THE EVOLUTION OF RESEARCH ON INFORMATION SYSTEMS: A FIFTIETH YEAR SURVEY OF THE LITERATURE IN *MANAGEMENT SCIENCE*

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Last revised: January 2, 2004

ABSTRACT

The development of the Information Systems (**IS**) literature in *Management Science* during the past fifty years reflects the inception, growth and maturation of several different research streams. The five research streams we identify incorporate different definitions of the managerial problems that relate to IS, the alternate theoretical perspectives and different methodological paradigms to study them, and the levels of the organization at which their primary results impact managerial practice. The *decision support and design science research stream* studies the application of computers in decision support, control, and managerial decision making. The *value of information research stream* reflects the early relationships that were established based on economic analysis of information as a commodity in the management of the firm. The *human-computer systems design research stream* emphasizes the cognitive basis for effective systems design. The *IS organization and strategy research stream* shifts in level of analysis away from the system user to the locus of value of the system investment. The *economics of information systems and technology research stream* emphasizes the application of theoretical perspectives and methods from analytical and empirical economics to managerial problems involving IS and information technologies (**IT**). Based on a discussion of these streams, we provide new perspectives on the IS literature's core contributions to theoretical and managerial knowledge, and make some predictions about the road that lies ahead for IS researchers.

KEYWORDS: Decision support systems, economics of information systems, human-computer interface, information strategy, information systems, information technology, information systems organization, organization, systems design, value of information.

ACKNOWLEDGEMENTS. The authors thank Kunsoo Han for research assistance.

INTRODUCTION

Looking back on the development of the information systems (**IS**) and information technology (**IT**) literature in *Management Science* during the past fifty years reveals where the field started and how far it has come. During this time, we have seen a new academic field emerge around an area of innovation involving electronic computation, the storage and manipulation of digital data, the specification of computer-based algorithms to support decision making, and the creation of systems that link people, business processes, firms, industries and markets together within the economy.

We organize this review around the important managerial problems in the field; for example, how to get systems design right, how to approach inter-organizational systems investment, how to evaluate IT for effective intra-organizational coordination, how to measure the value of IT-influenced changes, and how to assess the extent to which IT creates business value and productivity gains within the broad economy. Alternatively, we can analyze citations or gauge the critical mass of findings in different sub-areas of the IS field through careful "meta-analysis" of the literature (e.g., Culnan, 1986; Melone, 1990). We take a different approach, however. We examine the intellectual growth of the field via several different research streams that define the thrust of the theory and what managers have come to know as results.

The Multiple Streams of IS Research in *Management Science*

We identify five research streams that have developed over time to incorporate different definitions of the managerial problems that relate to IS, alternate theoretical perspectives and methodological paradigms, and the levels of the organization at which their results have impacted managers in modern organizations. These five streams are summarized in Table 1 in terms of their levels of analysis, their associated theories, their methodologies and their reference disciplines.

Decision Support and Design Science. This stream involves application of computers in managerial decision making and control (e.g., Coleman, 1956; Vasyonyi, 1957; Hertz, 1965; Raymond, 1966) and reflects the "starting point" of IS research, even though there was no recognition then of a distinct academic field. Early works examine IS to support organizational operations (e.g., Jackson, 1956;

Kalaba and Juncosa, 1956; Hoos, 1971; Johnson and Ward, 1972; Hamilton and Moses, 1974), and computer design, data storage and other systems (e.g., Hsu, 1968; Baba, Balachandran and Stohr, 1976). It later evolved intoa vehicle for technical IS research (e.g., Garfinkel, Gopal and Goes, 2002).

Table 1. The Five Streams of IS Research, 1954-2003

RESEARCH STREAM	LEVEL OF ANALYSIS	THEORIES	METHODOLOGIES USED	RELATED DISCIPLINES
Decision Support and Design Science	System level, mostly in conjunction with human users or business processes, up to the level of a strategic business unit	Decision Theory, Network Optimization, Microeconomics, Control Theory	Mathematical programming, forecasting, simulation, expert systems	Computer Science, Operations Research, Economics, Marketing, Strategic Management
Human-Computer Systems Design	User-focused, involving both individuals and groups	Cognitive Style, Behavioral Decision Theory	Experiments, argumentation, simulation, system test-beds	Psychology, Cognitive Psychology, Decision Science, Design Science
Value of Information	Individual decision makers, technologies in business process context, firm actions in market context	Information Economics, Real Options Theory, Information Sharing Theory	Decision trees, analytical models, statistical analysis, mathematical programming, simulation	Economics, Decision Science, Risk Management
IS Organization and Strategy	Spans levels: greatest emphases on individuals, groups and business units, and organizations, strategic interactions in the marketplace	Diffusion Theory, Media Richness Theory, Resource-Based View of the Firm, Transaction Cost Economics, Task-Technology Fit, Technology Acceptance Model	Models, case stud-ies, field studies, experiments, surveys cross-sectional and longitudinal designs, argumentation, blend of qualitative and quantitative methods	Organizational Theory, Strategic Management, Social Psychology, Cognitive Psychology, Economics
Economics of IS and Technology	Spans levels: individual decision makers, business process/ product/project, strategic business unit/firm, industry, market, economy	Theory of the Firm, Production Economics, Game Theory, Contract and Incomplete Contracts Theory, Network Externalities	Analytical modeling, empirical analysis and econometrics, cross-sectional and longitudinal design, experiments, simulation	Economics, Operations Research, Computer Science, Strategic Management

Value of Information. This research stream provides a basis for the inclusion of economic thinking in IS research, related to optimal use of information in decision making and the management of the firm (e.g., Miller, Moskowitz and Miller, 1975; Hilton, 1981). Representative search papers deal with issues of resource allocation and incentives under information asymmetry (e.g., Harris, Kriebel and Raviv,

1980), the value of information in sequential presentation (e.g., Miller, 1975; McCardle, 1987), and the analysis of information sharing in supply chain management (e.g., Lee, So and Tang, 2000).

Human-Computer Systems Design. This research stream emphasizes the individual-level human cognitive bases for effective systems design (e.g., Ackoff, 1967 and 1971; Bariff and Lusk, 1977; Lusk and Kersnick, 1979; and Huber, 1983), and the openness of human decision makers to accept the recommendations of systems that produced management science-based recommendations (Doktor and Hamilton, 1973). This research stream has led to a well-established body of knowledge within the field (Ramaprasad, 1987; and DeSanctis and Gallupe, 1987), however, it also has drawn reactions and responses, representing alternative explanatory theories (e.g., King and Cleland, 1975; Boland, 1978).

IS Organization and Strategy. This research stream shifts the level of analysis to the more aggregate level of the organization. It seeks to understand new ways that IT impacts operation of the firm, and creates strategic advantage. This stream has benefited from rapid development in the referent disciplines of macro- and micro-organizational behavior theory and organizational psychology. IS research has examined the impact of IT on individuals (e.g., Zmud, 1979; Lucas and Nielsen, 1980), groups of people and projects (Swanson, 1974; de Brabander and Edström, 1977; Ginzberg, 1981) and the firm as a whole (e.g., Van de Ven, 1986; Markus and Robey, 1988; Cooper and Zmud, 1990; and Nunamaker, Dennis, Valacich and Vogel, 1991). Such issues span the adoption of IT and software practices (Zmud, 1982), changes in communications among members of the firm in the presence of IT (Sproull and Kiesler, 1986), and changes in the relationships among stakeholders resulting from the development and implementation of IS (Robey and Farrow, 1982; Bailey and Pearson, 1983; de Brabander and Thiers, 1984).

