

## A Cost-Benefit Analysis for Determining the Value of an Electronic Security System

*A major problem confronting the library administrator today is the loss of an increasing number of books through theft. One solution to this problem is met by the installation of an electronic security system (ESS). Although it is relatively easy to estimate the cost of installation and operation of such a system, it is considerably more difficult to measure its benefits. In this research, two methods are presented for estimating the rate of book loss. Once the book-loss rate is determined, an analysis is presented for ascertaining the benefits yielded by an ESS relative to the cost.*

### INTRODUCTION

AT PRESENT, THERE EXISTS A CRITICAL NEED for improved decision making and planning to effectively utilize and allocate the library's scarce resources. This need results, on the one hand, from an increase in the intensity and complexity of demands registered by users for publications which are increasing in both numbers and cost. On the other hand, the budgets allotted to libraries are not increasing at a rate sufficient to accommodate these trends. Thus, it is imperative that funds be expended for those programs that contribute most to the library's effectiveness. Decisions must be made as to whether and at what level

each program merits funding. One such program, which is a candidate for funding in most libraries, is the installation of an electronic security system (ESS) to protect the library's collection from theft. It must be determined, however, whether the benefits yielded by such a system justify the cost of installation and operation.

This article reports on a study conducted at the Van Pelt Library of the University of Pennsylvania for documents in the collection which are permitted to circulate. Two methods for estimating the current yearly rate of lost documents are compared. Based upon the estimated number of lost documents, a further estimate is made regarding the number lost by theft. Next, computations are presented which estimate the costs of an ESS. These figures include the costs for both installation and operation. An analysis is then made of the benefits gained from installing an ESS with the appropriate costs.

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## ESTIMATING THE NUMBER OF DOCUMENTS LOST AS A RESULT OF THEFT

### Method I

The first method involves determining the number of documents lost from a *sample* of documents during a one-year period. An estimate of the number of documents lost for the *entire collection* during a one-year period is then extrapolated, based on these sample results. Of the total number of documents estimated to be lost, an estimate is then made for the number lost by theft.

A table of random numbers was used to select a random sample of cards from the University of Pennsylvania Library shelflist.<sup>1</sup> In all, 925 cards were selected, with 662 cards listing circulation documents. The 263 cards listing documents not for circulation (e.g., periodicals) were not included in this study. For each of the 662 cards (referred to here as the Van Pelt collection) the number of documents listed on the card and the publication date of the documents were recorded. These data are summarized by classes according to publication dates in columns 3 and 4 of Table 1. Data are grouped into classes in order to obtain more reliable estimates. The assumption is made that the loss rate for documents correlates with the publication date of documents. This assumption is based upon the fact that use rate of documents is correlated with document publication date (see for example Fussler and Simon, or Trueswell, or Bommer<sup>2-4</sup>), and the belief that the more a document is used, the more susceptible it is to theft.

An estimate of the number of documents in each class of the collection was then made. This was accomplished by first measuring the number of linear inches of cards in the entire shelflist (10,442), multiplying by the average number of cards per inch (100), and then multiplying again by the estimated proportion of these cards pertaining to

documents permitted to circulate which are held by Van Pelt (662/925), yielding an estimate of 747,308 cards. The estimated number of documents in each class was computed by multiplying the number of documents in the sample for each class by the ratio of the total number of cards in the sample. For example, the estimated number of documents in class I is determined by multiplying 84 by the ratio 747,308/662, yielding 94,824 documents. These results appear as column 5 in Table 1.

For each of the documents in the sample, thorough searches were conducted in December 1971 and December 1972. The number of documents that were unaccounted for is indicated in columns 6 and 7 of Table 1. The difference between these two columns represents the number of documents in the sample that were lost during this one-year period.

The estimated number of documents lost over this one-year period for the Van Pelt collection was determined by first computing the estimated proportion of documents lost in each class. The number of documents lost in the sample in the one-year period is divided by the number of documents in the sample. For example, for class I documents, one document was lost, which, when divided by 84, yields an estimated .01190 proportion of documents lost in the one-year period. These proportions appear as column 8 in Table 1. The estimated number of documents lost in each class was then obtained by multiplying the proportion of documents lost by the estimated number of documents in the class. For example, the estimated number of documents lost in class I in a one-year period is .01190 times 94,824, which equals 1,128 documents. These estimates appear as column 9 in Table 1. A summation of the entries in this column yields an estimate of the total number of documents lost in a one-year period from Van Pelt Library, which is 10,003.

