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AN OPERATIONS RESEARCH STUDY OF A VARIABLE LOAN AND DUPLICATION POLICY AT THE UNIVERSITY OF LANCASTER¹

MICHAEL K. BUCKLAND

ABSTRACT

The Library Research Unit of the University of Lancaster used an Operations Research (O. R.) approach to recommend changes in loan and duplication policies in the university library. The "variable" loan and duplication policy which was developed is described and also the considerable impact of implementation. Other libraries are now adopting this kind of policy. The work is presented as a case study in library O.R. The great importance of analyzing the structure of problems is stressed and the nature and usefulness of models is described. For the most useful results, suitable librarians should be included in the research team.

A library is a growing organism. [RANGANATHAN, *Fifth Law*]

The research and development activity within the University of Lancaster Library has concentrated on exploring, analyzing, and describing the interactions which take place in the provision and use of library services with the aim of providing an improved basis for making decisions about the way the library service is provided [1]. One of the topics we examined a few years ago was that of stock control—more specifically, loan and duplication policies. This has been chosen as a case study because it illustrates rather well the problems and possibilities of applying an O. R. approach in a library.

THE PROBLEM AREA DESCRIBED

During the winter of 1968 the university librarian felt dissatisfied with loan policies in force at that time.

¹ The work of the Library Research Unit was initiated and fostered by the university librarian, A. Graham Mackenzie. This case study would not have been completed without the O. R. expertise of Dr. A. Hindle. The encouragement and support of the Office of Scientific and Technical Information and the Council on Library Resources are gratefully acknowledged.

There had been complaints, and a "frustration survey" had shown that the main reason why users failed to find books was that they were out on loan at the time [2]. He therefore directed his research unit to examine the problem of loan policies and to prepare recommendations.

Every library has a loan policy of some kind, even if it is that no books may be removed from the library. University libraries commonly have several policies: some material may be confined to the library, some may be borrowed from a reserve collection for a few hours, the remainder usually for a longer period—the length of time permitted depending on the status of the borrower. Furthermore, there are also wide variations from library to library in terms of length of loan period, renewal policies, fine rates, and the administration of overdues.

This variety (and, indeed, changeability) seems to stem from the complex conflicts of interest involved and it is necessary to try to disentangle

these and examine the structure of the problem.

1. For the individual borrower a long loan period is desirable because it gives him greater freedom to retain a book at leisure without being bothered by overdue notices, fines and the need to bring it back. Another borrower might ask the library to recall this book, but this may not happen very often. He is, of course, quite free to return the book early—as soon as he has finished with it—but a long loan period is definitely more convenient for the individual borrower.

2. For everybody else this borrower's lengthy loan period is *inconvenient*, because there is always some probability that someone else may want that particular book. The longer the borrower retains it, the longer it is absent from the shelf and the less chance anyone else has of finding it immediately available when they want it. For everyone except the borrower, a *shorter* loan period is more convenient. The fact that every library user plays both the role of borrower and the role of "everybody else" does not remove this conflict of interest.

Now, although books can be made more readily available by inducing borrowers to retain them for relatively short periods only, five further complications arise.

3. The level of demand varies enormously from book to book or, to put it another way, the probability that a book will be sought while it is out on loan varies greatly. There is little justification for curtailing the loan of material which is unlikely to be asked for, but for material known to be in heavy demand there is a very good case for wanting borrowers to return their books quickly if the frustration of other

would-be borrowers is to be minimized. It does not make the librarian's task any easier that the probability that another reader will seek a book is not easy to assess.

4. Inducing the borrower to return a book soon is not the only way of reducing the frustration of other would-be borrowers because one can always provide another copy. Duplication is clearly an acceptable alternative strategy. However, it must be noted that although shorter loan periods and additional copies both increase the chances that a copy will be on the shelf, these policies differ in two important respects. First, shorter loan periods are definitely less convenient for the individual borrower, and to this extent undesirable. Second, the provision of duplicate copies uses up money and labor which the library could well have used for other purposes, such as another, *different* title. To this extent, duplication is also undesirable. The policy of providing different titles as deliberate alternatives in the event of failure to find the book originally sought is difficult to assess because little seems to be known about the "substitutability" of titles, especially in an academic environment.

