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BENEFIT-COST PRINCIPLES FOR LAND INFORMATION SYSTEMS

by

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Benefit-Cost Principles for Land Information Systems

With some notable exceptions (e.g. Blaine and Randall; Wunderlich and Moyer) past investigations into the economics of land information systems have apparently concluded that, at present, information economics has little to offer in the evaluation of alternative information systems. These investigations then proceed to either conduct cost comparisons of alternative information systems, or to discuss in broad terms the 'intangible' aspects of information and information systems (e.g. Epstein and Duchesneau, 1984; Gurda et al.; Moyer and Niemann).

Granted, the economics of information, and more specifically the economics of land information, is not well developed at this point in time. The lack of progress in this field is attributed to a number of factors, including the reliance of economists on the assumption of perfect information in constructing the core of microeconomic theory (e.g. Varian), the lack of consensus among economists concerning the definition of information (e.g. Chavas and Pope; Eisgruber; Luzar), and the public goods nature of information and information systems which necessitates that they be valued using non-market valuation techniques (e.g. Osborn; Chavas and Pope; Just, Hueth and Schmitz). Yet, in spite of these limitations, economic theory does offer basic concepts that should be adhered to in evaluating and comparing the costs and benefits of alternative information systems.

The primary objective of this paper is to review the economic concepts that relate to the valuation of information systems. The motivating assumption is that benefit-cost analysis of land information systems cannot be adequately addressed until the underlying theory is understood. Particular emphasis is given to the demand characteristics and value of information, an area of study that has received much attention in the general economic literature but is notably limited in studies concerned with the benefits and costs of land information.

A second objective of this paper is to demonstrate that the avoided cost method may either underestimate or overestimate the "true" benefits of a project when information is publicly provided. This contrasts with the prevailing view in the land information economics literature that the application of the avoided cost approach underestimates the value of improvements in land information system services [Blaine and Randall; Epstein and Duchesneau; 1984, 1990].

I. What is Information?

In conceptualizing information it is necessary to distinguish between data and information. Data are defined here as groups of non-random symbols which represent quantities, actions, qualities, goals, etc., that result from experimentation or sampling [Davis; Harsh; Eisgruber; Chavas and Pope]. Information is data that has been processed or organized into a form that is useful to the decision maker.

In this manner, information can be viewed as an intermediate product in an inquiry and decision making process [Chavas and Pope]. It is the output of a data system or inquiry process that collects, codifies, organizes, stores and transmits data [Marschak]. The supply characteristics of such systems and the relative costs of providing different types of information have been the primary focus of most studies of the economics of land information systems to date. Information also serves as an input into decision making processes and economic transactions. Thus, the demand for information, and hence for data, is governed by the specific needs of economic agents.

Another important feature of information and information systems is that they have public goods attributes [Epstein and Duchesneau, 1990; Boadway and Wildasen]. In other words, the information 'product' is characterized by joint consumption and is generally nonexcludable. The implication is that conventional market-price approaches of determining the preferences of individuals for marginal changes in information are not appropriate. In addition, land information is publicly provided and the level of information produced by the public sector will generally deviate from the equilibrium levels depicted in market models. Section IV demonstrates that this latter attribute will affect the direction and magnitude of the biases of the avoided cost approach as a measure of the benefits of changes in land information provision.

II: The Value of Information

Overview

In conventional economic analyses, the value of information derives from two, not necessarily unrelated, sources. First, improved information enables individual agents, acting in isolation, to make better economic decisions. Even Robinson Crusoe would have been willing to allocate some of his limited resources to obtain better information about the agricultural seasons. The second source of economic value is that information facilitates transactions between interacting agents. To this two-tiered classification, discussions of land information systems have identified a third category of benefits: improved land information systems enhance the implementation of environmental policies [Moyer and Niemann].

The benefits of improved information are often quite direct. For example, soil tests [Lee and Nicholson] and weather forecasting [Baquet et al.; Anderson, Dillon, and Hardaker] may improve production decisions for individual farmers. It is more common, however, that changes in information flows impact on a range of decisions in a variety of markets. For instance, linking parcels, zoning, soils, and land cover layers in a multipurpose land information system (MPLIS) should aid individual buyers in purchasing parcels with characteristics which they desire [Blaine and Randall]. Improved land information is also expected to enhance the efficiency of community planning [Wunderlich and Moyer] and accelerate compliance with conservation mandates [Licht; Moyer; Ventura].

With respect to these multifaceted impacts of information, the obvious first step in valuing information is to identify all the economic entities that are potentially impacted by the change in information provision. Past analyses of land information systems have made considerable progress towards this goal (e.g. Moyer and Niemann; Gurda et al.).

The second step in the valuation process is to quantify these impacts. Economists have developed a number of theoretical approaches to the analysis of information and its valuation [Hirsleifer; Chavas and Pope; Eisgruber; Luzar]. Of these, statistical decision theory and transactions cost analysis are particularly relevant to the valuation of land information systems. Because it is possible to envision supply and demand schedules for environmental goods, the transactions cost approach can also be used to evaluate the impact of information on government environmental programs.

The Value of Information to Individual Agents: Statistical Decision Theory

In analyzing the relationship between uncertainty, information, and the value of information to individual agents, economists have relied primarily on statistical decision theory. In applying this method, the traditional approach has employed an expected utility framework and Bayesian updating [Anderson, Dillon and Hardaker; LaValle; Winkler]. Although there is some controversy surrounding both these techniques, these assumptions are used in this exposition.

Statistical decision theory posits that, in uncertain situations, individuals have a subjective 'prior' probability distribution about parameters that are important to economic decisions, and the associated consequences of each possible state and action. In a simple example, a farmer in a pear growing region may have prior expectations about whether or not frost damage will occur on a given night (e.g. 35 percent chance of frost damage, and 65 percent chance of no frost damage). Or, a land buyer may have subjective beliefs about the quality of the land and its supply of desirable characteristics. Given these prior beliefs, the agent is assumed to choose an action that maximizes its expected returns, benefits or utility. In our examples, the orchardist must choose whether or not costly heater firing will be needed, and the land purchaser would formulate a maximum bid price for the parcel[1].

In statistical decision theory, information is a signal or message which alters agents' subjective probability distributions about possible states of the world. This revision in probability beliefs may lead agents to choose different actions: farmers may change their decision of employing frost protection and potential buyers may alter their willingness to pay for a parcel. With respect to its impact on decisions, the gross value of information is associated with the expected utility gains from choosing different, and presumably better, actions. It is defined as the maximum amount of money that the individual is willing to pay in order to make an informed choice using the uninformed choice as a reference. In other words, this bid price is precisely the amount of money that equates the expected utilities of the informed and uninformed decision makers.

Formally, this value is derived as follows. Let

s = States of nature, s=1,...S.
m = Information level, 0 denotes initial level of information and 1 denotes posterior to receiving information.
$\pi_{s|m}$ = Subjective probability of state s given information m.
y_s = State dependent income.
$a_{s|m}$ = Consequences of state contingent actions given information m.

