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Assessment of the Financial and Intellectual Value of a Research Library and its Application at the Idaho National Laboratory

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ABSTRACT

Over the last several decades, libraries across the nation have undergone dramatic budget cuts, despite being an important resource for regional and national economic growth and innovation. Numerous studies have attempted to show that libraries increase the intellectual level of users and contribute to the economic growth of communities through surveys and customer service data. Within this study, we have attempted to develop a more analytical method for assessing library performance, using the Idaho National Laboratory Research Library as a sample subject. We have developed a mathematical model to measure the financial value of a library's material resources as well as its intellectual value to determine if the library is a positive contributor to the wider organization and community it serves.

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1. INTRODUCTION

The issue of assessing the actual intellectual and financial value of a library has become urgent among communities, educational institutions, corporations, and research organizations in the United States. Recent trends for commercial, private, public, and collegiate libraries show continuous decreases in financial support with negative accelerated trends during the recent economic downturn of 2007.[1] In order to make proper decisions concerning investment in libraries, knowledge managers need to know the financial and intellectual impact their library has on the surrounding economy.

1.1 Previous Studies on Library Value and ROI

Previous studies on the economic impact of libraries have shown positive results for the surrounding community served. One study was conducted for the British Library, led by Nobel economists Kenneth Arrow and Robert Solow, to determine the nationwide economic impact of the library's services. After a thorough economic analysis, it was determined that the library's return on investment was 4.4 times annual government contributions to maintain the entire library: both collections and staff. Economic factors that were affected by the library included businesses and research institutions focused on innovation, thus increasing the competitiveness of the British economy.[2]

Similar economic studies have been conducted within the United States, on a state based level in South Carolina,[3] Florida,[4] and at the Carnegie Mellon Library[5] in Pittsburg, PA. Many of these studies focus on the effectiveness and value of libraries; however, these studies do not use quantifiable data that validate the intellectual or economic impact of resources and services on a community or organization. This may be due to the difficulty in analytically measuring social, cultural, and economic impacts.

A common method used to appraise the value of a library is through customer surveys. For example, the study performed by the Carnegie Mellon Library used survey data to determine time and cost savings of library customers. The survey data was then used to determine the Carnegie Mellon Library's taxpayer dollar return on investment. Other studies have attempted to determine the value of libraries based on estimated customer cost savings for services[6,7,8] or resource materials[9] that might have been incurred by

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[1] "Library Expenditures as a Percent of University Expenditures for 17 ARL Libraries, 1966-2007". *Association of Research Libraries*. (22 May 2009), http://www.arl.org/bm~doc/charts66-07.pdf.

[2] Pung, Caroline, Ann Clarke and Laurie Patten. "Measuring the Economic Impact of the British Library," *New Review of Academic Librarianship* 10, no. 1(2004): 87-90.

[3] Barron, Daniel, Robert Williams, Stephen Bajjaly, Jennifer Arns, and Steven Wilson. "The Economic Impact of Public Libraries on South Carolina: Executive Summary." University of South Carolina. (January 2005).

[4] Griffiths, Jose-Marie, Donald King, and Thomas Lynch. "Taxpayer Return on Investment in Florida Public Libraries: Summary Report." State Library and Archives of Florida. (September 2004).

[5] Carnegie Mellon University Center for Economic Development and Carnegie Library of Pittsburgh, *Carnegie Library of Pittsburgh: Community Impact and Benefits*, (April 2006).

[6] Sumsion, John, Margaret Hawkins, and Anna Morris. "Estimating the Economic Value of Library Benefits," *Performance Measures and Metrics* 4, no. 1 (2003): 13-27.

[7] Joseph R. Matthews, *The Bottom Line: Determining and Communicating the Value of the Special Library*, (Westport Connecticut: Greenwood Publishing Group, 2002).

customers utilizing other information sources (i.e. bookstores, journal subscriptions). Additional studies focus on the possible cost benefits of using library services to find information that may result in project cost savings[10,11] or loss[12] associated with utilizing library services.

The drawback of these previous studies is that they have not developed a complete analytical method of determining the value of library service output and the effect of this output on organizations/communities. For example, the common use of customer surveys to assess library value is subjective in nature and may contain response biases or low participation rates that skew data. Additionally, studies that attempt to tie library services to project outcomes may not be accurate measures of value due to the assumption that utilizing library services actually contributed to project outcome.

One key study focused on utilizing an analytical method to assess university publishing productivity based on library output measures.[13] However, this study did not focus on measuring a single library's long term overall impact on the community or region served. Our research study attempts to go beyond these subjective and analytical methods by using input and output data collected from both a research library and its supported organization over a 15 year period. The data was compiled and analytically compared to associate value output from both organizations over time.

1.2 An Introduction to the INL Research Library

The Idaho National Laboratory (INL) supports and utilizes a research library. In operation since 1949, the INL is a Department of Energy research laboratory located in the southeastern Idaho desert. Today INL's mission has broadened into other areas, such as biotechnology, homeland security, materials research, and conservation/renewable energy. Vannevar Bush argues in *Science: The Endless Frontier* that advances in science promote innovation, national security and job creation; a nation weak in scientific research will also be weak economically.[14] Scientific innovation, national security, job creation, and supporting economic growth are all goals of the INL.

The INL Research Library has served INL staff since 1952. During this time period the library has collected information materials in nuclear science, engineering, physics, chemistry, thermodynamics, fluid mechanics, mathematics, geosciences, materials science, energy, and computer science. These materials, which include both electronic and physical collections, are currently used by INL scientists and engineers to perform research and development activities. The INL's main purpose is to conduct research and development projects focused on a number of scientific and engineering issues that face the United States, including but not limited to nuclear test reactions, high-powered batteries for space travel, and high-quality material creation/generation.

The INL Research Library is attempting to create a world-class library that supports the expanding missions and initiatives of the INL by building upon the current collections and maintaining its excellent

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[8] Griffiths, Jose-Marie and Donald W. King, *Special Libraries: Increasing the Information Edge*, (Special Libraries Association, 2003).

[9] King Research Inc., *A Study of the Value of Information and the Effect on Value of Intermediary Organizations, Timeliness of Services and Products, and Comprehensiveness of the EDB*, Publication No. DOE/NBM-1078, September 1984.

[10] Volpe National Transportation Services Center, *Value of Information and Information Services*, (U.S. Department of Transportation, October 1998).

[11] Frank H. Portugal, *Valuating Information Intangibles: Measuring the Bottom Line Contribution of Librarians and Information Professionals*, (Special Libraries Association, 2000).

[12] Susan Feldman, "The Cost of Not Finding Information," *KMWorld* 13, no 3 (March 2004).

[13] John M. Budd, "Faculty Publishing Productivity: An Institutional Analysis and Comparison with Library and Other Measures", *College and Research Libraries* 56, no. 6 (1999): 308-315.

[14] Bush, Vannevar. *Science: The Endless Frontier*. Washington: United States Government Printing Office, 1945. p.16.

service philosophy. In the future, the library's roles will be similar to those it presently fills: creating a learning and research environment, anticipating and responding to customer learning and research needs, contributing to positive publishing outcomes, and providing the information infrastructure necessary for cutting-edge research activities. The library links researchers with information, enabling the INL to achieve research excellence.

1.3 INL Research Library Information Resources

The INL Research Library provides materials and services to library customers. The library material collection contains three major types of hardcopy and electronic materials: books, journals, and reports. Library services are composed of four major types of individualized services: high level information research, in-house document delivery, interlibrary loan, and customer training.

The physical space of the INL Research Library is composed of a main library with three small satellite libraries. The purpose of the satellite libraries is to provide outreach services to researchers located throughout INL facilities separated by distances of up to 50 miles.

