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ABSTRACT

Without exaggeration the basic challenge of management is economics: how to choose to employ scarce productive resources to accomplish limited objectives effectively. It is well recognized today, and increasingly so in post-industrial societies, that information, broadly defined, is a strategic economic resource that must be managed if it is to be productive. A comprehensive literature has developed in the discipline of economics which concerns information, information systems and information-related phenomena of import to management and the development of management information systems (MIS). Although this literature is vast, this overview attempts to relate some of this work to MIS and MIS research. We highlight results in three general areas: 1) those which concern the effect of information upon economic markets external to the firm; 2) those which concern issues of information and its relation to decision making and the internal organization of the firm; and 3) those which concern questions of allocation and control of information resources within the firm. In particular, attention will be directed to interpretation of the major results related to the effect of information upon markets and upon individual decision making, team theory, agency theory, decomposition theory, resource allocation and pricing, incentives, and information evaluation.

INTRODUCTION

Although the now classic MIS research article by Mason and Mitroff (58) highlighted the importance of understanding both behavioralist and rational-economic viewpoints in the conduct of MIS research, there has been considerably more emphasis on the former in current work. However, the MIS researcher interested in economic issues is faced with a vast amount of published research by economists in a bewildering number of topical areas. In an attempt to rectify the problem, this paper examines some of the major themes in economics which we believe are not only relevant to scholars interested in MIS research, but also to practitioners interested in understanding economic issues and their application to MIS. Our presentation will center on results in three general areas: 1) those which concern the effect of information upon economic markets external to the firm; 2) those which concern issues of information and its relation to decision making and the internal organization of the firm; and 3) those which concern questions of allocation and control of information resources within the firm. Although the relevant economics literature encompassed by these three areas is vast, we will attempt to highlight some of the salient results relevant to MIS researchers and practitioners attempting to integrate these aspects of economic theory into their thinking about MIS. Necessarily, commentary will be brief and interested readers are referred to the articles listed in the bibliography to obtain better understanding of the mathematical models employed by economists in these areas.

The paper is organized as follows. After providing some background material, attention is directed to the first general area, namely the effect of information on exchange economies and production economies. This is followed under the second general area by consideration of the economics of information applied to individual decision making within the firm, which is then extended to the multi-person case under the topic of organizational design. Within organizational design, consideration is given to team theory and a variation of it known as decomposition theory. The second general area concludes with a summary of relevant game theoretic models and their implications for MIS research. Finally, the third general area focuses upon pricing and incentive issues in allocating and controlling formalized MIS services within the firm.

BACKGROUND

In order to fully appreciate recent research in the economics of information and its application to MIS one must first have clear understanding of the framework embedded in the traditional competitive market model at the level of an intermediate micro-economics text. Although many textbooks would qualify as background reading in this area, a very useful and appealing presentation is given in the first few chapters of Sharpe (80). This text summarizes much of conventional micro-economic theory and gives an interesting application of it to the economics of computers. Unfortunately, much of the data on computers utilized in this text is dated.

Another framework important in understanding the economics of information is provided by what has come to be called "communications theory", based upon the pioneering work of Shannon (79). Useful notions related to information encoding and channel capacity are presented there. Although communications theory per se has not had significant impact uponm research themes in the economics of information, Shannon's ideas embodied the first attempt to quantify information content and methods of encoding information to achieve a given level of reliability. Much of the terminology associated with communications design originated with this work. However, Shannon-oriented theories ignore the crucial value-of-information question by tacitly assuming that all information is equal-valued to the decision maker, an unduly restrictive assumption. While this might be useful for the engineering design of reliable and efficient communication channels, it remained for Arrow (7) to extract meaningful interpretations of it in the context of decision-making economic theory and organizations. This non-technical, but abstruse, book is full of economic ideas useful for theories of MIS. In particular, Arrow develops analogies between information channels and managerial decision making by considering an information system as a form of channel involving irreversible managerial investment in its development and whose intended use is in the context of highly uncertain payoffs. He conjectured that in such a context the private incentive of decision makers to invest in new "channels" may be very low relative to the potential organization-wide benefits of its deployment. If one considers an MIS to be a kind of "channel" the analogy is quite suggestive of further MIS reserach ideas.

