1987

DEPENDENT VARIABLES FOR THE STUDY OF FIRM AND INDUSTRY-LEVEL IMPACTS OF INFORMATION TECHNOLOGY

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ABSTRACT

Macro-level impacts of information technology (those at the level of entire organizations, industries or the society as a whole) have not been studied in the depth accorded to impacts at the individual user level. Furthermore, there is a lack of studies that can claim to have successfully demonstrated specific impacts at this level. We believe that a well-defined and instrumented set of dependent variables at this level would make a significant contribution in this area. This paper addresses the issue of identifying the appropriate dependent variables for research on the impacts of information technology at the firm and industry levels. The role of different organizational perspectives is examined, and some implications for the design of empirical studies are discussed.

INTRODUCTION

Studying the organizational impacts of information technology is at the core of the information systems discipline, as evidenced by the substantial body of existing literature on the nature of these impacts at different levels, ranging from the individual user to the level of society as a whole. Ever since Mason and Mitroff (1973) posed the MIS problem in a task-focused setting, impacts of information technology at the individual level have provided the major focus of MIS research. Several efforts have been made to establish a number of theoretical propositions and build a cumulative tradition. One sign of the relative maturity of research at the individual level is the dominance of empirical studies and validated methodologies over work based on assertions and speculation. Although room for improvement may still exist, research on the impacts of information technology at the level of entire organizations, industries, or the society as a whole is still adolescent by comparison.

As any area of research matures, it becomes necessary to rigorously formulate its theoretical propositions and subject them to empirical testing, thus creating a need for the identification and measurement of the relevant dependent and independent variables. Issues related to the characterization and operationalization of information technology as the independent variable have been addressed elsewhere; in this paper, we focus on the identification of appropriate dependent variables for the study of the organizational and industrial impacts of information technology. Although an agreement on research variables is not a necessary prerequisite for research, it would provide several benefits, such as a better foundation on the underlying research disciplines, the possibility to transfer operationalizations and measures across settings and to generalize and compare the results of different studies, and a start toward building a cumulative tradition of research.

Research on user information satisfaction (UIS) at the individual user level provides an example demonstrating these benefits. Since UIS was established as a generally accepted important variable at the individual level, there has been significant improvement in our ability to understand it, measure it, and design proper studies that are more likely to produce rigorous results. Furthermore, significant controversy was generated about the proper definition, role, importance, use, and factors underlying or affecting this concept, which was constructive in refining its theoretical underpinnings and clarifying its practical significance.

This paper reviews the major research approaches related to the impacts of information technology at the organizational and industry levels, and argues that at this point information systems research should build on, and advance, relevant work in organization theory and industrial economics. One of our primary goals is to illustrate how the alternative perspectives on action and different organizational views in the underlying disciplines of organization theory and economics have different implications for the choice of the appropriate dependent variables. We also address some theoretical and empirical problems in studying the impact of information technology on these variables.

ORGANIZATIONAL PERSPECTIVES AND IMPACTS RESEARCH

In this section we present a meta-theoretical scheme for classifying the major perspectives in the organizational literature, based on three criteria: the level of organizational analysis, the dynamics of interaction among organizational units at each level, and the underlying assumptions about human nature.

Levels of Analysis

Organizations can be viewed at different levels of analysis, and efforts to predict or understand the impact of information technology are typically focused on one of these levels. Most existing literature is consistent with the following five-level view of organizations:

- o an individual performing a task
- o a work group including many individuals
- o an organization consisting of several groups
- o an industry with a number of firms
- o the entire economy, or society as a whole.

Views on Interaction

The hierarchical view presented above assumes that each organizational level can be seen as a system composed of relatively independent subunits of the next lower level, which may or may not differ in their goals and behavior. This leads to two points of view: assuming goal congruence or coherent action among organizational units at a certain level, we can focus on the structure and process characteristics of organizations; alternatively, assuming divergence in the goals and behavior of individual units, we can study the dynamics of their potentially conflicting interactions and their effect on the behavior of the composite system as a whole. These viewpoints, which we call *structural* and *dynamic*, will suggest different types of organizational impacts of information technology, and different dependent variables.

