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Preface

This technical report is the result of a literature search performed under the NCGIA Initiative # 4 - The Use and Value of Geographic Information. This initiative is part of a larger research agenda focused on the impediments to the adoption of GIS in organizations. At the Initiative # 4 Specialist Meeting, (May, 1989, University of Maine), it was quickly realized that determining the use and value of information would not be an easy task. Of great concern to the attendees of this meeting were research topics that would (1) develop taxonomies of information use, (2) develop a methodology for assessing the value of information, and (3) develop a model of the diffusion of technology. This technical report is in response to the second research topic.

Previous work on the economic evaluation of GIS is limited. For this reason, the first step of the research plan is an extensive bibliographic search aimed at identifying the concepts and methods used by other disciplines to address the value of information.

Articles on the value of information were found in the economics, information science, and management sciences literature. Computer searches were conducted on several data bases using the following keywords: value, information, value-added, value analysis, cost/benefit, evaluation, decision making, and decision analysis. The bibliography presented here is a subset of the results of the computer searches, containing only articles deemed relevant to the investigation into the value of information, either theoretical or empirical studies.

Abstracts are included for selected articles. The abstracts were written for those articles which either seemed most relevant to the work of Initiative #4 or representative of the most popular methods found in the literature. This list is not, however, an exhaustive list of relevant articles and reflects the first-cut computer search and those references which have been accessible to this researcher.

Partially Annotated Bibliography

1. Ahituv, N., 1980. A Systematic Approach Toward Assessing the Value of an Information System. *MIS Quarterly*, 4:4, 61-75.

This article classifies some of the theoretical background of information system evaluation into (1) pragmatic assessment (cost-benefit), (2) theoretical evaluation based on decision theory, and (3) evaluation based on utility theory. Types of "value" of information include perceived, revealed, and normative. The article discusses choosing between alternative information systems, using a multiattribute measurement of utility gained by using information. This involves ranking the attributes of a system, assigning a quantitative utility to each, summing the utility of all attributes for each system, and then plotting the utility against price for each system.

2. Ahituv, Niv, and Yair Ward, 1984. Comparative Evaluation of Information Under Two Business Objectives. *Decision Sciences*, 15:1, 31-51.

3. Anderson, Robert C., and Norman F. Meade, 1979. Cost Benefit Analysis of Selected Environmental and Data Information Programs. *NTIS Report PB-297189*, NOAA.

4. Antonovitz, F., and T. Roe, 1982. A Measure of the Value of Information for the Competitive Firm Under Price Uncertainty. *American Journal of Agricultural Economics*, 64:5, 1082.

5. Antonovitz, F., and T. Roe, 1986. A Theoretical and Empirical-Approach to the Value of Information in Risky Markets. *Review of Economics & Statistics*, 68:1, 105-114.

6. Arrow, K. J., and R. C. Lind, 1970. Uncertainty and the Evaluation of Public Investment Decision. *American Economic Review*, June, 364-378.

7. Arrow, K. J., 1985. Collected Works, Vol. 4*, The Economics of Information*. Oxford: Blackwell Publishing.

In Chapter 9, Arrow first explains with equations a model of behavior under uncertainty. The behavior is that of an expected value maximizer betting on occurrences of possible states of nature. Arrow discusses the amount of information (according to Shannon's 'H' concept), and how the value of information can also be measured by 'H' if the utility function is logarithmic, if the value of information is independent of the rewards, and if the value of the information in the channel is precisely the rate of transmission. The discussion of the demand for information continues with the above assumptions and shows a demand equation which maximizes the difference between the rate of transmission and the cost of channel capacity per unit.

Chapter 11 is a discussion of how information signals play a role in decision making as an economic behavior. The author points out that information signals have value and are worth acquiring and different individuals have different information. He also states that

since information has a "public good" characteristic, it will most likely be produced at a volume less than optimal in terms of welfare economics. He then discusses ways an organization can become more efficient in the acquisition of information (such as increasing the number of information receptors, i.e., people).

8. Barron, Michael, and David Targett, 1986. Sales Forecasting, Market Research and the Value of Information. *Marketing Intelligence & Planning*, 4:3, 12-31.

9. Bedford, Norton M., and Mohamed Onsi, 1966. Measuring the Value of Information - an Information Theory Approach. *Management Services*, 15-22.

This article is an application of information theory to accounting management. Three major concepts are cited: the concept of information, measuring the amount of information, and measuring the value of information. The function of information is to "reduce the amount or range of uncertainty under which decisions are made," (p. 16). The amount of information is "measured by the reduction of ignorance and uncertainty and not by the addition of knowledge," (p. 16). The value of information is* discussed in terms of its use by the person needing it. The flexibility of information is the ability one piece of information has to be used in different situations.

