Selecting a Circulation-Control System: a Mathematical Approach

By FREDERICK RUECKING, JR.

AT RICE UNIVERSITY, as at many colleges and universities throughout the country, increasing use of library resources by both faculty and students has necessitated changes in circulation control. The task of selecting a suitable control system is complicated by the lack of a specific method of comparison. The Fry report brings together a considerable mass of data pertaining to control systems, but those data are restricted in value to a single point in time and as a general norm for college and university libraries.[1] A method of adapting the data to local conditions and projecting the results beyond a single point in time is lacking.

Faced with this task at Rice University, the library administration made an attempt to derive a technique which would (1) provide a means of projecting circulation and staffing requirements beyond a single point in time; (2) permit the use of Fry's organization and data; (3) adjust Fry's data to local conditions; and (4) produce a more accurate comparison of existing systems. The result of this effort is a series of equations which are used in the Fondren library analysis of twelve charging systems.

This comparative analysis has led to a recommendation to the Rice University administration for the installation of an automatic, punched-card charging system similar to that of the Montclair public library.[2] It is felt that other college and

Mr. Ruecking is Head of the Circulation Department, Fondren Library, Rice University.

university librarians, facing the problem of selecting a new circulation control system, will find the Rice viewpoint of interest and the mathematical technique helpful.

HYPOTHESES OF THE STUDY

The hypotheses upon which the Rice University study is based may be set forth in five statements.

1. If the conditions (rising enrollment, expansion of the collection, increase of independent study programs, etc.) which affect circulation continue in the same direction with the same strength, the annual circulation is predictable by projecting known data.

2. If there is to be accurate comparison, the systems under consideration must be compared on the basis of the *same level of effectiveness*.

3. A relationship exists between unit operating time (Fry's element time) and system operating time.

4. Cost estimates for system operation *must* include the cost of staffing.

5. The final evaluation of any charging system must include its *cumulative* costs, its benefits, its capabilities for growth, and, especially, its suitability for local conditions.

PROJECTING CIRCULATION

If the annual circulation from previous years at Rice University is plotted as a

[1] George Fry and Associates, Inc., *Study of Circulation Control Systems* (Chicago: ALA, 1961).

[2] International Business Machines Corporation, *Circulation Records Control by Punched Cards* (N.Y., 1946); and Ralph H. Parker, *Library Applications of Punched Cards* (Chicago: ALA, 1952).

graph (Fig. 1*a*), a curve resembling an exponential curve is produced. If the same data are plotted on logarithmic paper (Fig. 1*b*), a straight line may be drawn through the plotted points, suggesting that the Fondren library circulation is increasing exponentially. This line may be expressed as a mathematical equation.

If X_n is the annual circulation, in thousands, after n years; X_o is the annual circulation, in thousands, of the beginning year of the known data; and R_x is the average, annual rate of increase, the equation is as follows:

$$X_n = X_o (1 + R_x)^n \quad (1)$$

If X_n is extrapolated from the position of the line at a given point within the limits of the known data (such as at A in Fig. 1*b*), the value of R_x can be computed as follows:

$$Log\ (1 + R_x) = \frac{Log\ X_n - Log\ X_o}{n} \quad (2)$$

The annual circulation can be projected into the future (points A to B in Fig. 1*b*) from equation 1, since R_x and X_b are now known. As the report *Automation and the Library of Congress* implies, an exponential increase could not continue indefinitely.[3] At some point in time the accelerated gain will slacken and an exponential regression would occur which would in later years resemble a linear regression.

[3] U.S. Library of Congress. *Automation and the Library of Congress* (Washington: Government Printing Office, 1963).

The Doctrine of Equal Effectiveness

As charging systems are studied, it is soon evident that a means of providing a common ground of comparison is required. Can one say that system A is the more suitable, being less expensive to operate than system B, although it does not produce the same results? A conclusion based upon such comparison is not mathematically valid. The common ground or equal level of effectiveness chosen by the Fondren library consists of six criteria. These are as follows:

1. Elimination of borrower participation in charging transactions.
2. Total random access to the circulation file by
   a) borrower
   b) date of issue
   c) call number
   d) overdue coding (tab, transaction number, etc.)
   e) type of record (loans, missing records, binding records, etc.)
3. *Required* use of library identification.
4. Rapid updating of the circulation file.