2. THE ECONOMICS OF THE LIBRARY SYSTEM

Knowledge based organizations, including libraries, are extremely important to today's information led society; yet, the value they contribute to economic growth is difficult to assess and may be underrated. For corporations and research institutions, the addition of a library has been shown to increase the economic growth of the organization.[15] Yet to properly assess the intellectual and financial benefits added by a library, an elementary understanding of how the library is incorporated into the economy of the organization must be understood. The following is a theoretical analysis of how a research library serves a larger economy.

2.1 Economics of the Library

In classical economics, three different factors create economic value: land, labor and capital. Within an information based society, the power of knowledge becomes an asset central to the development of economic growth. The work of a research library aims to maximize access to knowledge for its constituents.[16] This goal allows librarians to use the physical and human capital of the organization to promote intellectual capital, an asset that is considered more valuable than the three original variables, eventually developing into financial capital that correspond to the organization's mission. According to writer Peter Drucker, economic value within the current information age lies within productivity and innovation, which are both products of the application of knowledge to work.[17] This places intellectual capital as one of the central assets of a company in the economy of the twenty-first century.

Intellectual capital was originally developed by economists at the end of the late 1980's, pioneered by Thomas A. Stewart, author of "Intellectual Capital: the New Wealth of Organizations." In this book, he officially defines intellectual capital:

Intelligence becomes an asset when some useful order is created out of free-floating brain power – that is, when it is given coherent form [...] when it is captured in a way that allows it to be described,

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[15] Pung, Caroline, Ann Clarke, and Laurie Patten, "Measuring the Economic Impact of the British Library," *New Review of Academic Librarianship* 10, no. 1 (April 2004): 79-02.

[16] From the viewpoint of classical economics the library can be broken down into the three fundamental assets: land (physical space), capital (physical resources), and labor (librarians).

[17] Peter F. Drucker, *Post-Capitalist Society* (New York: HarperCollins, 1993).

shared, and exploited; and when it can be deployed to do something that could not be done if it remained scattered around like so many coins in a gutter. Intellectual capital is packaged useful information.[18]

This simple philosophy of considering intelligence as an economic asset is the foundation for the information age. The purpose of a research library is to filter through intellectual material[19] and prepare intellectual capital for researchers to develop innovative ideas.

2.2 Economic Impact on the User

The information services offered by a library, filter information within the library's internal and external sources inclusively, then impacting the external user. This information is condensed and presented to the recipient for his/her own personal knowledge generation.

The library acts as an indirect investment in human capital, because it presents the user with information in a concise form allowing for effective education for various goals. This is considered a general investment in human capital that cannot be separated from previous knowledge, skills or health, unlike measures of financial or physical capital.

An increase in an individual's human capital can expand the creative possibilities of the individual. In the case of the scientist, the access and exposure to background information for a project is highly beneficial. According to Jo Bryson, "Libraries can assist in the innovation process by linking researchers with information about potential users, public and private sector grants and investment schemes that turn a good idea into a commercial product."[20]

Researchers that utilize their access to paid information tools, like research libraries, are 87%[21] more likely to succeed in their research activities and 90% of researchers who work with librarians believe that the librarian made significant contributions to their research efforts.[22]

A research library acts as an essential connection between the research institution and other research that has been and is being conducted throughout the rest of the world. According to library research experts Paul B. Kantor and Tefko Saracevic, "In the sciences, good library and information services are considered indispensable for research … special libraries provide information that is considered essential for research, management, conduct of business, competitive position, and the like. [Therefore, libraries] have value for the organization as a whole."[23] Where there is an active economy, the need for access to new, energizing information is present.

For a national research institution with a highly educated population, like INL[24], an increase in intellectual and human capital for researchers and scientists will lead to a significant increase in innovation because these sectors explore different areas of science and there is no direct 'in-house' competition. This information and innovation becomes a basis for future research innovation. Creativity,

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[18] Thomas A. Stewart, *Intellectual Capital: The New Wealth of Organizations* (New York: Doubleday, 1997): 67.

[19] Anything that provides information whether or not it is pertinent to the organization.

[20] Jo Bryson, "Measuring the Performance of Libraries in the Knowledge Economy and Society," *Australian Academic and Research Libraries* 32, no. 4 (December 2001): 338-339.

[21] Martin Akel & Associate, *A Study of Correlation: The Effect of R&D Information Tools on Research Success* (Chester, New Jersey: commissioned by Reed Elsevier Publishing, 2005).

[22] *Ibid.*

[23] Kantor, Paul B. and Tefko Saracevic. "Studying the Value of Library and Information Services. Part 1. Establishing a Theoretical Framework," *Journal of the American Society for Information Science* 48, no. 6 (1997):538.

[24] Staff education levels have been fairly consistent at the INL over the past 15 years with 22% Graduate, 26% Bachelors, 14% Associates, 12% Technical and 26% High School or less.

the starting element of innovation, does not develop within a vacuum; a library's services act as an efficient link to current information.

2.3 Wider Economic Impact on the Population

While the more obvious impact of a research library's services is directly upon the user, the services can have a wide reaching impact on the total population (i.e., university, corporation, and nation). With an increase of a population's human and intellectual capital, information is openly shared between people and organizations. From this flow of information, more education and human capital is fostered, igniting more innovation that applies to various overlapping sectors within an organization.

This idea is reflected within the endogenous growth theory developed in the 1980's to promote economic growth within developing economies. The theory consists of a two sector model, dividing the population into an educated population (research community) and the rest of the population (manufacturing community). The general theory behind this two sector model is that a larger educated population will result in faster sustainable growth. By infusing an already educated population, such as the INL, with information that meets or rivals the user's initial intellectual capacity, the educated population grows – resulting in sustainable intellectual and economic growth for the organization.

Intellectual and economic impact is not only important for a federal facility, such as the INL, but also for the surrounding community. An increase in economic growth, fostered by employment opportunities at INL or through intellectually fostered spin-off companies, infuses income into the local economy.[25] The INL Research Library's main goal is to support research that not only generates intellectual property for the INL, but disperses this intellectual property throughout the region and nation to improve the quality of life of US citizens.

3. MATERIAL RESOURCES: FINANCIAL REPLACEMENT VALUES

To properly assess the material replacement value of the INL Research Library, sampling methods were used to approximate the value of each major material resource category within the library: books, reports and journals. Dividing materials into categories and separately calculating replacement value is important because each category has differences in distribution and pricing methods. It is more effective to divide the different resource types into categories for the calculation of their financial value.

3.1 Books

The calculation of the financial value of the complete book section of the INL Research Library was completed through a non-statistical survey method. Books were broken down into subject area and then into year increments. Data was obtained using the Research Library's catalog database with the main library book collection numbering approximately 46,000 and satellite library book collections numbering approximately 11,000 items (see Appendix A-1.1). Book subject area divisions were based on Library of Congress call numbers.[26]

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[25] Black, Geoffrey, Don Holley and John Church. *Impacts 2001: An Analysis of the INEEL's Impact on Idaho's Economy.* (Idaho National Laboratory, 2001): 7.

[26] Library of Congress number system: Technology, Engineering (T), Science (Q), Business and Economics (H), Health (R), Geography and Environment (G), Law (K), Information Science (Z), Agriculture (S), Reference works (A), Military and Naval (U, V), Government (J), Education (L), and Other (B, N, C, E, F, D, M, P).

Approximate book costs were calculated by subject area and year. Financial data for this survey was obtained from booksellers to approximate used book cost and availability (see Appendix A-1.2). The book data for 2000-2008 is based on average INL Research Library new book purchases over this time period.