10. Bentkover, Judith D., Vincent T. Covello, and Jeryl Mumpower, eds., 1985. *Benefits Assessment: The State of the Art*. Boston: D. Reidel Publishing Co.

11. Bonini, C. P., 1964. *Management Controls and New Directions in Basic Research*. New York: McGraw Hill.

12. Bosch, Darrell J., and Vernon R. Eidman, 1987. Valuing Information when Risk Preferences are Nonneutral: An Application to Irrigation Scheduling. *American Journal of Agricultural Economics*, 69:3, 658-668.

13. Bradford, David F., and H. H. Kelejian, 1977. The Value of Information for Crop Forecasting in a Market System: Some Theoretical Issues. *Review of Economic Studies*, 44:3, 519-532.

14. Branthwaite, Alan, 1975. Subjective Value of Information. *British Journal of Psychology*, 66:3, 275-282.

15. Brown, Thomas C., 1984. The Concept of Value in Resource Allocation. *Land Economics*, August, 231-246.

16. Carroll, Bonnie C., and Donald W. King, 1985. Value of Information. *Drexel Library Quarterly*, 21:3, 39-60.

17. Chan, Yuk-shee, 1981. A Note on Risk and the Value of Inforination. *Journal of Economic Theory*, 25:3, 461-465.

18. Chandler, J. S., 1982. A Multiple Criteria Approach for Evaluating Information Systems. *MIS Quarterly*, 6:1, 61-74.

In this article, Chandler introduces a method to support the performance evaluation of an information system. Evaluation occurs from two perspectives: the computer system domain (with measures of resource utilization, cost, and efficiency) and the user domain (with measures of throughput, reliability, and response time). The approach consists of three iterative stages: system evaluation, user goal evaluation, and design evaluation. The first stage evaluates the information system with respect to system measures. The second determines how well the system achieves the user goals and produces guidelines for altering the system to better meet these goals. The third stage examines the current system with respect to both system and user goals and defines the new system from specifications determined in stages one and two. The only reference to evaluating costs and benefits states the need for goals to be expressed in terms of the user's data processing budget.

19. Chavas, Jean P., and Rulon D. Pope, 1984. Information: Its Measurement and Valuation. *American Journal of Agricultural Economics*, 66, 705-727.

20. Clemen, R. T., and R. L. Winkler, 1985. Limits for the Precision and Value of Information from Dependent Sources. *Operations Research*, 33:2, 427-442.

21. Conrad, Jon M., 1980. Quasi-Option Value and the Expected Value of Information. *Quarterly Journal of Economics*, 94:4, 813-820.

22. Cougar, Daniel J., and Robert W. Knapp, 1974. *Systems Analysis Techniques*. New York: John Wiley and Sons, 395-425.

23. Demski, Joel S., 1972. I*nformation Analysis*. Massachusetts: Addison-Wesley Publishing.

24. Dertouzos, M. L., and J. Moses, eds., 1979. *The Computer Age: A Twenty Year Review*. Cambridge: The M.I.T. Press.

25. Dickson, Gary W.,. A. J. Senn, and N. L. Chervany, 1977. Research in Management Information Systems: The Minnesota Experiments. *Management Science*, 23:9, 46-55.

This article summarizes a set of experiments conducted to determine the relationships between various information system characteristics and the effectiveness of a decision made with that information. Van Horn's four methods of empirical research in the Management Information System (MIS) area are discussed: case studies, field studies, field tests, and laboratory studies. The experiments reported are of the laboratory type, specifically, simulation experiments. Five different simulators were used to create a particular decision-making environment. Each simulator also had specific information system characteristics (form of output, amount of data aggregation, presence of decision aids, etc.). The attributes of decision performance included: time to make the decision, confidence level, and decision quality. These experiments showed: complex (hard-to-use) systems had little impact on decision making and often resulted in lower confidence; CRT and graphic displays led to faster decisions and use of less data; and managers preferred to use interactive systems.

26. Edstrom, 0., 1973. *Man-Computer Decision Making*. Gottenburg Studies in Business Administration.

This book describes the different ways to improve decisions by means of information technology. The book is divided into two parts: a discussion on the framework of unstructured decision making and possible ways of giving technological support to the decision maker, followed by a description of three computer systems created to be used for research on man-computer decision making. The first part discusses the components of decision making best suited to man (such as pattern recognition, judgement, and processing of graphical information) and those best suited for a computer (such as calculations, repetitive tasks, handling large amounts of data). Many models of human decision making are referenced (Simon, Hedberg, Newell). This book is a good source of information on decision support systems from the management information science literature.