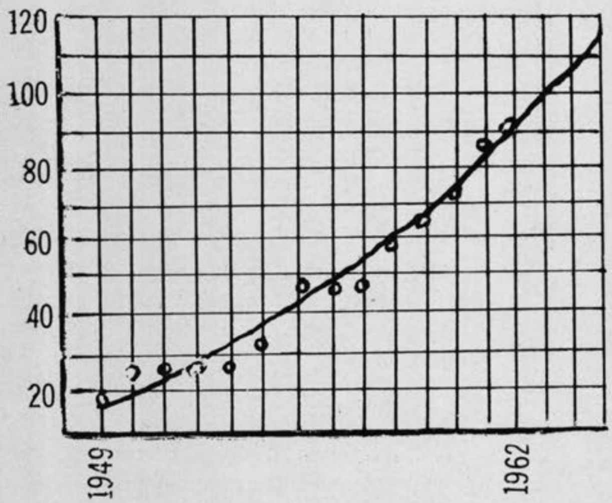

Fig. 1*a*.—Annual circulation in thousands, Fondren library.

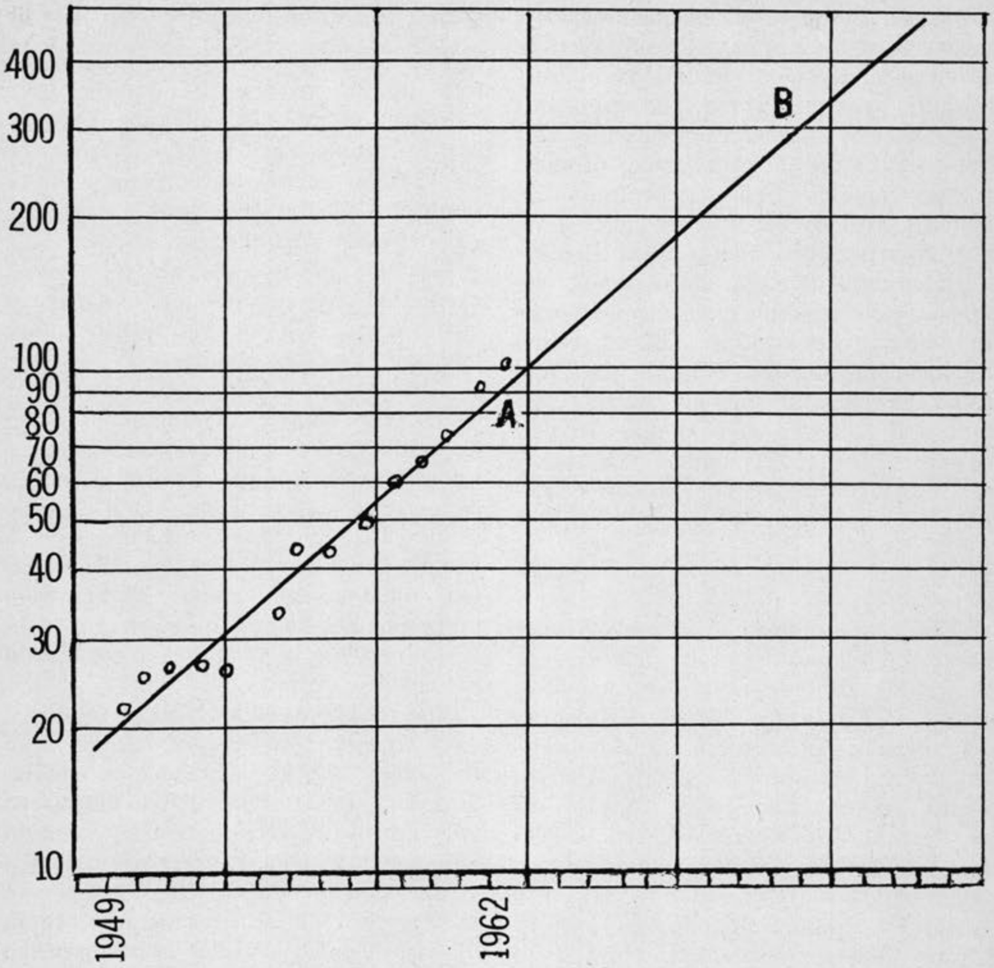

FIG. 1*b*.—Annual circulation in thousands, Fondren library.