Economics of IS and Technology. This stream applies economics theory and methods to managerial problems involving IS and IT. The problems addressed include estimation of the software production function based on the micro-economic theory of production (e.g., Banker, Datar and Kemerer, 1991; Banker, Davis and Slaughter, 1998), specification of optimal software contracts using contract theory concepts (e.g., Whang, 1992; Wang, Barron and Seidmann, 1997), IT adoption decisions using the theory

of network externalities (e.g., Riggins, Kriebel and Mukhopadhyay, 1994; and Xia and Sirbu, 1995), ownership of IS assets using the theory of incomplete contracts (Brynjolfsson, 1994), and financial intermediation using oligopolistic competition theory (e.g., Bakos, 1997; Clemons and Weber, 1997; Dewan and Mendelson, 1998). There is a shift from statistical analysis of experimental and survey data from human subjects to econometric analysis of archival data.

Although these research streams overlap in their major research contributions, their value lies in helping conceptualize the intellectual growth of the IS field as a whole.[1] The field has not evolved with the disappearance of one research stream followed by the emergence of the next. In the sections that follow, we explore the research findings central to each. Our approach to the construction of each stream is via the contents of research it represents. We also interpret connections among key threads of inquiry and discuss the importance of the research in terms of what managers have been able to do with the results. We conclude with predictions about the IS research directions that will characterize the future.

DECISION SUPPORT AND DESIGN SCIENCE

The genesis of the decision support and design science research stream lies in the earliest issues of *Management Science.* The application of the computing technology of the time, the late 1950s into the 1960s, was occurring in government and military applications, as well as in business organizations. In that time, the discipline of Management Science was exploring the range of applications of computing power in production, planning, and other managerial settings.

Early Decision Support Systems Research

The early vision of decision support systems (**DSSs**) (e.g., Coleman, 1956; Postley, 1957; Ericson, 1969; and Kwerel, 1969) is reflected in Beged-Dov (1967), who reasoned that employing IS provided a

[1] The streams should not be seen as stages in development leading to one "complete" or "unified" conceptualization of what we know about the science of managing IS and IT. Such unity of thinking can only diminish the vitality of the investigations, since certain kinds of problems will not be addressed by the prevailing theoretical wisdom. Instead, the research streams should be seen for what they are: instances of specific kinds of intellectual inquiry that may have their own separate goals and targets.

basis for the more effective market evaluation, long-range planning, and production control. His predictions of the benefits of computer technologies were primarily founded upon the emergence of high capacity random storage, falling data processing and telecommunications costs, the move from "applications" to systems, enhanced information retrieval capabilities and the emergence of telephone-based hook-ups to "desk size computers" with the power of medium-sized computers of the time.

Kriebel (1969) analyzed the design of information processing and DSS design. He employed team theory to illustrate the mutual dependency on the costs of acquired information and the decisions it supports. With a greater need for team members to be simultaneously involved in decision assessments, the predicted utilization factor level in time-sharing systems needed to be aggressively managed to support decision making. MacCrimmon (1974) validated descriptive aspects of team theory related to decision heuristics and communication among team members in a management game.

This stream also includes research on IS use in multi-criteria optimization for workforce scheduling (Geoffrion, Dyer and Feinberg, 1972), management of federal courts (Buchanan and Ferrell, 1981), bid-based scheduling of job interviews (Lau and Kletke, 1994), and expert system-based training for maritime navigation (Grabowski and Wallace, 1993). But Sharda, Barr and McDonnel (1988) questioned whether such success could be effectively documented—whether value claims are based on empirical facts or mislaid perceptions. Limits to value of these systems are tied to constraints on design effectiveness, and to the task and process analysis work that must be done prior to constructing such systems.

DSS Design

Hansen, McKell and Heitger (1979) described computer-supported analysis to enhance DSS design. Messier and Hansen (1988) elicited rules for a knowledge base so a decision engine could predict firm bankruptcy from available data, while Piramathu, Ragavan and Shaw (1998) built neural networks with better predictive capabilities. Kumar, Ow and Prietula (1987) used simulation to schedule facilities for hospital patients, and found critical dependencies that arose with respect to organizational structure, and Gaimon (1997) explored the application of decision technology to support knowledge workers.

This research emphasizes testing proposed and actual systems artifacts to establish their value in conceptual and technical design terms. Basu and Blanning (1998) used metagraphs to study DSS. Park, Lee, Park and Lee (2000) model telecommunication systems design to maximize network survivability with effective node clustering simulations. Garfinkel, Gopal and Goes (2002) provided algorithms for maintaining confidentiality in binary data sets, where threats to privacy exist (e.g., in medical data and voting records). Ram and Narasimhan (1994) constructed new approaches for providing concurrency controls in the allocation of database storage space for distributed and networked computing environments. Ramaswamy and Shell (1997) develop an "electronic bargaining table" to promote mutual gains in competitive negotiations. Intelligent agent technologies, as explored by Sikora and Shaw (1998) for printed circuit board manufacturing and enterprise sub-system coordination, remind us of the still-relevant call by Joyner and Tunstall (1970) for "computer-augmented organizational problem-solving."

Research Directions for Decision Support and Design Science Research

This research stream has been rapidly expanding with the annual Workshop on Information Technology and Systems, which we believe will continue to be the key forum for bringing together interested design science researchers. The range of topics encouraged by technological advances, the methodological innovations, and increased expectations for theory development and empirical and simulation-based analysis of the new artifacts is transforming the research.

VALUE OF INFORMATION

Information value arises as the difference between a decision maker's payoff in the absence of information relative to what can be obtained in its presence. Comparisons are often made between *imperfect information*, which leaves the decision maker with a lower willingness-to-pay, and *perfect information*, to establish the maximum value that decision-relevant information makes possible.

Information, Managerial Flexibility and Competitive Decision Making

Miller (1975) considered information presented sequentially to the user. Choices arise about which

information to purchase first, whether to wait for more, and whether the price is justified. Miller points out that it may be possible for perfect information to be less valuable than imperfect information, when the primary dependency is sequence of presentation. Ponssard (1975) identified dominance criteria for optimal strategic actions a decision maker should take with probabilistic outcomes. His results suggest that, with identical sampling costs, efficient "experiments" yield a more accurate reading of a conditional outcome. Ponssard (1976) assessed information value in competition, where states of the world and observed actions of managers or firms are correlated. This research suggests that trial marketing roll outs can convey information to competitors, but the experimenting firm can try the idea out first and benefit.

Merhofer (1997) showed why the value of perfect information is increasing in managerial flexibility—the adding of one potential managerial action while none are taken from the action set—when price and production quantity decisions are assessed. Hilton (1981) pointed to other research where the results are mixed. He shows why managerial flexibility has no general monotonic relationship with information value, and that there is no general monotonic relationship for a decision maker's aversion to risk and the value of information. Building on Blackwell's (1953) theorem of "information fineness," Hilton shows that the critical determinant of information value is its accuracy and aggregation level.