27. Emery, J. C., 1971. Cost/Benefit Analysis of Information Systems. SMIS Workshop Report: No. 1, *Society for Management Information Science*, Chicago.

This paper begins with an extensive discussion of the decision analysis (bayesian) technique for calculating the value of infomation. The author shows the relationship between the quality of information and its value and cost, (using abstract graphs to show the general trends). The next section discusses the important characteristics of an information system that must be kept in mind when determining costs and value. These characteristics include the man-machine interface, selectivity of displayed data, etc. A discussion of cost-benefit analysis includes cost reductions, tangible and intangible benefits. Treatment of intangibles does not include any new ideas. The author states that just using cost reductions to justify a system (and not assessing the benefits of better information), may be "misdirecting efforts away from projects that can make more fundamental improvements in organizational performance," (p. 39). The final section looks at the users' role in a cost-benefit analysis.

28. Emery, James C., 1987. *Management Information Systems - The Critical Strategic Resource*. New York: Oxford University Press. (Chapter 8)

The chapter begins with an overview of important attributes of a management information system (MIS), tradeoffs between the cost and quality (value) of a MIS along the "efficiency frontier" for a given system, and the difference between effectiveness ("doing the right thing") and efficiency ("doing the thing right"). The calculation of the value of information (in theory) follows the same concept as the bayesian decision analysis techniques (i.e., value of information = payoff with information -payoff without information). In practice, the author recognizes problems associated with collecting the empirical data for the above model. He first suggests breaking the evaluation into three questions directly related to the "assumptions" of the theoretical method:

"If we spend money on this information..."

1) what additional surprises will result (and how often)?
2) what decisions will be altered (for the better) if the surprise occurs?
3) what is the effect on payoff from an altered, improved decision?

The next section discusses the actual steps of a cost benefit analysis. Analysis of tangible benefits is separated from analysis of intangible benefits. Suggestions for reporting intangibles are:

- ,quantify in non-monetary terms (such as percentage change)
- estimate monetary benefits from associated benefits

- determine boundary estimates (worst case/best case)
- express the cost in break-even terms
- tradeoff with a tangible benefit (give the management an option of the intangible or a specific amount of money)
- use the cost of the lowest-cost alternative

An example of the two types of benefits plotted on a cash-flow-by-month diagram is then given. The remainder of the chapter discusses sensitivity analysis, setting priorities among competing projects, the use of the cost-benefit analysis in project management, and determining the price to charge for computing services.

29. Epstein, B. J., and W. R. King, 1982. An Experimental-study of the Value of Information. Omega *International Journal of Management Science*, 10:3, 249-258.

30. Etnyre, V. A., 1973. The Use of Indirect Methods to Determine Difficult Measures of Costs and Benefits in Information Systems. *36th American Society for Information Science*, Oct. 21-5.

31. Feltham, Gerald A., 1968. The Value of Information. *The Accounting Review*, October, 684-696.

This article has a good presentation of the bayesian decision analysis technique. From this technique, the article specifically develops an approach for measuring the value of changes in an information system. The author also discusses the relevance, timeliness, and accuracy of information signals.

32. Feltham, Gerald A., and Joel S. Demski, 1970. The Use of Models in Information Evaluation. *The Accounting Review*, XLV:4, 623-640.

This paper presents a model of the information choice situation. The choice process is shown, as is a way in which the evaluator may construct a prediction of the decision maker's choice model. A schematic of the information evaluation process is given. The model is based on expected payoffs and prediction of such parameters as demand, number of machines, maintenance, warehouse space, total labor hours, and others. The actual decision function is another mathematical model with its variables being quantity of the product, net sales price and hours of temporary labor hired. Probably of most importance is a section entitled "Information Research" which list examples of research in which these models have been constructed. Whether they are empirical or theoretical is not clear.

33. Feltham, Gerald A., 1972. Information Evaluation. (from *American Accounting Association*), Saratosa, Fla.

34. Flowerdew, A. D. J., and C. M. E. Whitehead, 1974. *Cost-Effectiveness and Cost Benefit Analysis in Information Science*. London School of Economics & Political Science, October.

35. Gallagher, Charles A., 1971. *Measurement and Analysis of Manager's Perceptions of the Value of Selected Management Information*. Ph.D. Dissertation, Florida State University.