5. If a book is not on the shelf then it can still be made available by means of a reservation and, if appropriate, by recalling it from the reader who has it. To the extent to which this is an acceptable substitute for immediate availability on the shelf, this arrangement reduces the importance of "immediate availability," and thereby permits longer loan periods and less duplication. Acceptability apart, this cumbersome procedure of reservation and recall is clearly unsuitable for those who are not seeking a specific title, but

are browsing, perhaps purposefully, for inspiration or amusement. If such a reader is browsing along the shelves, then it is clearly important that appropriate material should be on the shelves. Otherwise, unless he also browses in the catalogs, the reader will remain unaware of the existence of suitable material and the provision of procedures for reservation and recall will be irrelevant.

6. Administrative aspects must also be considered, since not all loan and duplication policies are equally easy to administer.

7. Similarly, it is essential to consider political aspects. It is not enough to devise loan and duplication policies: they have to be acceptable to the public served. In libraries, as in other public services, the users are, indirectly, the policy makers. It can be argued quite plausibly that the widespread practice of allowing more liberal loan privileges to faculty members than to undergraduates stems more from the power structure of universities than from any attempt by librarians to manage their resources effectively.

It will be quite clear from these observations that the wide variations in loan and duplication policies reflect quite complicated relationships involving a number of conflicting objectives. Any rational loan and duplication policy must be a considered compromise.

In order to clarify the roles of the various factors, the researchers at Lancaster adopted the strategy of relating each factor to the chances that a reader would find a copy of a book on the shelves when he wanted it. This can properly be regarded as a measure of library performance. We called it "satisfaction level." Apart from the number of copies held, the two critical

factors determining the satisfaction level of any given document are (1) the frequency with which the book is sought (its popularity); and, (2) the length of time it is off the shelves when used.

The basic relationship is in the following form:

a) *For any given loan period*, the chances of a reader finding on the shelves a copy of the book he seeks varies inversely with the popularity. The greater the popularity, the lower the satisfaction level; the less the popularity, the higher the satisfaction level (see fig. 1).

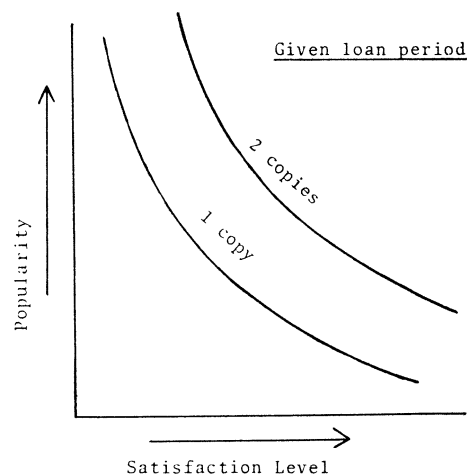


FIG. 1

b) *For any given popularity*, the length of the loan period and the satisfaction level are inversely related. The longer the loan period, the lower the satisfaction level; the shorter the loan period, the higher the satisfaction level (see fig. 2).

c) *For any given satisfaction level*, the popularity and the length of the loan period are necessarily also inversely related. The greater the popularity, the shorter the loan period has

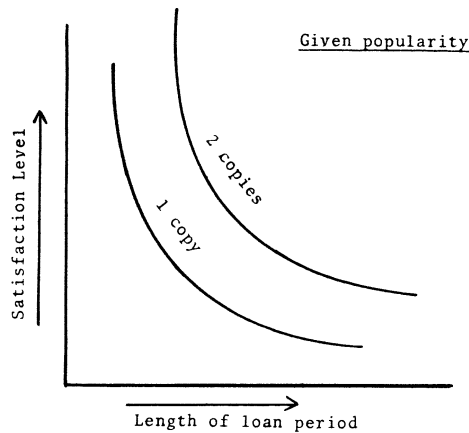


FIG. 2

to be; the less the popularity, the longer the loan period can be (see fig. 3).

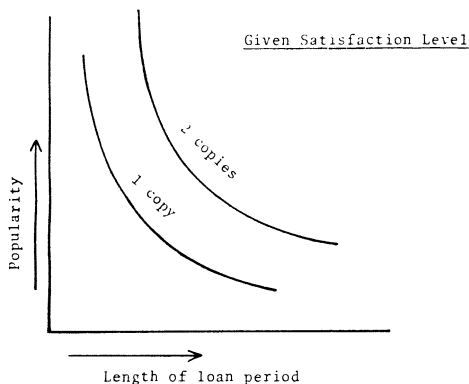


FIG. 3

d) *Increasing the number of copies* available, like shortening the length of loan periods, increases satisfaction level. To this extent, it is an alternative strategy. The relationship can be seen in figures 1–3 by comparing the curve for one copy with the curve for two copies.

These relationships have been described in some detail because they lead to a most significant conclusion.