Harris, Kriebel and Raviv (1982) analyzed settings in which divisional managers possess asymmetric information and different goals, but the firm is interested in allocating resources for optimal production. They propose an incentive-based transfer pricing scheme where divisions select transfer prices that are consistent with the revelation of full information about divisional productivity levels, but that does not require them to disclose them. McCardle (1985) and Mamer and McCardle (1987) used value of information-based thinking to optimize information acquisition for technology adoption under uncertainty with optimal stopping rules. Schwartz and Zozaya-Gorostiza (2003) applied real options to study commitment escalation and project investment, as information is gathered over time, recognizing the distinction between "IT investment" and "IT development" projects.

Information Sharing in Supply Chain Management

Inter-organizational information sharing in procurement also has been of interest. Lee, Padmanabhan and Whang (1997) explain the "bullwhip effect," the distortion of information to upstream suppliers as buyers' orders exhibit a greater variance than their sales. They point to problems with processing signals about market demand, rationing supplies to buyers when a supplier has limited production capacity and excess demand, effects of batched orders by buyers on suppliers' production choices, and fluctuating supply prices in the presence of spot-buying. Gavirneni, Kapucinski and Tayur (1999), Cachon and Fisher (2000), Lee, So and Tang (2000), and Li (2002) also analyzed demand information sharing in supply chains. Gavirneni, Kapucinski and Tayur (1999) model the value of information sharing between a buyer and a supplier in a two-level supply chain when there are capacity constraints on the supplies.

Cachon and Fisher (2000) analyzed the value of sharing information on both final demand in the market and firm inventory via inter-organizational information systems (**IOS**), and estimate positive business value gains associated with full information disclosure, in spite of the potential risks of the business partner's exploitation of sensitive demand information. Lee, So and Tang (2000) estimate the value of information sharing in a two-level supply chain involving retailers and upstream suppliers. Li (2002) analyzed information sharing when there is competition among buyers. He established a direct effect for firms that share information, an indirect effect on the competing firms, and the reasons why it may be appropriate to differentially share final consumer demand and operating cost data. Lee and Whang (2002) assessed information-related issues in e-procurement, and show why secondary markets for excess inventories improve a firm's allocative efficiency in supply chain performance.

Research Directions in Value of Information Research

We see two emerging directions in this stream. IS researchers will refine our managerial knowledge about the value of information as IT changes the availability and granularity of information (e.g., online, real-time data mining), the costs that decision makers face to retrieve it, the necessity for senior managers to better justify complex IT infrastructures and managerial processes to realize business value, and the sophistication of its use to create new strategic and revenue-generating opportunities for the firm, while

enhancing cost and risk management controls. We will see the development of new theory related to the value of information in information-intensive operating environments. This will occur in online contexts where automated software agents have a nearly costless ability to monitor and process pre-programmed information structures through intelligent sampling approaches, using decision making algorithms that are tuned to evaluate different decision making strategy and implementing different decisions in real-time.

We expect to see new theories of electronic agency, which will rely on emerging technological capabilities to specify richer, algorithmically-dynamic information endowments and the decision making profiles of software agents. These software agents will process newly-obtained information in an instant, to arrive at assessments of the "electronic value of information" in more competitively complex and faster-paced decision making environments than human decision makers are able to operate in unassisted by computers. Financial markets and e-procurement offer good contexts for these observations. Personal investment management software agents can develop risk profiles that match our comfort level and available financial resources for different levels of risk in investing. Also, algorithmic e-auction bidding tools for last-minute bidding, and other future technologies will permit "adaptive" solutions that change with the market or operating conditions, to maximize firm value in procurement decisions.

HUMAN-COMPUTER INTERACTION

A crest of interest in research on the DSS effectiveness occurred in the 1970s, while other researchers were assessing the more general impacts of the first fifteen to twenty years of management science research. The focus was on the limited impacts of management science practice, and the development of new approaches to improve the efficacy of DSS (Argyris, 1971; Doktor and Hamilton, 1973). Ackoff (1967, p. B147) worried about a core problem associated with IS: "management misinformation;" he claimed that users suffered "more from an over-abundance of irrelevant information than from a lack of relevant information." Ackoff (1971) argued for a "systems approach" to problem solving within "organizations as systems." He emphasized the need for a unified set of "systems concepts" to improve

management's understanding of the design process. He also admonished management science practitioners and theorists that the widespread implementation of IS and DSS within the firm would change their lives, and sought to jump-start management scientists' thinking about how to overcome the resistance in executive's use of DSS-supplied information to run their businesses.

Individual Traits, Psychological Types and Cognitive Style

Other authors targeted *individual differences* and *psychological types* (Mason and Mitroff, 1973; Myers-Briggs, 1962), also referred to as *cognitive style* (Doktor and Hamilton, 1973; Mitroff, Nelson and Mason, 1974). Cognitive style and individual traits research emphasized polar opposites for the purposes of exposition, while recognizing that people exhibit a continuum of traits: the *global or the heuristic cognitive style* versus the *analytic or systematic cognitive styl*e (Dickson, Senn and Chervany, 1974; and Bariff and Lusk, 1977). Zmud (1977, p. 1088) characterized the contrast: "those classified as analytics tend to approach problem solving with a formal, algorithmic search for causal relationship in data while those classified as heuristics employ a common sense, trial and error approach to problem solving."

The Minnesota Experiments. These studies (Chervany and Dickson, 1977) examined systems design issues and the role of adapting them for human users to maximize their effectiveness. Chervany and Dickson (1974) used an experimental research design involving potential "information overload" to determine the effectiveness of decision makers with the use of raw data in a management game simulation. They found that summarized data enabled decision makers to understand key management problems, and then develop consistent solutions. Similar to Blackwell (1953) and Hilton (1981), Chervany and Dickson recognize that summarized information does not offer the same basis for decision making in the absence of information of finer granularity. Related research argues for case, field and lab studies, and experiments to obtain a more refined understanding of *decision effectiveness* when the *decision maker,* the *decision environment* and the *characteristics of the IS that supports the decision maker* all vary. Dickson, Senn and Chervany (1977, p. 913) conducted nine computer simulation experimental games in production management, and suggest that participants'

decision making "was affected by the IS structure and attributes of individual decision makers."

A year later, *Management Science* published two point-counterpoint articles on "The Minnesota Experiments." Zmud (1978), questioning the broad conclusions, argued that the validity of the research instrument used in Dickson, Senn and Chervany (1977) to determine the impacts of analytic/systematic/thinking versus. heuristic/global/feeling approach to DSS-supplied information was unproven in view of a number of inherent weaknesses. He suggested the appropriate conclusion to draw about cognitive style from "The Minnesota Experiments" was more limited, pertaining only "to a decision maker's choice of a planned or spontaneous solution strategy" (Zmud, 1978, p. 1090).

Other papers examined cognitive processes, psychological traits, and user involvement in systems design (Boland, 1978). Barriff and Lusk (1977) and Lusk and Kersnick (1978) emphasized selecting (not creating for the specific purposes of the research) validated and reliable psychological test instruments to support learning about cognitive style and "implementation apprehension" as they relate to the outcomes of systems analysis work and IS-generated report formats on user task performance.