In this article, a questionnaire was used to establish the value of Management Information System (MIS) reports. Two measures of perceived value were requested. The first was the maximum amount the manager would recommend to be spent for both an existing report and a hypothetical, (more ideal) report if they had to be obtained from a source outside the firm. The second was a measure of value based on responses to a semantic differential technique (fifteen bipolar adjective pairs on a scale from negative three to positive three). The questionnaire was then tested in a firm currently using an MIS for cost accounting. There were seventy-four respondents. Dollar values estimated for an existing report ranged from $0 to $25,000 with a median of $550. The hypothetical report's value ranged from $0 to $50,000 with a median of $1,000. The semantic differential results showed mean values of 1.27 to 1.95 for the fifteen attributes.

36. Gallagher, Charles A., 1974. Perceptions of the Value of Management Information Systems. *Academy of Management Journal.* 17:1, 46-55.

37. Galliers, Robert, ed., 1987. *Information Analysis-Selected Readings*. Reading, Massachusetts: Addison-Wesley Publishing Company.

38. Goldsworthy, A. W., ed., 1984. *Technological Change - Impact of Information Technology*. Canberra: National Information Technical Committee.

39. Gould, J. P., 1974. Risk, Stochastic Preference, and the Value of Information. *Journal of Economic Theory*, 8:1, 64-84.

40. Grahamtomasi, T., 1980. A Theoretical and Empirical-Approach to the Value of Information in Risky Markets - A Comment. *Review of Economics & Statistics*, 70:3, 543-547.

41. Greenwood, William T., 1969. *Decision Theory and Information Systems*. Southwestern Publishing Co.

42. Greer, Willis R. Jr., 1980. Value Added Criterion for Decision Support System Development. *Journal of Systems Management*, 13:5, 15-19.

This article proposes a framework for measuring the value of information from a decision support system in terms of the value added to the organization (i.e., improved profits through improved timeliness and accuracy of information). In the example, the decision support system aids the decision maker in forecasting the firm's variable cost per unit so he may set prices accordingly. The timeliness of information is measured as "the expected opportunity costs of using information of different ages to make the pricing decision," (p. 17). The "value added" is actually the decline in opportunity costs that occurs when more up-to-date information is used. The accuracy of information measures the decrease of opportunity costs due to decreasing error ranges. The model does account for additional information that decreases error ranges as well as incorrect information that increases error ranges.

43. Griffiths, J. B., 1980. On the Value of Information. *Journal of American Society for Information Science*, 31:4, 303-304.

44. Griffiths, J. M., 1982. The Value of Information and Related Systems, Products, and Services. *Annual Review of Information Science & Technology*, 17, 269-284.

45. Grundstein, Nathan D., 1966. Urban Information Systems and Urban Management Decisions and Control. *Urban Affairs Quarterly*, 1:4, 20-32.

46. Hagerstrand, T., and A. R. Kuklinski, eds., 1971. *Information Systems for Regional Development*. Sweden: The Royal University of Lund.

47. Haimes, Yacovw Y., ed., 1981. *Risk/Beneflt Analysis in Water Resources Planning & Management*. New York: Plenum Press.

48. Hakansson, Nils H., J. Gregory Kunkel, and James A. Ohlson, 1982. Sufficient and Necessary Conditions for Information to Have Social Value in Pure Exchange. *Journal of Finance*, 37:5, 1169-1181.

This is an article based on the economic principle of pareto optimality and the subsequent social value of "free" goods. The conditions needed for information to NOT have value are:

1) the financial market achieves full allocational. efficiency
2) the information structures are essentially homogeneous
3) prior beliefs are essentially homogeneous
4) the two-period utility functions are time additive

Essentially, the article states that when any of the above do not hold, everyone is better off with information than without information.

49. Hedberg, B., 1973. *On Man-Computer Interaction in Organizational Decision-Making: A Behaviorial Approach*. Gothenberg Studies in Business Administration, 2nd ed.

50. Heller, Walter P., Ross M. Starr, and David A. Starrett, eds., 1986. *Uncertainty, Information, and Communication*. New York: Cambridge University Press.

51. Hess, James, 1982. Stochastic Preference and the Value of Information. *Journal of Economic Theory*, 27:1, 231-238.

52. Hilton, Ronald W., 1981. The Determinants of Information Value: Synthesizing Some General Results. *Management Science*, 27, 57-64.