A useful non-technical framework for examining the relationship of information to economic decision making is found in Marschak (55). This surprisingly prophetic article first identified societal trends toward the "knowledge economy" and developed in a straightforward way the jargon frequently associated with the information economics area. Indeed, much of today's research in economics of information can be traced to the pioneering work by Marschak in this and other articles by him (52, 53, 54, and 57).

Readers interested in a useful discussion of some of these fundamental economic issues, applied specifically to a computer related problem, are referred to Emery (25). Finally, a theme of research involving empirical study of mamagerial decision making in economic contexts with the use of alternative information systems is summarized in Dickson et. al (20). This collection of studies shows how some simple ideas related to economics of information can be useful in developing MIS research themes in this area.

EFFECT OF INFORMATION UPON ECONOMIC MARKETS

An ongoing theme in current economics literature involves models of a competitive economy in which information is explicitly treated endogenously. Although these models are often mathematically complex, the underlying motivations are quite straightforward: to examine the effect of information upon efficiency and allocation issues within the traditional competitive market framework. One example of this is found in Ackerloff (1) who examined the misallocations that can occur when sellers and buyers have differential information about the "quality" of products. In particular, he demonstrates the Pareto inferior movements that are made in a competitive economy when buyers have incomplete information, concerning the true state of traded commodities. In this case a Pareto inferior movement means that at least one person, the buyer, is worse off after the trade than before.

In the context of "pure exchange" economies in which no production of goods occurs, considerable research has been directed at the impact of the information on market equilibria. Development of the theory can be found in, for example, Hirshleifer (37) and Ng (66). Marshall (57) provides a good summary of this research. Although models differ, the underlying theme is that in a state-preference model of a pure exchange economy the public revelation of information, even if costlessly obtained, is at best socially valueless. While this may seem surprising, the underlying rationale is reasonably clear: under a limited definition of social welfare, involving consideration of Pareto superior movement in the competitive equilibrium, if information is publicly disclosed about uncertain future or otherwise unobservable "states of the world" prior to trading, then at least one trader will be made strictly worse off than he would be if trades were effected prior to the uncertain future state but without the information. Moveover, those (rare) situations in which public information is released yielding a net (windfall) gain to all traders occur only in the economically uninteresting case in which no change in trading occurs over the no-public-information case. Since public information is never completely costless to obtain in practice, society is made strictly worse off, even in the windfall case, because resources must be devoted to gathering and disseminating the public information!

While this result may not at first be considered relevant to MIS in organizations, it clearly does highlight several non-obvious issues related to the impact of information. First, one must be careful in defining criteria when dealing with the impact of information; the non-usefulness of public information result hangs critically on the common assumption by economists that interpersonal comparisons of "well-offness" among undominated economic equilibria are not considered. Public information is "valuable" only if a Pareto superior movement in the competitive equilibrium occurs. That is, if the revelation of public information would make at least one person worse off in his trading prospects, then the information is considered socially harmful by economists even if many other traders would be made better off in terms of their expected wealth after revelation of the public information. In addition, because most of these results depend critically on the assumption of homogeneity of traders' prior beliefs (prior to the revelation of information), one must very carefully define the assumptions relevant to how information affects decision making.

More important to MIS research, is the ancillary development in these models of the distinction between the private and social value of information. Both Hirshleifer and Marshall emphasize this distinction. It can be shown in these models that even though the public revelation of information is socially valueless, there is nevertheless an expected gain ex ante to an individual wishing to acquire the same information privately. That is, there is no value to publicly releasing the information, but a single self-serving individual could obtain benefit from privately acquiring the same information and using this informational advantage to condition his trading prior to everyone else learning it. The insidiousness of this result is clear; if there is private gain to a trader by acquiring information, then all traders will invest in information systems to obtain signals about uncertain but relevant states of the world. However, if everyone obtains this information then it becomes "public" and therefore at best no improvement occurs and society is the loser from excessive investments in MIS. It is important to note that this result holds even if there are "insurance" markets allowing (risk-adverse) traders to hedge against the occurrence of undesirable states of the world. If such hedging is (costlessly) allowed then the release of potentially adverse information harms no one (in an ex ante sense), since everyone is "insured", but society is out the cost of the information gathering process itself. Again, these results appear to hinge critically upon two assumptions: homogeneous beliefs by traders about states of the world (all traders have the same probability distributions over states) and the absence of productive technology (no production of goods is conditional on the information).