Zmud's (1977 and 1979) and Lusk and Kersnick's (1978) critique of "The Minnesota Experiments" made clear the growing sensitivity to research design quality that would support new contributions to knowledge. The latter paper is an exemplar for outstanding research design, both in the construction of the experimental tasks and methods, and the controls put in place to tease out useful results. Huber (1983) subsequently challenged the emphasis on individual traits and the psychological determinants of man-machine performance. He offered two conclusions from a "meta-analysis" of the research literature (p. 567): (1) "The … literature on cognitive styles is an unsatisfactory basis for deriving operational guidelines for MIS and DSS designs;" and (2) "[f]urther cognitive style research is unlikely to lead to operational guidelines for MIS and DSS designs." With Huber, we see indications that DSSs would need to be flexible—in terms of the different kinds of people, decisions and decision contexts they support.

Robey (1983, p. 580) responded with a different interpretation of the research results and the potential for research in this area, and argued: "[T]he cognitive styles research, however messy it has been, has

provided much of the rationale for a flexible DSS." With these words, we see an early glimpse of the future of IS research and practice, including "technology acceptance" (Davis, Bagozzi and Warshaw, 1989) and "task-technology-fit" theory (Goodhue, 1995), and prototyping and rapid/joint application design. Ramaprasad (1987, p. 139) pointed out that prior research failed "to address the fundamental reason for the failure of cognitive style research to provide specific, operational guidelines for MIS and design. The appropriate response [is] to focus on cognitive processes."

Group Decision Support

Later work studies systems support for individual and group decisions. They include situational factors when table-based data better support decision making than graphical data (Remus, 1984), the of data models and intuition in business forecasting (Blattberg and Hoch, 1990), and diagnostic reasoning with DSS (Bouwman, 1983). DeSanctis and Gallupe (1987) provided frameworks for conceptualizing how to design and apply group DSS (**GDSS**) and electronic meeting systems (**EMS**) to enhance the effectiveness in group meetings. Their call for research resulted in a 1991 special issue of *Management Science*. Nunamaker et al. (1991) showed how EMS is effective for brainstorming and generation of new ideas in group interactions. They emphasized the capabilities of EMS to support parallel communication, assisted group memory, and the anonymity of the respondents (thereby masking power and status relationships among the participants) .They further noted that EMS technology tends to have its most beneficial effects as group size increases, by controlling process losses and enhancing process gains.

Poole, Holmes and DeSanctis (1991) theorized about what happens when GDSS members experience conflicts. They characterized seven different kinds of impacts on conflict management that may arise in computer-supported meetings: exploration of alternatives, clarification of roles and procedures, more use of voting, de-emphasis of personal relations, equalization of participation, reliance on written media, and greater expression of affect. Rao and Jarvenpaa (1991) proposed additional contingency models for GDSS-related research, based on assumptions about what GDSS can provide.

Research Directions in Human-Computer Systems Design

We predict a resurgence in interest in this research stream. Why? First, the ongoing interest in human-computer interaction and man-machine systems design is likely to expand as the capabilities of IT continue to expand. Today, we have a new generation of handheld devices and PDAs, fixed point and mobile wireless technologies and increasingly ubiquitous network and Internet connectivity, automated software agents and decision "butlers," and embedded technologies in business processes and products. But all these technological aids present the human user with limits to value in actual use, so that the potential value is rarely realized by the user, decision makers and organizations who invest in them. Second, the business value of these technologies is as much a matter of the design of the business processes and organizational structures in which they are used, as they are the cognitive qualities and information processing capabilities of their users.

Emphasizing these aspects at the expense of other individual-level man-machine issues probably is not appropriate. We expect to see a more balanced research agenda, extending our knowledge of human cognition in man-machine environments, and enhancing our ability to design effective technological means to deal with current problems: fraud on the Internet, effective use of GDSS tools, information overload, and computer agent-based negotiations. We expect more integration between research approaches that involve theories from psychology and cognitive science, and others (e.g., value of information, organizational theory or economic theory). The reasons for this lie in the increasing openness in academic research to interdisciplinary theorizing related to human-computer interaction, and the real need for richer explanations to make IT work well in complex applied settings.

IS ORGANIZATION AND STRATEGY

The earliest indications of the emergence of the IS organization and strategy research stream came as IS researchers began to recognize the importance of conducting IS research at other levels of analysis, including the system, business process, strategic business unit and organizational level.

User Involvement and Satisfaction in Systems Development and Use

IS Use and User Satisfaction. Swanson (1974) and Lucas (1975) represent outstanding examples of field study research in the early IS organization and strategy research stream. Swanson (1974, p. 179) explores the importance of the appreciation of IS by managers. He argues for a link between the extent of *a priori involvement* by a user in the systems analysis and design process and her subsequent appreciation and use of the system to inform her managerial decision. Lucas (1975) looked at performance and use of IS in a descriptive model involving *users' individual attitudes and perceptions* and other *situational and personal factors* as precursors of *IS use.* He noted that the decision style of the user had impacts on both IS use and subsequent *managerial analysis and actions*, and how they can be evaluated in terms of *performance outcomes*. He evaluated this perspective for sales force performance and sales IS use for a large clothing manufacturer. His results are some of the earliest indications of the complexity of relationship between IS use and performance and the range of variables that make use of a system an imprecise predictor of user performance and system value.

Bailey and Pearson (1983) were first to validate a multi-factor instrument to analyze user satisfaction. It involved 39 empirically-tested factors, and was based on a definition of *user satisfaction* stated in terms of the "sum of the user's weighted reactions to a set of factors" (p. 531). Melone (1990) provided a theoretical and interpretative assessment of the "user satisfaction" construct. Her recognition of the lack of a clearly articulated theory tying user satisfaction to system effectiveness led other researchers to understand the business value of IT through other means of measuring the outcomes.

User-Developer Communication Patterns. Debrabander and Edstrom (1977) offered another assessment of the direction in which this research stream would develop. They studied the communication and interaction patterns of IS specialists and users to determine what led to success in development and use of systems, and argued that the central problem in their communication is that they bring different perspectives to their interactions. Huber (1982) identified other aspects of communication relative to IS performance involving *message effects*: *message routing* to targeted users, *message summarizing* to make information sent to users more easily understood, *message delays* reflecting the

sender's priorities, and *message modification*, including sender-to-receiver message distortion. Later, Sproull and Kiesler (1986) examined the consequences of message transmission by e-mail within organizations, recognizing a reduction in social context and concomitant changes in behavior, including self-absorption, status equalization, and a reduction in behavioral inhibitions in communication.

Robey and Farrow (1982) situated their analysis of effective user involvement in systems development in the Lewin-Schein conceptualization of three stages of behavioral change in the organization: unfreezing, moving and refreezing. However, the authors recognized the need to find a modeling representation that further captured "the dynamics within the change process itself" (Robey and Farrow, p. 74). They represented user participation in a process of conflict resolution related to the design of a system. Debrabander and Thiers (1984, p. 140) further examined the effectiveness of communications between IS users and developers to understand the "crucial intervening factor" of "effective communication" between developers and users. The authors emphasized that agreement should be reached by both sides about the systems artifact. Doll and Torkzadeh (1989) focused on "end user-control" and noted that user involvement does not always lead to enhanced satisfaction.