If the library is intended to make documents available and if promptness is a virtue, then *the cardinal rule of library stock control is that both the loan period and the duplication policy should be related to the level of demand for the title and to each other.*

In presenting this case study, the careful analysis and description of the problem area has been stressed not only because it sets the scene but also because this process constitutes the first and possibly the most important feature of the O. R. approach. A significant aspect of this systems analysis is the pinpointing of the need to develop measures of performance where these do not already exist.

MEASUREMENT

Exploring the structure of a problem is a necessary first stage in O. R. It is also necessary to make measurements and calculations in order to add proportion and precision to the relationships which have been perceived in a rather subjective manner—and, at some stage, their validity needs to be checked. It is at this stage that the skill of the professional librarian in collecting data and the technical mathematical expertise of the professional O. R. scientist become important. The details of the data collection and the calculations involved in this case study have been reported elsewhere [3, 4] and need only be summarized briefly here.

DATA COLLECTION

In addition to the collection of data relating to the way in which demand was spread over the book stock, surveys relevant to two neglected aspects of librarianship were made.

1. What effect does the official loan

period have on the length of time books are kept out? Circulation data from a number of universities showed that there is a marked tendency for books to be kept out until they are due back. There was little evidence that the status of the borrower or the subject matter of the book had any relevance.

2. What effect does the official loan period have on the frequency of renewal? It had been suggested that if loan periods were reduced in an attempt to increase satisfaction level, the users would respond by renewing their loans more often. If so, the time the book is off the shelves would remain the same. Satisfaction level would remain unchanged and a great deal of bureaucratic inconvenience would have been caused to library and user alike. Data on the actual frequency of renewal in various circumstances indicated that the great majority of loans were not renewed and that the status of the borrower, the subject matter of the book, and the length of the official loan period had little effect on the frequency of renewal.

These findings are highly significant. *They mean that the librarian has, in his ability to determine official loan periods, a powerful and precise control device for influencing the availability of the books in his library.* They permit us to predict how long books will be kept out under any given loan policy.

CALCULATION

By this time the necessary ingredients were available for making some numerical calculations. These were done in three stages:

1. The proportion of books at various levels of demand was estimated from circulation data. This had predictable affinities with the Bradford-Zipf distribution which seems to pervade library matters [5, 6].

2. The precise effect on satisfaction level had to be computed for any given combination of (a) length of loan, (b) amount of in-library use, (c) number of copies, and (d) probability that a reader will ask for it to be reserved or recalled if he cannot find it for each level of demand. Table 1 illustrates the form of result which emerged.

There are at least two ways of performing these particular calculations. At Lancaster they were done by simulating the borrowing process repeatedly on a computer to see what happened (Monte Carlo simulation). Morse has described in some detail how they can be done analytically by means of queuing theory [7]. Either way, this illustrates another essential feature of O. R. These most useful calculations could only be done by means of a model of the process involved. In the one case, this model is a logic diagram flow charting what could happen and used in conjunction with various estimates

TABLE 1
ESTIMATED SATISFACTION LEVELS FOR VARIOUS COMBINATIONS OF LOAN PERIOD, DEGREE OF DUPLICATION, AND LEVELS OF POPULARITY (%)

OFFICIAL LOAN PERIOD	NO. OF COPIES	ESTIMATED SATISFACTION LEVEL FOR BOOKS AT EACH OF FIVE LEVELS OF POPULARITY				
		A	B	C	D	E
5 weeks	1	52	62	72	82	97
5 weeks	2	84	91	97	99	100
1 week	1	90	94	98	99	100

of the chances that what might happen will happen. In the other case, the model is in the form of algebraic equations in which the values of various factors can be varied experimentally. *Without such models, one cannot predict the consequences of hypothetical changes and the data collection would be a much more sterile exercise.*

3. Given an estimate of the effect of any particular loan and duplication policy on material at each popularity level, and given an estimate of the amount of material at each popularity level, the overall satisfaction level of the library as a whole could be estimated. The University of Lancaster Library was estimated to have had a satisfaction level of about 60 percent during the session 1967–68. In other words, we judged that a user seeking open-shelf material was finding it about six times out of ten. The impact that a selection of other loan and duplication policies would have had on satisfaction level was also estimated.