This article is deeply based in economic theory and mathematical equations. Three definitions of information are given purely in equation form. Then the four determinants are set up in equation forms and mathematical proofs are used to show their relationship with the value of the information. The four determinants are:

1) the decision maker's flexibility (action set)
2) the decision maker's technology and environment and his relative

preference for outcomes (payoffs)

3) the decision maker's initial uncertainty about some aspects of the technology or environment

4) the nature of the information itself (timeliness and accuracy)

The article discusses the statistical proofs used to show how these determinants influence the value of the information. However, the author warns against any generalizations of the theorems, and seems to only accept the fourth determinant. A good list of references and short descriptions for each of the determinants is given.

53. Hirsch, Rudolph E., 1968. The Value of Information. *Journal of Accountantcy*, June, 41-46.

54. Hirshleifer, Jack, 1971. The Private and Social Value of Information and the Reward to Inventive Activity. *American Economic Review*, 61, 561-574.

55. Hirshleifer, Jack, 1973. Economics of Information: Where are We in the Theory of Information. *American Economics Association*, 63:2, 31-39.

This article deals with information about price, markets, technology, consumer behaviors, product quality, etc. as used by both the consumer and the seller. Uncertainty is defined as the "dispersion of individuals' subjective probability distributions over possible states of the world," and information is defined as "events tending to change these probability distributions," (p. 31). The economically significant attributes of information are cited as - certainty, diffusion, applicability, content, and decision-relevance. Hirshleifer gives a general discussion of the (then) current issues of: technological information (general information and patents), particular information and the disclosure problem, transferability of information, and market-information processes.

56. Hirshleifer, Jack, and John G. Riley, 1979. The Analytics of Uncertainty and Information: An Expository Survey. *Journal of Economic Literature*, 17:4, 1375-1421.

57. Howard, R. A., 1966. Information Value Theory. *IEEE Transactions in Systems Science*, SSC-2(l), 23-34.

58. Humphreys, P., 0. Svenson, and A. Vari, eds., 1983. *Analyzing and Aiding Decision Processes*. New York: North Holland Publishing.

59. Isaac, R. M., 1987. The Value of Information in Resource Exploration -The Interaction of Strategic Plays & Institutional Rules. *Journal of Environmental Economics & Management*, 14:4, 313-322.

60. Jussawalla, Meheroo, Donald M. Lamberton, and Neil D. Karunaratne, 1988. *The Cost of Thinking: Information Economics of Ten Pacific Countries*. New Jersey: Albex Publishers Corporation.

61. Karp, Larry, Arye Sadeh, and Wade L. Griffin, 1986. Cycles in Agricultural Production: The Case of Aquaculture. *American Journal of Agricultural Economics*, 68:3, 553-561.

62. Keen, P. G. W., 1981. Value Analysis: Justifying Decision Support Systems. *MIS Quarterly*, 5:1, 1-15.

Keen establishes that the "traditional cost-benefit analysis is not well-suited to DSS [decision support systems]. The benefits they provide are often qualitative... [such as] the ability-to examine more alternatives, stimulation of new ideas, and improved communication of analysis. It is extraordinarily difficult to place a value on these. In addition, most DSS evolve ... new facilities are added in response to the users' experience and learning. Because of this, the costs of the DSS are not easy to identify," (pp. 1-2). Also, since DSS is a form of innovation, it is an investment in research and development, not in a defined product. Keen draws an analogy between the decision to build a DSS and management education. A five-day management training course is sponsored as an investment in the future, with no evaluation of the seminar's payback period or rate of return on investment.

The benefits quoted in DSS case studies are grouped into twelve categories and each is labelled with respect to their ease of measurement and the ability to quantify in terms of rate of return or payback figures. "Value Analysis" is offered as an alternative to other methods used to evaluate proposed systems (traditional cost-benefit analysis, scoring evaluations using weighted scores, and feasibility studies). The value analysis method involves the construction of a prototype DSS at a scale below the capital investment level, (i.e., a research and development exercise). The benefits can then be identified through the use of the prototype. The user asks, "what exactly will I get from the system?," and- "if the prototype costs $X, do I feel that the cost is acceptable?" The next step is to build the full DSS after first calculating the cost of the full system and then determining the threshold of values needed to justify this cost and the probability that these benefits will occur.

63. Keen, Peter G. W., and M. Scott Morton, 1978. *Decision Support Systems -An Organizational Perspective*. Massachusetts: Addison-Wesley.

64. Keim, R. T., and R. Janaro, 1982. Cost/Benefit Analysis of MIS. *Journal of Systems Management*, 33, 20-25.

65. King, D. W., 1982. An Approach to Measuring the Value of Information and Information Products and Services. *Proceedings: American Society for Information Science*, 19, 367.