These latter results have direct implications for MIS in organizations. First, these models suggest that the development of MIS in the public sector for the accumulation and disclosure of "public information" is not necessarily always desirable, at least under the restrictive Pareto dominance criteria. Second, these results highlight a notion which has much broader implications for MIS; namely, that there may be in practice substantial differences in the private incentives by managers to acquire additional information for decision making from that which is more broadly or socially desirable. The implications for the over investment in MIS are obvious and there may be direct parallels between these results as applied to, for example, a divisionalized organization in which the individual managers from their narrow perspective have incentive to invest excessively in MIS in light of what is best from overall organizational objectives.

On the other hand, more recent research in this area has produced counterexamples which challenge the social uselessness of information result, even in the case of pure exchange economies. Models developed by, for example, Verrechia (93) and Ohlson (71) focus upon the homogeneity of beliefs assumption in these early models. Verrecchia has shown, for example, that in the context of "sufficiently heterogeneous" beliefs that the result does not hold. Moreover, it is commonly agreed that in an economy involving production, as well as exchange, in which the revelation of information can affect not only trades but also productive opportunities, that public information need not be socially valueless. However, even in this context there are likely to be differential incentives to acquire information from what is socially optimal.

In a contrasting vein, Wilson (95) developes several simple models to illustrate how the acquisition of information can dramatically affect outcomes when production of goods can occur. In a novel approach to formulating models, he demonstrates that under uncertainty a producer faced with a constant returns to scale productive technology could nevertheless through the acquisition of information exhibit in the marketplace economies of scale. That is, the combined affects of production and information permit the organization to achieve economies of scale even if the underlying production technology has no such economies. The implications of this and similar models to our understanding the role of MIS are obvious and this is a fruitful area for further studies. Interested readers are also referred to Hurwicz (38) and Alchian and Demsetz (2) who have developed, somewhat technically, additional models illustrating the richness with which information can affect the comparative statics of economic models.

INFORMATION, DECISION MAKING AND INTERNAL ORGANIZATION

INDIVIDUAL DECISION MAKING

The impact of information upon decision making by a single individual is now a common topic in management science textbooks. Since most management science textbooks treat topics, such as Bayesian revision and the expected value of perfect information, they will not be surveyed here. However, useful summaries of this and related ideas can be found in Marschak (52), Stigler (89) and Arrow (5). Discussions of the behavioral impact of information in economic decision making can be found in Simon (81,82), while an interesting empirical application of the impact of information upon economic decision making can be found in Chervany and Dickson (12).

Less well known in the individual decision making literature and of immediate relevance to MIS researchers is the work on comparisons of information structures. Seminal contribution to this literature was make by Blackwell (9), but since it was published in a statistical journal, its relevance to economics and MIS went largely unnoticed until recently. Although not explicitly documented, as such, in the information literature. A concise, readable summary of it is given by McGuire (60) for the case of discrete signals. Marschak and Miyasawa (50) present the full theory with some extensions, the reading of which requires considerable mathematical dexterity.

