phi\left(\frac{\ell n\, d - \mu}{\sigma}\right) = \Phi\left(\frac{\mu - \ell n\, d}{\sigma}\right) \qquad \text{(B3)}$$

where $\Phi(x)$ is the cumulative distribution function (c.d.f.) for the standardized normal distribution, i.e. the normal distribution with zero mean and unit

variance. Equation (B3) tells us that the fraction of titles with demand less than or equal to d is given by the c.d.f. for a standardized normal distribution evaluated at $(\ell n\ d - \mu) / \sigma$.

Now let us consider the fraction of requests satisfied by these titles. From (B1) it follows that the number of requests for titles between x and x + dx requests is given by:

$$T\ xf(x)dx = \frac{T}{\sqrt{2\pi}\,\sigma}\ e^{-\frac{(\ell n\ x - \mu)^2}{2\sigma^2}}\ dx \qquad \text{(B4)}$$

Where T is the total number of titles with nonzero demand in the collection. From (B4) it follows that the number of requests for titles with d or more requests per title is:

$$R(d) = \frac{T}{\sqrt{2\pi}\,\sigma} \int_{x=d}^{\infty} x\ e^{-\frac{(\ell n\ x - \mu)^2}{2\sigma^2}}\ d\ \ell n\ x \qquad \text{(B5)}$$

If we let $z = \frac{\ell n\ x - \mu - \sigma^2}{\sigma}$, then

$$x = e^{\mu + \sigma^2 + z\sigma} \qquad \text{(B6)}$$

$$\frac{1}{2}\ \frac{(\ell n\ x - \mu)^2}{\sigma^2} = \frac{1}{2}\ (z + \sigma)^2 = \frac{1}{2}\ z^2 + z\sigma + \frac{1}{2}\ \sigma^2 \qquad \text{(B7)}$$

$$d\ \ell n\ x = \sigma d\ z \qquad \text{(B8)}$$

and (B5) becomes:

$$R(d) = \frac{T}{\sqrt{2\pi}} e^{\mu + \frac{1}{2}\sigma^2} \int_{z}^{\infty} e^{-\frac{z^2}{2}} dz \qquad \text{(B9)}$$

$$z = \frac{\ln d - \mu - \sigma^2}{\sigma}$$

or

$$R(d) = T\, e^{\mu + \frac{\sigma^2}{2}}\, \Phi\left(\frac{\mu - \ln d + \sigma^2}{\sigma}\right) \qquad \text{(B10)}$$

If we let d approach zero, then requests for all titles with nonzero requests will be included in the "summation" and we obtain:

$$R(0) = e^{\mu + \frac{\sigma^2}{2}}\, T \qquad \text{(B11)}$$

since $\Phi(\infty) = 1$.

The fraction of requests satisfied by titles with d or more requests per title is, therefore,

$$F_R(d) = \frac{R(d)}{R(0)} = \Phi\left(\frac{\mu - \ln d}{\sigma} + \sigma\right) \qquad \text{(B12)}$$

The fraction of satisfied requests for the more heavily used titles $F_R(d)$ is related to the fraction of titles $F_T(d)$ for each value of d. Therefore, as d is varied from ∞ to 0 both $F_R(d)$ and $F_T(d)$ vary from 0 to 1. Since both $F_R(d)$ and $F_T(d)$ are expressible in terms of the c.d.f. of the standardized normal distribution, it is particularly convenient to plot $F_R(d)$ versus $F_T(d)$ on a two-way probability plot. The fact that the arguments of $\Phi(\ )$ for $F_T(d)$ and $F_R(d)$ differ by an amount σ means that the relationship on such a plot is linear and displaced from the 45 degree line by an amount σ, estimated to be approximately 1.94.

APPENDIX C

THE COVERAGE OF A SAMPLE WHERE DEMANDS ARE LOG-NORMALLY DISTRIBUTED

The proportion of the number of species represented in a random sample of animals of size N is given by

$$C = 1 - \frac{n_1}{N} \tag{C1}$$

where n_1 is the number of singleton species. This result was derived by Good [7]* and studied more recently by Robbins [8].

If we set up a correspondence between animals and requests, and between species and titles, then (C1) can be used to estimate the proportion of the number of titles represented in a random sample of requests of size N where n_1 is the number of singleton titles. The purpose of this appendix is to specialize (C1) for the case where the number of requests per title is log-normally distributed.

Let T be the total number of titles represented in the sample of N requests. Then the average number of requests per title which has a non-zero demand is $D = \frac{N}{T}$ (C2)

In view of (B11) we have:

$$D = e^{\mu + \frac{\sigma^2}{2}} \tag{C3}$$

or

$$\mu = \ell n\, D - \frac{\sigma^2}{2} \tag{C4}$$

From (B3) it follows that

$$n_1 = T\, \Phi\left(\frac{\log 1 - \mu}{\sigma}\right) = T\, \Phi\left(-\frac{\mu}{\sigma}\right) \tag{C5}$$

---

*Citations are to references on page 58.

Substitution of (C4) into (C5) and the result into (C1) produces

$$C = 1 - \frac{T}{N} \Phi \left(- \frac{\ell n\, D}{\sigma} + \frac{\sigma}{2} \right) \qquad \text{(C6)}$$

Since by (C2) $\frac{N}{T}$ equal D (C-6) becomes

$$C = 1 - \frac{1}{D} \Phi \left(\frac{\sigma}{2} - \frac{1}{\sigma} \ell n\, D \right) \qquad \text{(C7)}$$

Since σ has a value of 1.94 it follows that C is a function of D, the average value of the demand per title in the sample.

APPENDIX D

CHARACTERISTICS OF DEMAND FOR SERIALS

D-1. The Distribution of Demand by Title

The data of Table 3.1 have been plotted in Figure 1 which has a logarithmic vertical scale and "normal probability" horizontal scale. A straight-line distribution, that is, a frequency distribution which would have the normal (bell) shape if the horizontal scale (the demands in our case) were converted to logarithms.

It may be seen that a straight line is not a bad representation for the points, with the exception that the points drop off too rapidly at the right hand edge of the graph, particularly with regard to the National Library of Medicine (Schilling) and the National Agricultural Library.

The dropoff possibly can be explained by the overloading of the system which occurs when demand becomes too high for a given title. There may also be some planned or unplanned discouragement of lending items which are commonly held by local libraries.

The graph is to be read as follows. Consider the top line which is the demand observed by Kurth at the National Library of Medicine: titles with 5 or fewer requests (vertical scale) accounted for 57 percent (horizontal scale) of the total requests.

Notice that all of the distributions presented in Figure D-1 are reasonably well represented by straight lines. Consequently, one may assume that for collections of serial titles, the distribution of demand per title is log-normal.

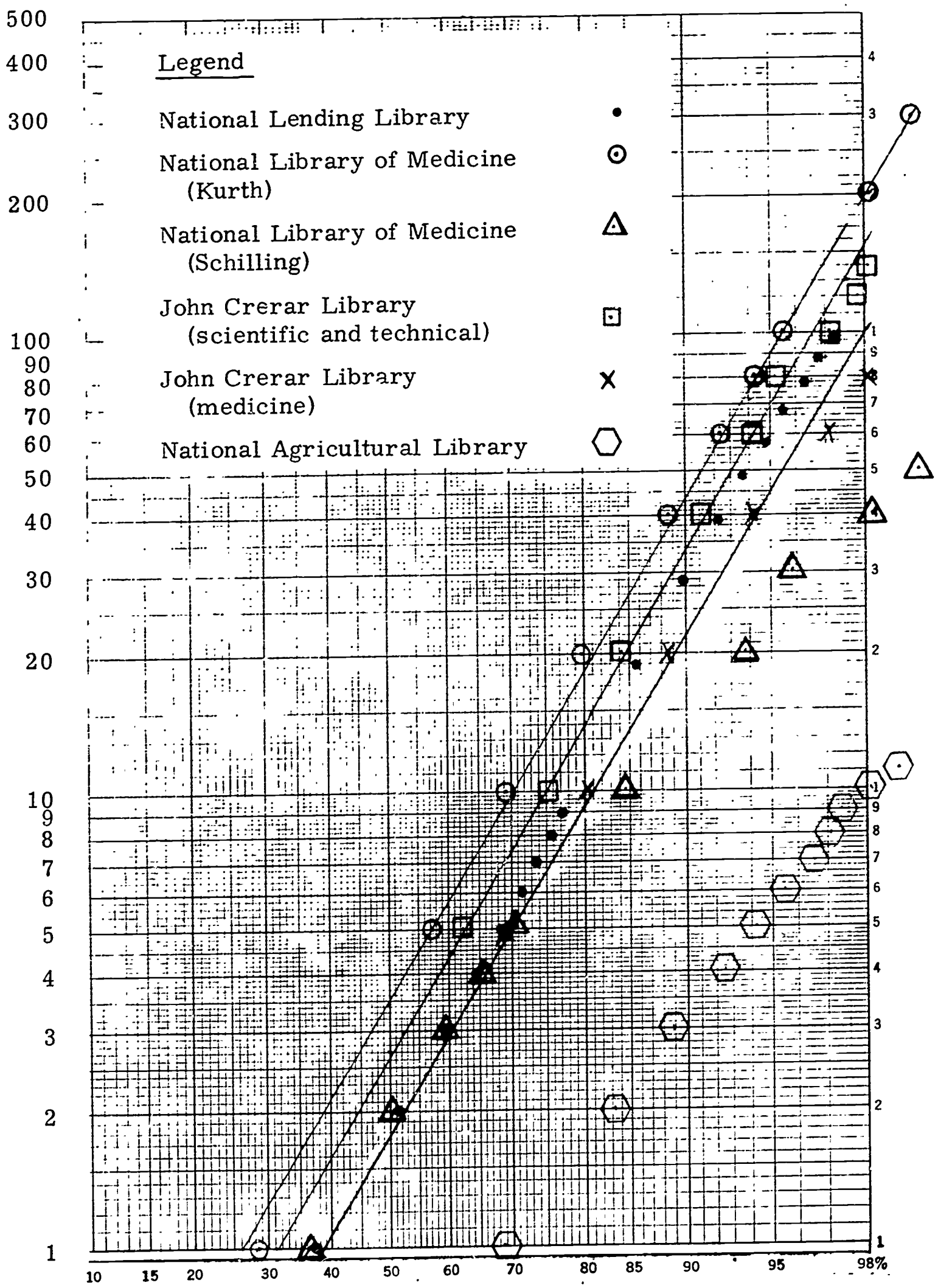


Figure D-1 Distribution of Demand per Title over Titles for Several Central Libraries.