66. King, Donald W., Nancy K. Rodserer, and Harold A. Olsen, eds., 1983. Key Papers in the Economics of Information. *Knowledge Industry Publication for American Society for Information Systems*.

67. King. John L. and Edward L. Schrems, 1978. Cost-Benefit Analysis in Information Systems Development and Operation. *Computing Surveys*, 10:1, 19-34

The authors begin by stating three uses of cost-benefit analysis: as a planning tool, as an auditing tool, and to develop quantitative support for political influence. Four issues in cost-benefit analysis include: the purpose, time period, scope, and the criteria for the analysis. A stepwise procedure for analysis involves: selection of the analyst, identification of alternatives, identification and measurement of costs and benefits, comparison of costs and benefits, and final analysis of all alternatives. The article also includes possible categories for costs and benefits of an information system and further discusses the problems encountered when performing a cost-benefit analysis.

68. King, John L., 1980. Cost Benefit Analysis for Decision Making. *Journal of Systems Management*, 31:5, 24-219.

In accordance with his 1978 article, King sees cost benefit analysis as a planning tool for making cost-effective decisions, as an audit tool for current situations, and as a provider for political support. There are four guidelines for a cost benefit analysis: the purpose, time period, scope, and decision criteria. The author includes lists of potential costs and benefits from applications of computers, as well as a step by step recipe for performing a cost benefit analysis. He specifically discusses the use of present value to determine the cost of capital. Issues in cost-benefit analysis of information systems include: incomplete identification of alternatives, cost accounting (double counting and hidden costs), assignment of benefits, and the cost of performing the analysis. In reference to assignment of benefits, the author just states that those benefits which cannot be converted to dollar values cannot be used in a cost-benefit analysis evaluation.

69. King, William R., and B. J. Epstein, 1976. Assessing the Value of Information. *Management Datamatics*, 5:4, 171-180.

70. King, William R., and 1. Rodriquez, 1978. Evaluating Management Information Systems. *MIS Quarterly*, 2:3, 43-51.

71. Kingsmith, C., 1986. Assessment of the Value of Information in Military Decision-Making. *Journal of Operational Research Society*, 37:12, 1164.

72. Kirk, Andrew, 1966. Company Organization and Control. *Management Accounting*, February, 58-66.

Kirk applies the "systems" concept to business administration. He divides data processing into three functions of increasing complexity: transmission (input and output of data with no change in form or content), translation (input data is changed in form, but not content, e.g;, re-coding), and transformation (change in both form and content). Transformation involves "matching the new input data with other data, either from another source or from another time; the assigning of weights to each piece of data and finally the deduction of new information, (p. 60)." The article discusses the increasing trend of risk and uncertainty in decision making due to such factors as: longer time-spans of projects, accelerated speed and risk of innovation, more complexity in the business world, and higher levels of required input capital. The author sees the need for strategic planning to ensure that the risk-taking decisions made today are performed with future conditions and reactions in mind.

73. Kleijnen, J. P. C., 1984. Quantifying the Benefits of Information Systems. European *Journal of Operations Research*, 15:1, 38-45.

This article begins by making a clear distinction between the economic evaluation of clerical applications of computerized information systems (i.e., same products produced more efficiently), and the management information systems applications. The first can be handled mathematically with techniques employing net present value and probabilities over uncertain states of nature. For the management applications, the author distinguishes three levels of decision making: operational, tactical, and strategic decisions. The quality attributes of information for a management information systems (MIS) include: timeliness, accuracy, aggregation, report mode, retention time, reliability and recovery, scope, flexibility, and multiplicity of users.

The new framework for MIS evaluation proposed here consists of four steps of decision making: transaction, data creation, decision, and reaction. The article does not offer a way to actually quantify benefits. However, it does suggest looking into the following areas for ideas toward a model for benefits: control theory with its mathematical optimization techniques, feedback, steering frequency, and delay and oscillation concepts; system dynamics with the more realistic, (and more complicated) simulation models; and information economics with its bayesian decision analysis and sensitivity analysis.

74. Kunkel, J. G., 1982. Sufficient Conditions for Public Information to Have Social Value in a Production and Exchange Economy. *Journal of Finance*, 37:4, 1005-1013.

75. Laffont, Jean-Jacques, 1976. Risk, Stochastic Preference, and the Value of Information: A Comment. *Journal o Economic Theory*, 12:3, 483-487.