Essentially, Blackwell views an information system (structure) as a device which produces "signals" about unobservable states of the world to a decision maker. He then incorporates this signalling, via the information system, into a Savage-rational model of decision making in the standard way. In this context the function of the information signal is to modify the decision maker's unconditional prior probability over which of the states will obtain by conditioning on the observed signal. This is then used to calculate expected payoff over alternative actions, given the observed signal, so as to determine the payoff maximizing action given the signal. Blackwell assumes that the dexision maker must select one of several alternative signal generating information systems before observing the specific signal. To do this the payoffs resulting from the optimal actions, given the possible signals that could be generated from each of the alternative information systems, are weighted by the decision maker's prior probability of observing the signals in order to compare the relative payoff of the alternative information structures. This allows the decision maker to rank order the information structures according to the expected payoffs derived from utilizing them. Blackwell then goes on to ask the question "Under what conditions can alternative information structures be rank ordered without going through the process of determining payoff maximizing decisions for each candidate structure?." In addressing this he develops the notion of "fineness" of an information structure. Loosely speaking, one (costless) information structure is finer than another if the first structure yields a more precise description of which of the states will occur than the second. Not all information structures can be ranked by the fineness criterion. Basically, his theorem establishes that one information structure is generally preferred to another if it can be shown to be finer. While this is intuitively obvious (the finer structure tells you as much and possibly more about which of a set of states has occurred), the value of Blackwell's Theorem is the concrete operationalization of the concepts employed. In addition, the real practical value of Blackwell's Theorem appears to be those situations when it does not apply. The MIS implications of this case are developed in detail elsewhere, Moore (64).

ORGANIZATIONAL DESIGN

Organizational design refers to the class of problems in which the organizational structure itself is treated as a controllable variable which is causally related to organizational performance by some criteria. Although there has been no definitive work in addressing the optimal design of organizations even in the economics literature, the models which have been developed in organizational design have direct and immediate implication for MIS. Organizational design is a somewhat confusing rubric, largely because there is a considerable body of sociological literature which examines the behaviorally oriented aspects of the design of organizations. Useful background reading of this literature is essential if MIS researchers are to intelligently apply the economics of information models related to organization design. Background reading on the behavioral aspects of organizational design can be found in Cyert and March (15, 16). An extensive summary of recent work in this area can be found in Moore (65).

Economists have differentiated their research into organization design from the sociologists by viewing organizations primarily as formalized, impersonal, goal seeking systems which, under decentralization, can be partitioned into a collection of goal seeking subsystems according to some rules of hierarchy. The thrust in this research has been to examine models of such organizations from a normative perspective so as to, for example, examine effects of alternative hierarchies upon the problem of coordinating the interacting subsystems. In this more narrow economics arena, organizational design refers to the application of economic theory in multi-person organizations in which the effect of markets, if any, is indirect or minimal. The operative question is "What structures and decision making procedures should be adopted in order to make rational decisions, in some sense, in the absence of complete markets?". Background reading in this area can be found in Hirshleifer (34,35,36), Hurwicz (38,39,40) and Arrow and Hurwicz (6). Advanced treatment of the economics of internal organizations are given by Spence (88), Stiglitz (90), and reading in McGuire and Radner (59). More broad base and less mathematical treatment of the philosophical issues related to the economics of organization design can be found in Williamson (94), Grochla and Szyperski (29), Heal (30), Galbraith (27), and Marschak (56). Most of these authors attempt to address organizational design from two perspectives: 1) that of organizational design as regards centralization versus decentralization with particular emphasis upon specialization and incentives in decentralized environments and 2) resource allocation in decentralized organizations. More will be said about resource allocation in a subsequent topic.

Decentralization is of interest to MIS because in almost all cases authors have defined decentralization in terms critically related to information economics. That is, firms are viewed as decentralized if discretionary decision making authority is delegated to subsystems within the organization, there is some degree of informational autonomy among the subsystems and, finally, that the decision made by one subsystem influences the goal attainment by other subsystems. Organizational design theories encompass a wide range of alternatives from the somewhat uninteresting case of a fully centralized organization, which contains no subsystems, to the fully separable organization in which identifiable subsystems do not interact. The interest in these models from an MIS perspective stems from the fact that these models necessarily identify quite concretely the nature of the information flows, distributed computation, managerial incentives and detailed bureaucratic procedures as components of the organizational design process. That is, although the motives of economists have been to compare organizational designs or to address resource allocations, the informational "byproducts" of these models are of considerable interest in developing theories of normative MIS design which can stand the test of rigor. Furthermore, many of these alternativs models have proven to be sufficiently rich in structure to capture one or more observable tenents of actual managerial behavior in organizations, at least as it pertains to formalized decision making procedures. For example, versions of these models can not only illustrate but demonstrate the optimality of the need for increased communication as organizations with high interaction among subsystems decentralize their decision making. More importantly, the exact nature of the messages among various subsystems and the signals from the environment, as components of the MIS, are operationally defined and their economic value can be imputed in some cases. Although organizational design models have been largely ignored by MIS researchers, there have been many specific models proposed which are relevant. For expository convenience alone, a game theoretic paradigm will be offered to examine organizational design. Team theory and decomposition theory will be used to illustrate cooperative game models, while a brief discussion of incentive compatible models and agency theory will be used to illustrate applications of non-cooperative game theory.