So far discussion has been in terms of users seeking specific items. Since users also browse more or less purposefully, the effects of loan and duplication policies on the quality of service provided for browsers was also examined. Let us consider what happens when the user of a typical university library browses rather vaguely for “something on economics.” What are the characteristics of the array of documents available on the shelves? First, the library staff will probably have removed all the strongly recommended books and put them in a reserve collection—perhaps on closed access. Second, other recommended or popular books are likely to be out on loan. Those which are little recommended and little used, however, are much

more likely to be present. In brief, the array of documents made available to the browser is likely to be systematically biased toward the least recommended and the least used. This “collection bias” can be measured readily in terms of, for example, the 10 percent most popular books which are off the shelves at any given time. At Lancaster, at that time, there were three return dates a year for undergraduates and one only for postgraduates and teaching staff. We estimated that 45 percent of these popular books would be off the shelves. Since the effect of alternative loan and duplication policies on the satisfaction level of material at each popularity level can be estimated, the impact on collection bias could also be assessed.

Other calculations were used to assess the administrative costs likely to be incurred by alternative policies, but these were subsidiary to the critical element. This was the indispensable use of a model to predict what would have happened with other policies without having to actually implement them experimentally.

DECISION

The effects of the policies then in force had been analyzed in terms of satisfaction level, collection bias, and administrative cost, and compared with the effects of a selection of alternative policies. In order to reach a decision, it was necessary to make a series of value judgments concerning the relative importance of these measures and other relevant factors. For example, if satisfaction level were at 60 percent, by how much ought it to be increased and at what point would improvement become too expensive?

As a basis for informed judgment,

the research unit prepared a memorandum for the librarian, setting forth alternative ways of raising satisfaction level to about 80 percent and reducing collection bias to 20 percent or less. These included:

A. No change in loan policies but enough systematic duplication to achieve the desired standards. Estimated cost of duplication £10,000–£15,000 (\$24,000–\$36,000) initially and £2,000 (\$4,800) recurrently.

B. Staff and graduate students, four return dates a year; undergraduates, two weeks; renewals permitted. Although traditional, policies based on the status of the borrower are rather inefficient from the point of view of stock control—and, arguably, inequitable. This particular policy would have achieved an estimated satisfaction level of 73 percent and a collection bias of 32 percent.

C. A variable loan policy, whereby the most popular books are subject to a shorter loan period regardless of the status of the borrower. Numerous permutations are possible. One was that about 10 percent of the stock should be subject to a one-week loan period, the rest would have four return dates a year. This was expected to raise satisfaction level to 86 percent and reduce collection bias to 8 percent.

After intensive discussion of both principles and practicalities, the librarian prepared a revised memorandum² for the university's Library Committee, which approved his recommendation that the variable loan period be adopted whereby about 10 percent of the stock would be subject to a one-week loan period. The loss of faculty privilege,

²This memorandum is reprinted in [2, pp. 50–53].

the avoidance of high expenditure on duplication as in solution A, the expected improvement in the standards of library service, and doubts about whether the change would be acceptable, were all considered.

Although this O. R. study had analyzed and quantified the issues involved to an unprecedented degree, the decision-making process still involved subjective judgments. The contribution of the study had been to provide better information on many, but not all, of the issues involved.

CONTROL

A number of administrative changes had to be made in order to implement the new system. The key problem was that of deciding which books were the most popular ones. It was decided to base decisions directly on past usage as recorded on the date label attached inside each book, as suggested by Fessler and Simon [8]. Clerical labor "monitored" 70,000 monographs and, if appropriate, reprocessed them with distinctive markings. This took 2½ days and cost £110 (\$264) plus supervision.

A particularly important feature of a variable loan and duplication policy of this type is that it presupposes repeated monitoring at intervals to ensure that the items made subject to a one-week loan period are in fact the most popular ones. This has a significance which goes far beyond the reluctant acceptance of yet another clerical routine, because the recurrent monitoring of the stock is in effect a matter of using feedback to make the library provision continuously responsive to changes in the pattern of demand. In engineering terminology, this constitutes a self-adaptive stock con-

trol system. If the demand on a particular section of the library increases, then the proportion of material subject to a one-week loan will increase, thereby maintaining satisfaction level and collection bias, albeit at a cost in terms of increased inconvenience through an increased proportion of one-week loans. As the popularity of a section declines, the proportion of material subject to a one-week loan period also declines, to the greater convenience of the reduced number of users who still borrow from this section.