During the survey it was determined that approximately 33% of the books within the library's collection, despite being included in the survey population, are considered irreplaceable. These books are no longer available in print or for purchase from booksellers.

Using this sampling method, the estimated total replacement costs were calculated. The cost was calculated by multiplying the number of books by the estimated average item replacement cost for each subject area (see Appendix A-1.3).

Table 3-1. INL book replacement costs (for complete chart see Appendix A).

Subject Area	Total ($)
Technology, Engineering	4,373,132
Science	2,534,648
Business, Economics	156,387
Health, Medicine	302,727
Geography, Environment	151,319
Law	32,864
Information Science	30,215
Agriculture	60,586
Reference Works	60,586
Military, Naval	16,516
Government	5518
Education	5518
Other	32,854
Total	$7,762,870

The result of this non-statistical survey placed the value of the INL Research Library's book collection at approximately $7,762,870.[27]

3.2 Reports

The financial value of the report section of the INL Research Library was determined through the average cost calculated from INL Research Library NTIS[28] account purchase statements in 2008. NTIS account statements list the cost of reports purchased by the INL Research Library and represent a range of subjects.

The microfiche portion of the report section were separated by topic area by calculating the approximate percentage of reports historically purchased through the Selected Research in Microfiche service by the total microfiche and microcard holdings (see Appendix A-2.1.) The number of hardcopy

[27] This number is conservative and does not reflect high priced or irreplaceable materials.

[28] National Technical Information Service is operated by the U.S. Department of Commerce.

and electronic reports was determined by approximating the number of reports on library shelves and through the library catalog database data (see Appendix A-2.2 and A-2.3.)

Based in this information the average INL cost in 2008 for one report of various media (i.e., electronic, microfiche, print-on-demand) is approximately $31.12. It should be noted that this average cost excludes special high cost reports such as EPRI and potential duplicate reports.

Table 3-2. Approximated value of INL research library reports at the main.

Total Number of Reports	1,419,100
Average Cost Per Report	$31.12
Total Replacement Value	$44,162,392

The financial replacement value of the reports section in the INL Research Library, in 2008, is $44,162,392. This represents the most important section of the library, and a key information resource for researchers and scientists at INL.

3.3 Journals

To calculate the overall value of the library materials, each resource type complied of its own population entirely to estimate financial values. For the appropriate application of statistics, we concentrated on the journal section (the largest section by volume in the library) and divided the section into scientific topic subcategories or various strata.

3.3.1 Appropriate Calculation of Sample Size

After the total number of items was calculated for each category, the sample size for estimating the financial value of the journal section was determined. Because no previous data or research has been done on the Library's assets, primary statistical measures are unknown (standard deviation, level of variation, etc.). Thus the application of Yamone's simplified sample size formula[29] is sufficient because the level of variation of the financial data is ultimately unknown.

$$n_o = \frac{N}{1+N(e)^2}$$

N = finite population size of the resource type

e = estimated error expected (within this study, 5% error was expected)

n_o = necessary sample size (assuming sampling with replacement)

However, because the sampling will be done without replacement, it needs to be multiplied by a correction factor. The formula for the final sample size will be:

$$n_f = n_o * \sqrt{((N - n_o) \div (N - 1))}$$

Thus the final sample answer n_f will be the size of the total sample for the journal section.

[29] Taro Yamane, *Statistics, An Introductory Analysis, 2nd Ed.* (New York: Harper and Row, 1967): 886.

3.3.2 Weighting the Data within Stratified Random Sampling

By calculating the percent each subcategory represents out of the entire resource population,[30] the application of stratified sampling can be weighted to fully reflect the contents of the collection.

$n_s = n_f * p_c$

n_s _ number of data points that are to be pulled from that particular subcategory

n_f = sample size without replacement

p_c = percent of the resource type the subcategory represents

By multiplying the proportion of the subcategory by the total necessary sample size, each stratum is assigned a number that relates to the amount of data points that should be pulled from that stratum. The amount of data to be pulled from each subcategory represents the prevalence of that subcategory in the entire collection (see Appendix A-3.1).

3.3.3 Calculating Financial Costs

Data concerning the replacement value of the datum point must be drawn from the population at random to represent the true population as close as possible. To properly reflect the current value of the journal collection, a general depreciation method was applied to the calculation of the final value. Each data point was broken down into years subscribed, and the number of years was broken down into year segments. Each section was multiplied by an average depreciation factor for each decade (see Appendix A-3.2).

Since depreciation is linear for print values, the following linear expression represents the rate of depreciation used within this study: $y=0.01246x - 0.6121$. The x-intercept represents the year 1949, the year the INL was founded.

Table 3-3. Summary of depreciation values (for full data see Appendix A).

Decade	Depreciation Factor (DF)
past-1960s	0.240
1970s	0.304
1980s	0.407
1990s	0.538
2000s	0.746

For each data point, the following formula was used to calculate the number of depreciated years that the point would represent in relation to the 2009 price of that journal subscription.

Depreciated years for data point x = $(\#years_{past\text{-}1960s} * DF_{past\text{-}1960s}) + (\#years_{1970s} * DF_{1970s}) + (\#years_{19_{80s}} * DF_{19_{80s}}) + (\#years_{19_{90s}} * DF_{19_{90s}}) + (\#years_{20_{00s}} * DF_{20_{00s}})$

Multiplying the total depreciated rate by the current 2009 price for each sample journal, results in the total value for that specific data point within the Research Library's journal collection.[31] By repeating this

[30] This can be accomplished by taking the total number of items in the subcategory, say the number of volumes within the chemistry category, under journals, and dividing it by the total number of journals within the collection.

process for the entire sample, and adding the data points together, the result will be the total value of the sample size. By dividing the total value of the sample size, by the total number of journals included in the sample size, n_f, the result is the average or mean value for a journal set in the Library's collection. The total number of journals held within the INL Research Library is multiplied by this average journal value, resulting in the estimated total value of the complete journal collection (see Appendix A-3.3).

The final replacement value estimate for the journal collection in both print and electronic format is $41,694,847[32] with the print section alone estimated at $34,472,610.[33]

3.4 Data Results

Through the calculations of the individual sections of the book, report and journal collections of the INL Research Library, an estimated total replacement value can be made. The total financial replacement value of the INL Research Library material is approximately $93,620,109. This value is conservative and does not reflect high cost or irreplaceable resources.

Table 3-4. Total estimated value of INL research library materials.

	Estimated Value
Book Collection	$7,762,870
Report Collection	$44,162,392
Journal Collection	$41,694,847
Total value:	$93,620,109

4. INTELLECTUAL VALUE OF THE LIBRARY

Since its establishment at the beginning of the technology age, intellectual capital has been referred to as the growing tool that companies can create. According to Nick Bontis, information will double approximately every 11 hours by the year 2010.[34] Yet many economists have deemed that calculating the actual value of intellectual capital is much more complicated then identifying its existence. This is because intellectual capital is impacted by numerous factors, both qualitative and quantitative. Yet as time has progressed, economists have realized that this intangible asset is also intertwined with human capital. To construct any model on intellectual value, you must have at least two variables: the source where knowledge is entering the organization and education of the user.

Most intellectual capital models used today have been developed within the past fifteen years. According to Stewart, NCI Research was one of the first organizations to develop a method of calculating

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[31] It should be noted that the INL Research Library's journal collection also exists of online subscriptions. Those years are included within the study, but instead of multiplied by the depreciation factor, they were multiplied by 10%, the value that most publishing companies value the addition of an online subscription of the normal print subscription. This method is used by major publishers like Emerald, Elsevier, and Wiley InterScience Publications. This resulting number was added into the years of each data point for one part of the study, which resulted in the total value of the journal section (print and online), only. It did not factor into the print only calculations of this study.