TABLE 1  
 NUMBER OF DOCUMENTS LOST FROM COLLECTION DURING ONE-YEAR PERIOD AS ESTIMATED  
 USING DATA COLLECTED OVER A PERIOD OF TIME

(1) Class of Documents	(2) Class Publication Dates	(3) Shelflist Sample		(4)* Number of Documents in Class	(5) Estimated Number of Documents in Class	(6) Number of Documents Lost as of December 1971	(7) Number of Documents Lost as of December 1972	(8) Proportion of Documents Lost during One-Year Period	(9)† Total Number of Documents Lost in One-Year Period
		Number of Cards in Class	Number of Documents in Class						
I	1966-1970	71	84	94,824	4	5	.01190	1,128	
II	1960-1965	98	125	141,107	14	18	.03200	4,515	
III	1950-1959	108	138	153,524	9	10	.00725	1,113	
IV	1940-1949	58	68	79,765	4	5	.01471	1,089	
V	1920-1939	93	110	124,175	5	6	.00909	1,129	
VI	1900-1919	96	128	144,494	8	8	.00000	0	
VII	1870-1899	78	99	111,751	6	7	.01010	1,129	
VIII	1700-1869	60	103	116,272	5	5	.00000	0	
Total		662	905	965,912	55	64		10,003	

\* A sample larger than 905 documents would have afforded a greater degree of precision in our estimate. However, because of the limited resources available to collect the sample and physically determine the status of each document, this luxury was not permitted. For a sample size of  $n = 905$  and the proportion of documents lost over a one-year period of approximately  $p = .01$  ( $9/905$ ), a crude estimate of the standard error of the estimate is

$$s = \sqrt{[(p)(1-p)]/n} = \sqrt{[(.01)(.99)]/905} = .0033.$$

It would have been more desirable to utilize a sample size in the neighborhood of 2,500, which would reduce the standard error of the estimate to approximately .002 using the same formula for  $p = .01$ .

† The marked differences in the estimated number of documents lost in each class can be explained by the modest sample sizes for each class and by the random nature of the data. Although the estimate for the number of documents lost in a particular class may vary from the exact mark, the total for all classes represents a reliable estimate of the total number of documents lost.

Because it is expected that a portion of the total number of documents presumed to be lost will turn up, a further estimate is required to predict the number of documents lost by theft. Of the 55 documents not accounted for in December 1971, 7 have been accounted for after an exhaustive one-year search. It is doubtful that more of these documents will be accounted for in the future. Thus we estimate that approximately 7/55 or 13 percent of the documents estimated to be lost will be accounted for in the future. This would indicate that of the 10,003 documents estimated to be lost, 1,300 might be expected to turn up, with the remaining 8,700 documents assumed lost by theft.

#### Method II

The major drawback in employing method I is that a period of time must elapse between the collection of the sample data used in the estimation procedure. Using method II, the annual number of documents lost from the collection can be estimated using certain assumptions and sample data collected at a particular point in time.

Using random numbers, a random sample of cards for documents acquired in the years 1968-1971 was obtained.<sup>5</sup> A search was conducted to determine the number of these documents which were unaccounted for and presumed lost. The results appear in Table 2.

The assumption is made that the annual loss rate over the past few years has been constant. It is also assumed that the loss rate for the group of most recently acquired documents (1968-71) is similar. For this group, the number of documents lost from a set acquired in a particular year is assumed to be a direct function of the length of time these documents have been on the shelf exposed to patrons. Thus, for the set of documents that has been on the shelf two years, there would be approximately twice as many losses as for the set of

documents on the shelf for one year. This assumption holds over a relatively short timespan, unless the rate of book loss changes.

The sample represented in Table 2 was taken in September-October of 1971. Thus, of the 1971 acquisitions in the sample, some had been on the shelf since the first of the year (approximately  $\frac{1}{2}$  of a year) while others had just been placed on the shelf (0 years). Therefore, the average time duration for 1971 acquisitions on the shelf, assuming a constant rate of addition, was about  $\frac{1}{4}$  of a year. Similarly, the average time that documents acquired in 1970 were on the shelf at the time of the sample was about 1 $\frac{1}{2}$  years; 1969 acquisitions, 2 $\frac{1}{2}$  years; and 1968 acquisitions, 3 $\frac{1}{2}$  years.