Within this framework, the ex post gross value or bid price of an information signal is the value γ that satisfies the following equation:

$$(1) \qquad \max_a E\{u(a_{s|1}, y_s - \gamma; \pi_{s|1})\} = \max_a E\{u(a_{s|0}, y_s; \pi_{s|0})\}$$

where, $u(.)$ is the utility function and E is the mathematical expectation operator. However, as Hirshleifer notes, the decision to seek information

[1]. The orchard and the land parcel examples derive from Baquet et al. and Blaine and Randall, respectively.

must necessarily be made ex ante: i.e. before the decision maker knows which particular message he will obtain. The decision maker is not able to chose a particular message or signal. But rather, can only purchase "an *information service* μ generating a probability distribution of messages *m*" [Hirsleifer, p. 1395]. Thus the value of information is more appropriately defined in ex ante terms as γ' which satisfies:

$$(2)\quad E_m\left[\max_a E\{u(a_{s|1}, y_s-\gamma'; \pi_{s|1})\}\right] = \max_a E\{u(a_{s|0}, y_s; \pi_{s|0})\}$$

where E_m is the mathematical expectation operator over the possible messages. Given appropriate convexity assumptions on the utility function, the gross value of information is always positive.[2]

While useful for theoretical purposes, the application of this approach is extremely data intensive: it requires the elicitation of subjective prior probabilities for all the possible states of the world, knowledge of the consequences of each action, the valuation of utilities associated with each possible outcome and action, and complete knowledge of all the possible messages. Moreover, there is some concern whether individual decision makers conform to Bayesian updating and the expected utility axioms. Thus, the valuation of information in this manner can be characterized by a measurement problem [Chavas and Pope].

A possible solution to this measurement problem may be found in the literature of the valuation of "non-market" goods, which focuses on methods of valuing goods that are not traded in organized markets. In particular, the contingent valuation approach [Mitchell and Carson], seems to be

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[2]. This result is detailed in a number of sources: including, Hanemann; Bishop; Chavas and Pope; and Chavas.

relevant for estimating discrete points on the demand for information schedule. Essentially, this method employs personal interviews, telephone interviews, or mail surveys to ask people about the values that they would place on non-marketed commodities "*contingent* on the existence of a market or other means of payment" [Anderson and Bishop, p. 91]. For example, individuals could be asked their willingness to pay for specific types of land information products ranging from the conventional manual systems to a multiple layer system with precise geo-coding.

The development of a contingent valuation survey for information services will be particularly difficult due to the need to describe and differentiate between each product or information bundle. This description will necessarily include the relative time and effort taken to procure information required by lending agencies (e.g. title and appraisal) and optional information desired by purchasers about uncertain characteristics of the parcel (e.g. zoning, local environmental regulations, eligibility for government programs, historical yields, soil type, etc.). It will also need to include measures of the quality and precision of each information service. Additional difficulties may arise in defining the population whose values are to be measured, especially in light of the fact that many individuals who are not currently in the market for land information will have positive option prices. In spite of these difficulties, a well thought out contingent valuation survey should be able to provide estimates of the aggregate willingness to pay for specific information services.

The Value of Information: The Markets Approach

The second method of analyzing the value of information that is relevant to land information systems has been to focus on transactions costs and the impacts of information on aggregate supply and demand in markets that are affected by changes in information signals. In this analysis, it is posited that market transactions are impeded by lack of information, a factor that increases the costs of voluntary exchange and reduces the aggregate welfare of society. Coase notes:

> In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up a contract, to undertake the inspection to see that the terms of contract are being observed, and so on. These operations are often extremely costly, sufficiently costly at any rate to prevent many transactions that would be carried out in a world in which the pricing system worked without cost. (15)

Dahlman categorizes these transactions costs, and relates all transactions costs to resource losses and imperfect information.

> Both search and [market] transaction costs owe their existence to imperfect information about the existence and location of trading opportunities or about the quality or characteristics of items available for trade. The case is the same for bargaining and decision costs: these represent resources spent in finding out the desire of economic agents to participate in trading at certain prices and conditions. What is being revealed in a bargaining situation is information about willingness to trade on certain conditions, and decision costs are resources spent in determining the terms of trade that are mutually agreeable. Policing and enforcement costs are incurred because there is a lack of knowledge as to whether one (or both) of the parties involved in the agreement will violate his part of the bargain...Therefore, it is really necessary to talk only about one type of transaction cost: resource losses incurred due to imperfect information. (148)

In brief, three general forms of transactions costs are recognized: market information costs, contracting costs, and enforcement costs. A convenient way of remembering this taxonomy is the acronym ICE [Bromley, 1986].

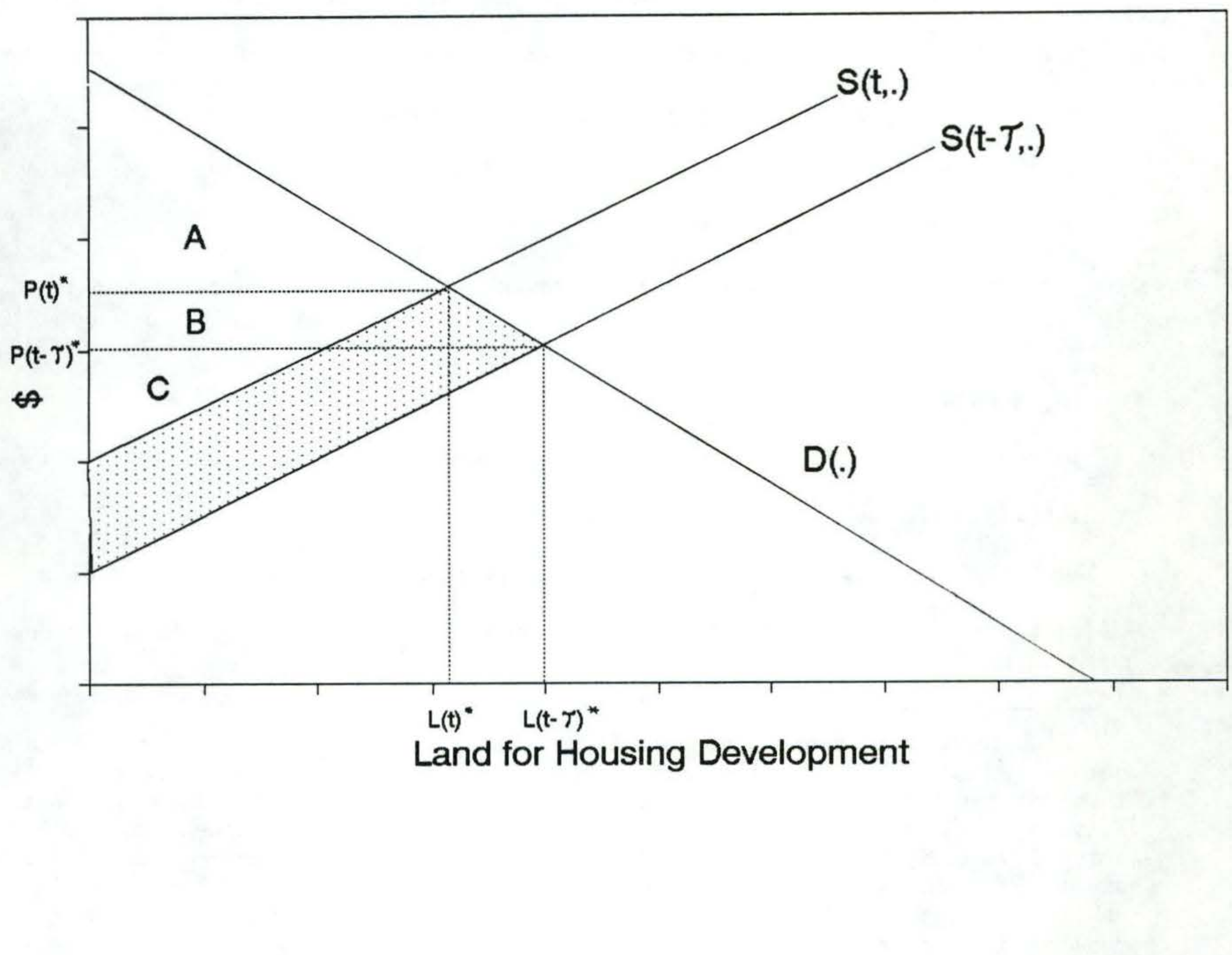
The ICE conceptualization is particularly relevant to the valuation of improved land information systems. Blaine and Randall argue that there is a demand, and thus a value, for improved market information.