The "Theory of Reasoned Action." Other researchers argued that user involvement and participation have not been adequately understood. Hartwick and Barki (1994, p. 440) differentiated the constructs of *user participation* and *user involvement*, with "participation leading to involvement, and involvement mediating the relationship between participation and system use." Their analysis was conducted using Fishbein and Azjen's (1975) *theory of reasoned action* (**TRA**), to argue that *attitudes toward behavior* (e.g., a person's use of a system) tend to have a more important bearing on the prediction of a user's behavior with a system than *attitudes toward an object* (e.g., the system itself). They assert that "overall responsibility is the most important antecedent of user involvement and attitude toward the system" (Hartwick and Barki, p. 457). Kirsch, Sambamurthy, Ko and Purvis (2002) examined four kinds of control of IS projects when there is client-side leadership: *behavior control*, *outcome control*, *clan control* and *self control*. They advocated including behavioral measures for the project manager and outcome

measures for the IS project as predictors of the different project control modes, in the presence of a moderating effect involving the client's understanding of the IS development process.

The Technology Acceptance Model and Diffusion of Innovations

The user involvement work led to the exploration of other aspects of systems design and use, and user satisfaction. Davis, Bagozzi and Warshaw (1989), in one of the most-cited *Management Science* articles, provided an alternate perspective to TRA. Their *technology acceptance model* (**TAM**) incorporated *perceived usefulness* and *ease of use* of a system, to form a basis for predicting the degree to which user acceptance should occur. Szajna (1996) extended TAM. Prior to implementation, perceived usefulness and perceived ease of use are drivers of a user's intention to use a system. After implementation, ease of use conditions usefulness more than a person's intentions to use the system. Venkatesh and Davis (2000) proposed a new model, "TAM 2," with the original predictors of perceived usefulness, Szajna's additions, and subjective norm, job relevance, output quality, voluntariness of use, user experience and result demonstrability. They evaluated the new theory with four longitudinal studies. The results show a remarkable consistency across organizations and over time periods, and show the robustness of TAM 2.

Another important topic is the *diffusion of technological innovations*. Zmud (1982) recognized the inconsistency in the findings about *centralization* and *formalization* in studies of organizational innovations with administrative processes and technology. The former indicates the preferred origin of the strategic motivation for technological innovation, as well as the desired locus for innovation-related activities. The latter refers to the process by which efforts to create technological innovations are undertaken. A formalized innovation process contrasts with an informal process: the latter can yield innovation by surprise, whether the firm wants it or not.

A decade later, Cooper and Zmud (1990) developed a new theory to explain the success of the organizational adoption and infusion of new technology in terms of the compatibility of the *technology's characteristics* with the *characteristics of the task*, and the *complexity of the technology* relative to the *task complexity* that necessitates it. The main results were derived from an empirical study of material

requirements planning (**MRP**) adoption for U.S. manufacturing firms. Organizational adoption of MRP was inhibited by more complex production planning and control tasks, and by whether an organization's planning and control tasks are in synch with MRP capabilities. This work presaged development of other perspectives that focused on contextually-rational and political explanations about firm adoption of IT.

An example is Nilakanta and Scamell (1990), who showed that the diffusion of tools for data base requirements analysis and logical design is influenced by the multiple information sources used by decision makers. Swanson (1994) further structured our understanding of IS innovation types and their associated diffusion dynamics: task-related innovations, administrative innovations, and infrastructure technologies. Goodhue (1995) proposed the *task-technology fit model* for understanding IS user evaluations to extend Cooper and Zmud's (1990) theory. Task-technology fit is "the extent that individual technology functionality matches task requirements and individual abilities" Goodhue (1995, p. 1829). He hypothesized that good fit should lead to higher performance of the user.

IS, Strategic Planning and the Organization

Ein-dor and Segev (1978) analyzed the importance of the organization's strategy for a system, its planning mode (e.g., bottom-up, evolutionary, etc.), the support of IS in the organization structure, whether the system is an innovation, and its overall purpose. They also point to how a system creates value through direct and indirect benefits, the impact of human resources competencies, issues related to construction, and functional sophistication of a system. Sethi and King (1984) studied how IT creates external competitive advantage, and Malone et al. (1999) illustrated how firms can use IT-based tools internally to identify value-bearing business process redesign and reinvention approaches.

This sensitivity to organizational strategy, systems planning and IT value prompted follow up work. Apte and Mason (1995) analyzed effective global disaggregation of IS services for outsourcing and in-house development, and Zaheer and Zaheer (1997) explained how IT-driven *organizational alertness* and *strategic responsiveness* affect the capabilities of international firms. Faraj and Sproull (2002) explore how to effectively coordinate technical and process knowledge and expertise in software development

teams (Faraj and Sproull, 2000). This stream of research also has called for new methods. For example, (Bharadwaj, Bharadwaj and Konsynski, 1999) offer methods for measuring longitudinal impacts of IT on organizational performance and Keeney (1999) assessed the potential value of e-commerce activities.

Research Directions in IS Organization and Strategy

Based solely on the extent of the articles that we identified that are associated with the IS organization and strategy stream of IS research, the reader may take away the impression that the bulk of the development and impact of this research occurred during the late 1970s and the 1980s into the early 1990s. This is not the case, however. Many of the best works in this stream have been published elsewhere (INFORMS *Information Systems Research*, *MIS Quarterly* and the *Journal of Management Information Systems.* In fact, this stream has been the largest in the IS field for last two decades, and we expect it to continue to make exceptional contributions to managerial knowledge in IS.

This stream will seek to formulate stronger theoretical bases for the contexts in which it offers explanatory and interpretive models of individual, group and organizational behavior associated with the management of IS. We also expect that there will continue to be efforts made to adopt more sophisticated quantitative tools for the analysis of applied problems, and more instances of the use of various theoretical perspectives, blending the work here with the economics of IS and technology stream.

ECONOMICS OF IS AND TECHNOLOGY

The economics of IS and technology research stream spans: IT-based coordination for organizations, markets and industries; software engineering economics and IT value; market microstructure; network externalities and the adoption of network technologies; and e-commerce and information goods.

Early Foundations. The earliest works associated with this research stream occurred in the 1960s. Gold (1964) assessed the effects of technological innovations for the first forty years of the twentieth century for a variety of American manufacturing industries. He emphasized the economy-level adjustment and impacts of technological changes in production on unit costs, cost proportions, product

prices, output levels. He hypothesized that increasingly technological production capabilities supported production of more complex goods with higher costs, lessening unit cost and cost proportion reductions. Zani (1970) considered impacts of real-time systems relative to batch processing systems, and found no empirical evidence for operational or competitive advantage. He suggested that real-time systems advantages would arise only from integrating them into the management processes of firms.

Productivity and the Business Value of IT

Kriebel and Raviv (1981, p. 299) analyzed computer systems performance through the microeconomic production process that "relates inputs used to the outputs produced, and determines the set of feasible output combinations" for the system. They used mathematical programming, a precursor to the later data envelopment analysis (**DEA**) applications, to estimate "technical efficiency" and "overall efficiency," and support effective managerial decisions about system investments and expectations for the highest feasible systems outputs. Chismar and Kriebel (1982) extended the model to settings where only subsets of the inputs are required, to identify bottlenecks in the production of computer services.