Team theory was originally developed by Marschak (53,54). Marschak defines an organization to be "a group of persons whose actions agree with certain rules that further their common interests" and a team as "an organization in which its members have only common interests." That is, team theory models 1) eliminate non-cooperative behavior from multi-person organization models, concentrating instead upon the design of communication networks and the specification of decision rules for the agents in a decentralized organization when scarce resources must be allocated to competing uses; 2) assume the goal of the organization is expressible as a single non-separable objective function; and, finally, 3) assume uncertainty in environmental variables affecting outcomes is present. Example models incorporating these ideas can be found in Radner (72,73,74) while much of the work has been unified in a book by Marschak and Radner (51). An example of an interesting team model would be one in which agents in a decentralized organization each independently observe, via an MIS, noisy signals relevant to their own economic environment, but the environments are correlated such that intelligent "sharing" of the observed information could through cooperation improve oprganizational payoff over what each of the agents would genetrate acting autonomously. The major question in this case is "What should be observed and what should be communicated (two central questions of any MIS design) in order to optimally, in some sense, make decisions?". An interesting, if oversimplified, example of such a team theory model can be found in Radner (73). In this model Radner examined the relative value of several alternative organizational designs, such as fully autonomous decision making, complete communication among agents, partitioned communication, decision by committee and management by exception cases. All involved alternative information structures for observation and communication in a simple organizational setting for a single time period. An interesting application of similar concepts in team theory to empirical research can be found in MacCrimmon (49).

The mathematical programming approach to organizational design is closely related to team theory and is based in concept on the decomposition of mathematical programs as representations of the fundamental decision making problem faced by a decentralized organization. The approach taken in this literature is to examine alternative ways of breaking down the overall problem faced by the organization into a series of smaller problems whose composite solutions yield the solution to the overall organizational problem. MIS interest in this approach is stimulated by the organizational implications drawn from the alternative methods of breaking down or, more precisely, decomposing the overall problem. That is, if the overall problem can be decomposed in alternate ways, each of which induces a different organizational structure, then the problem of organizational design is to evaluate the desirability of one versus another of these decompositions. Again, from an MIS standpoint these decompositions are of interest primarily because of the iterative solution procedure commonly associated with decomposition models. After each iteration information must be communicated among subordinate agents and between subordinate agents and a superior in order to begin the next iteration. The analogy between these models and concepts of management control and coordination via information and communication systems is obvious.

Background reading in this area can be found in Baumol and Fabian (8), Burton and Obel (11), Ruefli (77) and Jennergren (41). MIS readers of this literature must be careful to see beyond the narrow resources allocative focus of these models in order to concentrate upon the normative MIS implications. A specific example of how these models can be utilized to evaluate alternative information systems is given by Freeland and Moore (26). In this model it was shown that a highly plausible and intuitively appealing information system in which subordinate agents communicate "bids" for desired resources can be shown not to work in the sense that the overall organizational problem would never be solved unless a richer information system were utilized. By richer it is meant that non bid-related messages must be allowable for the imposed coordination to be effective. An empirical application of decomposition theory to study the effects of alternative information systems can be found in Moore (62).