> The buyer is willing to pay for a certain amount of parcel quality information to help him identify the parcel which contains the characteristics he desires. In the traditional land market literature the implicit values of these characteristics are capitalized into the total value of the parcel. In a world of imperfect information, this capitalization will be imprecise and perhaps biased...Even if the implicit values of the parcel characteristics are perfectly capitalized into parcel values, the individual buyer is unable to observe either the implicit values or the characteristics (6).

Evidence also suggests that contracting of soil and water conservation programs is accelerated by improved land information systems. For example, the computerized MPLIS in Dane county enabled contractors to prepare 20% of all conservation plans in Wisconsin, even though the county comprises only 4% of all the agricultural land in the state. This difference in rates is attributed to improved land information technology in Dane County [Moyer; Licht]. Similarly, there is some evidence that improved land information systems may also aid in the enforcement of conservation mandates. Moyer and Niemann argue that the failure to share information layers has impeded enforcement of the "swampbuster provisions" of the 1985 Food Security Act in the prairie pothole region. Ventura demonstrates that a MPLIS can be used to target highly erosive parcels for conservation planning.

Using a land market for new housing development as an example, Figure 1 demonstrates a theoretical approach to valuing changes in transactions costs. In this figure D(.) represents the demand for land by housing developers, a demand that is, in itself, derived from consumer demands for new housing units. The supply curve of land units represents the marginal cost of each additional unit of land. This supply curve not only accounts for the opportunity cost associated with each parcel, but is also defined

FIGURE 1: The Market Method for Valuing Improvements in Information



to include a unit transactions cost, t, associated with each unit of land purchased[3,4]. These latter costs primarily consist of search costs for locating parcels that have suitable site characteristics, zoning patterns, current ownership patterns, soil and subsoil characteristics, location relative to major arteries, etc.

Economic theory posits that the efficient allocation of resources occurs when marginal benefits equal the marginal costs in every market, i.e., where supply meets demand. In this example, the equilibrium quantity and price of land for housing development is given by $L(t)^*$ and $P(t)^*$, respectively. At this point, total benefits exceed total costs, resulting in net social benefits of A+B+C.

Now, let us assume that an improvement in information provision is made such that there is a net reduction in transactions costs of τ, where τ is necessarily less than t. Such a reduction could correspond to lower search costs discussed previously. In Figure 1 this change is depicted by a fall in the supply curve to $S(t-\tau,.)$. As a result of this shift, equilibrium prices fall to $P(t-\tau)^*$ and the number of land units increases to $L(t-\tau)^*$. To the extent that lower land costs and more land transactions

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[3]. In this instance, the unit transactions cost is attached to the supply curve. Alternatively, with similar results, the transactions costs could be incorporated into an effective demand curve. In both cases the transactions costs drive a wedge between the seller's price and the buyers willingness to pay. In actuality, it is unlikely that transactions costs will fall only on the producer or the consumer. Rather, a portion of the transactions costs will typically fall on both groups. For example, people selling land may incur the costs of a realtor to locate buyers, while purchasers may expend time and resources in search.

[4]. As Nicholson (p. 372) notes, this analysis of transactions costs is somewhat limited by its failure to consider agents that benefit from such costs such as middleman brokers in real estate transactions. Discussion of such benefits is beyond the scope of this paper.

for development are desirable, such a change increases the welfare of society. This increase is depicted by the shaded area in Figure 1.

Like the statistical decision theory approach, the markets method of valuation is characterized by a measurement problem. In this case the difficulty lies in determining supply and demand characteristics in each affected market. With environmental goods such as erosion abatement, wetlands protection, and groundwater quality the determination of demand and supply is particularly difficult. For these goods there is no demand and supply functions per-se, but it is still possible to estimate marginal benefits and costs for specific levels of quality that could be useful for guiding to guide public sector activities.

III: Information Economics

The objective of information economics is to determine the information system that will maximize net social benefits over time. Since net benefits are defined by the difference between total benefits and total costs, both demand and supply characteristics must be considered in defining the economically optimal level of information.[5] This proposition

[5]. Adapting a framework developed by Marschak, Eisgruber [1973, 1978] has formulated this problem as follows:

$$\text{Max: } NB = E(g) - E(k)$$

where E(g) is the expected gross returns or maximum aggregate willingness to pay, and E(k) is the expected costs. Moreover,

$$E(g) = G(\lambda,\alpha;\ \Pi,\xi)$$

$$\text{and, } E(k) = K(\lambda,\alpha;\ \Pi,\chi_\lambda,\chi_\alpha)$$

where λ corresponds to the data system or inquiry process; α is the decision-making process; Π is the probability that certain states will occur; ξ is the consequence or payoff function; χ_λ is the costs of inquiring; and, χ_α is the cost of deciding. The semicolons in the above equations separate the factors that are controlled by the agent from those that are exogenously determined.

is demonstrated in a single period framework in Figures 2A and 2B. Although the analysis in this section follows the statistical decision making framework presented earlier, it is also possible to develop a parallel exposition using supply and demand curves for information derived from the market valuation approach or information as a product literature (e.g. Wunderlich and Moyer; Blaine and Randall). Some difficulties do arise with these alternative approaches in defining what constitutes a unit of information and accounting for differences in quality of information.