IT Investments, Firm Size, Productivity and Value. Subsequent studies considered the impacts of IS in terms of productivity, business value, and quality, as well as in terms of their impacts on industrial organization. Brynjolfsson, Malone, Gurbaxani and Kambil (1994) asked the question: "Does IT lead to smaller firms?" Similar to Gold (1964), they hypothesized that production in the U.S. economy was shifting, only to smaller firms in the presence of technological change. The authors used two-stage regression with instrumental variables to test hypotheses about the effects of firm size, production costs and coordination costs at the industry. IT was associated with smaller firm sizes, based on multiple models and different specifications of firm size. Also, rapidly declining prices for IT inputs set up exogenous forces for growth in IT investment, which also created favorable conditions for a shift to smaller firms. Kelley (1994) also contributed to our knowledge of IT-driven productivity gains, with an empirical study of U.S. machining and manufacturing process firms. She hypothesized about the influence of technical, economic and organizational factors that mediated manufacturing productivity, and

were moderated by firm size. Using least squares regression, the author was able to gauge the benefits associated with programmable, numerically-controlled machining, especially in terms of the labor effort required to set up jobs that required fine tolerances in their machining.

Srinivasan, Kekre and Mukhopadhyay (1994) also studied manufacturing firms in the U.S. Their focus was on the impacts and business value of electronic data interchange (**EDI**) technology on just-in-time (**JIT**) product shipments. They found that vertical integration that EDI permits in a firm's supply chain activities enhances JIT product creation and the performance of an organization's logistics and distribution. A significant result is the empirical regularity that suppliers with a larger variety of supply parts tend to experience a larger number of shipping discrepancies, and higher operating costs as a result.

The Productivity Paradox. Although the studies we have cited reported positive findings on the productivity impacts and business value of IT, the cumulative record of empirical research on IT value creates more mixed impressions. Brynjolfsson and Hitt (1996) asked the question "Paradox lost?" regarding their positive firm-level evidence on the returns to IS investments in American industry. Using a seemingly unrelated regression approach for five annual Cobb-Douglas production functions representing 367 large firms in a variety of industries, the reported a statistically significant correlation between computer capital stock and firm output, with an estimated net marginal product of 67% per year. Adjusting the net marginal product for the shorter useful lifetime of computer capital than the firms' stock of plants and equipment, their result was one-third less at 48%, still quite high.

Gurbaxani, Kraemer and Vitalari (1997) reported on an industry survey of corporate budget practices that attempted to distinguish between personnel expenditures and hardware expenditures. They found no scale size effects for information services production, at both levels of analysis, across both the manufacturing and services industries. Application development was positively associated with additional IS staff, but negatively associated with hardware. This suggests the labor-intensiveness of applications development and maintenance, an explanation for a different budget share to go to personnel.

IT Substitution and International Productivity Estimates. Dewan and his coauthors took this inquiry two other directions. Dewan and Min (1997) measured how much IT investments were substituting for other factors of production. Their data set involved 1,131 firms in the manufacturing and services industries in the U.S. They used Cobb-Douglas and *constant elasticity of substitution* (**CES**) production functions, and other more flexible forms, such as the translog and the mixed CES-translog production function, that permit the elasticity of substitution to vary. They found that the CES-translog production function offered the best fit with the data. Their results confirm the general estimate of gross and net marginal products from IT investments of Brynjolfsson and Hitt (1995), and suggest that there was some positive substitution occurring between IT capital and "ordinary capital" and labor. Dewan and Min (1997) found evidence for greater excess returns to IT and a higher observed level of substitution in the manufacturing sector compared to the services sector. Dewan and Kraemer (2000) examined differences in IT investments and productivity for developed and developing countries, and found evidence that returns for IT capital were positive and significant in the former. Developing countries tended to have substantial returns from non-IT capital, but no significant positive returns from IT capital spending.

Process Performance, Customer Satisfaction and Systems Use Effects. Recent work on IT value emphasizes other aspects of organizational performance. Mukhopadhyay, Rajiv and Srinivasan (1997) studied optical character recognition and barcode sorting technologies in U.S. Postal System mail facilities over three years. Mail sorting output performance and quality was enhanced by the application of barcoding technology. Krishnan, Ramaswamy, Meyer and Damien (1999) used Bayesian econometric analysis methods to study IT as a potential driver of customer satisfaction in financial services. They found that the primary driver of perceived quality of service has to do with a bank's product offering, but that IT can be a useful lever to create high levels of satisfaction in the other measures. Devaraj and Kohli (2003), in a study of healthcare firms' investments in IT, make the point that for business value to accrue, it is essential to determine if a sufficient level of actual use of the systems and applications has occurred.

Software Engineering Economics

Software engineering economics reflects theoretical and methodological advances for the practice of management science in real world software development. The work in this area during the 1980s and early 1990s focused on software cost estimation and the assessment of the productive efficiency of software projects. A representative example is Cusumano and Kemerer's (1990) study of U.S. and Japanese software practices. The authors reported that both countries' software projects were of approximately equal size, complexity and sophistication, and that they used similar tools. But Japanese software projects evidenced a greater reliance on software testing professionals and higher code reuse, while both seemed to show equal use of development support tools. No evidence was found to support any performance differences for productivity and quality.

Software Development Productivity. Data envelopment analysis (**DEA**) (Charnes, Cooper and Rhodes, 1981) and its extensions to handle scale economies (Banker, Charnes and Cooper, 1984) and hypothesis testing about the estimated production frontiers (Banker, 1993) offer measurement innovations for software project assessment. Using DEA, an analyst can software development as input-output production. A software project is a decision making unit (**DMU**) with controllable inputs and controllable environmental conditions for production. Banker, Datar and Kemerer (1991) used stochastic DEA, which permits assessment of random errors and mismeasurement, to evaluate software maintenance projects. They explored whether labor effort for analysis and design is separable from coding and testing, how structured analysis and design impacts productivity, and whether high productivity can be sustained for higher quality software products and larger projects. Banker and Slaughter (1997) studied enhancement projects in software application maintenance for returns to scale based on an initial set of DEA efficiency ratings. They used a statistical hypothesis testing technique for DEA (Banker, 1993) to reject a null hypothesis of constant returns to scale in software maintenance, and suggested why variable returns for different project scale sizes are observed.

Maxwell, Van Wassenhove and Dutta (1999) examined the efficacy of developing firm-specific software cost estimation models, relative to an industry-wide model for productivity estimation, using

projects from the European Space Agency. They found that benefits could be derived from the firm-specific models for cost estimation, but that there would be insufficient resources available at many firms to build them. Banker, Davis and Slaughter (1998) blended an economic and psychological view of software development maintenance to specify a theoretical framework for the effects of software complexity, code generation and packaged software use on maintenance project performance.

Software Quality, Capability Maturity and Software Contracts. Other studies emphasize the management of software quality. Harter, Krishnan and Slaughter (2000) conducted an empirical study of software projects that shows firm use of the Software Engineering Institute's Capability Maturity Model (**CMM**) results in software applications of higher quality produced at a higher cost. Krishnan, Kekre, Kriebel and Mukhopadhyay (2000) investigated quality conformance and productivity. Quality was predicted by software size, development personnel capabilities, front-end investments, software process differences, and CMM methods conformance. Also, Harter and Slaughter (2003) found that higher levels of software process maturity yields higher product quality and reduced infrastructure activity costs, but the benefits obtained from CMM methods were empirically justified.