[32] A small percentage of the Library's online journal access can only be accessed by year to year subscription. This percentage is so small that it would not severely affect the final value of the complete journal collection. With a 5% statistical error the value is between $39,610,105 and $43,779,589.

[33] With a 5% statistical error the value is between $32,748,979 and $36,196,241.

[34] Nick Bontis, "Assessing knowledge assets: a review of the models used to measure intellectual capital," *International Journal of Management Reviews* 3, no. 1 (March 2001): 41-60.

intellectual capital.[35] Some models focus on efficiency and components of intellectual capital, such as determining human capital and structural capital values like Skandia's *Navigator*,[36] applying a dollar value after qualifications are met and questions are answered,[37] using citation-weighted patents,[38] or by calculating the company's book value and subtracting accounting factors like in the Sveiby method and the Economic Value Added method.[39,40]

These methods are complicated and structured towards evaluating a corporation in its entirety. Most libraries do not have the variables required to develop these types of models, or at least access to the type of information needed to assess their intellectual capital using these methods. Therefore we have developed a simple method to assess positive or negative intellectual growth impacts of a library with limited independent and dependent variables.

4.1 Behind the Intellectual Assessment Model

This model strives to focus on the most crucial factors of library and organizational output to determine a correlation of both outputs. A mathematical assessment was made to estimate the impact the library has on the organization's intellectual output. The model is geared toward a research library; however the method could be tailored for use by all libraries.

4.1.1 Input of Production: The Library's Resources and Services

One of the key measures used in this model is not the library budget itself, but a set of carefully divided and calculated measures of library output. In a study by Lewis Guodo Liu on cost function and scale economies in Academic Research Libraries, output measures of a library were determined to be group presentations, reference transactions, interlibrary loans borrowed and lent, and total number of circulated items.[41] For the purpose of this study, INL Research Library output data analyzed included: number of information research training seats filled, use of the INL Research Library's web based resources, interlibrary loans borrowed[42], information service requests[43], and publications budget. This represents the INL Research Library's key service activities.

4.1.2 The User

The users of information are a key factor in calculating the intellectual value of a library, because they act as the connection between the library and innovative ideas. For most libraries, the user consists of a diverse population. At the INL, the user demographic is more condensed. INL Research Library

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[35] Thomas A. Stewart, *Intellectual Capital: The New Wealth of Organizations* (New York: Doubleday, 1997): 227.

[36] Edvinsson, Leif and M.S. Malone, (1997). *Intellectual Capital: Realizing Your Company's True Value by Finding its Hidden Brainpower*. New York: HarperBusiness.

[37] Anne Brooking, *Intellectual Capital: Core Assets for the Third Millennium Enterprise* (London: Thomson Business Press, 1996).

[38] L.E. Lynn, *The Management of Intellectual Capital: The Issues and the Practice*, Management Accounting Issues Paper 16,, Management Accounting Practices Handbook (Hamilton, Ontario: Society of Management Accountants of Canada, 1998).

[39] K.E. Sveiby, *The New Organizational Wealth: Managing and Measuring Knowledge-based Assets* (San Francisco: Barrett-Kohler, 1997).

[40] N. Brontis,"Intellectual Capital: An Exploratory Study That Develops Measures and Models," *Management Decisions* 36, no. 2 (1998): 63-76.

[41] Lewis Guodo Liu, "The Cost Function and Scale Economies in Academic Research Libraries," *College and Research Libraries* 63, no. 5 (2003): 406-420.

[42] The source of this information was collected on 8 July, 2009 from Tamera Waldron, the Interlibrary Loan Coordinator for the Idaho National Laboratory.

[43] Service transactions include high-level literature and data research, materials circulation, and various other customer transactions.

customers procure scientific information for research conducted at the post-collegiate level. Over the past 15 years at the INL, staff education levels have remained at a consistent, high-level – particularly within the research community.

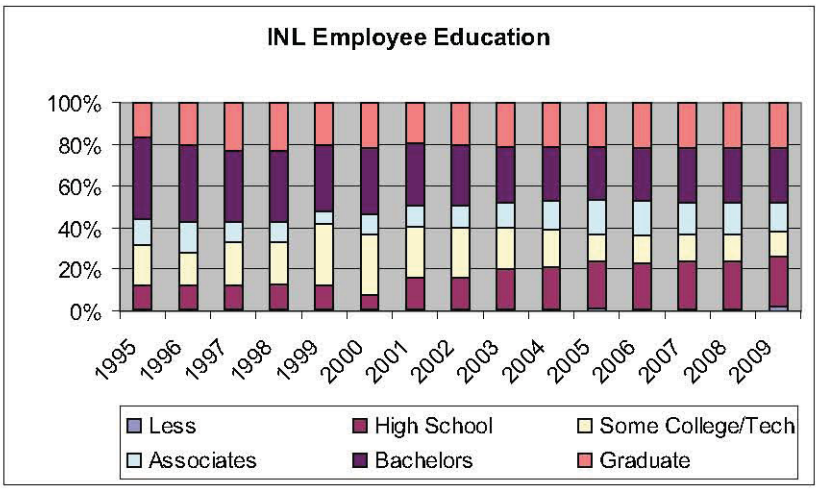

Figure 4-1. Total INL Employee Education. Bachelors and Graduate degrees represent the predominant research sectors of the Laboratory.

Another aspect of calculating intellectual output that has been a challenge to measure is the middle factor of the user and his ability to understand and process the information given. According to Jennifer Cram:

One of the difficulties in attempting to measure the value of a library is the near impossibility of measuring its intellectual output, because that is wholly dependent on the proportionate intellectual input of the library user. For example, the library acquires published information – intellectual output of authors and publishers. Then it might enhance the publication or information by organizing and possibly analyzing it. When the library hands the publication or information to a customer, that customer in turn adds value by evaluating the information presented in the context of his or her personal knowledge, experience and judgment.[44]

With a highly-educated employee population, the INL scientific community is well equipped to process background information for research projects. INL employees are trained to process information efficiently because of their academic backgrounds in research. Because the educational community is highly educated and education rates have remained consistent over the past 15 years, this intermediary factor will be considered constant and the library and INL output will be considered *ceteris paribus*.

4.1.3 Output: Intellectual Capital

For the purposes of this study INL output is divided into invention disclosures, cooperative research and development agreements, publications, patents and spin-off company outputs. These categories are considered the innovation products of research projects at the INL. Each of these categories is supported by INL Research Library information research services. These five variables represent the intellectual property generated at the INL.

[44] Jennifer Cram, "Six impossible Things Before Breakfast. A Multidimensional Approach to Measuring the Value of Libraries," *Proceedings of the 3rd Northumbria International Conference on Performance Measurement in Libraries and Information Services* (1999):19-29.

4.2 Calculation Method and Results

For the assessment of intellectual value creation, data on the INL was collected from a series of sectors within the organization. Most data was collected from management and information resources including previous studies, such as INL impact reports from 1995-2001, INL benchmarking output study for 2002-2007 and annual internal library studies.

4.2.1 Regression analysis

Before completing a regression analysis of the various input and output variables, each variable was multiplied by a fraction representing its estimated monetary value (see Appendix A-4.1and A-4.2. Thus all the variables had the same base unit, allowing for a total input/output value of the study to be calculated. These overall values were what were used for calculating the regression.

The first regression between these straight total values, using library services calculated as "input," were used as the independent variable and INL intellectual productivity variables were used as "output," the dependent variable. The first regression resulted in a highly uncorrelated relation, resulting in $R^2 = 0.02077$. However, upon further inspection of the data, a pattern emerged. Both sets of data strongly correlated with third-degree polynomial curves, at $R^2 = 0.771$ and $R^2 = 0.8626$ respectfully (see Figure 4-2).