In Figure 2, information is measured on the horizontal axis as the inverse of an uncertainty parameter θ. It is most convenient to interpret θ as a standard deviation or some other measure of the spread of a distribution, but it may also be possible to incorporate higher moments or other descriptive statistics of distributions into its definition. As presented, the level of information is not assumed to be zero at the origin, but rather it is assumed that the agent has some prior information about the distribution. In other words, individuals are not assumed to exist in an initial state of complete ignorance. The vertical axis in Figure 2A measures the total benefits and total costs of information, while the vertical axis of Figure 2B measures the marginal benefits and costs of additional increments of information. Both vertical axes are expressed in monetary units.

In Figure 2A the total benefits or maximum willingness to pay curve is defined as the vertical summation of individual bid/valuation curves. It is assumed that the willingness to pay for additional units of information is characterized by the law of diminishing returns: initial

FIGURE 2A: Total Benefits and Costs of Information

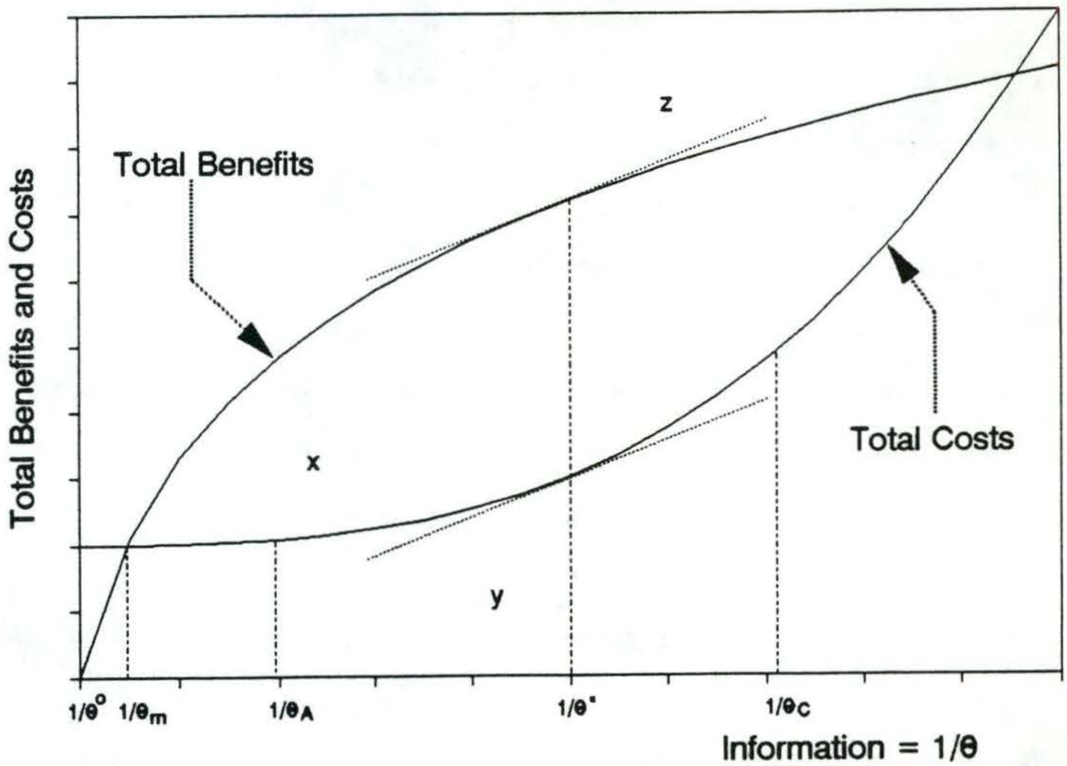
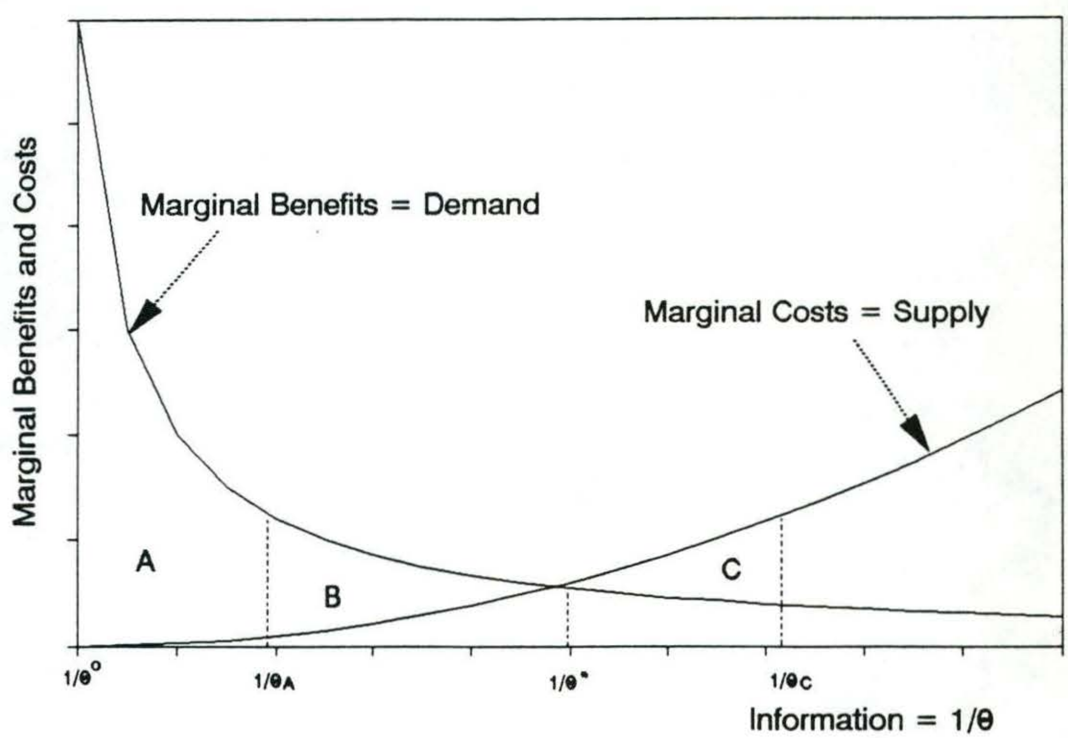


FIGURE 2B: Marginal Benefits and Costs of Information



reductions in uncertainty are valued highly by individuals, while subsequent units have decreasing marginal benefits. The total cost curve represents the aggregate costs of the inquiry process and is assumed to be a convex function of information. That is, the 'production' of information (reductions in uncertainty) is characterized by rising marginal costs. Implicitly, this formulation recognizes that although perfect information exists in concept, a degree of uncertainty will always remain in practice. Combined with assumptions of smooth and continuous total benefit and cost functions, these characteristics of information assure increasing marginal costs and decreasing marginal benefits of information. These functions are depicted as supply and demand schedules in Figure 2B.