Whang (1992) investigated software contracts in terms of the definition of the software product, the related intellectual property rights, and the payment structure and contingencies. He also developed a game-theoretic model to show how the divergent interests of the purchaser of the system and the develop can be reconciled through a contracting mechanism that specifies the damages that must be paid by the developer according to a set of pre-specified performance contingencies. Wang, Barron and Seidmann (1997) evaluated contract structures for customer software development that related to both internal development and software outsourcing.

IT Planning, Knowledge Workers and IS Human Capital

This stream also includes research on IS planning. Berg (1975) suggested a planning perspective that incorporates ideas from international trade theory. He thought that comparative advantage-based thinking assist in the adoption of new IS and technological innovations among universities. Hann and

Weber (1996) explained why IS planning practices differ across organizations. They characterize the differences in terms of the uncertainty that senior managers and their employees may face, the extent to which a relational dependency arises between different stakeholders, the agency costs that are involved in monitoring compliance, and the monitoring activities that go into the development of a plan as a "contract."

Labor costs associated with IS professionals represent a significant component of most corporate IS budgets (Brynjolfsson and Hitt, 1995; Gurbaxani, Kraemer and Vitalari, 1997). Ang, Slaughter and Ng (2002) discussed the basis for the compensation of IS professionals in terms of their human capital and other institutional determinants. They estimated a model with human capital variables for education and IT experience, gender and job. Human capital—educational level and IS experience—explained the variation in observed levels of compensation among IT professionals in Singapore. Institutional differences did not explain the compensation differences in isolation from other explanatory variables. Anderson, Banker and Ravindran (2000) studied executive compensation in the IT industry. They showed that the compensation shares of both bonuses and stock option are increasing in executive performance, and that these compensation tools lead to higher performance by the firm.

Economics of Technology Diffusion

Another major topic of research represented in the IS literature is adoption and diffusion of technological innovations (Norton and Bass, 1987). Randles (1983) modeled the diffusion of handheld calculators and time-sharing computer terminals in engineering environments in the electronics industry, and then estimated a logistic function and analyzed a diffusion model in differential equation form.

In the 1980s, IS researchers began to use network externality theory for the analysis of technology adoption, pricing and use. Westland (1992) modeled the optimal short-run pricing of IS services to obtain efficient schemes for transfer pricing and IT service levels in the presence of positive demand and negative congestion externalities. Brynjolfsson and Kemerer (1996) estimated the hedonic value of individual applications that comprise software suites, and found that the linkages between different

products elicit higher levels of consumers' willingness-to-pay. Xie and Sirbu (1995) characterized optimal pricing behavior for network products when an incumbent firm and a new entrant compete. They argued that the new entrant should choose compatibility when the incumbent's installed base is large and there are network externalities, and the incumbent should prefer to support the development of a common standard, which the new entrant could also adopt. Conner and Rumelt (1991) found that software piracy has a counter-intuitively positive impact, since it increases the installed base of the software in the market, leading to larger network externalities, which, in turn, may lead to greater sales demand.

Network externality theory also has been used to interpret adoption for interorganizational IS. Riggins, Kriebel and Mukhopadhyay (1994) noted a "stalling" problem due to negative competitive externalities that suppliers face as a buyer's EDI network grows, leading to downward pressure on suppliers' prices. They call for a subsidy to neutralize supplier reluctance to adopt. Wang and Seidmann (1995) distinguished between the positive externalities of a large installed base of suppliers for a buyer, and the negative externalities of increasing competition for participating suppliers. They observe that a subsidy policy would never confer sufficient benefits to push suppliers beyond partial adoption.

Loch and Huberman (1999) proposed a *punctuated-equilibrium model of technology diffusion.* The authors noted that better technologies are not always adopted in the marketplace due to the existence of two different stable equilibria. One outcome involves the old IT as the standard, with the associated network externalities; the second involves the new IT as the standard, which is reached in the presence of a sudden shift in consumer preferences, accompanied by consumers' willingness-to-pay switching costs.

Coordination Mechanisms and the Ownership of IT Assets

Malone (1987) and Malone, Yates and Benjamin (1987) contributed new theoretical perspectives on intra-organizational and inter-organizational coordination that are built on transactions cost theory. IT shifts the boundaries of the firm and changes the risks it faces in procurement, production and transaction-making. The authors proposed new IT-driven coordination structures that are consistent with improving organizational performance. Brynjolfsson (1994) applied the theory of incomplete contracts (e.g.,

Grossman and Hart, 1986; Hart and Moore, 1990) to explore the conditions under which the ownership of information assets and IT makes sense for the organization, why firm boundaries may shift in the presence of business processes that involve more or less contractible elements, and how decisions about the location and use of coordination information affects the distribution of ownership of productive assets across firm boundaries. Nault (1998) modeled informational asymmetries in IT investments from the perspective of "central" or corporate-level managers versus "local" managers in divisional and field operations. The author's model does not favor centralized over decentralized decision making control; instead, it sheds light on the conditions under which one coordination structure is preferred.

Related problems for coordination in market settings were treated by Nault and Tyagi (2001), who constructed incentive mechanisms for the coordination of inter-organizational production activities when the business partners benefit from network externalities through IT alignment and form horizontal strategic alliances. Anand and Mendelson (1997) compared centralized, decentralized and distributed coordination structures for firms that face stochastic demand in multiple markets, in both upstream and downstream operations. The authors characterize decision making problems for production with team theory: participants in procurement and sales operations are tied together by their joint goal of maximizing firm profits. Finally, Lee et al. (2000) investigated channel coordination in supply chain management in the personal computer industry, and showed how manufacturers can work to optimize *price protection credits* as rebates to retailers who are stuck with unsold inventories of rapidly depreciating PCs, while the next generation versions are set to ship.

IT, Financial Markets and Internet-Based Mercantile Exchange

The impacts of IT in financial markets and in mercantile exchange have received considerable attention during the last ten years in IS research.

IT Impacts in the Financial Markets. IT changes the operating environment for market traders and dealer intermediaries. Clemons and Weber (1997) developed a market simulation based on the trading mechanisms of the London Stock Exchange, to test the effects of dealer quotes on price-quantity

combinations of a stock and Exchange customers' order flow. The authors provided simulation evidence that an effective signaling mechanism is necessary to balance the needs of traders (including *liquidity traders* and *informed traders*) and dealers, and communicate information about the time-sensitive nature of the trade—which involves self-revelation by a trader of the urgency of his trader. Marsden and Tung (1999) examined how IT can be used to test for insider trading and the exploitation of asymmetric information in a controlled laboratory environment. They found that better informed traders tended to earn high profits in their simulations. But the imposition on a penalty for the detection of use of insider information made the profit levels indistinguishable. They also showed that shared information is transmitted very rapidly, leading to equal profitability outcomes for informed and uninformed traders.

Other research contributes insights on how IT enables more well-informed traders to profitably participate in financial market trading activities. Dewan and Mendelson (1998, p. 596) modeled the process by which traders "close the gap between value and price due to new information." They emphasized the ability of a trader, who recognizes a difference between the market value of a security and the value the firm's IS indicates, to leverage knowledge of the difference by buying or selling a security, as appropriate. IT investments supporting trading activities in competitive markets have strategic benefits, but they are operating cost advantages, not information-driven trading leverage. Dewan and Mendelson (2001) deal with IT investment with an intermediary-dealer or market-maker. The authors found that investment levels will be sustained for a larger number of traders, but eventually will decline when liquidity is exogenously determined, because profitability is less sensitive to the use of information.