Non-cooperative game theory makes the same assumptions as in team theory except that the agents do not share a common goal, thereby inducing non-cooperative behavior. Fundamental background reading is, of course, von Neumann and Morgenstern (97). Although the published literature in non-cooperative games is sizeable, one segment of it, agency theory, is of immediate relevance to MIS. Agency theory considers the special case of two, or possibly more, individuals in which one individual, the principal, hires another individual, who possesses technology or expertise, to act as his agent in the conduct of some decision making task. Since it is assumed that the agent does not necessarily share the same objectives as the principal, these models cover a wide range of practical situations. Furthermore, in most cases the principal is unable to completely be informed about some aspect of the agent's problem, such as his utility function or the exact nature of the resources or expertise offered by the agent. The goal in agency theory is often to establish contracts which induce incentives for the agent to act in complete accordance with the preference of the principal, despite initially conflicting objectives, or to devise penalty or sanction schemes to prevent decision making by the agent which would not be in the interests of the principal. Useful references in this area are given by Ross (75,76), Spence and Zeckhauser (87), Amershi (3), and Mirrelees (61). Incentives and incentive compatible control of decentralized organizations in this context have been studied by Groves (30), Loeb (48) and Demski and Feltham (18). The interesting case of a collection of principals without necessarily identical tastes who must reach a common decision under uncertainty was studied in a seminal study by Wilson (96).

While there are insights useful for MIS in examining these models, there would appear to be numerous areas in which the models themselves could be applied in further understanding MIS related issues. For example, the application of agency theory of incentive compatibility models to the contracting for software development or to the design of MIS systems themselves fits nicely with the assumptions commonly employed in these theories. Extensions of these and similar models to the case of the single principal and multiple agents are currently underway and could provide a richer context for modeling information systems in hierarchical organizatons.

ALLOCATION AND CONTROL OF INFORMATION SYSTEMS

Information systems for management, as well as other environments, require investments in resources. This fact immediately raises questions regarding how the use of these resources should be allocated and controlled within the firm. Typically, such questions focus on the formal information systems in existence or under consideration and the organizational unit, such as an EDP or MIS department, "officially" assigned the primary responsibility for providing information processing industry, the output of an IS department is an intermediate means to some other, final purpose of the consumer or principal in the firm. For example, an IS report provides the basis for a management decision. Thus, it is well-recognized in principle that the "true costs" of IS are those incurred indirectly through the realized or lost opportunities of the consumers, and as such, they are "hidden" from the accounting system in place. Nonetheless, resource allocation and control in practice usually translates into monitoring, estimation and recovery of direct costs. Many of these direct costs are relatively fixed (e.g., physical equipment and labor), although a number of them do vary with IS output and some outputs are discretionary (e.g., systems development).

In a series of articles (17, 28, 69, 70) Nolan has surveyed contemporary EDP administrative practices by a number of organizations, especially management policies with regard to control. For example, despite recognition that IS is a support function and the IS department is a cost center, in some firms EDP is organized as a profit center; in other firms EDP costs are allocated as (pure) overhead. Nolan hypothesizes that the supply (or availability) of EDP services in an organization experiences different and distinct "stages of growth" (28,70) in response to various characteristics of user demand and the environment. To manage EDP effectively, he advocates that control policies as reflected by chargeout systems or resource pricing, should be flexible and adapt to the conditions of a given stage. For example, management might subsidize prices during early growth and full-cost or monopoly price services in excess demand stages to contain expenditures. Under a chargeout system a customer is charged for service on a job-by-job basis according to some formula as a function of resources used and unit prices (e.g., see 42).

Rather than rely on conventional wisdom exclusively, we can productively consult economic theory for some insight on these issues. First, given the support status of the IS department one should seek an objective which maximizes the net discounted value of this group's output to the firm. That is, if one measures this value only as the department's profits (or the producer's surplus), it is well-known from economics that the firm will incur a loss in benefits or welfare (what economist's call "consumers' surplus"). Thus value should be measured as the sum of the producer and consumer surplus. A second consideration at the outset is whether or not the IS department is a monopoly in providing services or if organizational customers have access to external suppliers. Typically, in most large organizations the monopoly situation (or a variant on it) prevails with exceptions being made for unique capabibltles, such as access to a commercial databank.