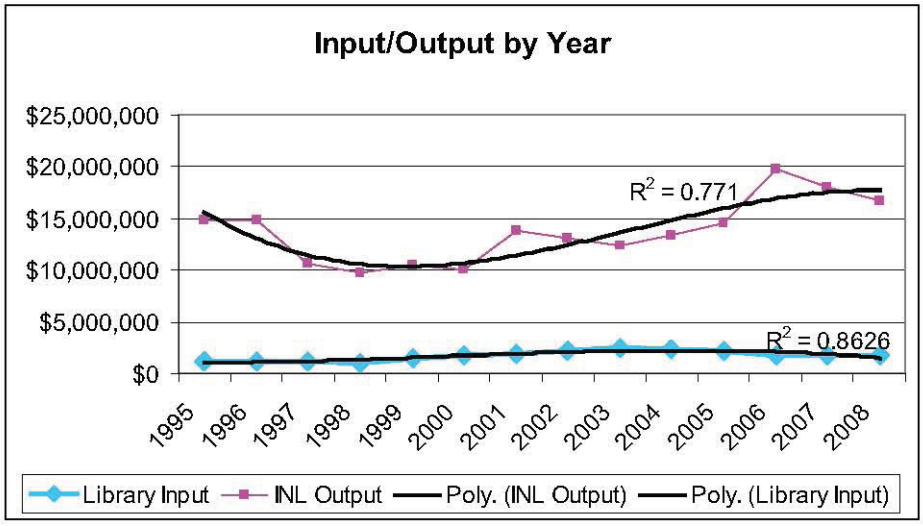

Figure 4-2. Input/output comparison by year with third-degree polynomial function treads.

This general curvature of both data sets, independently, suggests a possible relationship between the two, with different maxima and minima for each associated function. By calculating the maxima, minima and inflection point of each curve, it was revealed that the two curves were even more related. There was an average 3.69 year shift between each critical point on the input and output curves (with a 0.01 marginal error). This suggests a relationship between library services and researcher intellectual output; however, there exists a time delay of approximately 3.69 years between the use of library resources and measureable intellectual output. Interestingly, based on researcher interviews, the average project life at the INL is approximately three to four years, further supporting a time-delay correlation between library services and organizational intellectual output.

Because data was collected for each year and not divided into shorter time periods, the data was shifted four years. This shift paired 1995 library data with the 1999 INL output data. After the time shift

was made, only 10 observations were available for study. The regression showed a $R^2 = 0.744$, a much stronger correlation between library input and INL output (see Figure 4-3). This further emphasizes the existence of a time delay between library input and intellectual output.

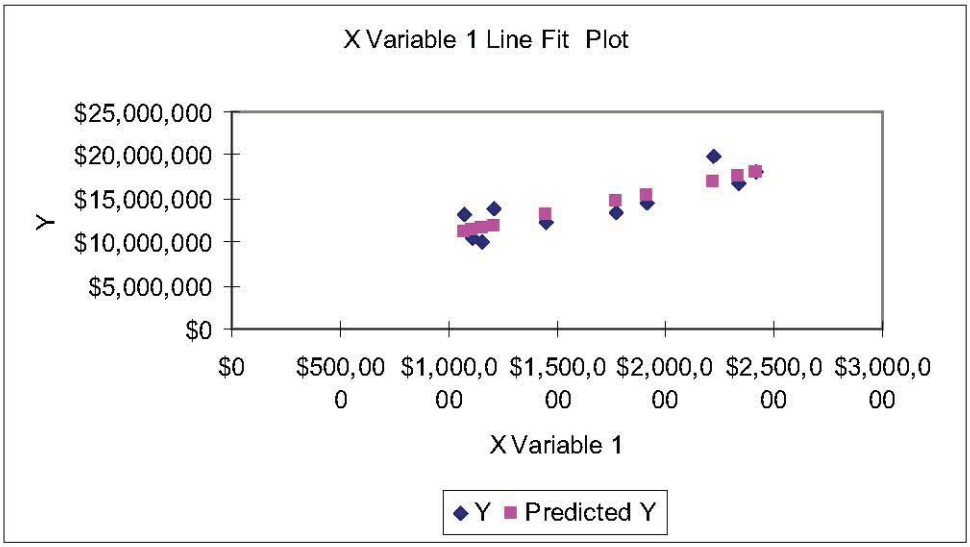

Figure 4-3. Line fit plot of shifted library input (X) to INL output (Y).

With this time shift, there appears to be a strong relationship between library services and total INL intellectual output, reflecting the time needed to transform information into innovation through scientific discovery.

4.2.2 Intellectual Value Model

Due to the methods used to collect data for this study, no controlled experiments were conducted. Verification of the correlation between library input and INL intellectual output would require future data collection to suggested relationship by the regression. For this model, we assumed that a direct relationship between library services and INL output has been established. We assume this for the following reasons:

- Most research conducted at INL requires extensive scientific background research on a topic being investigated.
- Most INL scientists and engineers use the library's resources to help maximize research findings.
- The library user's educational profile at INL has not changed over the past fifteen years. This factor is considered statistically constant and becomes insignificant after differentiation.

However in a community environment, education growth/decline would be a multiplication factors that needed to be included in a model. Therefore by accepting this relationship, we observe the following.

Assume: $f(t)$ = Best approximated line (slope-intercept) for INL output

$g(t - 2)$ = Best approximated line (slope-intercept) for library services

$h(t - 2)$ = Best approximated line (slope-intercept) for library budget

$j(t - 2)$ = Best approximated line (slope-intercept) for education growth of an organization's research force or a community's user profile

ε = time delay of research completion

t = time in years

α = intellectual value multiplication factor

ϑ = education multiplication factor (assume $1 \leq \vartheta \geq 10$ to determine importance of a specific educational background in information application)

a) $\partial f(t) / (\partial g(t - \varepsilon) * (1 + \vartheta * \partial j(t - \varepsilon))) = A$ = approximated rate of $ created from INL output per $ of library service distributed

b) $\partial f(t) / \partial h(t - \varepsilon) = B$ = INL output to INL library budget ratio

c) $(\partial f(t) / \partial h(t - \varepsilon)) * ((\partial g(t - \varepsilon) * (1 + \vartheta * \partial j(t - \varepsilon))) / \partial f(t))$

$$= \underline{(\partial g(t - \varepsilon) * (1 + \vartheta * \partial j(t - \varepsilon)))}$$

$$\partial h(t - \varepsilon)$$

= C = Knowledge Management Productivity multiplier

a) $(\partial f(t) / (\partial g(t - \varepsilon) * (1 + \vartheta * \partial j(t - \varepsilon))) - ((\partial g(t - \varepsilon) * (1 + \vartheta * \partial j(t - \varepsilon))) / \partial h(t - \varepsilon))$

= D = Intellectual Productivity multiplier

a) $\alpha = C * D$ = total intellectual value of materials *a priori.*

The final calculations of these models will reveal if economic growth is occurring. If the answers to equations a through d are less than or equal to one ($[A,D] \leq 1$), no return is being made on the library investment. If equations a through d are greater than one ($[A,D] > 1$), returns are being made in the specific section of the information cycle that the equation represents. If $\sum$ of $[A,D] \gg 1$, then significant returns are being made throughout the entire cycle, and all applications related to the library are economically efficient.

4.3 Final Data Results

For the INL Research Library, these methods were applied and the following calculations and estimations were made to assess the Library's direct impact on Laboratory performance.