76. Lamberton, Donald M., 1971. *Economics of Information and Knowledge*. Baltimore, Maryland: Penquin Books.

77. Lamberton, Donald, M., 1974. National Information Policy. *American Academy of Political & Social Science*, March.

78. LaValle, 1968. On Cash Equivalents and Information Evaluation Under Uncertainty - Part I Basic Theory. *Journal of American Statistics Association*, 63, 252-276.

79. Lawrence, D. B., 1979. *The Quantification of the Value of Information in Decision Making*. PhD Thesis, Iowa State University, Ames, Iowa.

80. Lawrence, D. B., 1987. The Assessment of the Expected Value of Information in the Binary Decision-Model. *Managerial & Decision Economics*, 8:4, 301-306.

81. Lay, P. M. Q., 1985. Beware of the Cost/Benefit Model for Information System Project Evaluation. *Journal of Systems Management*, 36:6, 30-35.

Peter. Lay argues against using cost benefit analysis as a justification or planning tool in the information system environment. He examines two areas of shortcomings associated with the cost benefit analysis: problems in estimating costs and benefits and costs that cannot be measured at all. Usually, a return-on-investment evaluation is used when benefits are tied to the production of output for sale. However, intangible benefits should also be included in the justification process. This creates a need for a systematic, consistent approach to handling intangibles so they can be compared across systems. The approach should also use realistic estimates, and provide appropriate methods of post-implementation monitoring of intangible benefits actually received. Lay further discusses unquantifiable benefits (those which cannot be expressed in monetary terms, or for which the analyst cannot attempt to suggest a value). Lay points out that even where cost-benefit analysis is inappropriate (as with information systems), it is still the method often used since it is an easily understood concept and one that leads to a simple choice between the net present value of two or more alternatives.

82. Luzar, E. J., 1987. The Economics of Precision: A Leaming Theory Approach, *Proceedings: The Economics of Land Information Symposium*. Baltimore, Maryland, March.

83. Machlup, Fritz, 1962. *The Production and Distribution of Knowledge in the United States*. New Jersey: Princeton University Press.

84. Machlup, Fritz, 1980. *Knowledge: Its Creation, Distribution, and Economic Significance*, Volumes 1, 2, and 3. New Jersey: Princeton University Press.

85. MacKay, Donald M., 1969. *Information, Mechanism and Meaning*. Massachusetts: The M.I.T. Press.

86. Magson, M. S., 1973. Techniques for the Management of Cost-Benefit in Information Centers. *ASLIB Proceedings*, 25:5, 164.

87. March, James G., 1982. Theories of Choice and Making Decisions. *Society*, 20:1, 29-39.

88. Marschak, J., 1954. *Towards an Economic Theory of Information and Organizations*. (in Thrall, R. M., 1954), 187-220.

89. Marschak, J., and K. Miyasawa, 1968. Economic Comparability of Information Systems. *International Economic Review*, 9, 137-174.

90. Marschak, J., 1968. Decision-Making: Economic Aspects. *International Encyclopedia of Social Science*, 42-55.

91. Marschak, J., 1971. Economics of Information Systems. *Journal of American Statistics Association*, 66, 192-219.

92. Marschak, Jacob, 1964. *Problems in Information Economics*. (in Bonini, 1964), 38-74.

93. Marschak, Jacob, 1968. Economics of Inquiring, Communicating and Deciding. *American Economic Review*, 58:2, 1-18.

94. Martyn, J., and A. D. J. Flowerdew, 1983. *The Economics of Information*. London: British Library.

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This article discusses a highly controlled, empirical study used to compare experienced decision makers' estimates of information value before its actual use with the actual value after use. The experiment involved military simulation of airborne antisubmarine warfare and the use of three levels of information by the decision making teams performing the exercise. The levels of value were subjective and labelled as high, medium, and low. The conclusion was that information given a higher subjective value before use, did indeed lead to less uncertainty in target location.

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This is a set of papers, used at a workshop in Madison, Wisconsin on developing geographic mapping and analysis systems. The issues of costs and benefits are presented in outline format. The first paper, "Comparing the Costs: Manual Versus Automated Procedures for Handling Land Records," by Moyer et. al., reports the costs of developing the prototype multipurpose land information system (LIS) for Dane County, Wisconsin. The second paper, "Economic Features of Land Information Systems," by Gene Wunderlich and Moyer, discusses different economic concepts as they relate to LIS (treated as a subset of GIS). These concepts include: production functions, technological advances, demand, supply, joint products, and information marketing. The paper states that we know very little about the true nature of these concepts within LIS, and requests help from economists to begin answering the questions put forth. The paper ends with discussions of two case studies (Virginia and Wisconsin). In the case studies, uses of the systems are discussed, costs are reported, and benefits are discussed but not quantified.