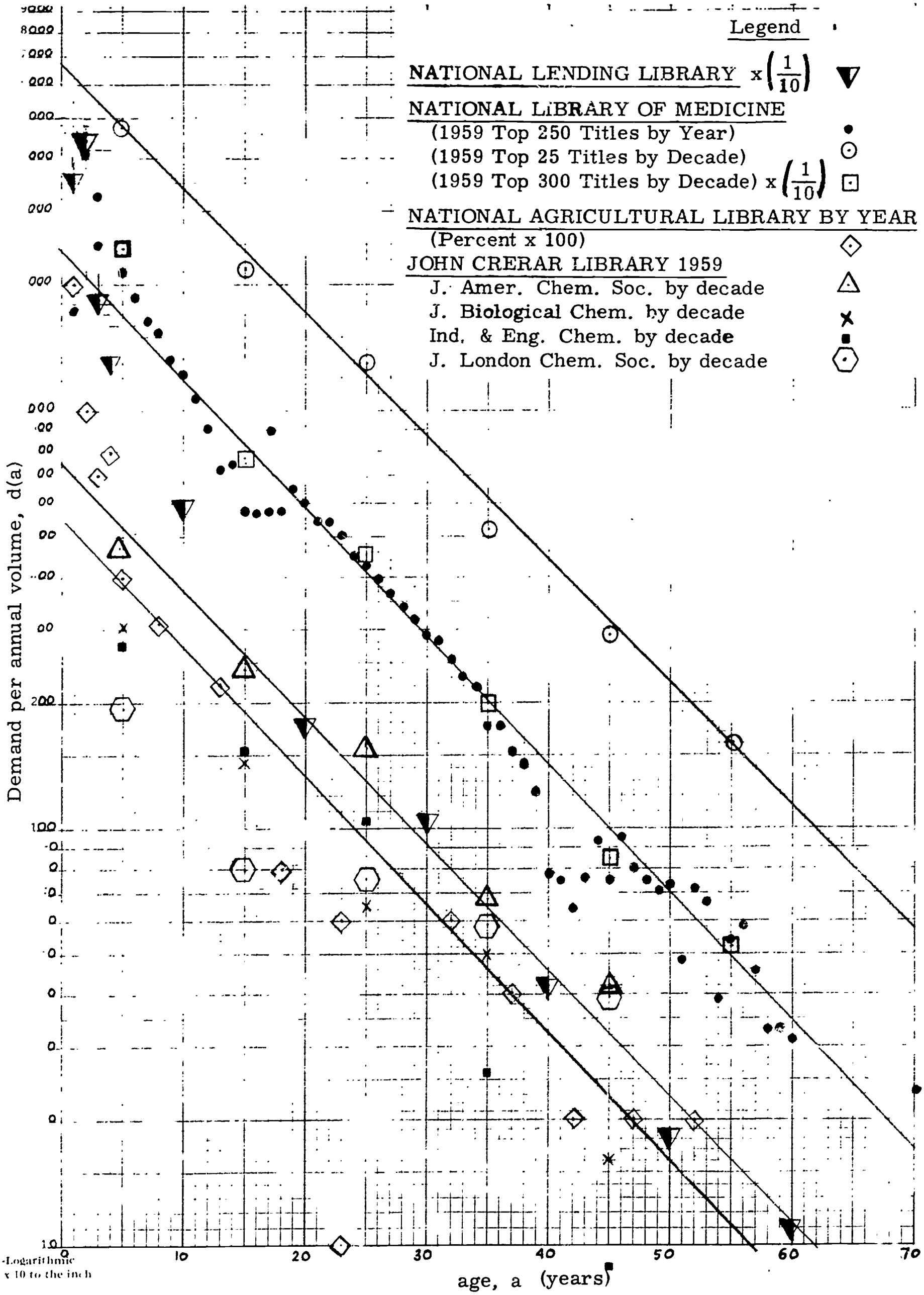


Figure D-2 Demand per annual volume as a function of age.

The fraction of total demand for a serial title for annual volumes whose ages are less than or equal to A years is given approximately by:

$$F(A) = 1 - r^{A} \tag{D-2}$$

where r equals 0.93. This result is developed as follows:

The demand in the present year for a serial title whose age is equal to a years is approximately given by:

$$d(a) = d_o r^{a} \qquad a = 1, 2, 3, \ldots \tag{D-3}$$

and the demand in the present year for annual volumes whose age is less than or equal to A is given by:

$$D(A) = \sum_{a=1}^{A} d(a) = d_o r \frac{1-r^{A}}{1-r} \tag{D-4}$$

Let A^* be the age of the oldest annual volume of the serial title, then the total demand for the serial title is

$$D(A^*) = d_o r \frac{1-r^{A^*}}{1-r} \tag{D-5}$$

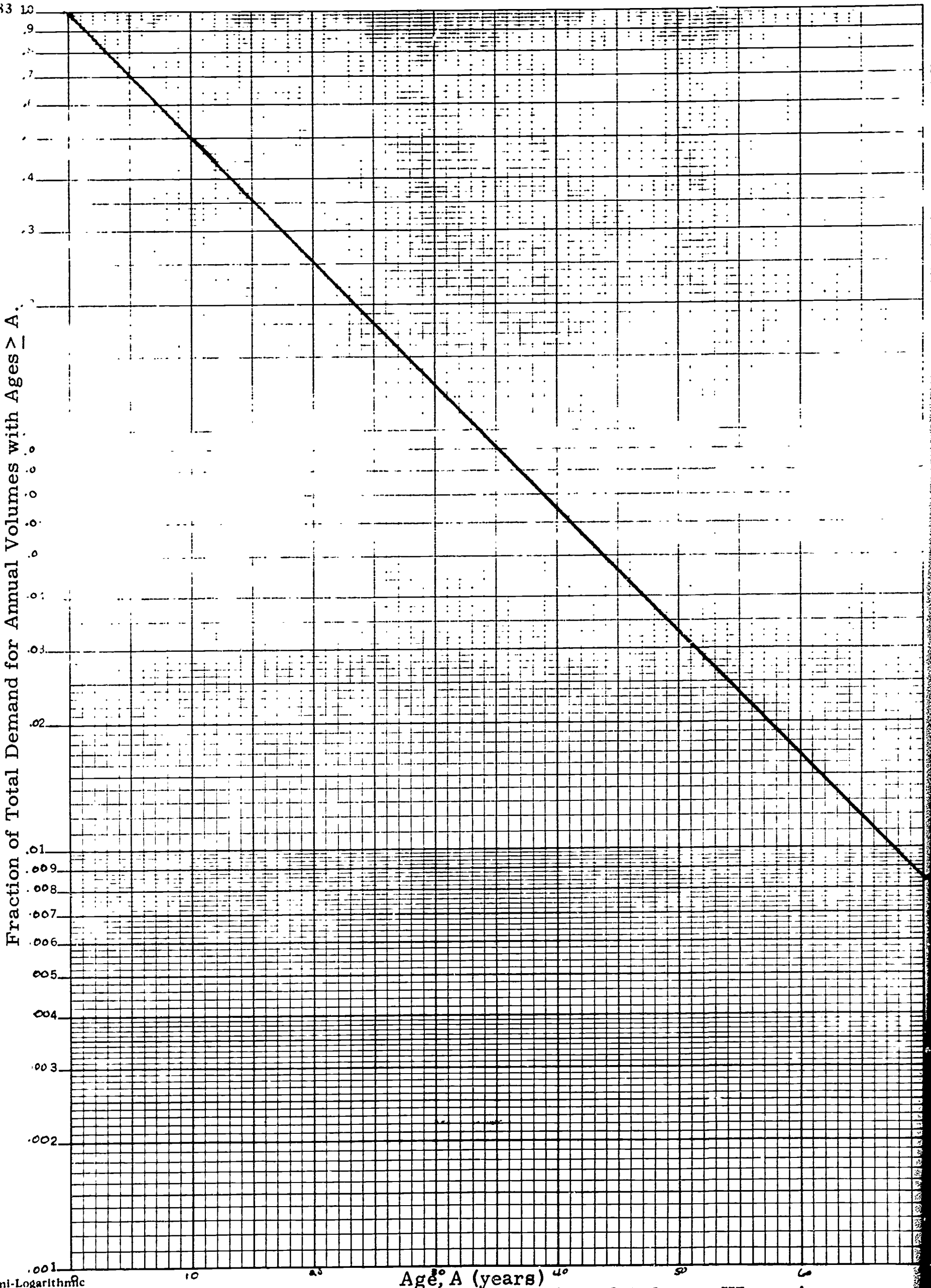
Therefore, the fraction of the total demand for annual volumes whose age is less than or equal to A is

$$F(A) = \frac{D(A)}{D(A^*)} = \frac{1-r^{A}}{1-r^{A^*}} \tag{D-6}$$

In general A^* varies from title to title. However, assuming that A^* is large for all titles, r^{A^*} is approximately equal to zero and (D-6) reduces to:

$$F(A) = 1-r^{A} \tag{D-7}$$

Figure D-3 is a graph of the complement of Equation D-2. Assuming that Equation (D-2) is valid for all titles, F(A) also equals the fraction of the total demand for two or more titles for annual volumes whose ages are less than or equal to A years.



Semi-Logarithmic
3 Cycles x 10 to the inch

Figure D-3 Fraction of Total Demand for Annual Volumes Whose Ages are Greater than A Years.