To estimate the yearly rate at which the most recently acquired documents are being lost, the ratios of the number of documents lost divided by the number of years the documents were on the shelf are summed. This sum is then divided by the total number of documents in the sample. This calculation is made for the data in Table 2 as follows:

$$\begin{aligned} &\text{Estimated yearly proportion of documents lost} \\ &\text{for the most recently acquired documents} \\ &\text{(1968-71)} = \\ &\frac{5/\frac{1}{2} + 7/1\frac{1}{2} + 17/2\frac{1}{2} + 14/3\frac{1}{2}}{1391} = .0228. \end{aligned}$$

Because the .0228 figure represents the yearly loss rate for the most recently acquired documents, it is not justifiable to conclude that .0228 of the entire collection is lost each year. A more reasonable assumption is that the document loss rate is in direct proportion to the use rate: documents in a class with a relatively high circulation rate are more susceptible to loss than those in a class with a relatively low use rate. Using this assumption, circulation data were collected according to publication date of the document over a two-week period. These data appear as column 3 of Table 3. A weekly circulation rate for each



the yearly rate of  $(.0228)(.5665) = .0129$  per year. Yearly document loss rates for each class are shown in column 7 of Table 3. Although the .0228 figure was calculated for documents *acquired* in recent years, this rate is now applied to documents *published* in recent years. Although not all documents published in a particular year are acquired in that year, the loss rate for documents *published* in a particular period will not be significantly different from the loss rate for documents *acquired* in a particular period.

Finally, given the annual loss rate for each class of documents, an estimate of the annual number of lost documents can be made. The loss rates of column 7 are multiplied by the estimated number of documents in column 4 of Table 3. For example, for class II, the estimated number of lost documents is  $(.0129)(141,107) = 1,820$ . These results are shown in column 8, Table 3. Summation of this column indicates that the estimated number of documents which were lost from the Van Pelt collection during 1972 is 8,820.

As with method I, it is estimated that approximately 13 percent of the documents will eventually turn up. Thus,  $8,820 - [(.13)(8,820)] = 7,673$  documents lost as a result of theft. This compares with the estimate of 8,700 documents lost by theft as computed using method I. The estimates vary by a magnitude of approximately 1,000 documents. This difference probably can be attributed to sampling errors.

The loss estimates of 7,673 and 8,700 documents are slightly lower than the *total* number of documents lost from Van Pelt Library by theft, as these estimates are only for the set of documents in Van Pelt which are allowed to circulate. These estimates do not include such documents as reference works or periodicals, which are also susceptible to theft.

### Cost of an Electronic Security System (ESS)

In this analysis, only the costs for the outright purchase of an ESS will be assessed. Other plans are available, which allow for renting an ESS or a combination of renting and purchasing over a period of time. In general, these plans are slightly more expensive than direct purchase.

The costs for the purchase and employment of an ESS can be conveniently separated into an initial cost, which includes the purchase cost and installation of the detection equipment and the purchase cost plus cost of installing detectors in documents currently held by the library, and annual future costs, which include the purchase cost plus cost of installation of detectors in newly purchased documents plus a yearly equipment maintenance cost.

For each of two commercial ESSs studied, the price for two detector equipment units—one for each of the two exits from the Van Pelt Library—was approximately \$16,000. Subsequent installation of these terminals was estimated at \$3,000.

Rather than placing a detector in every document, it was reasoned that the presence of the detection equipment alone would be sufficient to decrease the theft rate significantly. To reinforce the deterrent, detectors would be placed in a portion of the documents currently held by the library. Using the assumption that the most used documents are the ones most susceptible to theft, greatest protection at the least cost is offered by inserting a detector in each document that passes over the circulation desk during a future, unspecified period of time. Studies by Trueswell and also Fussler and Simon indicate that approximately 20 percent of a library's collection receives 80 percent of the collection's use.<sup>6,7</sup> Using these findings as a guide,

if detectors were purchased and inserted in 20 percent of Van Pelt's collection,  $(.20)(965,912) = 193,182$  detectors would be required. With the cost of purchase  $(\$0.13)$  plus insertion of each detector  $(\$0.02)$  equal to approximately  $\$0.15$ , the cost for placing detectors in the current Van Pelt collection is  $(\$0.15)(193,182) = \$28,977$ , or about  $\$29,000$ .