Assume: $f(t) = 893{,}466(t) + 9{,}000{,}000$

$g(t - \varepsilon) = 168{,}465(t - \varepsilon) + 740{,}169$

$h(t - \varepsilon) = 83{,}508(t - \varepsilon) + 2{,}000{,}000$

$j(t - \varepsilon) = C$[45]

$\varepsilon = 4$ years

$t = [1999,2008]$

---

[45] Note: $\partial j(t \quad \varepsilon) = 0$ because $j(t \quad \varepsilon)$ is a constant. Thus, $1 + \vartheta * \partial j(t - \varepsilon) = 1$. As a multiplication factor for this study, it falls out and is considered insignificant for INL.

$\vartheta = 10$ (educational background importance is maximized at INL)

a) $\partial f(t) / (\partial g(t - 2) * (1 + 10 * \partial j(t - 2))) = \$5.30$

b) $\partial f(t) / \partial h(t - 2) = \$10.70$[46]

c) $\underline{(\partial g(t - 2) * (1 + 10 * \partial j(t - 2)))}$

$\partial h(t - 2)$

$= \$2.02$

a) $(\partial f(t) / (\partial g(t - 2)) - (\partial g(t - 2) / \partial h(t - 2)) = \$3.28$

b) $\alpha = C * D = \$6.63$

Thus, from data analysis, it can be concluded that the INL Research Library provides valuable research services and generates intellectual value for the INL. This is accomplished in two ways. First from knowledge management productivity, INL librarians increase the value of resources collected by a factor of 2.02. (This value is an average estimate of the total trend of spending versus output from 1995-2008.) Second from intellectual productivity, INL scientists increase the value of information by a factor of 3.28.

In the mathematical model the value of α is \$6.63, which represents the value of information serviced by the library to the scientist *a priori*. As noted above, this means that for every \$1 of information the library inputs into the research sector of INL, it generates \$6.63 in intellectual value that goes to form intellectual property (innovation) (see appendix B). By applying this multiplier to the total financial assets of the library, an estimated intellectual value of the library's hard assets is assessed. Thus, the estimated value of the library's information material collection *a priori* to the Laboratory in innovation is \$614,616,015.

True values of annual estimates should fluctuate around these estimates. To maximize the value of generated output, more training classes for more accessible internet based library services and more highly trained research staff to increase the caliber of services provided to INL scientists and engineers should be considered.

4.4 Error

In the calculation of INL output, our main goal was to capture the average rate at which output was growing using the five measures chosen. There are other variables, such as copyright royalties, general licensing agreements and work-for-others funding that also generates output for the INL and is significant to the INL's mission. Likewise, in the calculation of INL Research Library input, other factors were not considered such as electronic communication services (routing transactions, photocopies), technical support activities (publication, materials management), and responsiveness (averaging 94%).

In the creation of the model, the decision to exclude the factor of the user variability was due to the consistent education levels of users. The obvious impact from a user perspective is how users interpret research information crucial to the development of the five output factors mentioned, yet education level over the past 15 years at INL has stayed consistent, varying within the margin of error. Although this model only relies upon quantified data and does not include dummy variables, other qualitative factors could have been overlooked that relate to the user but are not captured in data recorded by the INL.

[46] The final product of intellectual property doubles in value in its final stage from the actual generation of a new idea from human capital input. This is not related to library services and thus not studied in this report.

5. CONCLUSION

As communities try to cut back on costs due to challenging economic times, libraries are being affected – hindering the intellectual growth of the population. Yet libraries are a key component for promoting economic growth within a community. Assessing the value of a library, on both a financial and an intellectual level, is central to proving this importance; but previous models fail to provide a short, simple analytical method for assessing the impact of a library. In this study, we have provided methods for estimating the financial value of a library's assets and a method of estimating the intellectual value a library gives to a larger organization. All methods were tested using the INL and the INL Research Library.

The financial value of the Research Library's hard assets was estimated to be worth $93,620,109, excluding irreplaceable and electronic resources. The intellectual value created by the library's services was estimated to be approximately $2.02 for every dollar spent investing in the library. Combined with the economic value of information to scientists for research, it is estimated that every dollar of input from the library, approximated $6.63 is created in INL intellectual property (output), between information/services issued and intellectual application. This means that the addition of library services increases information value in output by 62%. With the discovery of a multiplication factor specifically for INL, the estimated worth of the library's collection to INL is $614,616,015 in economic value (opportunity cost). By applying analytical methods to data collected from within the INL community, we have concluded that the library is as a positive economic factor for the INL and the wider community.

APPENDIX A

Referenced Tables

A-1. Financial Book Data

A-1.1 Book Subject Area Distribution by Year: Main, MFC, & IRC Libraries.

Subject Area	pre-1949	1950-59	1960-69	1970-79	1980-89	1990-94	1995-99	2000-04	2005-08	Total	Percent
Technology, Engineering	300	1099	3806	6312	7700	3700	2146	1993	666	27,759	48.70%
Science	206	756	2618	4342	5322	2545	1476	1371	458	19,095	33.50%
Business, Economics	35	129	445	739	905	433	250	233	78	3249	5.700%
Health, Medicine	25	90	313	518	635	304	176	164	55	2280	4.00%
Geography, Environment	12	45	156	259	318	152	89	82	27	1140	2.00%
Law	7	27	94	156	191	91	53	49	16	684	1.20%
Information Science	7	25	86	143	175	84	48	45	15	627	1.10%
Agriculture	5	18	63	104	127	61	34	33	11	456	0.80%
Reference Works	5	18	63	104	127	61	34	33	11	456	0.80%
Military, Naval	4	14	47	78	95	46	25	25	8	342	0.60%
Government	1	5	16	26	32	15	8	8	3	114	0.20%
Education	1	5	16	26	32	15	8	8	3	114	0.20%
Other	7	27	93	156	191	91	54	49	16	684	1.20%
Total	615	2258	7816	12,963	15,850	7598	4401	4093	1367	57,000	
Percent	1.08%	3.96%	13.71%	22.74%	27.87%	13.33%	7.73%	7.18%	2.40%		100%

Data was obtained using the Research Library's catalog database with the Main and IRC Libraries book collection numbering approximately 46,000 and MFC Library book collection numbering approximately 11,000 items. This data was obtained by general non-statistical survey and excludes eBooks

A-1.2 Book Subject Area Average Replacement Cost and Availability per Item by Year: Main, MFC, & IRC Libraries

Subject Area	pre-1949	1950-59	1960-69	1970-79	1980-89	1990-94	1995-99	2000-04	2005-08
Technology, Engineering	$ 155	$ 115	$ 95	$ 183	$ 169	$146	$126	$ 215	$ 215
Science	101	72	108	129	113	180	111	215	215
Business, Economics	13	16	27	47	35	10	17	215	215
Health, Medicine	101	72	108	129	113	180	111	215	215
Geography, Environment	101	72	108	129	113	180	111	215	215
Law	13	16	27	47	35	10	17	215	215
Information Science	13	16	27	47	35	10	17	215	215
Agriculture	101	72	108	129	113	180	111	215	215
Reference Works	101	72	108	129	113	180	111	215	215
Military, Naval	13	16	27	47	35	10	17	215	215
Government	13	16	27	47	35	10	17	215	215
Education	13	16	27	47	35	10	17	215	215
Other	13	16	27	47	35	10	17	215	215
Irreplaceable	40%	38%	30%	40%	40%	40%	20%	30%	5%

Data for this survey was obtained using the Research Library's catalogue database and online booksellers to approximate used book cost and availability. The data was obtained by general non-statistical survey with a focus on a sampling on various book types. To simplify sampling, book groupings included 1) Technology, Engineering, 2) Science, Health, Medicine, Geography, Environment, Agriculture, Reference works, and 3) all other subject areas. Data for 2000-08 is based on surveyed average new book cost. This data excludes high cost reference items and complete volume sets.