How should services be priced? The answer to this question depends on how much of the real world complexity one wishes to capture in a model of the environment (44, 45, 67, 68, 83-86). For example, consider the simplest of worlds in which we have a single productive resource, a single output, a known, fixed planning horizon over discrete time periods, and known demands in each period. We wish to determine prices in each period and how much resource capacity to procure. Under the normal assumptions on "well-behaved" demand and cost functions, the optimal pricing and investment policy may be characterized as follows. In each period where capacity is not binding, produce the amount demanded and set price equal to marginal variable costs at total output. The difference (or present value of the difference) between a "market clearing price" based on the aggregate (inverse) demand function and the marginal variable cost at a given output level (and in a given period) can be interpreted as the marginal opportunity cost (or value) of capacity at that output level (and time period). When there is slack, this marginal (opportunity) value is zero. In each period where capacity is binding, set total output at capacity and set price equal to the marginal variable cost at capacity plus the future worth of the marginal (opportunity) value of capacity for that period. The investment criterion is to purchase capacity up to the point where total marginal (opportunity) value of it is equal to its marginal (purchase) cost over the planning horizon.

Some observations are worth nothing on even this simple case analysis because the results in more realistic but complicated models are similar, notwithstanding the algebraic details. First, there is no price discrimination by user - a desirable feature. (Under a profit maximization criterion there will be price discrimination in favor of users with greater demand elasticities.) Second, there is differential pricing to reflect peak and off-peak demand periods, wherein peak demand consumers pay a premium. Third, if the operating and investment cost functions are linear, then marginal costs equal average costs and the cited decision rules will recover total costs. Note in this instance that the total investment cost is recovered from the peak-demand period users only. More generally, however, the cost functions would be non-linear which means that the optimal policy is for the firm to subsidize IS use. If operating costs are a pseudo-concave function of output, a dynamic version of the basic model yields the following behavior: At low output relative to capacity marginal costs are significantly below average cost and users are heavily subsidized. As output (use) expands, marginal and average costs converge, and the amount of the subsidy reduces. At the point where marginal costs equal and/or exceed average costs, it is optimal for the firm to expand capacity in order to recapture consumer surplus -- returning to the high subsidy situation.

The basic model has been generalized in (44). In that analysis, the assumptions are: heterogeneous resource capacities by age (or vintage); costs as a function of system load, capacity and resource age; resource replacement; and an infinite planning horizon. (Rental vs. purchase decisions are also included within the framework as a special case; see also 80). Among the results we obtain is the determination of a natural planning subhorizon which is finite and corresponds to the duration of time and individual resource is actively employed in production. The analysis also shows that when it becomes optimal to dispose of a particular resource vintage it is optimal to replace all of that resource vintage's capacity (or equivalently, to "write off" all of its economic value).

A number of other models have appeared in the economics literature dealing with various aspects of pricing for the allocation and control of information services in computers - communications networks, (e.g., 19, 24, 78). Space limitations preclude a review of this work here. A review of some of this literature can be found in Moore (63). In most of these cases, as above, the analyses postulate the existence of user demand functions and output cost functions (or equivalently production and expenditures functions). There is reasonably good evidence available in the literature to support the contention that IS production and cost functions can be developed, (e.g., 14, 45-47, 80). There has also been empirical work done at the industry and the firm level in identifying and estimating demand functions, (e.g., 10, 13, 14). The evidence is somewhat less satisfactory at the intraorganizational level for payments or individuals. Some work has been done by Streeter (91, 92) on IS demand by "computer-dependent workers;" however, demand by the general consumer (the manager or professional) has not been studied in any depth. One obvious problem here is identifiability, since many (if not most) general consumers are passive agents in their interactions with IS. Another issue concerns the definition and measurability of IS outputs in general, i.e., in determining what to include or exclude. In the area of MIS we do not have a convenient metric as a basis for quantifying output and communicating requirements.