APPENDIX E

A QUEUEING MODEL FOR DELAYS DUE TO OUTAGES

To specify a queueing process with say c channels (annual volumes) requires a knowledge of the distributions of service times and interarrival times, and the queue discipline, i.e., the order in which the waiting units (requests) are selected. If it assumed that the interarrival times and service times are exponentially distributed with mean values of $1/\lambda$ and $1/\mu$, respectively, and that the queue discipline is first come first served, then it can be shown that the probability that no units (requests) are in the queueing system, p_o and the expected number of units (requests) waiting for service in the queue, L_q, are given by the following equations:

$$p_o = \frac{1}{\sum_{n=0}^{c-1} \frac{(c\rho)^n}{n!} + \frac{(c\rho)^c}{c!(1-\rho)}} \qquad \text{(E-1)}$$

$$L_q = \frac{\rho(c\rho)^c}{c!(1-\rho)^2} \; p_o \qquad \text{(E-2)}$$

where

$$\rho = \frac{\lambda}{c\mu} \qquad \text{(E-3)}$$

References

Morse, P.M. Queues, Inventories and Maintenance, John Wiley and Sons, New York (1958) E-1

Cox, D.R. and Smith, W. Queues, Methuen & Company, London, and John Wiley and Sons, New York (1961). E-2

Saaty, T. L. Elements of Queuing Theory, McGraw-Hill Book Co. New York (1961) E-3

Parzen, Emannel. Stochastic Processes, Holden-Day Inc., San Francisco (1962) E-4

The factor ρ is sometimes called the utilization factor because it characterizes the degree to which a service facility is utilized. This can be seen by noting that: (i) the mean arrival rate per channel is approximately λ/c, (ii) the mean service rate per channel is approximately μ, and (iii) ρ is the ratio of λ/c to μ.

Furthermore, the expected waiting time in the queue is given by

$$W_q = \frac{L_q}{\lambda} \qquad \text{(E-4)}$$

These equations are presented on page 116 of Saaty [E-3].

Figure (E-1) is a plot of L_q as a function of c and ρ using (E-3). It describes the relationship between the expected number of requests for a particular item waiting due to an outage, L_q, the number of multiple copies of the item held by the library, c, and the utilization factor, ρ. Therefore, from a knowledge of c and ρ one can obtain an estimate of L_q from Figure (E-1) and an estimate of the expected waiting time of a request, W_q, from E-4).

The overall arrival rate of requests λ can be related to the arrival rates of each type of request. Let λ_i be the arrival rate of requests of type c. (More precisely $1/\lambda_i$ is the mean interarrival time of type i outages). Because interarrival times are exponentially distributed, it follows that the number of requests of type i entering the queueing system in time T are Poisson distributed with parameter $\lambda_i T$. Since the sum of a number of independent Poisson distributed random variables is also Poisson distributed, the number of requests of all types entering a queueing system is Poisson

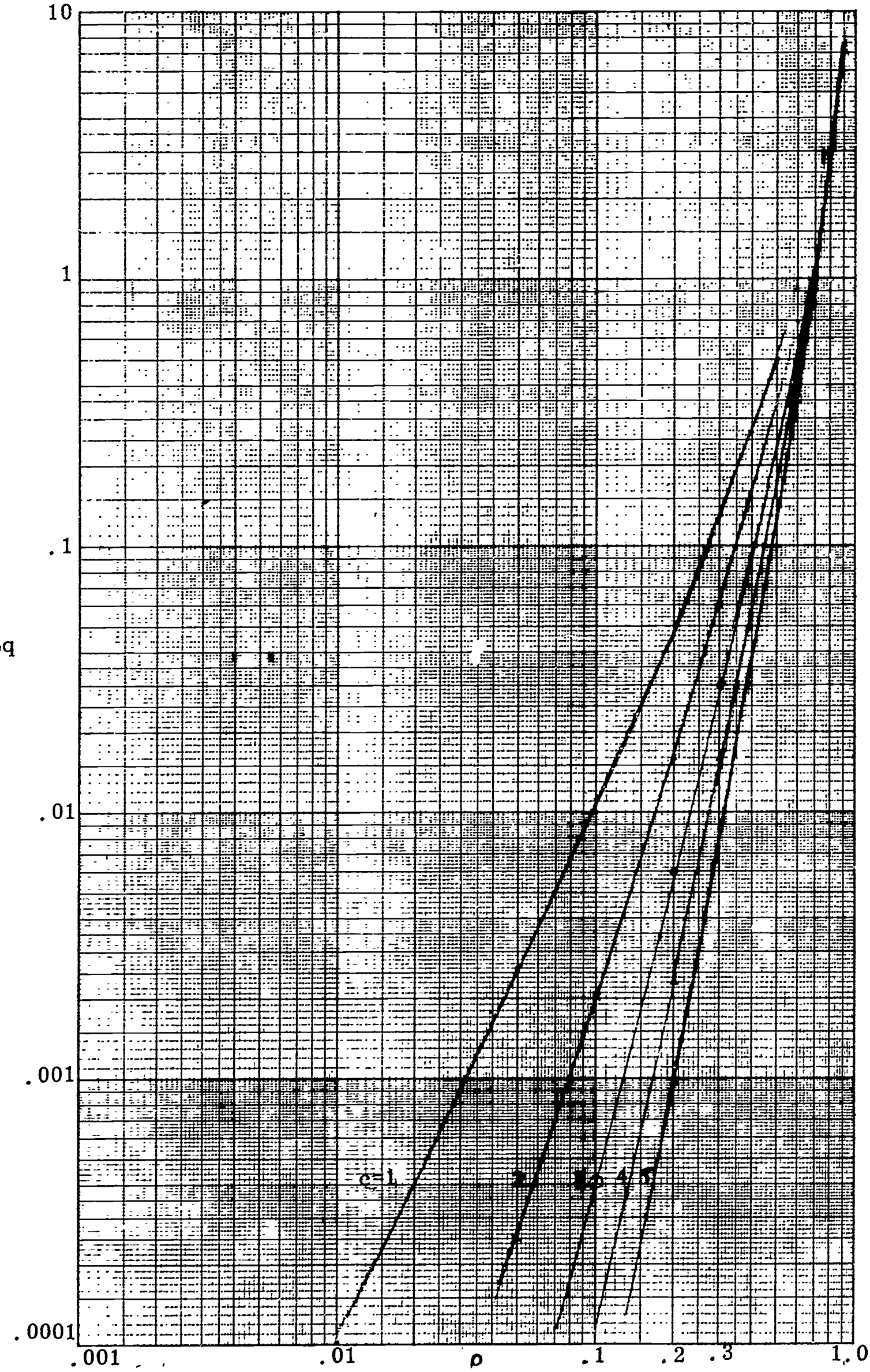


Figure E-1. Relationship between Lq and ρ for various numbers of copies.

distributed with parameter $\Sigma \lambda_i T$. Equivalently we may write

$$\lambda = \sum_{i=1}^{s} \lambda_i \qquad \text{(E-5)}$$

where s is the number of types of requests.

The overall service rate μ may be related to the service rates and arrival rates of each type of request. Let λ_i be the arrival rate and μ_i be the service rate of the i^{th} type of request. The output from a service facility depends on what kind of unit or request is in the service facility. If a type i request is in the service facility, the output from the facility in time T is Poisson distributed with parameter $\mu_i T$. In other words, the number of units discharged from a service facility in time T given that the service facility is occupied by type i requests is Poisson distributed with parameter $\mu_i T$. Let p_i be the probability that the service facility is occupied by type i request. Because a Poisson process is preserved under random selection (e.g. see Parzen [E-4, p. 47), it follows that the output from such a service facility in time T is a Poisson process with parameter equal to $\sum_{i=1}^{s} p_i \mu_i T$. However, the output from such a process is also a Poisson process with parameter μT so that

$$\mu = \sum_{i=1}^{s} p_i \mu_i \qquad \text{(E-6)}$$

One step remains: the determination of p_i. The probability that the service facility is occupied by a type i request p_i, is the ratio of the expected number of requests of type i which arrive at the service facility

in time T' to the expected number of requests of all types which arrive in time T or

$$p_i = \frac{\lambda_i}{\sum_{i=1}^{s} \lambda_i} \qquad \text{(E-7)}$$

Substitution of (E-7) into (E-6) yields

$$\mu = \frac{\sum_{i=1}^{s} \lambda_i \mu_i}{\sum_{i=1}^{s} \lambda_i} \qquad \text{(E-8)}$$

To illustrate the utility of the above results we shall consider the following situation. A particular annual volume of a serial title has been acquired by a library. The expected number of requests for this annual volume by patrons in the coming year is estimated to be some number, λ_1, and the average loan duration for each patron request is two weeks. Furthermore the bindery is expected to request the annual volume once during the coming year for an expected period of 1 month. The values of i, λ_i and μ_i for the two sources of "requests" mentioned above are presented in Table 2 below:

Table 2. Values of Arrival Rates and Services Rates For the Various Types Of Requests

i	Type of Request	Arrival Rate, λ_i (Requests per year)	Service Rate, μ_i (Requests per year)
1	Patron	λ_1	26
2	Bindery	1	12

The overall service rate for the values in Table 2 according to Equation (5) is

$$\lambda = \lambda_1 + 1 \qquad \text{(E-9)}$$

and the overall service rate according to Equation (E-8)

$$\mu = \frac{26\lambda_1 + 12}{\lambda} \qquad \text{(E-10)}$$

From a knowledge of λ_1, therefore, one can determine λ and μ. For a given number of copies, c, one can also determine ρ via (E-3). From ρ and c one can determine L_q from Figure (E-1) and from L_q and λ one can determine W_q via (E-4). Hence, the waiting time W_q can be determined from a knowledge of λ_1 and c for the values presented in Table 2.

APPENDIX F

NOTES ON SPECIFICATIONS FOR A LENDING LIBRARY SYSTEM

F. 1 Introduction

It is not the function of this report to develop a model for a national lending library system. However, Section 2 presumes the existence of such a system as an alternative to acquisition and holding of titles by local research libraries. It seems appropriate, therefore, to present some preliminary models of cost and service characteristics of a lending system to serve as a background against which to judge the feasibility of alternatives presented earlier.