5. Rapid overdue processing.
6. Maintenance of an accurate and orderly circulation file.

Certain systems *cannot* be manipulated to meet these criteria. In the Fondren library study such systems are eliminated from consideration. Other systems do not meet these criteria, but can be organized so that all six are included. Systems which can be so manipulated are compared in the Fondren library study.

UNIT TIME AND OPERATING TIME

The compilation of data in the Fry report is very useful if one recognizes its limitations.[4] One of these limitations is that the data are not applicable universally. A second limitation is that the data for system A and system B may not be directly comparable, because of the local conditions under which each is operated. A third limitation is the erroneous interpretation of the cause of filing and slipping time. Despite these limitations, the data may be used to project operating time and costs.

The first step is to adjust Fry's data to

[4] Fry, *Op. cit.*, pp.49-53. Exhibit IV, A and B.

the local situation. Consequently, it is necessary to measure the amount of time required under local conditions to perform the operations listed. The results obtained may be used with Fry's corresponding data for the same system to produce a ratio which can be applied to the other systems given by Fry.

If E_f represents Fry's element time for the operation of a specific charging system, E_l represents the element time measured under local conditions; T_e represents the element time given by Fry for the same operation of another charging system; and T_l is the element time for that operation and system under local conditions, the conversion equation is as follows:

$$T_l = T_e \frac{E_l}{E_f} \qquad (3)$$

The data obtained are element times expressed in minutes per transaction. Care must be exercised in utilizing quantities given by Fry, since the proportions to Fry's standard of one thousand loan transactions will not apply in all cases. Certain operations may be excluded from this reduction ratio as being controlled by factors outside the charging system. The local situation must be carefully reviewed before Fry's data are applied.

The total times obtained from these computations provide a means of comparing systems, but not at a point in time nor realistically. If one multiplies total element time by the annual circulation, in thousands, as Fry suggests, the product is not operating time.[5] A factor is missing which is controlled by other conditions (the time the desk is open for service, loan policies, etc.). Consequently, an equation which expresses the computation of operating time may be stated. If Y is the operating time in hours; k is the conversion factor; X is the annual circulation, in thousands; and Z is the element time in hours per thousand circulation, the equation is as follows:

$$Y = kXZ \qquad (4)$$

The value of k can be approximated from the above equation by substituting (1) the total staffing, in hours, for system operation for the previous year for Y; (2) the annual circulation, in thousands, for the previous year for X; and (3) the measured element time for Z.

Use of equation 4 provides a means of examining charging systems on a current basis. It cannot be used to project future operating time requirements.

Certain operations are influenced by changes in circulation volume—for example, filing. It *might* require two hundred minutes to file one thousand cards into a twenty thousand card file, but if that file is increased to thirty thousand cards, it will require more than two hundred minutes to file the same one hundred cards—filing time not being a function of a number of cards to be filed, but of the size of the file.

The change of element time, produced by a change in circulation volume, is of the same order as the change in circulation, but not necessarily of the same value. If other records are included in the circulation file, it is possible that a 10 per cent increase in circulation might produce only a 6 per cent increase in file size. Consequently, it is necessary to study the composition of the circulation file.

Since element time is subjected to the same *kind* of increase as circulation, the expansion of element time can be expressed mathematically, by referring to equation 1.

Let Z_n be the amount of element time at the end of n years, Z_o the element time measured by Fry (adjusted to local conditions) and R_z the rate with which element time changes. Then, the equation is as follows:

$$Z_n = Z_o (1 + R_z)^n \qquad (5)$$

The value of R_z can be *approximated* by calculating the size of the file, measur-

[5] *Ibid.*, worksheets.

ing the amount of time required to file a known number of cards, and performing some computations.

If F_s represents the size of the card file at present, F_n represents the size of the file in n years, and T_f is the measured filing time required for one thousand cards at the present time, the equation is as follows:

$$R_z = \frac{\left(\frac{T_f\ F_n}{F_s} - T_f\right)}{T_f} \quad (6)$$

As suggested above, a change in circulation does not always produce changes in element time for all operations. Consequently, equation 5 must be altered to include this variation.