At present, Van Pelt Library is adding approximately 50,000 documents per year. Assuming that a detector is inserted in each new document, the yearly cost for detectors is  $(\$0.15)(50,000) = \$7,500$ . In addition, there is an annual maintenance cost for detector equipment of about  $\$500$ . Because the two exits are currently monitored by an employee at all times, there is no added personnel cost in employing an ESS.

A summary of the costs incurred by Van Pelt Library to install and employ an ESS includes:

<i>Initial one-time costs</i>	
Equipment (2 units)	\$16,000
Installation	3,000
Detectors	29,000
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	\$48,000
<i>Annual costs</i>	
Detectors	\$7,500
Maintenance	500
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	\$8,000

#### BENEFIT-COST ANALYSIS

To assess the benefits of an ESS, the costs currently incurred by the library and the library community as a result of the theft of their documents is examined. These costs, when eliminated or diminished, represent benefits attained by the system.

An implicit assumption is made that documents have value only if they will be consulted by a user or users sometime in the future. Of the estimated 8,000 documents lost by theft last year, some undoubtedly would never be in future demand even if they were available, and they would not be replaced by the library if reported missing. Therefore, the monetary loss incurred by the library is

not necessarily  $(8,000)(\$20) = \$160,000$  per year, where the replacement cost of a document is estimated at  $\$20.00$ . However, over the past three years approximately 1,000 documents per year were reported by users and verified by library personnel to be lost. Of these 1,000 documents, approximately 500 were replaced at a cost of  $(500)(\$20) = \$10,000$  per year. The remaining 500 documents were not replaced, as a newer edition or duplicate copy was available, or it was believed there would not be sufficient future interest in the document to warrant its replacement. If an ESS were 90 percent effective, the actual "out-of-pocket" cost to the library in terms of replacing documents which could be saved would be approximately  $(.90)(\$10,000) = \$9,000$ . (No ESS is assumed 100 percent effective, particularly with only 20 percent of the documents initially protected.)

Another "out-of-pocket" cost incurred by the library results from the time consumed in tracing and evaluating for replacement the 1,000 documents reported missing per year. Assuming that each tracer and evaluation requires  $\frac{1}{2}$  hour and that employee salary plus benefits is  $\$3.50$  per hour, the potential savings in this area would be  $(.90)(1,000)(\frac{1}{2})(\$3.50) = \$1,575$ .

Often documents are requisitioned from other libraries via the interlibrary loan system (ILL) when a user requests a document which is missing from the library. In the past year, it was ascertained that approximately 200 ILLs were for documents missing from the library. Using the cost figure of  $\$7.61$  as estimated by Westat Research, Inc.,<sup>8</sup> the estimated cost savings in this area would be  $(.90)(200)(\$7.61) = \$1,370$ .

The total annual "out-of-pocket" costs incurred by the library which could be saved by an ESS is then  $\$9,000 + \$1,575 + \$1,370 = \$11,945$  per year. This sum does not include a cost to the library of "good will or confidence" incurred when the

library does not have a desired document and cannot obtain a document (out-of-print document) to replace one lost by theft. This inability to serve could lead to a reduction in the quality of research and teaching conducted at a university. Thus the benefits derived by the library as a result of installing an ESS would be \$11,945 plus an increase in the "good will or confidence" factor, which is difficult to equate in monetary terms.

A cost to the user is yet another consideration in estimating the benefits of an ESS. As noted previously, only 500 documents of the estimated 8,000 documents lost by theft each year are replaced. One reason for this low replacement rate is that, for the most part, the library is unaware of which documents are lost. Usually, a user searching for stolen documents will never report them missing. Assuming that these 8,000 documents lost by theft are also in active demand, a significant number of frustrations are experienced by users seeking them. These frustrations can be measured by the time expended to locate a copy of the document in a neighboring library, delay while waiting for a replacement copy or for an ILL copy to arrive, and, finally, loss of scholarship when a user is unable to obtain a copy of the document at all within his time requirements. Unfortunately, these costs are extremely difficult to measure objectively. The benefits reaped by the

employment of an ESS at Van Pelt Library include not only \$11,945 per year but a confidence factor and user benefits as well.