F. 2 Service Characteristics

Two facets of service which largely determine whether a lending library system will be used are: (1) Collection size and integrity and (2) Response time. We consider the second facet first.

F. 2. 1 Response Time

A measure of the quality of service of a lending library system is how long it takes for a user to receive a copy of the serial article requested after initiating the request. Response time may be viewed as the sum of four component times as follows:

$$T_R = T_T + T_P + T_W + T_F$$

where:

T_T is the time of transit of the request to the central library

T_P is the time required to process the request at the central library

T_W is the waiting time at the central library to recover the requested volume due to an outage

T_F is the time required to deliver the desired article to the requester

Each of these component times may assume different average values depending on how the corresponding function is performed. For example, the transit time to the central library will be a matter of minutes if the request is sent via TWX or telephone and a matter of a few days if it is sent via mail. The processing time will be a fraction of an hour if the request is given high priority service and hours or possibly days if it is given low priority or routine service. The processing time, in general, depends strongly on the volume of requests processed, the frequency distribution of the requests, and the work force available for handling them. The waiting time due to an outage will usually be a matter of hours if each request is satisfied with a photoduplicate copy but may be a matter of weeks or months if the original volumes are loaned to patrons. In the later case the waiting time can be decreased by the following methods: (1) By having multiple copies of each volume available for loan, (2) By shortening the loan period, (3) By not combining and binding individual issues which normally comprise a bound volume, and instead loaning the individual issues to patrons, (4) By adopting policies which minimize outage due to loss, theft, binding, indexing, and so on.

Some values for the component times, with the exception of waiting time, are presented in Table F.1 for planning purposes. The waiting time or delay time warrants more detailed description and is considered in the next section.

Table F. 1 Components of Response Time.

COMPONENT	METHOD	TIME (DAYS)
Transit To Library	TWX	0. 005
	Phone	0. 005
	Air Mail	1
Processing Time at Library	Priority Service	0. 5
	Regular Service	2
Deliver To Patron	Air Mail	1
	Surface Mail	6-10

F.2.2 Delay in Request Fulfillment Due To Items Not On The Shelf

Items acquired and supposedly held by a library may be missing from the library shelf because the item is: (1) On loan to a patron, (2) in transit to the shelves within the library, (3) at the binder, (4) being indexed, (5) misshelved, or (6) lost or stolen. If a request for the item is received from a patron while it is missing, the patron must wait or go elsewhere.

One factor affecting the duration of the patron's wait is the duration of the outage. The durations of outages (1), (2), (3), and (4) may be as long as several months while the duration of outages (5) and (6) may be as long as several years.

A second factor affecting the duration of the patron's wait is the frequency with which items are removed from the proper location in the library for reasons (1) through (6). In particular, if the item is frequently requested by other patrons, there is a high probability that a given patron will have to wait.

A third factor affecting the patron's wait is the number of copies of the item held by the library. The expected duration of a patron's wait will be shorter if multiple copies are available than if only a single copy is available. A reasonable way to view this waiting time problem is in terms of a "queue" or "waiting line." Each copy of the item in the library is capable of providing a service and corresponds to "service facility" or "channel", terms commonly used in queueing theory. The frequency of occurrence of each type of "request" corresponds to the frequency of

arrivals which possibly form a queue for a particular copy of the item. The duration of the outage corresponds to the time required to "service" a request (i.e., the loan period). Having multiple copies of an item available corresponds to having multiple service facilities or multiple channels in a queueing process. The theory serving as the foundation for the results presented below is given in Appendix E.

Some delay time curves are shown in Figures F.1 and F.2. For these curves, it is assumed that the average loan time is two weeks and that an annual volume is loaned, rather than a single issue. Annual demand, as used consistently throughout this report, refers to the expected number of requests for all issues of a title which has been in existence for 10 previous years. If the title is a new one, the actual demand must be calibrated upwards, by using Table 2.6, to arrive at a "normalized" annual demand. For example, a title having 10 demands with one year of back issues is expected in 10 years to have an annual demand of 41 requests.

Figure F.1 shows expected (or average) delay time for the most recent annual volume, under the assumption that the volume must also be bound during this period, the binding period being the equivalent of two uses by borrowers. With 10 or less demands (as defined above) the average delay is only about two days if there is a single copy, and exceeds 10 days if the normalized annual demand exceeds 69. The reader must remember what is meant by normalized annual demand in interpreting this graph.

Figure F.2 shows average delay time for all issues of the title in the collection under the assumption that 10 years of issues are in

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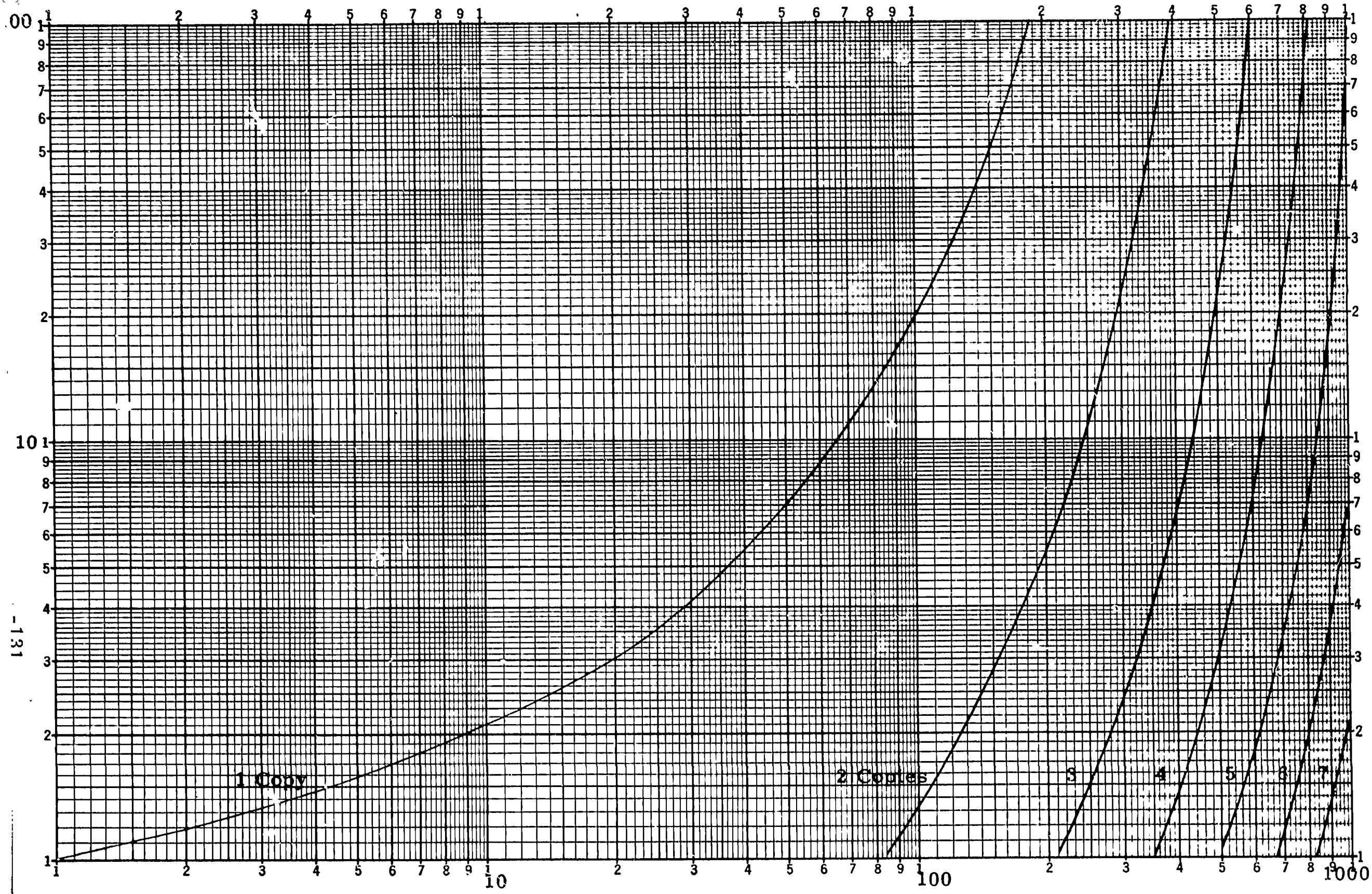

Figure F.1 Average delay in fulfillment due to annual volumes being on loan-most recent annual volume only.