The net value of information is simply the gross value less the cost of obtaining that information. Although the gross value of information is always non-negative [Chavas and Pope; Chavas] it is possible for the costs of information to exceed their benefits, a possibility that is depicted in Figure 2A for levels of information to the left of $1/\theta_m$. These situations occur when the quality of information is low, the costs of information are high, or a combination of the two. When the net benefits are positive, the optimal acquisition of information occurs where the marginal benefits equal the marginal costs. In Figure 2 this equilibrium occurs at $1/\theta^*$. In instances where information is publicly provided, it is likely that information acquisition does not correspond to such an optimum. Instead, the provision of information may occur at other sub-optimal levels such as $1/\theta_A$ or $1/\theta_C$.

IV. Benefit-Cost Analysis and Its application to Land Information Systems

Economic Surplus as a Measure of Welfare Change

Across disciplines benefit-cost analysis (BCA) has taken on a variety of interpretations. For economists, BCA is the application of the tools of welfare analysis to evaluate how a particular investment or monetary decision affects economic efficiency and equity. Here, efficiency is defined as the maximization of the total welfare of society. Equity is concerned with the distribution of resources across individuals and plays a central role in defining how the preferences should be aggregated to form a social welfare function. Due to space considerations, only efficiency aspects are discussed in this analysis. In doing so, we are implicitly accepting the value jud7gement that the existing distribution of income can be used as a basis of welfare analysis [Anderson and Settle; Bromley, 1989].

Extending the ideas developed earlier in this paper, suppose that a market exists for information and that this market is characterized by a downward sloping aggregate demand schedule and an upward sloping supply curve for information. As discussed, the demand curve represents decision makers' aggregate willingness to pay for, or marginal benefits of, additional information. The area underneath this curve provides a monetary measure of the total benefits associated with each level of information. The supply curve depicts the information system's ability to provide information at various prices. Total costs for each level of information are measured by the area beneath the marginal cost curve. The difference in the area under the demand curve and the area below the supply curve defines economic surplus - a monetary measure of social welfare. For example, A+B denotes the economic surplus at the equilibrium value of $1/\theta^*$ in Figure 2B. If only $1/\theta_A$ was supplied the surplus value would only be A. Similarly, if information were supplied at level $1/\theta_C$, then the surplus value would be A+B-C. Clearly, surplus is maximized at the equilibrium of supply and demand for information.

Benefit-cost analysis measures how surplus values change with new policies or projects. These surplus changes are called the net benefits, or simply the benefits, of the project or policy change. Basically, the criterion for project acceptance is that there is a net gain in economic surplus resulting from the project [Boadway and Bruce; Just, Hueth and Schmitz]. In practice, this is measured by subtracting the change in total costs from the change in total benefits.

Benefit-cost analysis of land information systems has traditionally followed two approaches: descriptive discussions of the costs and benefits, and the avoidance of costs method. From an economic perspective both approaches are limited, or otherwise inappropriate for the economic evaluation of alternative land information systems.

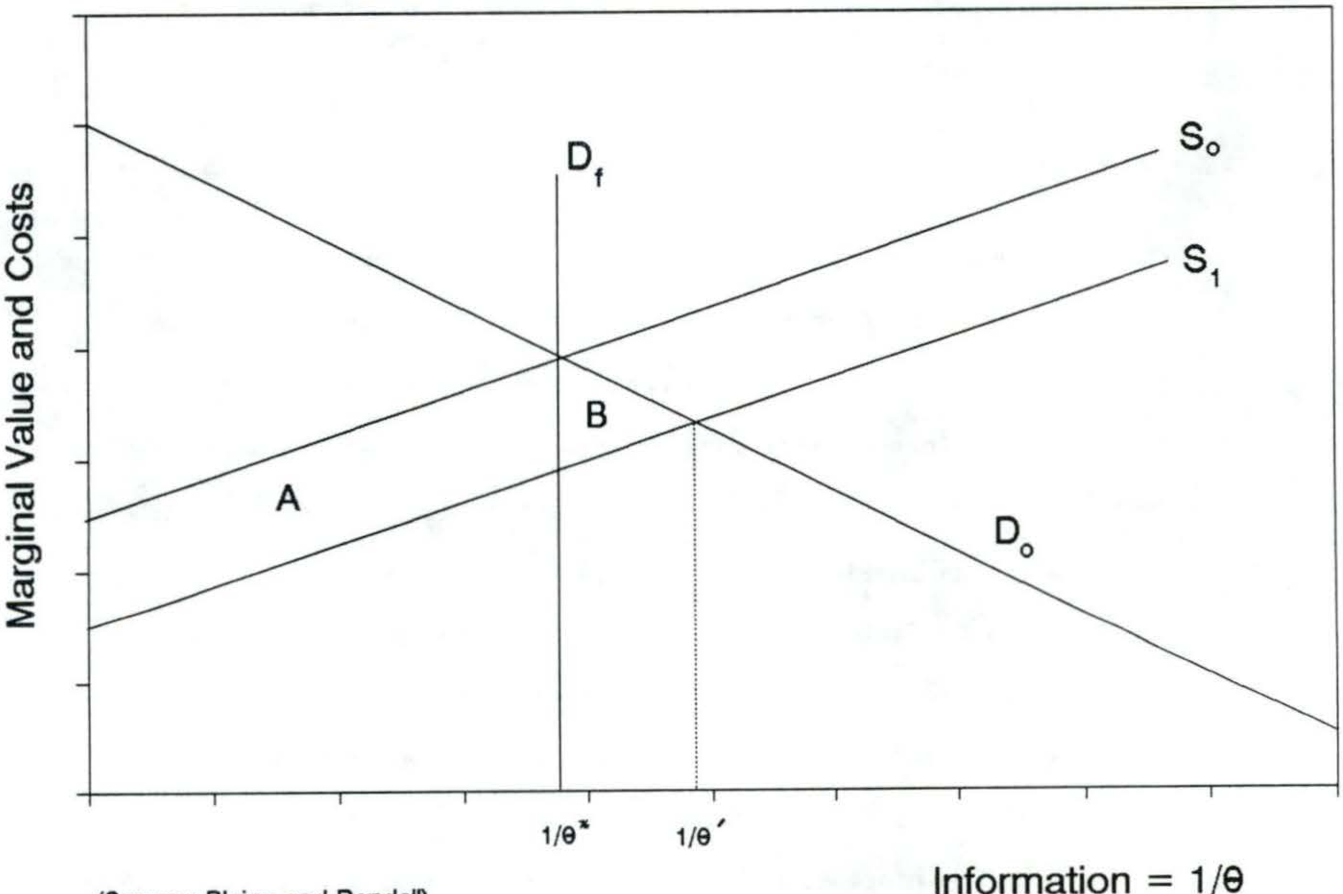
Descriptive analyses are usually intended to be the initial stage of a BCA. They identify, in qualitative terms, the benefits and costs that should be considered. For example, relevant cost reductions may be found in the reduction of the duplication of effort [Larsen]. Other potential benefits of a MPLIS that have been cited are increased flexibility to meet new informational demands that may arise, enhanced effectiveness in meeting conservation demands, and the elimination of inconsistencies between agencies [Wisconsin Land Records Subcommittee; Gurda et al., Moyer and Niemann]. Although qualitative information such as this is valuable, it is difficult to compare qualitative values with the quantified costs of the project. Thus, to enhance the policy making process, efforts should be made to attach values to some of these qualitative benefits and costs.