A-1.3 Book Subject Area Total Replacement Costs by Year: Main, MFC, & IRC Libraries

Subject Area	pre-1949	1950-59	1960-69	1970-79	1980-89	1990-94	1995-99	2000-04	2005-08	Total
Technology, Engineering	46,500	126,385	361,570	1,155,096	1,301,300	540,200	270,396	428,495	143,190	4,373,132
Science	20,806	54,423	282,744	560,118	601,386	458,100	163,836	294,765	98,470	2,534,648
Business, Economics	455	2064	12,015	34,733	31,675	4330	4250	50,095	16,770	156,387
Health, Medicine	2525	6480	33,804	66,822	71,755	54,720	19,536	35,260	11,825	302,727
Geography, Environment	1,212	3240	16,848	33,411	35,934	27,360	9879	17,630	5805	151,319
Law	91	432	2538	7332	6685	910	901	10,535	3440	32,864
Information Science	91	400	2322	6721	6125	840	816	9675	3225	30,215
Agriculture	505	1296	6804	13,416	14,351	10,980	3774	7095	2365	60,586
Reference Works	505	1296	6804	13,416	14,351	10,980	3774	7095	2365	60,586
Military, Naval	52	224	1269	3666	3325	460	425	5375	1720	16,516
Government	13	80	432	1222	1120	150	136	1720	645	5518
Education	13	80	432	1222	1120	150	136	1720	645	5518
Other	91	432	2511	7332	6685	910	918	10,535	3440	32,854
Total	$72,859	$196,832	$730,093	$1,904,507	$2,095,812	$1,110,090	$478,777	$879,995	$ 293,905	$7,762,870

Replacement cost was calculated by multiplying the number of books by the estimated individual item replacement cost. This data does not take into account that approximately 18,910 books, or 33% of the collection, are irreplaceable.

A-2. Financial Report Data

A-2.1 Microfiche and Microcard, Main Library

Subject Area	Number	Percent
Batteries and Components	4992	0.52%
Ceramics, Refractories, and Glasses	12,480	1.30%
Composite Materials	22,944	2.39%
Corrosion and Corrosion Inhibition	5760	0.60%
Environmental Engineering	384	0.04%
Environmental Safety and Health	59,328	6.18%
Environmental Studies	15072	1.57%
Fluid Mechanics	61,344	6.39%
Geology and Geophysics	18,240	1.90%
Hydrology and Limnology	40,992	4.27%
Industrial Safety Engineering	4416	0.46%
Iron and Iron Alloys	7296	0.76%
Isotopes	11,136	1.16%
Materials Degradation and Fouling	5760	0.60%
Microbiology	38,304	3.99%
Nonferrous Metals and Alloys	23,712	2.47%
Nuclear Auxiliary Power Systems	1344	0.14%
Nuclear Instrumentation	19,200	2.00%
Nuclear Propulsion	1056	0.11%
Photochemistry and Radiation Chemistry	4032	0.42%
Policies, Regulations, and Studies	27,840	2.90%
Radiation, Shielding, Protection, and Safety	106,176	11.06%
Radioactive Wastes and Radioactivity	262,080	27.30%
Radiobiology	29,760	3.10%
Reactor Engineering and Nuclear Power Plants	97,920	10.20%
Reactor Fuels and Fuel Processing	37,824	3.94%
Reactor Materials	4608	0.48%
Reactor Physics	7296	0.76%
Selected Studies in Nuclear Technology	14,880	1.55%
Soil and Rock Mechanics	7776	0.81%
Soil Sciences	6048	0.63%
Total	960,000	100.00%

A-2.2 Hardcopy and eReports, Main Library

Originator/Media	Number	Percent
Idaho National Laboratory - Hardcopy	37,000	13.63%
Idaho National Laboratory - Historical (SL-1, etc.)	200	0.08%
Other (DOE, NASA, Commercial, etc.) - Hardcopy	233,000	85.85%
eReports	1200	0.44%
Total	271,400	100%

A-2.3 Reports, MFC Library

Originator/Media	Number	Percent
Idaho National Laboratory - Hardcopy	7,000	3.70%
Other (DOE, NASA, Commercial, etc.) - Hardcopy	10,700	5.70%
Microfiche	170,000	90.60%
Total	187,700	100%

A-3. Financial Journal Data

A-3.1 Weighted Sample Size by Journal Subject Area: Main, MFC, & IRC Libraries

Subject Area:	Total	%of total	Sample Size (5%)	Corrected (%5)
	x	x/1,889	x/(1+x*(0.05^2))	(x/1889)*SCC
Agriculture	72	0.0381	61	11
Arts and Social Sciences	34	0.0180	31	5
Biology (Biotechnology)	31	0.0164	29	5
Business/Management Science	52	0.0275	46	8
Chemistry	469	0.2483	216	74
Computer Science	17	0.0090	16	3
Energy	46	0.0244	41	7
Engineering and Technology	340	0.1800	184	54
Environmental Science	61	0.0323	53	10
Geology and Earth Science	76	0.0402	64	12
Health and Safety	23	0.0122	22	4
Information Sciences	93	0.0492	75	15
Instrumentation	43	0.0228	39	7
Material Science	116	0.0614	90	18
Mathematics and Statistics	51	0.0270	45	8
Nuclear Science and Technology	151	0.0799	110	24
Physics	170	0.0900	119	27
Other: Law, Library Sciences	44	0.0233	40	7
Total population size:	1,889	1.0000	330	300

A-3.2 Depreciation Data and Averaged Factors

Year	Sample 1	Sample 2	Sample 3	Averages	Decade Average
1965	0.15	0.3	0.28	0.243333	0.243333333
1966	0.15	0.3	0.28	0.243333	
1967	0.15	0.3	0.28	0.243333	
1968	0.15	0.3	0.28	0.243333	
1969	0.15	0.3	0.28	0.243333	
1970	0.15	0.3	0.366	0.272	0.303923077
1971	0.25641	0.3	0.366	0.30747	
1972	0.25641	0.3	0.366	0.30747	
1973	0.25641	0.3	0.366	0.30747	
1974	0.25641	0.3	0.366	0.30747	
1975	0.25641	0.3	0.366	0.30747	
1976	0.25641	0.3	0.366	0.30747	
1977	0.25641	0.3	0.366	0.30747	
1978	0.25641	0.3	0.366	0.30747	
1979	0.25641	0.3	0.366	0.30747	
1980	0.25641	0.3	0.366	0.30747	0.407203419
1981	0.25641	0.3	0.366	0.30747	
1982	0.25641	0.56	0.48	0.432137	
1983	0.25641	0.56	0.48	0.432137	
1984	0.25641	0.56	0.48	0.432137	
1985	0.25641	0.56	0.48	0.432137	
1986	0.25641	0.56	0.48	0.432137	
1987	0.25641	0.56	0.48	0.432137	
1988	0.25641	0.56	0.48	0.432137	
1989	0.25641	0.56	0.48	0.432137	
1990	0.25641	0.56	0.48	0.432137	0.537871795
1991	0.25641	0.77	0.48	0.502137	
1992	0.25641	0.77	0.48	0.502137	
1993	0.25641	0.77	0.48	0.502137	
1994	0.25641	0.77	0.48	0.502137	
1995	0.25641	0.77	0.48	0.502137	
1996	0.25641	0.77	0.48	0.502137	
1997	0.683761	0.77	0.48	0.644587	
1998	0.683761	0.77	0.48	0.644587	
1999	0.683761	0.77	0.48	0.644587	

Year	Sample 1	Sample 2	Sample 3	Averages	Decade Average
2000	0.722222	0.77	0.48	0.657407	0.745868946
2001	0.726496	0.77	0.48	0.658832	
2002	0.747863	0.77	0.48	0.665954	
2003	0.811966	0.77	0.48	0.687322	
2004	0.854701	0.77	0.48	0.701567	
2005	0.888889	0.98	0.48	0.782963	
2006	0.901709	0.98	0.48	0.787236	
2007	0.923077	0.98	0.48	0.794359	
2008	0.961538	1	0.97	0.977179	
2009	1	1	1	1	

Sources for this sample for price changes were from the following journals and major publishers.