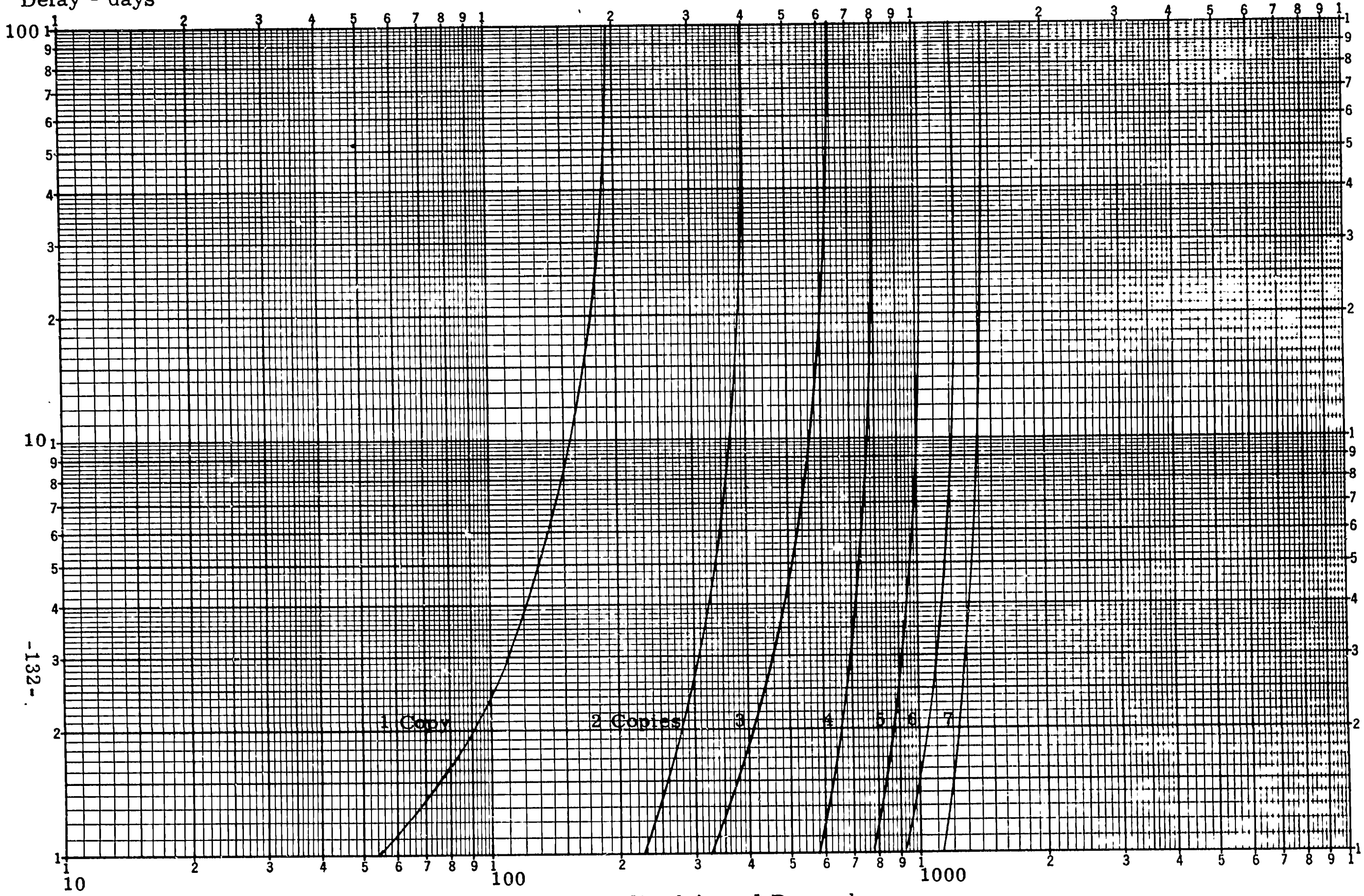

Figure F.2 Average delay in fulfillment due to annual volumes being on loan-average over 10 years of back issues

the collection. Since demand for the most recent annual volume is expected to be the highest, averaging over 10 years reduces the average waiting time over that shown in Figure F. 1.

It is clear that one can get along with fewer copies by employing one or more of the following expedients:

1. Photoduplicate rather than lend, in which case the time for processing through photoduplication replaces loan time in the queueing model.

2. Do not bind annual volumes, but loan individual issues, as is done by the National Lending Library. Thus, if a journal is published quarterly, an annual demand of 1000 for annual volumes is equivalent to an annual demand of 250 for separate issues. The resulting economies are clearly demonstrated by Figures 4.1 and 4.2.

3. Acquire additional copies which remain unbound and circulate separately until their age reduces demand to where a single bound copy will meet the demand. At that point, destroy the unbound issues.

4. Reduce the lending period, at the risk of failing to provide the service desired by borrowers.

The economic consequences of the above policies have not been examined, although it appears to be entirely feasible to do so.

Some data from the National Lending Library reflect experience in the provision of multiple copies to meet high demands for certain titles. The following numbers of multiple copies were under

subscription in 1966 among about 26 thousand active titles:

Two copies	1500
Three copies	345
Four copies	21

The policy of the National Lending Library is to loan for an average of about three weeks and to loan single issues rather than bound annual volumes.

F.2.3. Collection Coverage

The number of titles to be maintained in national lending library systems depends upon the objectives of the system and the assumptions made about the collections in the libraries to be served. It is sometimes assumed that there is a fairly large number of frequently used journals that are in "every" research library, and that the national system would therefore be asked for, and need collect, only those titles infrequently used in every library. This assumption, though, is contrary to the actual experience of both the National Lending Library in Great Britain and the National Library of Medicine in the United States. This experience shows that the titles most frequently requested from both institutions on loan, or in photocopy, are the same titles assumed to be in "every" research library. One possible explanation is that the common titles in large research libraries serving many disciplines are not common in the more numerous small and specialized libraries whose needs in adjacent and collateral fields, require what is most frequently used in those fields. Another explanation is that the high demand for local copies of the most frequently used titles in research libraries causes delay times that are longer than interlibrary borrowing or photocopying.

This experience indicates that a system intended to serve the nation, and on which every library could rely to provide what was not available locally, clearly requires comprehensive coverage that includes the most frequently used titles, including some in multiple copies, as well as those titles infrequently used in every library. As is shown by the curves in Figure 3.1, and by the figures above on the small number of titles needing duplication at the NLL, the difference in number of titles between a comprehensive collection and one covering only infrequently used titles is quite small in any case.

F.3 Costs

Only limited cost data have been collected on lending libraries, since an examination of such costs lies outside the scope of this study. However, even some gross cost comparisons may be informative.

Section 2.2 contained some speculations about the potential savings of local research libraries if a lending library system were available which could provide acceptable service. Such a system would, of course, cost money which should be subtracted from potential savings of local libraries if one is concerned with total costs to society.

Consider a library containing 50,000 active titles. The National Lending Library has about 31,000 current titles, so 50,000 titles may be overgenerous. On the other hand, a wider range of disciplines is anticipated. Fussler and Simon (5) estimated that there were 35,000 open serial titles at the University of Chicago, but many of these were in the humanities. The number of titles to be stocked depends upon one's objectives.

Suppose the annual demand stabilizes at about 2.5 million requests. Then, if one can rely on the experience of the National Lending Library, something less than 10,000 multiple-copy subscriptions would be needed, so that total annual subscription costs (using midrange subscription prices) might amount to about $1 million. (Currently, the N.L.L. is spending about $0.75 million on literature and binding).

One might plan a capitalization cost of roughly five times that figure for acquisition of back issues and establishment of records. Maintenance costs, using low figures from the surveyed libraries, could amount to about $720 thousand per year, exclusive of storage costs.

Good data are not available on cost because no comparable system exists in the United States. An indication of costs, however, can be obtained from the National Lending Library which, in March 1968, had a total of 177 non-industrial employees, of which 37 were "Scientific and Experimental Officer grades" and 45 (including 16 part-time) were industrial grades. With this staff, all of the activities of the Library were conducted, including the lending of around 600,000 items annually. The proportion of that staff attributable to lending activities is unknown.

Total staff cost per item lent by the National Lending Library in 1967-68 amounted to about $0.85 in equivalent U.S. dollars. Some further economies due to volume could be expected in going from 600,000 requests to 2.5 million, but one must also adjust for differences in wage scales and other costs between the United Kingdom and the United States. Perhaps one should double the N.L.L. cost per item lent to establish a target figure of $1.70 for a comparable lending library system in the United States. If so, annual operating costs would amount to about $5.25 million for labor and subscription

costs for 2.5 million requests. Maintenance could easily amount to another million, and start-up capitalization costs amortized over ten years would add about another $.6 million something like $6.85 million might be a target annual operating cost for a U.S. system.

If one is concerned with savings to society from a national lending system he should estimate total savings in operating costs by research libraries, in the manner of Section 2, less this annual operating cost of $6.85 million, if that is, in fact, a reasonable figure. At this stage of investigation it is sheer speculation as to what the total savings might be. However, if we use the data from Table 2.10, converted to an annual saving per title per year of, say, $40, only a small percentage reduction in serials intake by research libraries because of the system would be required to realize significant total savings.

There are hidden savings in addition. The typical university research library could save a substantial portion of its interlibrary lending costs. Also, its borrowing costs would be less. The experience of the N.L.L. has shown that, as users develop confidence that the wanted item is in the N.L.L. collection, requests come directly to the N.L.L. rather than through intermediate libraries. Also, less researching is done to determine which libraries may have the item - it is taken on faith that the item will be in the lending library.

APPENDIX G

COST MODELS FOR POLICIES CONCERNING A PARTICULAR SERIAL TITLE

G. 1. Introduction

The purpose of this appendix is to derive equations which quantitatively describe how the cost associated with the ownership and handling of a particular serial title varies with a number of alternative policies, such as: (1) whether to acquire a serial title, (2) whether to weed older copies of the title and, if so, at what age, (3) whether to purchase back issues of a title, and so on. By comparing the costs from the various alternative policies, one can determine which policy is least costly.

G. 2 The Total Cost Associated with a Serial Title

G. 2. 1. The Present Value of a Policy - General

The total cost associated with a serial title will be expressed as the discounted cost flow over the planning period, that is, the present value. Let the planning period be T years and let t denote a year during the planning period where t satisfies the following convention: the present year will correspont to t = 0 and the last year of the planning period will correspond to t = T - 1. Costs and demands occurring during a given year will be treated as though they all occurred at the beginning of the year. In the case of costs, one can visualize this treatment as corresponding to setting up a fund at the beginning of the year to cover all costs incurred during that year. (Similarly an annual volume* published during the present year has a value of age, a , equal to zero; an annual volume published last year has a value of age, a equal to 1, and so on).

Furthermore, let C_t denote the costs incurred in year t and let C denote the present value of all costs incurred over the planning period discounted at annual interest rate of i. Then C is given by

$$C = \sum_{t=o}^{T-1} \frac{C_t}{(1+i)^t} \qquad (G\text{-}1)$$

G. 2. 2. Contributions to the Annual Cost, C_t

The cost incurred in year t of the planning period, C_t, is the sum of a number of component costs and may be expressed as follows:

---

*All of the issues of a title published during one year.

$$C_t = I_o\,\delta(a_o - t) + A_t + S_t + W_t + U_t + B_t - R_T\,\delta(t - T) \qquad (G\text{-}2)$$

where

I_o = the initial cost of acquiring and cataloging a new title. This cost is incurred only during the first year of the planning period when $t = 0$.

$\delta(x)$ = the Kronecker delta function which assumes the value of 1 when x equals zero and a value of 0 otherwise, x being the year in which the title was ordered $(a_o - t)$ or "salvaged" $(t - T)$.

a_o = the age of the oldest annual volume of a particular title at the beginning of the planning period $(t = 0)$.