From some of the recent literature, it appears that a productive way to approach the individual demand problem may be indirectly through the mechanism of incentives. That is, assume individuals are rational and that each knows (personally) the value or impact on his welfare of a given of potential IS output. This might be viewed as the individual's "reservation price" for the commodity, i.e., he would be willing to pay up to or less than that price and not more. If these reservation prices were public they could be used to set priorities and allocate output, since in the aggregate they constitute the "true value" to the user population. But for selfish reasons individuals have no natural inclination to reveal them and to the contrary, it may be in their self-interest to lie. Can a scheme be designed through which an individual maximizes his own welfare by revealing his true "reservation prices?" Dolan (21-23) has investigated this issue in the context of congested service systems and the cost to users of delays in receiving service. He shows that a "Priority price" should be based on "marginal delay cost which services at any time impose on other users." Harris, et al. (32) have also studied the general problem in the presence of asymmetric information and divergent preferences (i.e., between users or divisions and the resource allocating authority or headquarters). They show that for a particular (linear) model structure, certain forms of (rank ordered) transfer pricing schedules are optimal (cost-minimizing) allocation mechanisms. In general, these issues merit further research as a basis for enhanced organization design.

CONCLUSION

Even under the space limitations of this brief survey, it should be clear that there is substantial interaction between MIS and economic theory. The relative inattention to economic issues related to the impact of information by MIS researchers is serious. Although behavioral theories related to such things as cognitive information processing, implementation of MIS, and management of the MIS design process are important to our understanding of this complex topic, in the final analysis the goal of an MIS should be improvement in decision making effectiveness. We believe that incorporation of economic theory into MIS research should be central to achieving that goal.

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AN EXAMINATION OF THE INTERACTION BETWEEN TECHNOLOGY, METHODOLOGY AND INFORMATION SYSTEMS: A Tripartite View

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INTRODUCTION

In this paper we set out to explore the interaction between technology, methodology and information systems. Our original purpose in doing so was to review the co-evolution of technology and methodology and their interactions. However, in exploring the interactions, it became evident that even within a fixed time frame of methodological and technological advancement there are important interactions which need to be understood if information systems are to be developed which are both "user-successful" and technologically sound. Thus a second purpose of this paper is to highlight what some of these interactions are, how they impact on an information systems outcome, and the need for further research in this area.

To accomplish these somewhat lofty objectives in the short space of this paper, it is necessary to erect a simple (but expandable) framework by which these interactions can be explored. The device chosen is to relate the notion of an information system to two systems: a user system and a (computer-based) data-processing support system (DP system). An information systems methodology is then taken as the means by which one alters, over time, the content of both the user system and the data-processing system so as to introduce into the organization a "new" information system.

CLARIFICATION OF CONCEPTS

USER-SYSTEM

We take, as the target for IS development, a user-system. A user-system we define to be one or more individuals co-operating on the accomplishment of one or more functions in an organizaion. The user-system is said to have criteria by which it implicitly or explicitly measures both the success with which it performs its functions and the satisfaction it derives from doing so. The individuals are said to assume jobs which are in turn comprised of tasks. The assignment of individuals to jobs constitutes the organizational structure of the user-system, the assignment of tasks to jobs constitutes the work structure.

A task, for our purposes, is initially viewed as a black-box transformation which, when triggered, employs external inputs and/or internal knowledge, to produce an output or response. One can, of course, decompose tasks into sub-tasks recursively, assuming that the internal structure of the task can be determined to some level.

Tasks, at a given level of analysis, can be classified along a number of dimensions; we elect two:

1. Decomposible v. Non-decomposable (Definable v. Non-definable)

2. Data-oriented v. Non-data-oriented

By "decomposable" we intend a task which is capable of being decomposed into labelled sub-tasks; i.e., it possesses a determinable structure. At some point in the decomposition, we reach a point at which one can no longer discover sub-tasks (although there may be an underlying "deep structure"); we call this a non-decomposable task. This invokes a sub-criteria: is the task definable or not? This gives rise to the following labels assignable to a task at any point in analysis: decomposable (structurable), non-decomposable-definable (programmable), non-decomposable-non-definable (indeterminate).

By "data-oriented" we mean data as potentially processable by the then existing data-processing system. This might be data used to trigger the task, to supply external input to it, to alter its