- Sample 1: *Annual Review of Materials Research* from Wiley InterScience Publications.
- Sample 2: *Accounting, Auditing and Accountability Journal* from Emerald Publishing.
- Sample 3: *SIAM Journal of Mathematics* from the Society for Industrial and Applied Mathematics.

Percentages represent the percent which the publisher is selling back volumes of each particular journal in comparison to its present subscription price (2009). Fractions were averaged for each year from 1965 to 2009, and then averaged for each decade. Highlighted values in the far right column represent the average depreciation value that was used in this study. Only the first three digits were used in the calculation of each journal datum point's overall value in the INL Research Library's collection.

A-3.3 Depreciation Data and Averaged Factors

Subject Area	Number	Percent (%)	Sample	Total Cost ($)	Total Cost (print only) ($)
Agriculture	72	3.81	11	148,812	137,756
Arts and Social Sciences	34	1.80	5	92,733	92,716
Biology (Biotechnology)	31	1.64	5	150,053	144,963
Business/Management Science	52	2.75	8	171,246	146,105
Chemistry	469	24.83	74	2,303,974	1,761,022
Computer Science	17	0.90	3	6,238	6,238
Energy	46	2.44	7	14,921	14,921
Engineering and Technology	340	18.00	54	971,759	800,783
Environmental Science	62	3.28	10	35,173	33,170
Geology and Earth Science	76	4.02	12	443,653	381,319
Health and Safety	23	1.22	4	33,179	27,447
Information Sciences	93	4.92	15	280,137	248,636
Instrumentation	43	2.28	7	78,444	62,168
Material Science	116	6.14	18	265,836	230,825
Mathematics and Statistics	51	2.70	8	285,807	260,232
Nuclear Science and Technology	150	7.94	24	654,230	571,766
Physics	170	9.00	27	677,550	550,293
Other: Law, Library Sciences	44	2.33	7	7,990	4,380
Total:	1,889	100.00	300		

Sample total:	(the sum of the subject areas)	6,621,733	5,474,740
Average journal cost:	(sample total/sample size)	22,072	18,249
Total journal value:	(average journal cost*Journal#)	41,694,847	34,472,610
Online journal value:	((total print + online)-total print)	7,222,237	0
Estimated Error (5%):	(total journal value*0.05)	2,084,742	1,723,631

A-4. Intellectual Data

A-4.1 Input/Output Data Collected as Measuring Factors on INL

Library Input

	Training	Computer	ILL	Service	Publication Spending
1995	50	99,768	3,110	23,205	$563,870
1996	50	175,330	2,945	18,845	$611,196
1997	50	114,012	2,772	17,575	$742,515
1998	50	58,356	2,963	17,932	$660,710
1999	50	203,976	2,877	18,428	$879,968
2000	100	325,884	2,772	15,072	$1,133,471
2001	200	254,028	2,590	18,228	$1,306,417
2002	400	426,528	2,920	14,527	$1,475,030
2003	300	597,852	2,639	13,388	$1,525,599
2004	300	443,736	2,257	10,556	$1,654,732
2005	100	420,231	1,997	11,495	$1,477,503
2006	100	490,539	2,075	5,778	$1,099,600
2007	200	455,856	2,820	6,800	$1,101,435
2008	200	473,198	3,580	9,400	$1,007,811

INL Output

	CRADAs	IDR	Patents	Spin-Off	Publications
1995	20	116	10	$8,380,000	315
1996	20	119	12	$16,538,000	219
1997	11	114	125	$21,078,000	183
1998	7	123	130	$31,050,000	156
1999	7	112	119	$34,050,000	228
2000	7	121	128	$34,050,000	154
2001	13	162	175	$39,426,315	165
2002	9	126	135	$43,010,525	268
2003	9	78	87	$43,010,525	237
2004	10	150	160	$43,010,525	227
2005	10	110	120	$43,010,525	375
2006	19	77	96	$48,386,840	337
2007	15	118	133	$48,386,840	394
2008	14	83	38	$50,178,945	349

A-4.2 INL Input/Output Data Changed to Units of U.S.D.

Library Input

	Training*$40	Computer	ILL*$30	Service*$15	Publication Spending	Total Input
1995	$2,000	$99,768	$93,300	$348,075	$563,870	$1,107,013
1996	$2,000	$175,330	$88,350	$282,675	$611,196	$1,159,551
1997	$2,000	$114,012	$83,160	$263,625	$742,515	$1,205,312
1998	$2,000	$58,356	$88,890	$268,980	$660,710	$1,078,936
1999	$2,000	$203,976	$86,310	$276,420	$879,968	$1,448,674
2000	$4,000	$325,884	$83,160	$226,080	$1,133,471	$1,772,595
2001	$8,000	$254,028	$77,700	$273,420	$1,306,417	$1,919,565
2002	$16,000	$426,528	$87,600	$217,905	$1,475,030	$2,223,063
2003	$12,000	$597,852	$79,170	$200,820	$1,525,599	$2,415,441
2004	$12,600	$443,736	$67,710	$158,340	$1,654,732	$2,337,118
2005	$4,000	$420,231	$59,910	$172,425	$1,477,503	$2,134,069
2006	$4,000	$490,539	$62,250	$86,670	$1,099,600	$1,743,059
2007	$8,000	$455,856	$84,600	$102,000	$1,101,435	$1,751,891
2008	$8,400	$473,198	$107,400	$141,000	$1,007,811	$1,737,808

INL Output

	CRADAs	IDR	Patents	Spin-Off	Publications	Total Output
1995	$9,562,913	$1,163,333	$177,360	$8,380,000	$3,150,000	$14,891,606
1996	$9,562,913	$1,186,667	$212,832	$16,538,000	$2,190,000	$14,806,211
1997	$5,259,602	$1,140,000	$248,304	$21,078,000	$1,830,000	$10,585,706
1998	$3,347,019	$1,230,000	$478,872	$31,050,000	$1,560,000	$9,720,891
1999	$3,347,019	$1,120,000	$354,720	$34,050,000	$2,280,000	$10,506,739
2000	$3,347,019	$1,210,000	$478,872	$34,050,000	$1,540,000	$9,980,891
2001	$6,215,893	$1,620,000	$407,928	$39,426,315	$1,650,000	$13,836,453
2002	$4,303,311	$1,260,000	$514,344	$43,010,525	$2,680,000	$13,058,707
2003	$4,303,311	$780,000	$532,080	$43,010,525	$2,370,000	$12,286,443
2004	$4,781,456	$1,500,000	$461,136	$43,010,525	$2,270,000	$13,313,645
2005	$4,781,456	$1,100,000	$549,816	$43,010,525	$3,750,000	$14,482,325
2006	$9,084,767	$770,000	$1,738,128	$48,386,840	$3,370,000	$19,801,579
2007	$7,172,185	$1,180,000	$922,272	$48,386,840	$3,940,000	$18,053,141
2008	$6,694,039	$830,000	$673,968	$50,178,945	$3,490,000	$16,705,901