The cost avoidance method of valuing information systems is based on the principle that

> The benefits generated from a government operation can be represented by the costs avoided as the result of the operation. These savings are properly interpreted as benefits. The rationale, in terms of demand and expenditure, is that one would be willing to pay an amount equal to the cost savings in order to obtain the savings. [Epstein and Duchescneau, 1984, p. 7].

From an economic perspective, this method has two principle flaws. The first is that demand characteristics are not accounted for in the analysis, and thus, the avoided cost approach provides a biased measure of the change in consumers surplus [Blaine and Randall; Epstein and Duchesneau, 1990]. This result is conventionally demonstrated in a market model as in Figure 3, where D_o depicts the a downward sloping demand curve for information. That is, as predicted in the theoretical discussion, lower prices will increase the amount of information demanded. The alternative avoided cost assumption of demand exogeneity is captured by the perfectly inelastic demand schedule D_f. Initially, the market for information is assumed to be at equilibrium, $1/\theta^*$, where $S_o = D_o$ $(=D_f)$. If the actual demand for information is indeed D_o and the market is free to adjust to a new equilibrium, then the introduction of a new technology that shifts the supply from S_o to S_1 results in new equilibrium level of information at $1/\theta'$. The net benefits that correspond to this shift are measured by the area A+B. In contrast, the

FIGURE 3: Avoided Costs and Consumers Surplus: The Market Approach



(Source: Blaine and Randall)

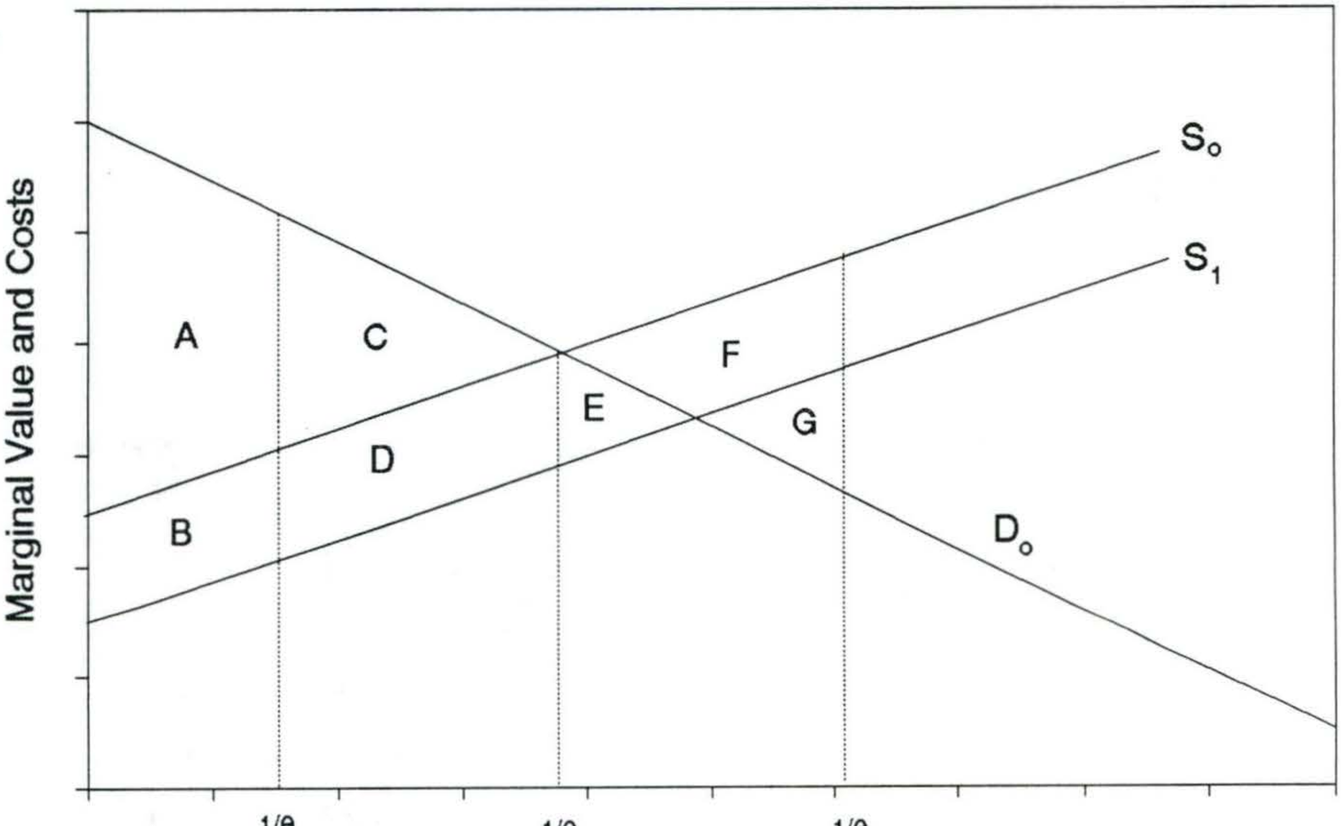
avoided costs approach implicitly assumes that there is no change in the level of information, and that the cost savings, and hence the benefits, are given by area A. In this manner, the avoided cost approach is said to underestimate the true benefits by area B. This difference may or may not be large depending on the elasticity of the true demand curve and the size of the shift in the supply curve.

A key assumption in the above analysis is that the information market clears, and there is no excess supply and demand. Given that land information is a rationed public good, wherein the level of information provided is determined outside the market, it is extremely unlikely that market clearing conditions will exist. It is much more probable that information is provided at a non-clearing level, where supply exceeds demand or vice versa. In these instances, the magnitude and the direction of the bias associated with the avoided cost approach are uncertain.

The biases associated with the avoided cost approach when information services are publicly allocated is demonstrated in Figure 4. If, for example, the level of information services was fixed by the public sector at $1/\underline{\theta}$, both before and after a downward shift in the supply curve, then the avoided cost benefit measure, B, would exactly equal the consumer surplus measure. Under these conditions, the avoided cost approach does provide a valid and complete measure of the benefits of the change. In essence, this has been the motivation for the parity approach adopted by the Dane County MPLIS (see Gurda <u>et al.</u>).

It is more common, however, that shifts in the supply of information are accompanied by a change in the level of information

FIGURE 4: Avoided Costs and Consumers Surplus: The Public Goods Approach



allocated by the public sector. In these instances, the direction and the magnitude of the bias will depend upon the relation between the market clearing level of information and the level of information exogenously determined by the public sector. For example, if the level of information were set at $1/\underline{\theta}$ before the supply shift and $1/\theta_1$ afterwards, the true benefits measure would equal C+D. In contrast, the avoided cost benefit measure would correspond to area D. Thus, in situations where information provision is set at levels at or below the equilibrium, the avoided cost measure of benefits still provides an underestimate of the true benefits of improvements in information provision. Yet, the magnitude of this bias, area C, is much larger than that presented in the avoided cost analysis of Figure 3.