To determine whether an ESS should be installed, a comparison is made of these benefits with the cost of installation and operation (see Figure 1), in which  $t = \text{years}$ ;  $n = \text{planning horizon of the library}$ ;  $L = \text{subjective benefits accrued to the library, including confidence factor, etc.}$ ; and  $U = \text{subjective benefits accrued to users as a result of eliminating delays in obtaining desired document, loss of time in attempting to locate desired document, and loss of scholarship when desired document is not obtainable}$ . Therefore, the benefit-to-cost ratio for employing an ESS at Van Pelt Library is

$$\frac{B}{C} = \frac{\sum_{t=1}^n (11,945 + L + U)}{48,000 + \sum_{t=1}^n (8,000)} = \frac{(11,945 + L + U)(n)}{48,000 + (8,000)(n)}$$

For simplicity, it is assumed that the discount rate for the future stream of benefits and costs is approximately offset by the rate of inflation.

The value for the B/C ratio depends in part upon the values assessed for  $L$  and  $U$  by the library administrator. The larger the values assessed for  $L$  and  $U$ ,

Cost of system		Installation cost		Yearly operating costs		
C	=	\$48,000	+	$\sum_{t=1}^n$ \$8,000		
Benefit of system		Monetary benefits accrued to the library		Subjective benefits to the library	Subjective benefits to the user	
B	=	$\sum_{t=1}^n$ (\$11,945	+	$L$	+	$U$ )

Fig. 1

Cost-to-Benefit Comparison



the greater the ratio of benefits to costs. Thus, if the monetary benefits accrued to the library do not significantly exceed the annual operating costs of the ESS (as in this case), the decision to use an ESS is not clear. In this case, it is up to the library administrator to make the difficult assessment of the subjective library and user benefits,  $L + U$ .

If, for example, a library administrator estimates that  $L + U$  is worth \$10,000 per year, and the planning horizon for the library is 15 years, then the value of the B/C ratio is

$$\frac{B}{C} = \frac{(11,945 + 10,000)(15)}{48,000 + (15)(8,000)} = 1.96.$$

This implies that for each dollar expended for the ESS, \$1.96 worth of benefits is reaped.

To determine whether the ESS program merits funding, the programs of the library would be ranked according to benefit-to-cost ratios for all other alternative programs. The set of programs with the highest benefit-to-cost ratios, which, if funded, would expend the library's budget, constitutes the set of programs actually to be funded. If the ESS program were included in this set, it would be funded and employed.

Alternatively, using a break-even analysis, the costs of installing and operating an ESS are equated with the benefits derived from an ESS. This equation is then solved for  $t$ , which provides an estimate of the number of years required before the benefits exceed the costs of an ESS.

If, for example,  $L + U = \$10,000$  and the discount rate is neutralized by the rate

of inflation as before, then equating costs with benefits yields

$$48,000 + (8,000)t = (11,945 + 10,000)t,$$

which when solved for  $t$  equals 3.4 years. Thus at point 3.4 years the system has just paid for itself. If the system is employed for more than 3.4 years, the total benefits will exceed the total cost of the system.

A procedure similar to the one used in the benefit-cost approach is then applied to determine whether an ESS merits funding. The break-even point is calculated for the alternative programs available to the library. These programs are then ranked according to the break-even points. The set of programs with the smallest break-even points which exceeds the library's budget constitutes the set of programs to be funded. If the ESS program is included in this set, then it should be funded.

#### CONCLUSION

It is unfortunate that the problem of document theft has to be considered at all. Because of the values and actions of a few patrons, the library administrator is placed in the difficult position of either watching a vital portion of the library collection disappear or spending considerable funds on an ESS. Patron behavior in this area will probably continue; thus, administrators must confront the problem and realize that a decision must be made about employing an ESS. Ignoring this problem is tantamount to deciding not to employ an ESS. Hopefully, the analysis presented in this paper can be used by an administrator to assist in making the decision that will provide the greatest benefit for all concerned.

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