Duplication policies are inseparable from loan policies and merge particularly well in the context of a variable policy. The effect of increasing the number of copies is to reduce the level of demand on each copy, which in turn determines the loan period for that copy. A situation of steadily rising demand would be signaled by an increase in the proportion of books subject to a one-week loan period and in the proportion of borrowings which is for material subject to a one-week loan period. If the librarian considered that these proportions were becoming higher than was suitable for the convenience of his users, then he could increase his expenditure on duplicates. This would have the effect of reducing the level of demand on individual copies and thereby eventually reducing the proportion of one-week borrowing. In this manner the librarian has a continuous and objective indication of the adequacy of duplication in relation to specified standards of service. Furthermore, titles suitable for duplication can be identified during the monitoring process.

This illustrates the key concept of feedback, which needs to develop in

step with automation. An automated circulation control system harnessed to a policy of this kind and a clear concept of management information would be much more than an electronic location indicator.

IMPACT

Implementation of the new policy was followed by a dramatic increase in library use. After six months, a survey of users' opinions revealed a widespread opinion that the effects had been good. After one year, the stock was extensively remonitored to adapt to the large increase in demand. This was followed by a further substantial increase in library use. It may be a few years before provision and demand stabilize. It should be stressed that library use per capita had always been unusually high, nonetheless borrowing from the open shelves has increased by 200 percent over two years, although the user population had only increased by 40 percent.

Since an increase of this magnitude had not been expected, it highlighted a gap in our understanding of user behavior. The calculations had not allowed for it: the models were incomplete. This has led the research unit to concentrate much more on the development of more detailed models of user behavior. This is necessary if library-user interactions are to be better understood.

A feature of O. R. is that there is considerable emphasis on explicit, objective description. This facilitates the communication and, therefore, the impact of ideas. So far four British university libraries have announced the adoption of a variable policy for some or all of their collections.

REFLECTIONS ON O. R.
IN LIBRARIES

Five years of active involvement in this type of work at the Lancaster University Library Research Unit leads naturally to a number of reflections on O. R. in libraries and the relationships between librarians and professional O. R. scientists. The views expressed are highly personal ones. The viewpoint is that of a librarian based inside a library but privileged to be working with O. R. experts.

The key problem lies in analyzing the structure of library problems. Without this little progress can be made. The *responsibility* for doing this rests entirely on the shoulders of the librarian. It is the essence of management in a library, as elsewhere, *but* a professional O. R. expert, especially one with previous experience of O. R. in social services, can make an enormous contribution as a stimulus and catalyst in clarifying the issues involved. This is the most important role of a professional O. R. expert and can, in itself, have remarkable consequences [9]. The sophisticated mathematical techniques associated with O. R. play a less important role. Every project needs access to this expertise but it is not always needed and can hinder effective dialogue between O. R. experts and librarians.

The personality of the chief librarian is important, since O. R. recommendations are unlikely to be satisfactorily implemented unless the chief librarian is not only genuinely anxious to improve his services but also capable of appreciating an analytical approach to his problems.

The knowledge of competent librarians is also useful in describing library

problems to the O. R. team and in advising on methods of data collection.

If the work is to be useful, a mixed research team of librarians and others is appropriate. Librarians working in this role definitely need to be capable of analyzing problems. They do not have to be expert in the mathematical techniques, however. For the most useful results, librarians ought to constitute about half of those actively engaged in the research, as opposed to persons in an advisory or liaison capacity. This judgment stems from three considerations:

1. A significant element of librarianship is likely to help keep the research in touch with library realities and the reports intelligible to the library profession.

2. This element is likely to act as an antidote to motivations on the part of professional O. R. scientists which could deflect the research from actually being useful. Such motivations include the need to provide funding and points of departure for technical dissertations by O. R. students. Also there is the desire to develop highly sophisticated papers for the O. R. press which may improve their author's reputation more than his library service.

3. Most important is the question of manpower. Working on an O. R. project is an excellent training. All too often O. R. specialists who have acquired experience in library planning problems move on to other pastures, such as transportation, computers, or industrial problems, and the expertise is lost. In contrast, a librarian with this experience is likely to remain in librarianship and to continue to contribute to library problems. In the long

term, this absorption of experience may in itself be more beneficial to libraries than the original project was. In a sense, projects staffed entirely by O. R. specialists can have a preemptive, even stultifying, effect on the library profession which has little enough expertise in effective management anyway.

In the context of research and development in librarianship and in comparison with, say, classification research, historical bibliography, and

computerization, research of an O. R. type into basic planning and management problems seems to offer the best prospects, at least in the short term, of enabling librarians to improve the library services for which they are responsible. The best kind of self-confidence and professionalism is that which stems from a better informed and more quantitative understanding of the nature of the complexities in the provision and use of library services—of the library as a growing organism.

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