Quite a different result occurs if the level of information provision is set at levels exceeding the market clearing conditions. Such a situation is depicted in a move from $1/\theta_1$ to $1/\theta_2$, where, in this case, $1/\theta_1$ is assumed to be associated with the initial supply schedule S_o. Under these assumptions the true benefits are given by E+F-G, while the benefits as measured by the avoided costs approach are E+F. As such, the avoided cost approach provides an overestimate of the benefits of the new policy.

The implication of this analysis is that, in cases where information is publicly provided, the avoided cost approach does not necessarily provide a lower bound estimate of the 'true' benefits of improved information provision. Knowledge of, or strong assumptions about, the demand for information and the structure of the information market are required before broad statements about the direction of the biases associated with the avoided costs approach can be made.

In a similar vein, the second limitation of the avoided cost approach is that it may be an invalid measure of benefits for evaluating new types of information. The question of validity would arise when either the old system could not provide the new type of information at any cost or the costs of providing information with the old system exceed society's willingness to pay for that type of information. In the former case, there is simply no costs with which to make a comparison. In the latter case, the costs of providing the new information with the old system do not serve as a valid base for comparison. In this instance cost savings, using the old system's costs to provide the additional information, do not represent a true benefit to society. Instead, the correct theoretical measure of the benefits from previously unavailable information is the resulting increase in consumers surplus.

Benefit-Cost Analysis for Discrete Changes in Supply

To this point, supply and demand curves for information have been assumed to be continuous, and the economic optimum occurs where the supply equals the demand. In general, however, a given land information system does not provide a continuum of information levels. It is more common that a set of discrete information systems are available for policy makers to choose between at a given point in time: each providing a different level of information with an associated cost. For example, a policy maker might be asked to choose between a manual system and a computerized MPLIS (e.g. Moyer et al.; Licht). Or, different combinations of information layers and discrete levels of resolution might be contemplated (e.g. Gurda _et al._).

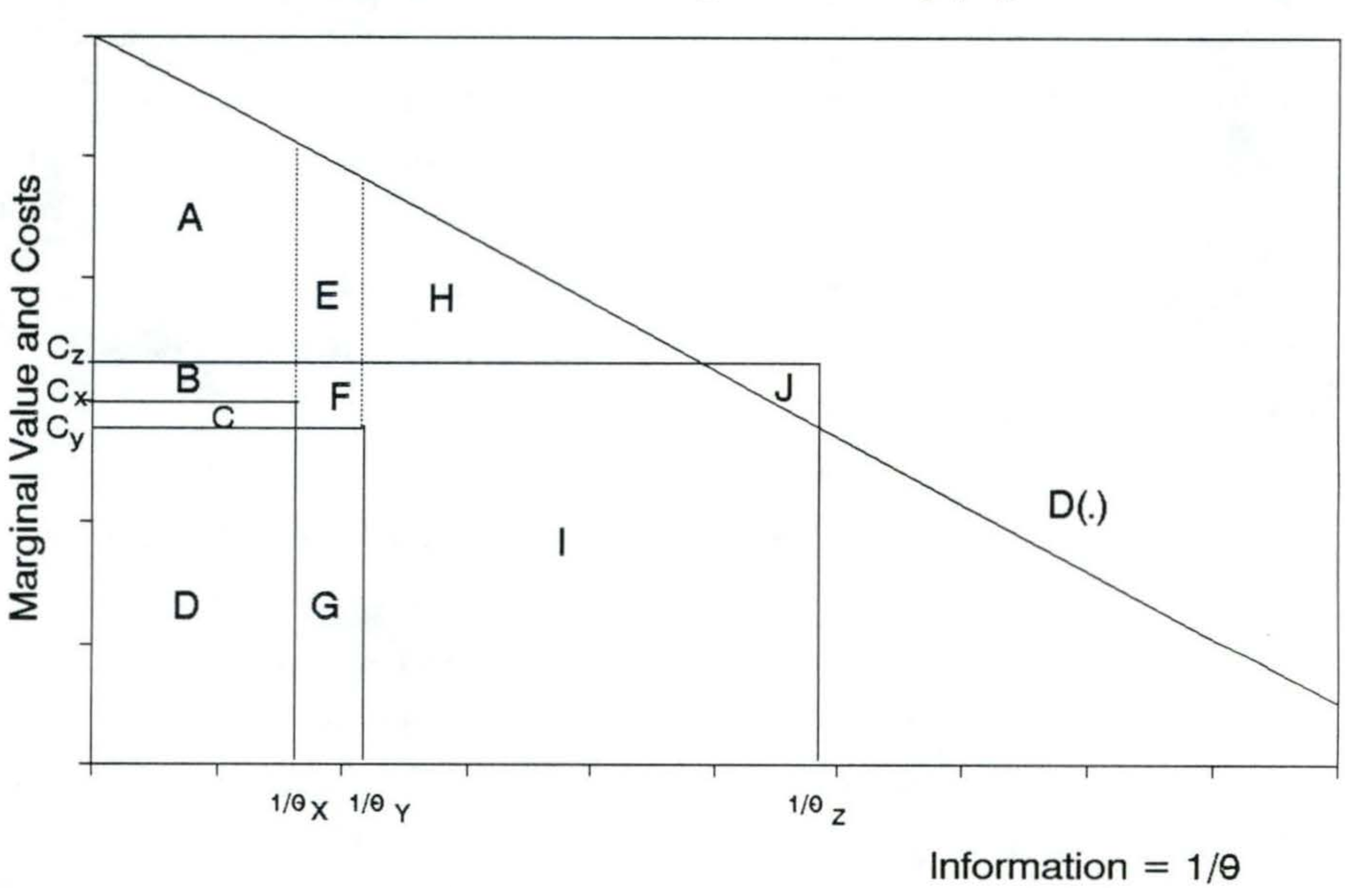
Let the points denoted by x, y and z in Figure 2a depict a hypothetical array of possibilities that are offered to a policy maker, and assume that no other alternatives are available. These possibilities are depicted in a supply and demand framework in Figure 5. Given that none of these options corresponds to an optimal level where information supply is exactly equal to demand, Which policy should be chosen? Again the answer is the option which maximizes the economic surplus.

Suppose that the information system initially provides $1/\theta_x$ level of information, and that each bundle of information is offered to the public at price C_x (which equals average cost). Under these conditions, economic surplus consists of area A+B.

Now suppose that two alternatives become available. One of these corresponds to the provision of $1/\theta_y$ of information with price equal to the average cost of C_y, while the other provides $1/\theta_z$ of information with a price equal to the average cost of C_z. Should either of these options be selected over the existing system?

If option $1/\theta_y$ is adopted, the new surplus would equal A+B+C+E+F. Since the area C+E+F is obviously positive, the economic surplus of $1/\theta_y$ exceeds that of the initial system. Similarly, if $1/\theta_z$ is implemented, the net additional benefits of the project equal E+H-B-J. As drawn, this value is positive. This means that, in spite of the fact that costs rise and the level of information provided exceeds present demand, the net change in economic surplus would be positive for this particular

FIGURE 5: Benefit-Cost Analysis for Discrete Changes in Supply



project.