If C represents the amount of element time not affected by a change in circulation volume, then equation 5 must be restated as follows:

$$Z_n = (Z - C)\ (1 + R_z)^n - C \quad (7)$$

Now it is possible to project staffing requirements for any charging system, adjusted to local conditions, into the future. Substituting equations 1 and 7 in equation 4, the equation for projection is as follows:

$$Y_n = kX_o\ (1 + R_x)^n \left[(Z_o - C)\ (1 + R_z)^n - C\right] \quad (8)$$

Estimating Staff Costs

To provide a more accurate means of comparing charging system suitability as well as forecasting budget requirements, the results of equation 8 may be used to predict costs. If the present ratio of full-time and part-time staffing is expected to continue, application of that ratio to Y_n produces preliminary cost estimating equations.

Let S_f represent the present annual staffing of full-time personnel, in hours, S_p the number of part-time hours used, P_n the projected total of full-time needs in n years, and S_n the projected total of part-time hours needed in n years. Two equations may be stated, as follows:

$$P_n = Y_n \left(\frac{S_f}{S_f + S_p}\right) \quad (9)$$

$$S_n = Y_n - P_n \quad (10)$$

Cost estimates can be obtained from these results. If W_s is the average salary of the full-time staff, and W_p is the average hourly wage, the projected annual cost E_n is calculated from the following equation:

$$E_n = W_s \left(\frac{F_n}{2080}\right) + W_pS_n \quad (11)$$

When this expense is added to the charging system cost schedule, as Fry provides, a more accurate comparison of total expense can be made.

Final Evaluation

A charging system should not be selected merely because it is "cheaper" than others. If the selected system does not meet present and *future* library needs, the choice is poor. Determining the precise needs is the first and most important step of charging system selection. Alternative systems, regardless of cost, should be examined from the standpoint of suitability.

The importance of *cumulative* costs cannot be overlooked. Increases in charging system costs, stemming from circulation increases, are minor compared to increased costs for additional staff. There is a point in time at which manual methods will become more expensive than mechanized methods, even on an annual cost basis. Similarly, a second point in time exists at which mechanized techniques will become more expensive than electronic methods. These points in time are not necessarily the same for all libraries—the local situation is the controlling factor.

A subsidiary factor, frequently overlooked in the evaluation of charging systems, are the byproducts—added benefits. The amount of staff time released for other duties is an important benefit and one to which a value cannot always be assigned. By adroit utilization of his staff, the librarian can provide better service to the library's public if the most appropriate charging system is selected.

In some instance the system may require special equipment. Frequently, this equipment can be utilized for noncirculation procedures, providing added service to internal library operation.

Conclusion

The suitability, cumulative cost, and derived benefits of any charging system constitute the determining factors of charging system selection. Any one of these three may have special significance which may represent a controlling or limiting factor.

The Fondren library study reveals that the cumulative costs of a six-year period, including the initial cost of converting the collection to automatic processing, the continuing cost of IBM rentals, and other expenses, including staff costs, would be the same as, or less than, any manual system—because the departmental staff at Rice University is primarily full-time. The total cumulative cost of the proposed system, by 1980, is estimated to be approximately 50 per cent of the cumulative cost of any non-IBM system.

Converting the collection at this time and installing the IBM 375 teleprocessing system will bring about an on-line computer application more quickly and make ultimate participation in a national electronic system more feasible. It is our aim and hope to provide detailed studies on our techniques, decision, costs, and experiences in converting the collection and operating the proposed system. ■■

Book Illustration Papers Published

Essays on Book Illustration, the lectures presented at the third Rare Book Conference at Coral Gables in 1962, has been published by Verlag Gebr. Mann. 1 Berlin West 62, Hauptstrasse 26, West Germany. The papers were edited by Mrs. Frances J. Brewer, chief of the gifts and rare books division of Detroit public library. Mrs. Brewer was chairman of ACRL's Rare Books Section at the time of the conference in which the papers were read. The volume is dedicated to Hellmut Lehmann-Haupt in honor of his sixtieth birthday, and includes, in addition to the papers, an annotated Checklist of Hellmut Lehmann-Haupt's Contributions to the Literature of Book Illustration. It is available from the publisher at $10 per copy. ■■