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113. Munro, Malcom C., and G. B. Davis, 1977. Determining Management Information Needs; A Comparison of Methods. *MIS Quarterly*, 1:2, 55-67.

Munro and Davis compare two methods used to determine the information needs for management decision makers: data analysis (bottom-up) and decision analysis (top-down). They also looked at the interaction between the method used and type of decision made (programmed vs. non-programmed) and also the interaction between method used and area of application (academic vs. administrative). The effectiveness of either is determined by the decision makers perceived value of the resulting information requirements. The perceived value was established by showing thirty pairs of bi-polar attributes of information, each with a seven-slot continuum to be marked. The word-pairs were used to ask if the information was complete, orderly, concise, applicable, meaningful, etc. The responses were scaled from +3 to -3 to give a weighted value per attribute. This value was then used to establish the average overall value of the information.

The analysis of variance technique showed: the perceived value of information generated is not significantly different between the two methods used to establish information requirements; the perceived value is significantly different between programmed and non-programmed decisions; the perceived value generated in one functional area is significantly different from the other; there is no significant interaction between the functional area- and the method used; and there is significant interaction between the type of decision made and the method used.

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132. Repo, A. J., 1989. The Value of Information - Approach es in Economics, Accounting, and Management Science. *Journal of American Society for Information Science*, 40:2, 68-85.

This article is an excellent overview of how the different disciplines describe and measure the value of information. An extensive bibliography is also included. The author sets forth a dichotomy of value of information: the exchange value (what is paid for the information) and value-in-use. An entire section is dedicated to reporting empirical studies, most with poor results. The article also includes a taxonomy of values: philosophical, practical, exchange, value-in-use, expected, and perceived. Finally, a framework for research is given. Techniques to gather data about use of information including interviews, questionnaires, diaries, and content analysis are suggested. The author stresses that it is not possible to develop a general model for information value; instead, "more detailed methods and techniques for assessing the value of information must be developed for the particular research task at hand," (p. 83).

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This article looks at the relationship between the entropy measure of information and the perceived value of information by decision makers. Experiments were performed to test this relationship. Subjects were given a hypothetical amount of $10,000 initial investment in capital for each of several projects. Revenue and variable costs of the projects were given. The subjects then had to predict the total costs (including such things as labor, overhead, material). Since each dollar of prediction error would "cost" them, they could "purchase" information about the exact breakdown of costs to help avoid this error. The subjects were to maximize the total net return for each project and specify the amount they would be willing to pay for the information. Then the subjects' perceived value of information was tested for positive correlation with each projects' entropy measure. A copy of the post-experimental questionnaire used to determine the perceived value of information is included in the article.

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This article develops a model for land development planning. Planning is defined as "the activity of producing information to reduce uncertainty with respect to decisions," while information is viewed as "an intermediate good because it is used as an input to the decision making process relative to the final good," (pp. 1221-2). A three-phase stochastic model of planning behavior is discussed. The model makes use of the economic theory of expected net benefit from actions, conditioned on the information available.

139. Schell, George P., 1986. Establishing the Value of Information Systems. *Interfaces*, 16:3, 82-89.

This article uses the bayesian decision making technique (here, called decision analysis), to determine value of information. For a full information system (IS), though, this technique would have to be repeated multiple times for each decision made when evaluating a multiple-objective IS. The author stresses that the value of an IS must look at benefits to decision making, not just cost savings of capital versus labor. Schell uses his evaluation, performed during the design phase, as a 'first-cut' estimation of the costs and benefits of the IS. The article points to other articles which address ways of placing values on intangible benefits: Matlin 1979, Chandler 1982 (multiple criteria), and Keen, 1981 (value analysis).

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157. Wei, Y., 1981. The Value of Information. *Proceedings: American Society for Information Science*, 18, 196.

158. Wendt, Dirk, 1969. Value of Information for Decisions. *Journal of Mathematical Psychology*, 6:3, 430-443.

159. Young, Paul, 1987. *The Nature of Information*. New York: Praeger Publishers.

In this book, the author takes a historical look at the concept of information, starting with Plato's theory of forms. He discusses information as a "form" in mass energy systems, including the use of the entropy measure in physics and how information exists in

physical, biological, and chemical systems. Information is defined as both a phenomenon and a concept, as well as the key ingredient to all communication.

160. Zmud, Robert, W., 1978. An Empirical Investigation of the Dimensionality of the Concept of Information. *Decision Sciences*, 9:2, 187-195.