Internet-Based Market Mechanisms for Mercantile Exchange. IT creates opportunities for enhancing mercantile exchange in non-financial markets that result in new transaction-making environments. Kelly and Steinberg (2000) discussed the design of a combinatorial auction for the assignment of the electromagnetic spectrum for public mobile telecommunications services. More recently, Bapna, Goes and Gupta (2003) studied bidder behavior and multi-unit auction design on the Internet. They modeled the optimal bid increment based on the revenue earned by the auction operator,

and then performed empirical analysis of real world auctions to show the different behaviors of three different kinds of auction participants in the presence of different bid increments.

Ba, Stallaert and Whinston (2001) view the value of knowledge as a public good in an organization. They proposed a knowledge sharing mechanism in an internal market in which traders have incentives to reveal true valuations for the components of knowledge goods in a bundle. Any market mechanism that does not permit trading knowledge bundles yields underinvestment in knowledge by the firm. Lee and Whang (2002) considered effects of secondary markets for reselling excess inventory in supply chains. The problem arises with the failure to forecast demand well for short-life-cycle products. Their results show that even though the presence of a secondary market for inventory reselling leads to improved supply chain performance, it is only possible to specify whether a manufacturer's sales will increase or decrease when certain conditions are present (i.e., larger reseller purchases from the manufacturer cause secondary market prices to fall). So resellers will tend to carry more inventory and resell less.

Economics, IS and Electronic Commerce

The application of theory, modeling and empirical methods from economics has been a natural direction for research on e-commerce on the Internet.

Consumer Internet Search, Price Dispersion and Information Goods. Bakos (1997) noted the transformational impact of e-intermediation services that link buyers and sellers in e-markets, reducing buyer search cost. Predictions about seller profits and buyer surplus are complex when buyer tastes are heterogeneous though: they must search for matching product descriptions and low prices. E-intermediation can improve market efficiency through lower prices and seller profits. However, buyers will tend to over-invest, while sellers, recognizing negative impacts on profit, will tend to under-invest.

This literature also explores the behavior of prices for goods and services sold on the Internet. Brynjolfsson and Smith (2000) found evidence of 9% to 16% lower prices and price dispersion for books and CDs during 1998 and 1999. They noted smaller incremental price adjustments among Internet retailers than traditional sellers, whose menu costs for posted price changes are higher. Clemons, Hann

and Hitt (2002) studied online travel agents, and found that that airline ticket prices varied by as much as 18% across different OTAs, due to differences in product specs, despite identical customer requests.

Bakos and Brynjolfsson (1999) showed that bundling information goods, which have low marginal production costs, enables a seller to better predict a consumers' valuation than when the information goods are sold separately. This *predictive value of bundling* leads to higher profit for the seller and more profit per information good included in the bundle. Another insight involves the use of *third degree price discrimination*, involving price-setting for different consumer segments based on observable characteristics. Sellers of bundled information goods can exploit such information—and even induce consumers to reveal it—to set prices and identify appropriate information goods to bundle up.

Jain and Kannan (2002) found that variations in the expertise of consumers and the extent to which they value the information goods delivered via the servers will have an important influence on how the firm selects information goods pricing strategy. Dewan, Freimer and Seidmann (2000) analyzed Internet service providers' (**ISPs**) and information goods content providers' choices about how to distribute and price goods and services. Different equilibrium outcomes will occur, depending on average value of proprietary content to consumers, and the number and cost structure of competing ISPs.

The Internet also has transformed the delivery channels for corporate and consumer financial services (Balasubramanian, Konana and Menon, 2003). Hitt and Frei (2002) found that PC banking customers tend to be more profitable, even after they controlled for differences in the customers' demographic profiles, and the lifetime of customers' accounts, and distinguished between short-term and long-term relationship effects. studied customer satisfaction for Internet-based investment services.

Research Directions for the Economics of Information Systems and Technology

We see several different directions for IS research in this area. There are new perspectives associated with this research stream that increase the strength of the theory and enhance managerial knowledge. The "Carnegie School" contributions in the area of software engineering economics in *Management Science* are an exemplar of the increasing sophistication of insights that are available for effective management of

software projects and software quality. We expect this trend to continue, and include other managerial issues, such as knowledge management, IS development and infrastructure outsourcing, Internet access pricing, design of IT-based market mechanisms, and intellectual property rights and information goods).

Future research in this stream will increasingly deal with problems that are viewed as central to other disciplines, because IT has become a critical enabler of business processes in other functional areas of business. The work on IT impacts on financial market microstructure and the interactions of informed and uninformed traders with market-making intermediaries are good examples. The relevance of this IS research extends well beyond the borders of the IS field.. Tracking this trend, we expect IS researchers to increasingly to publish in journals associated with other primary reference disciplines of business, as well in the fields with supporting theory (i.e., economics, and computer science).

A third trend reflects IS researchers' interest in new theoretical perspectives, and then to refine them for application in IS and electronic commerce. The literature that we reviewed from the last fifteen years has brought new theories to change our perspective about what constitutes a meaningful contribution to IS managerial knowledge. Future theoretical research on e-business themes (e.g., price dispersion and menu cost theories, theories of market unity and market fragmentation, theories of channel power and firm distribution channel choices, principal-agent and monitoring cost theory) will move in a similar direction.

CONCLUSION

The purpose of this review article has been to provide *Management Science* readers with a retrospective view of the research contributions that form the foundational knowledge in the field of Information Systems. We identified five major streams of research, the reach of theoretical perspectives in dealing with important managerial issues, and the range of methodologies and techniques to study different empirical settings. Although the approaches, problems studied, and the results represent a diversity of contributions that underlie the research that is occurring in the field today, much of the work

that has been published here informs managers about the central problems associated with the management of IS.

We expect that future IS research will continue to be characterized by the study of problems in IS management, including systems analysis and design science, the management of software and IT investments within the firm, the configuration of business processes and the formation of business strategies that rely on IT, and the continued use of IT to create unique capabilities for users, decision makers, work groups, organizations and industry sectors. At its best, IS research has the potential to inform managers and academicians about how to understand, interpret, adapt to and effectively manage technologies that have been in use, as well as emerging technologies whose impacts are just being felt. If this capability can be brought to bear more strongly on the IS management function, there will be significant leverage to make one of the important business functions within the contemporary firm deliver on the promises that IT investments are supposed to offer. Clearly, however, much research is still to be done to accomplish this. IT infrastructure development, software project practices, setting up for the development of technology standards, optimizing networking capabilities for the firm, and structuring interorganizational IS investments all need to be treated as central problems that deserve increased attention. All of these issues require careful consideration of how IT impacts other management functions. Consequently, we also expect that the extent of interdisciplinary research in the IS field will increase, as other fields recognize the importance of developing knowledge related to specific problems that arise that are best assessed with an information systems view in mind.

Although other fields, including economics, operations research, organizational theory and strategic management will continue to play a key role in the development of managerial knowledge of IT, researchers in the IS field have an opportunity to leverage their in-depth knowledge of technology and the work group, organizational, market and economy settings in which it is deployed. This will require thoughtful problem selection, exploitation of knowledge of the role of information systems, and the capability to recognize situations where management science techniques make a difference.

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