A_t = the costs incurred in year t which are independent of how many annual volumes of the title are held by the library and include the subscription cost, the overhead and administrative costs, and the maintenance costs, (viz., check-in, claiming, binding, marking, and bindery costs). $A_t = M_t + P_t$ (defined below).

M_t = maintenance cost in year t.

P_t = subscription cost (purchase cost) in year t.

S_t = the storage cost in year t.

W_t = the weeding cost in year t. This includes the cost of catalog revisions indicating the new status of the remaining annual volumes of the title held by the library in year t.

U_t = the cost of using volumes of the title held at the library in year t. This includes the cost of circulating, reshelving, and shelf maintenance due not only to inhouse use but interlibrary loan usage as well.

B_t = the cost of borrowing from an external source volumes of the title not held by the library in year t. This cost may include a penalty cost for the delay in request fulfillment.

R_T = the residual value or salvage value of volumes of the title held by the library at the end of the planning period. This cost is incurred only in the last year of the planning period.

Equation (G-2) accounts for all cost components and, therefore may be used to consider any number of alternatives. When an alternative is considered where some of the components are missing, then the corresponding cost is zero. For example, if (G-2) is applied to a title presently held by the library, then I_o, the cost of acquiring and cataloging the title in t = 0, the first year of the planning period, is zero. If (G-2) is applied to a title not presently held by the library, and the library considers the cost of not acquiring the title, the only non-vanishing terms would be B_t, the cost of borrowing volumes of the title from an external source.

G. 3 Development of Models for Annual Cost

Most of the terms on the right hand side of Equation (G-2) depend on which annual volumes are held by the library. Before deriving expressions for these terms, it is convenient first to obtain expressions for a number of quantities related to the number of volumes held by the library, and second to use these expressions to develop equations for the cost terms appearing in Equation (G-2).

In the following development we shall first derive expressions for the following quantities: (1) the age of the oldest and youngest annual volume held by the library, (2) the number of annual volumes held by the library in a specified year, (3) the number of annual volumes weeded in a specified year, and (4) the demand in a specified year for annual volumes either held or not held by the library. We shall then use these results to develop expressions for the terms appearing in Equation (G-2).

G. 3. 1 The Age of the Oldest Annual Volume held in the Library in Year t, α_t^+

Let a_o be the age of the oldest annual volume of a particular title at the beginning of the planning period. If no annual volumes are weeded during this period up to year t, then the age of the oldest volume held by the library in year t will be $a_o + t$. However, if annual volumes are weeded when their age exceeds a_c, then the age of the oldest annual volume will be either a_c or $a_o + t$, whichever is the smaller. If we let α_t^+ be the age of the oldest annual volume in year t, then we may write

$$\alpha_t^+ = \min (a_c, a_o + t) \qquad (G-3)$$

Alternately, Equation (G-3) may be expressed as follows:

$$\gamma_t^+ = \begin{cases} a_o + t & t \leq a_c - a_o = \pi \\ a_c & t \geq a_c - a_o = \pi \end{cases} \qquad \text{(G-3a)}$$

The quantity a_c is called the cutoff age. Annual volumes whose age exceeds the cutoff age will be weeded from the library.

G. 3. 2 The Age of the Youngest Annual Volume Held by the Library In Year t, α_t^-

For a title held by the library whose subscription is maintained over the planning period, the age of the youngest annual volume of the title held by the library will be 0 for all years. If α_t^- denotes the age of the youngest annual volume in year t, then

$$\alpha_t^- = 0 \text{ if the subscription maintained.} \qquad \text{(G-4)}$$

Suppose, however, that the subscription is terminated at the beginning of the planning period and no annual volumes are weeded during the period up to year t. Then the youngest annual volume will be one year older each year, that is

$$\alpha_t^- = t \text{ if subscription terminated on beginning of planning period.} \qquad \text{(G-5)}$$

If weeding out is permitted, then instead of Equation (G-5) it follows by an argument similar to that leading to Equation (G-3) that:

$$\alpha_t^- = \min (t, a_c) \qquad \text{(G-6)}$$

G. 3. 3 The Number of Annual Volumes Held By The Library in Year t, α_t

Assuming that the library holds all of the annual volumes between the youngest and the oldest, then the number of annual volumes held by the library in year t and denoted by α_t is given by:

$$\alpha_t = \sigma_t^+ - \sigma_t^- + 1 \qquad \text{(G-7)}$$

Two special cases of Equation (G-7) will be used in the following development. The first case is one in which a subscription for the title is maintained over the entire planning period and Equation (G-4) applies. Then from Equations (G-3) and (G-7) we obtain:

$$\alpha_t = \sigma_t^+ + 1 = \min (a_c, a_o + t) + 1 \qquad \text{(G-7a)}$$

(subscription maintained)

The second case is the one where the subscription for a title held by the library is terminated in the first year of the planning period and no old volumes are weeded during the planning period. Here Equation (G-5) applies and Equations (G-3) and (G-4) yield:

$$\alpha_t = a_o + 1 \qquad \text{(G-7b)}$$

(subscription terminated in year t = 0)

G. 3. 4 The Period of Growth of the Number of Annual Volumes, π

If the original number of annual volumes, a_o, equals or exceeds a_c, the library will hold a_c annual volumes over the planning period, and the number of annual volumes will never increase. In this case the period of growth of the number of annual volumes is zero. On the other hand, if a_o is less than a_c, the number of annual volumes will grow until α_t equals a_c,

i.e., until $a_o + t = a_c$. In this case the period of growth is $\pi = a_c - a_o$. Of course π would exceed T, but we are only concerned out to T. In general, therefore, the effective period of growth of the number of annual volumes is given by:

$$\pi = \min (a_c - a_o, T) \qquad \text{(G-8)}$$

G.3.5 Number of Annual Volumes Weeded in Year t, w_t

The cutoff age a_c is equal to the maximum number of annual volumes of the title that will be held by the library. Consequently as long as the number of annual volumes is less than a_c, the number of annual volumes will be permitted to increase and no weeding will be required. However, as soon as the number of annual volumes exceed a_c, one annual volume (the oldest) will be weeded each year. In other words, if a_o, the number of annual volumes at the beginning of the planning period, is less than or equal to a_c, the number of annual volumes weeded in year t, w_t, is given by:

$$w_t = \begin{cases} 0 & \text{if } a_o + t \leq a_c,\ a_o \leq a_c \\ 1 & \text{if } a_o + t > a_c,\ a_o \leq a_c \end{cases} \qquad \text{(G-9)}$$

If the above equation is expressed in terms of the growth period $\pi = \min (a_c - a_o, T)$, then

$$w_t = \begin{cases} 0 & t \leq \pi,\ a_o \leq a_c \\ 1 & t > \pi,\ a_o \leq a_c \end{cases} \qquad \text{(G-9a)}$$

On the other hand, if a_c is less than a_o, weeding $a_o - a_c$ annual volumes will be required in the initial year of the planning period and one copy will be weeded each year thereafter. The number of annual volumes

weeded in year t in this case is given by:

$$w_t = \begin{cases} a_o - a_c & t = 0,\ a_o > a_c \\ 1 & g > 0,\ a_o > a_c \end{cases} \qquad \text{(G-9b)}$$

The weeding that takes place in year t = 0 will be called "initial weeding".

Equations (G-9a) and (G-9b) may be combined into a single equation. First let w* be the initial number of copies weeded. Then

$$w^* = \max (0,\ a_o - a_c) \qquad \text{(G-10)}$$

We may say that w* annual volumes are always weeded in year zero, and that one annual volume is always weeded when $t \geq \pi + 1$. Consequently, the number of annual volumes weeded in year t is always given by

$$w_t = w^* \delta(t) + H(t - \pi - 1) \qquad \text{(G-11)}$$

where $\delta(t)$ is the Kronecker delta function defined earlier and H(x) is the Heaviside function defined to be zero for $x < 0$ and one for $x \geq 0$.

If a weeding policy is adopted it may be desirable to weed less frequently than once a year. For example, it may be desirable to weed once every five years. One can still apply the above equation tothis situation as will be discussed later under weeding costs.

G. 3. 6 The Demand in Year t for Annual Volumes Whose Age Exceeds α, $D_t(\alpha)$

The demand in year t for annual volumes whose age in year t is equal to k is given by

$$d_t(k) = d_o r^k p^t \qquad \text{(G-12)}$$

where p is a factor which accounts for the fact that the demand may increase with time due to the fact that the population of users and advertising effectiveness may increase with time, d_o, is a parameter which measures the general intensity of demand for the serial title, and r is a parameter which measures the rate of obsolescence of the serial title. The demand in year t for annual volumes whose age in year t exceeds α, denoted by $D_t(\alpha)$, is the sum of the demands over annual volumes with ages exceeding α:

$$D_t(\alpha) = \sum_{k=\alpha+1}^{\infty} d_t(k) \qquad \text{(G-13)}$$

Substituting Equation (G-12) into Equation (G-13) and performing the summation yields

$$D_t(\alpha) = D_o\, p^t\, r^{\alpha+1} \qquad \text{(G-14)}$$

where

$$D_o = \frac{d_o}{1 - r} \qquad \text{(G-15)}$$

If we consider the age of the title to be α_t^* in year t then the demand in year t for all annual volumes is given by:

$$D_t(-1) - D_t(\alpha_t^*) = \sum_{k=o}^{\alpha_t^*} d_t(k) \qquad \text{(G-16)}$$

G. 3. 7 The Demand In Year t For Annual Volumes Held By The Library, D_t^+

Since α_t^- is the age of the youngest annual volume held by the library and α_t^+ is the age of the oldest annual volume, it follows that the demand in year t for annual volumes held by the library, D_t^+, is given by:

$$D_t^+ = D_t(\alpha_t^- - 1) - D_t(\alpha_t^+) \qquad \text{(G-17)}$$

Two special cases of Equation (G-17) will be considered. The first case involves maintaining the subscription for the title over the entire planning period. Here Equation (G-4) applies so that Equations (G-17) and (G-14) yield

$$\begin{aligned} D_t^+ &= D_t(-1) - D_t(\alpha_t^+) \\ D_t^+ &= D_o p^t - D_o p^t r^{\alpha_t^+ + 1} \end{aligned} \qquad \text{(G-17a)}$$

(subscription maintained)

The second case involves terminating the subscription in the first year of the planning period and retaining the old volumes over the entire planning period. Here Equation (G-5) applies and $\alpha_t^+ = a_o + t$ so that Equation (G-17) becomes

$$\begin{aligned} D_t^+ &= D_t(t-1) - D_t(\alpha_t^+) \\ D_t^+ &= D_o(pr)^t - D_o p^t r^{a_o + t + 1} \end{aligned} \qquad \text{(G-17b)}$$

(subscription terminated in year t = 0)

G. 3. 8 The Demand in Year t for Annual Volumes Not Held By The Library, D_t

Annual volumes not held by the library consist of two types, those whose ages are less than α_t^-, and those whose age exceeds α_t^+. The demand in year t for annual volumes not held by the library, denoted by D_t^-, is given by:

$$D_t^- = D_t(-1) - D_t(\alpha_t^*) - D_t(\alpha_t^- - 1) + D_t(\alpha_t^+) \qquad \text{(G-18)}$$

Notice that the sum of D_t^+ and D_t^- equals $D_t(-1)$, the demand in year t for all annual volumes.