Indeed, the relative areas depicted in Figure 4 indicate that the net additional economic surplus associated with $1/\theta_z$ exceeds that of $1/\theta_y$. Thus, by the net economic surplus measure, project $1/\theta_z$ should be the option chosen.

Exact comparisons of this surplus approach with the avoided cost and parity approaches cannot be made in this example because of the assumption that the supply curve for information is not continuous across levels of information. In a heuristic sense, however, it can be argued that a decision maker adopting the parity or avoided cost rule would be likely to choose option $1/\theta_y$ instead of $1/\theta_z$. With lower costs and better information, $1/\theta_y$ is clearly preferred to $1/\theta_x$. And, because costs of $1/\theta_z$ greatly exceed those of $1/\theta_y$, the option of $1/\theta_z$ might be selected against using the parity or avoided costs concepts.

In summary, the change in economic surplus is the appropriate measure of welfare change. Other methods of approximating these benefits will generally provide biased estimates and may even lead to erroneous policy choices between alternative information systems.

III. Summary and Application

The principle thrust of this paper has been to conceptualize benefits and costs of information, and to demonstrate, in a theoretical framework, that both benefit and cost characteristics should be considered in evaluating alternative information systems. Past studies have tended to focus on only the cost aspects, with benefits perceived as intangible. It was shown that such methods generally provide a biased estimate of the net social benefits of improved information systems and could lead to misguided advice about which information systems are most desirable from an economic perspective.

Following Chavas and Pope, information was defined to be an intermediate product in the inquiry and decision process. The values of improved information can be determined indirectly by examining the impact on transactions costs and welfare in markets that require information as an input. It can also be directly valued in terms of its impact on optimal decisions in uncertain situations. The choice between methods of valuation will depend on the context of the situation.

Primarily, this paper has been confined to theoretical discussions. The extension of these concepts to actual valuations of benefits will certainly not be easy. Clearly, demand functions for information are not readily determined, and even point estimates of the value of information services will be difficult to measure. However, it is argued that the theoretical model does provide a framework for practical valuation of information systems. It identifies the factors that should be considered, and allows us to hypothesize whether our estimate understates or overstates the true value of information.

As an example, let us consider the case of the Land Conservation Committee (LCC) in Dane County, Wisconsin which uses data from a number of sources, and processes the data using a GIS/MPLIS. The product is a tract map overlaid with soils data showing an erosion index and parcel ownership information. The primary benefit of this system is perceived to be the acceleration of the contracting of conservation programs that require the development of farm plans. Prior to the installation of a MPLIS at the LCC, these data were processed manually by visually comparing maps containing the required data. The process of identifying and developing farm plans for those farms with erodible soils was highly labor intensive and time consuming.

We may also consider future advances in technology which may enable the introduction of an additional layer of information to ensure farmer compliance with conservation plans. Satellite photographs linked to a GIS could identify tillage practices and crop rotations. Given this additional information, the MPLIS at the LCC would not only be able to identify erosion problems and facilitate the development of farm plans, but could also automatically generate maps highlighting farms that do not appear to be in compliance with the plans. The MPLIS could then generate lists of names and addresses for use by field agents in making on-site inspections, as well as notification letters asking farmers to comply with their plans or risk losing program benefits.

The benefits that may be achieved under such a program stem from three primary sources:

1. Data processing cost savings,
2. Compliance enforcement cost savings, and
3. Increased compliance with the conservation restrictions resulting in lessened soil erosion.

Benefits from savings in the cost of data processing occur when the process of identifying erodible soils, notifying farmers, and developing farm plans is made more efficient. The costs of new hardware and staff training must be weighed against labor savings in processing data from soil and tract maps.

As pointed out in the discussion of the avoided cost approach, the extent to which the work would have been undertaken by the LCC in the absence of a MPLIS must also be considered. If it is determined that the Dane County LCC would have undertaken the process of planning and examining the same acreage even without a MPLIS, then cost savings from the MPLIS will represent a valid partial measure of benefits to the county. As Licht has demonstrated, however, counties that do not have computerized systems tend to complete many fewer farm plans. If such a relation holds for Dane County, the entire cost of the proposed MPLIS at the new, high level of identification and planning should be subtracted only from those expenditures which would have been made in the absence of a MPLIS. Intuitively, given the high start up costs of a MPLIS, it may be the case that cost savings in this area will be quite low or even negative if it can be shown that Dane County would not have been very enthusiastic about soil conservation in the absence of a MPLIS.

A similar framework may be used to evaluate the benefits from a MPLIS based enforcement program under the hypothetical photograph information system described above. The costs of obtaining and processing the new data must be weighed against the cost of otherwise identifying farms failing to comply with registered farm plans. The degree to which such an enforcement program would have been undertaken in the absence of a MPLIS must also be determined and evaluated as it was in the case of data processing cost savings.

The third type of benefit from the MPLIS will stem from lessened soil erosion as a result of any increased compliance with the regulations--the ultimate goal of the conservation program. The additional number of farms that will be brought into compliance must be

TABLE 1: Summary of the Economic Benefits of a Hypothetical MPLIS

1. DATA PROCESSING COST SAVINGS = (Costs to process data to achieve the current or expected level of erosion identification and conservation planning under a manual system) - (Costs to achieve the new, high level identification and planning under the MPLIS)

2. COMPLIANCE ENFORCEMENT COST SAVINGS = (Costs under a manual system to process data, perform field inspections, etc. to achieve the current level or expected level of enforcement) - (Costs under an MPLIS to achieve the new, high level of enforcement)

3. BENEFITS FROM COMPLIANCE = (Benefits from increased compliance resulting in greater production and less pollution) - (Increased costs to farmers resulting from changed farming practices as a result of compliance)

determined. Studies of the relative rates of filing of farm plans (eg. Licht) between conservation districts with a computerized GIS/MPLIS and conservation districts employing manual techniques would be a logical starting place for such a comparative analysis. The degree to which compliance will lessen soil erosion and its associated on and off-site costs of erosion must also be evaluated[6]. These benefits should be weighed against any increased costs incurred by farms in changing their practices, crop rotations, machinery requirements, and so on [Mueller, Klemme and Daniel].

Total benefits will then be total costs at the old, manual level of identification, planning and enforcement less the full costs of the proposed MPLIS, plus benefits from increased production and lessened pollution, less any additional costs to the farmer. These considerations are summarized in Table 1. Although this approach to benefit measurement would not completely capture the surplus gain associated with the movement along an erosion abatement demand curve, it

[6]. Poe, Klemme and McComb discuss a method for translating soil loss into economic values. See also Crosson and Stout, and Clark, Haverkamp and Chapman for discussion of the economic costs of erosion.

does provide a closer approximation to the true change in economic surplus than methods that only consider cost characteristics.

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