Two special cases of Equation (G-18) will be considered. The first case, which involves maintaining the subscription over the planning period so that $\alpha_t^- = 0$. Here Equations (G-18) and (G-14) produce

$$D_t^- = D_t(\alpha_t^+) - D_t(\alpha_t^*) = D_o p^t r^{\alpha t^+ + 1} - D_o p^t r^{\alpha t^* + 1} \quad \text{(G-18a)}$$

The second case involves terminating the subscription in the first year of the planning period and retaining all old volumes over the planning period. Here Equation(G-5) applies so that Equations (G-18) and (G-14) become:

$$D_t^- = D_t(-1) - D_t(\alpha_t^*) - D_t(t-1) + D_t(\alpha_t^+)$$

$$= D_o p^t - D_o p^t r^{\alpha_t^* + 1} - D_o (pr)^t + D_o p^t r^{\alpha_t^+ + 1} \quad \text{(G-18b)}$$

G.3.9 Usage Costs of Annual Volumes Held By The Library in Year t, U_t

The cost of using annual volumes of the title held by the library in year t, depend on the demand for these annual volumes and the cost of satisfying such demand. Let c_{ut} denote the cost of satisfying a request for an annual volume held within the library in year t. Since the demand in year t for annual volumes held by the library is D_t^+, the usage cost of annual volumes held by the library in year t, U_t, is simply:

$$U_t = c_{ut} D_t^+ \quad \text{(G-19)}$$

The cost c_{ut} depends on the cost of satisfying internally generated requests for volumes held at the library, c_{uit}, the cost of satisfying an externally generated request (interlibrary loan request) for volumes held at the library c_{uet}, and the fraction of requests which are

interlibrary loan requests, f, according to the equation

$$c_{ut} = (1 - f)\, c_{uit} + f\, c_{uet} \qquad \text{(G-20)}$$

G. 3. 10 Usage Costs Of Annual Volumes Not Held By The Library In Year t, B_t

The cost of borrowing annual volumes of titles not held by the library in year t depends on the demand for these annual volumes and the cost of satisfying a demand. Let c_{bt} denote the cost of satisfying a request for an annual volume not held by the library in year t. A penalty cost for the delay in satisfying the request may also be included in c_{bt}. Since the demand in year t for annual volumes not held by the library is $\bar{D}_t$, the borrowing cost of annual volumes not held by the library in year t, B_t, is:

$$B_t = c_{bt}\, \bar{D}_t \qquad \text{(G-21)}$$

The Storage Cost in Year t, S_t

Let c_{vt} be the cost of storing an annual volume in year t. Then the storage cost for storing the α_t annual volumes held by the library in year t is given by the equation:

$$S_t = c_{vt}\, \alpha_t \qquad \text{(G-22)}$$

The Weeding Cost in Year T, W_t

Let c_{wt} be the cost of weeding an annual volume. The weeding cost in year t is the product of c_{wt} and the number of annual volumes weeded in year t:

$$W_t = c_{wt}\, w_t \qquad \text{(G-23)}$$

G. 3. 11 The Effect Of Inflation On Costs

Costs for both labor and materials have been steadily rising

over the years. If j is the amount rate of inflation, then the cost in one year exceeds the cost in the previous year by a factor of (1 + j). As a result of this fact, the costs in year t introduced above may be expressed as follows:

$$M_t = M_o (1 + j)^t \qquad \text{(G-24)}$$

$$A_t = A_o (1+j)^t \qquad \text{(G-25)}$$

$$c_{ut} = c_{uo} (1 + j)^t \qquad \text{(G-26)}$$

$$c_{bt} = c_{bo} (1 + j)^t \qquad \text{(G-27)}$$

$$c_{vt} = c_{vo} (1 + j)^t \qquad \text{(G-28)}$$

$$c_{wt} = c_{wo} (1 + j)^t \qquad \text{(G-29)}$$

G. 4 A Model for the Present Value

In Section G. 3 expressions were derived for the components of the annual cost.

In this section these expressions will be combined to yield a detailed expression for the present value. If Equations (G-19) through (G-29) are substituted first into (G-2) and the result substituted into (G-1), one obtains the following result:

$$C = I_o - \frac{R_T}{(1+i)^T} + A_o \sum_{t=o}^{T-1} \theta^t + c_{vo} \sum_{t=o}^{T-1} \alpha_t \theta^t + c_{wo} \sum_{t=o}^{T-1} W_t \theta^t + c_{uo} \sum_{t=o}^{T-1} D_t^+ \theta^t + c_{bo} \sum_{t=o}^{T-1} D_t^- \theta^t \qquad \text{(G-30)}$$

where

$$\theta = \frac{1 + j}{1 + i} \qquad \text{(G-31)}$$

The last five terms in Equation (G-30) can be evaluated explicitly. The summation in the term involving A_o is a geometric series so that the present value of the annual expenses A_t is:

$$A_o \sum_{t=o}^{T-1} \theta^t = A_o \frac{1 - \theta^T}{1 - \theta} \qquad \text{(G-32)}$$

Now consider the present value of storage costs. The storage cost in year t depends on the number of annual volumes held by the library in year t, α_t, which in turn depends on whether or not the subscription for the title is maintained. First consider the case where the subscription is maintained and $a_o \geq a_c$. Here Equation (G-7a), holds so that:

$$\alpha_t = \begin{cases} a_o + t + 1, & t < a_c - a_o = \pi \\ a_c + 1 & t \geq a_c - a_o = \pi \end{cases} \qquad \text{(G-33)}$$

Therefore:

$$\sum_{t=o}^{T-1} \alpha_t \theta^t = \sum_{t=0}^{\pi-1} (a_o + 1 + t) \theta^t + \sum_{t=\pi}^{T-1} (a_c + 1) \theta^t$$

$$= H(\pi - 1) \left[(a_o + 1) \frac{1 - \theta^\pi}{1 - \theta} + \theta \left(\frac{1 - \theta^\pi}{(1 - \theta)^2} - \frac{\pi \theta^{\pi - 1}}{1 - \theta} \right) \right]$$

$$+ H(T-1-\pi) \left[(a_c + 1) \theta^\pi \frac{1 - \theta^{T-\pi}}{1 - \theta} \right] \qquad \text{(G-34)}$$

where H(x) is the Heaviside function defined by

$$H(x) = \begin{cases} 0 & x < 0 \\ 1 & x \geq 0 \end{cases} \qquad \text{(G-35)}$$

Therefore, the present value of storage costs is

$$c_{vo} \sum_{t=o}^{T-1} \alpha_t \theta^t = c_{vo} \left\{ H(\pi - 1) \left[(a_o + 1) \frac{1 - \theta^\pi}{1 - \theta} + \theta \left(\frac{1 - \theta^\pi}{(1 - \theta)^2} - \frac{\pi \theta^{\pi - 1}}{1 - \theta} \right) \right] \right.$$

$$\left. + H(T-1-\pi) \left[(a_c + 1) \theta^\pi \frac{1 - \theta^{T-\pi}}{1 - \theta} \right] \right\} \qquad \text{(G-36)}$$

(subscription maintained)

In the case where the subscription is terminated at the beginning of the planning period and no weeding takes place then Equation (G-5) and (G-7a) apply:

$$\alpha_t = a_o + 1 \text{ for all t.} \tag{G-37}$$

Consequently, the present value of the storage cost in this case is

$$c_{vo} \sum_{t=o}^{T-1} \alpha_t \theta^t = c_{vo} (a_o + 1) \frac{1 - \theta^T}{1 - \theta} \tag{G-38}$$

(subscription terminated)

Now let us consider the term for the present value of the weeding cost in Equation (G-30). Substitution of Equation (G-11) into this term produces:

$$c_{wo} \sum_{t=o}^{T-1} w_t \theta^t = c_{wo} w^* + c_{wo} \sum_{t=\pi+1}^{T-1} \theta^t$$

$$= c_{wo} w^* + H(T-\pi-2)\, c_{wo}\, \theta^{\pi+1} \frac{1 - \theta^{T-\pi-1}}{1 - \theta} \tag{G-39}$$

Now let us consider the present value due to borrowing costs, the last term on the right hand side of Equation (G-30). Two cases will be considered. The first case involves maintaining the subscription over the planning period so that Equation (G-18a) applies and $\alpha_t^+ + 1 = \alpha_t$, $\alpha_t^* = \alpha_o^* + t$ for

$$\sum_{t=o}^{T-1} D_t \theta^t = D_o \sum_{t=o}^{T-1} (p\theta)^t r^{\alpha_t} - D_o \sum_{t=o}^{T-1} (p\theta)^t r^{\alpha_o^* + t + 1} \tag{G-40}$$

In view of (G-3) we have

$$\sum_{t=o}^{T-1} D_t \theta^t = D_o \sum_{t=0}^{\pi-1} (p\theta)^t r^{a_o + 1 + t} + D_o \sum_{t=\pi}^{T-1} (p\theta)^t r^{a_c + 1}$$

$$- D_o \sum_{t=o}^{T-1} (p\theta r)^t r^{\alpha_o^* + 1} \tag{G-41}$$

$$= D_o r^{a_o+1} H(\pi-1) \frac{1-(p\theta r)^{\pi}}{1-p\theta r} + D_o r^{a_c+1} H(T-\pi-1)(p\theta)^{\pi} \frac{1-(p\theta)^{T-\pi}}{1-p\theta}$$

$$- D_o r^{\alpha_o^*+1} \frac{1-(p\theta r)^{T}}{1-p\theta r} \quad \text{(G-42)}$$

Hence the present value due to borrowing costs in this case is given by:

$$c_{bo} \sum_{t=o}^{T-1} D_t^{-} \theta^t = D_o c_{bo} \left[H(\pi-1)\, r^{a_o+1} \frac{1-(p\theta r)^{\pi}}{1-p\theta r} + H(T-\pi-1)\, r^{a_c+1} (p\theta)^{\pi} \frac{1-(p\theta)^{T-\pi}}{1-p\theta} \right.$$

$$\left. - r^{\alpha_o^*+1} \frac{1-(p\theta r)^{T}}{1-p\theta r} \right] \quad \text{(G-43)}$$

(subscription maintained)

The second case involves terminating the subscription in year t = 0 and retaining all old volumes over the entire planning period. In this case Equations (G-18b) and (G-7b) apply and

$$\sum_{t=o}^{T-1} D_t^{-} \theta^t = D_o \sum_{t=o}^{T-1} (p\theta)^t - D_o \sum_{t=o}^{T-1} (pr\theta)^t + D_o \sum_{t=o}^{T-1} (p\theta)^t r^{a_o+1+t}$$

$$- D_o \sum_{t=o}^{T-1} (p\theta r)^t r^{\alpha_o^*+1} \quad \text{(G-44)}$$

All terms on the right are geometric series. Consequently, the present value due to borrowing costs in this case is given by:

$$c_{bo} \sum_{t=o}^{T-1} D_t^{-} \theta^t = c_{bo} D_o \left[\frac{1-(p\theta)^{T}}{1-p\theta} + \frac{1-(p\theta r)^{T}}{1-p\theta r} (r^{a_o+1} - r^{\alpha_o^*+1} - 1 \right] \quad \text{(G-45)}$$

(subscription terminated in year t = o)

Now consider the term for the present value of the internal usage costs. For the case where the subscription is maintained over the entire planning period, Equation (G-17a) applies and

$$\sum_{t=o}^{T-1} D_t^{+} \theta^t = D_o \sum_{t=o}^{T-1} (p\theta)^t - D_o \sum_{t=o}^{T-1} (p\theta)^t \; r^{\alpha_t} \qquad \text{(G-46)}$$

Notice that on the right hand side the second term is given in Equation (G-42) and the first term is a geometric series. Consequently the present value of the internal usage cost in this case is given by:

$$c_{uo} \sum_{t=o}^{T-1} D_t^{+} \theta^t = D_o c_{uo} \left\{ \frac{1-(p\theta)^T}{1-p\theta} - H(\pi-1)\, r^{a_o+1} \frac{1-(p\theta r)^{\pi}}{1-p\theta r} - H(T-\pi-1)\, r^{a_c+1} (p\theta)^{\pi} \frac{1-(p\theta)^{T-\pi}}{1-p\theta} \right\} \qquad \text{(G-47)}$$

(subscription maintained)

The second case involves terminating the subscription in year t = o and retaining all old volumes over the entire planning period. In this case Equation (G-17b) applies and

$$\sum_{t=o}^{T-1} D_t^{+} \theta^t = D_o \sum_{t=o}^{T-1} (pr\theta)^t - D_o \sum_{t=0}^{T-1} (p\theta)^t \; r^{a_o+t+1} \qquad \text{(G-48)}$$

Solving the right hand side, the present value of the internal usage cost in this case is given by:

$$c_{uo} \sum_{t=o}^{T-1} D_t^{+} \theta^t = c_{uo} D_o (1 - r^{a_o+1}) \frac{1-(p\theta r)^T}{1-p\theta r} \qquad \text{(G-49)}$$

(subscription terminated in year t = o)

Finally we shall consider the term:

$$\frac{R_T}{(1+i)^T}$$

which represents the residual value or salvage value of volumes of the title held by the library at the end of the planning period discounted to the year t = 0. Again two cases will be considered.

In the first case the subscription for the title is maintained over the planning period so that at the end of the planning period the library will hold annual volumes whose ages are between 0 and α_T^+ (the age of the oldest annual volume of the title in year T). The salvage value of these annual volumes at the end of the planning period may be estimated by accumulating the discounted annual savings resulting from holding each annual volume until its age exceeds the cutoff age, a_c. The annual savings resulting from holding an annual volume beyond the end of the planning period is the cost that would be incurred if one had to borrow each request for the annual volume less the cost incurred due to holding the annual volume. The exact procedure is spelled out in the following paragraphs.

Consider a particular annual volume held by the library at the end of the planning period and let a denote the age of this annual volume. Then in year $t \geq T$, the age for this annual volume will be a + t - T, and according to Equation (G-12) the demand in year t for this volume is given by:

$$d_t(a + t - T) = d_o\, r^{a+t-T}\, p^t \qquad \text{(G-50)}$$

Therefore, the savings in year t = T resulting from holding this annual volume beyond the end of the planning period is given by:

$$\Delta_t(a) = c_{bt}\, d_t(a + t - T) - c_{ut}\, d_t(a + t - T) - c_{vt} \qquad T \leq t \leq T + a_c - a \qquad \text{(G-51)}$$

$$\Delta_t(a) = 0 \qquad t > T + a_c - a$$

This equation tells us that the annual savings for the annual volume whose age is a at $t = T$ equals: (1) the cost that would be incurred if one borrowed the annual volume for each request, less the cost of holding the annual volume and satisfying the requests internally when the age of the annual volume is less than or equal to the cutoff age, and (2) zero when the age of the annual volume exceeds the cutoff age. The weeding costs are assumed to be negligible in the first part of the expression.

The residual value of the annual volume whose age is a at the end of the planning period discounted to year T is given by:

$$r_T(a) = \sum_{t=T}^{\infty} \frac{\Delta_t(a)}{(1+i)^{t-T}} \qquad \text{(G-52)}$$

Substitution of Equations (G-51), (G-26), (G-27) (G-23) and (G-31), into Equation (G-52) yields:

$$\frac{r_T(a)}{(1+i)^T} = (c_{bo} - c_{uo}) \sum_{t=T}^{T+a_c-a} d_t(a+t-T)\,\theta^t - c_{vo} \sum_{t=T}^{T+a_c-a} \theta^t \qquad \text{(G-53)}$$

The above equation gives the residual value of annual volumes whose age is a at the end of the planning period discounted to year 0.

The first summation on the right hand side of Equation (G-53) can be obtained from Equation (G-50) as follows:

$$\sum_{t=T}^{T+a_c-a} d_t(a+t-T)\,\theta^t = d_o \sum_{t=T}^{T+a_c-a} r^{a+t-T} p^t \theta^t$$

$$= d_o\, r^a (p\theta)^T \frac{1-(p\theta r)^{a_c-a+1}}{1-(p\theta r)} \qquad \text{(G-54)}$$

Since the second sum on the right hand side of Equation (G-53) is a geometric series, Equation (G-53) can be shown to be

$$\frac{r_T(a)}{(1+i)^T} = \frac{(c_{bo} - c_{uo})\, d_o (p\theta)^T}{1 - rp\theta}\left[r^a - (rp\theta)^{a_c+1}\right] - \frac{c_{vo}\,\theta^T}{1-\theta}\left[1 - \theta^{a_c+1-a}\right] \qquad \text{(G-55)}$$

To obtain the residual value of all annual volumes held by the library at the end of the planning period discounted to year zero we must sum Equations (G-55) over the ages of annual volumes held by the library in year T. Recall that when the subscription is maintained, the age of the youngest volume in year T is zero and the age of the oldest volume in year T is α_T^+ given by Equation (G-7a). Therefore the residual value at the end of the planning period discounted to the present is given by:

$$\frac{R_T}{(1+i)^T} = \sum_{a=0}^{\alpha_T^+} \frac{r_T(a)}{(1+i)^T} \qquad \text{(G-56)}$$

Substituting Equation (G-55) into (G-56) yields

$$\frac{R_T}{(1+i)^T} = \frac{(c_{bo} - c_{uo})\, d_o (p\theta)^T}{1 - rp\theta}\left[\frac{1-r^{\alpha_T^+ + 1}}{1-r} - (\alpha_T^+ + 1)(rp\theta)^{a_c+1}\right] - \frac{(c_{vo}\,\theta^T)}{1-\theta}\left[\alpha_T^+ + 1 - \theta^{a_c+1}\left(\frac{1-\theta^{-\alpha_T^+ - 1}}{1-\theta}\right)\right]$$

(Subscription maintained) (G-57)

Equation (G-57) assumes that the residual value equals the annual savings from holding each annual volume beyond the end of the planning period. This is a reasonable salvage value provided the computed value does not exceed the market price of the retained annual volumes. If the value computed by Equation (G-57) exceeds the market price then the market price should be used.

In the second case the subscription for the title is terminated at the beginning of the planning period and no weeding takes place. In this case the youngest annual volume held by the library is at least T years old and will probably generate almost no demand. The residual value in this case therefore will be negligible so that

$$\frac{R_T}{(1+i)^T} = 0 \qquad \text{(G-58)}$$

(subscription terminated)

At this point all the terms on the right hand side of Equation (G-30) have been evaluated explicitly for two cases: subscription maintained, and subscription terminated in the initial year of the planning period. Consequently, the present value of costs incurred over the planning period may be computed for a number of alternative policies by means of Equation (G-30) and its terms which are given by Equation (G-32) through (G-49).