Assumptions About Human Nature

Three major perspectives on action emerge in the organizational literature, based on different assumptions about the nature of people and organizations:

- o The rational (mechanistic) perspective assumes that action is purposive, intentional, and goal directed. People and organizations have goals, and they take actions to achieve them. This perspective underlies most work based on mathematics, systems theory and economics. It has also been dominant among information systems researchers.

- o The externally constrained (evolutionary) perspective sees action as environmentally driven. People and organizations react in response to environmental constraints that leave little room for individual rationality, their primary goal being survival *per se*.

- o In the organismic (process) perspective, action is emergent, almost random, dependent on organizational processes and social structures. Any rationality is posterior, and goals often emerge as a by-product of the process.

Organizational Perspectives and the Selection of Dependent Variables

We have identified five levels of organizational analysis, two views of organizational systems, and three perspectives on action. Figure 1 illustrates this scheme for the organizational levels of interest in this paper and provides examples of major approaches falling into its subcategories. Astley and Van de Ven (1983) have proposed an alternative scheme, essentially based on the third and the first of these dimensions: "[our scheme is based on] two sources of antithesis [which are] manifested in structure-action and part-whole dialectics" (p. 245).

We strongly recommend to the interested reader their discussion of the underlying debates on the nature and structuring of organizations, although

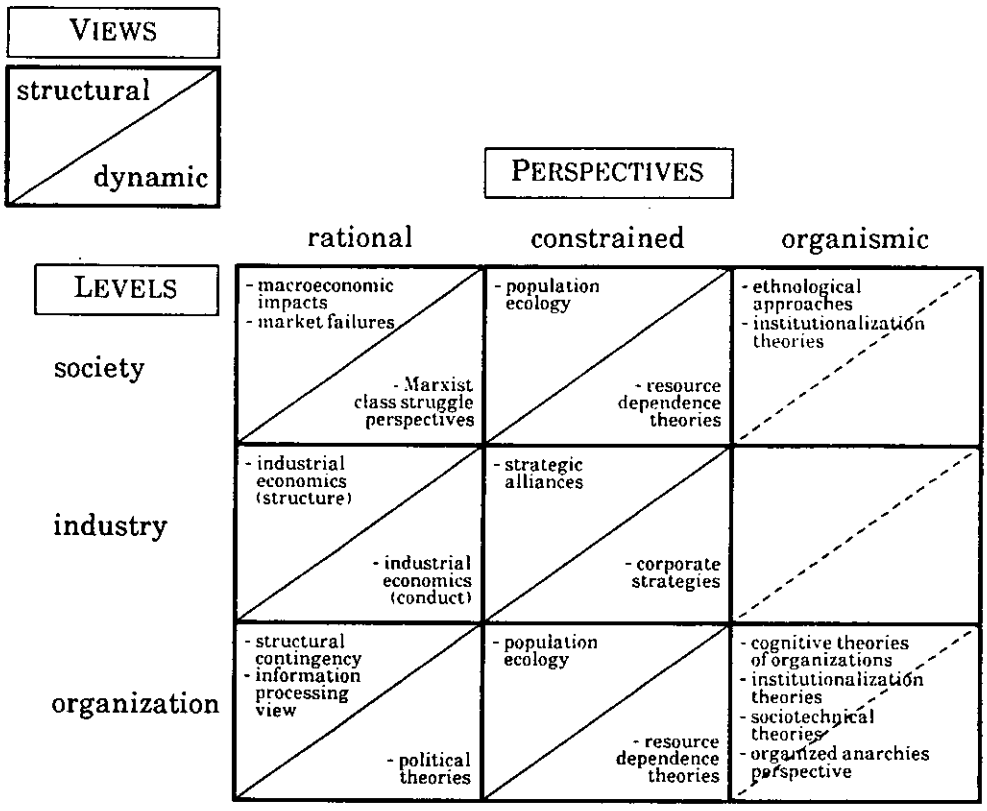

Figure 1. Alternative Organizational Perspectives

they conclude that these debates, representing conflicting world views, are unlikely to be resolved in the foreseeable future. However,

> an awareness of the underlying values and biases upon which the theory is constructed becomes essential. These values and biases act as assumptions, taken for granted, in the world views that guide theorizing, and they constitute paradigms that channel attention in specific directions and preclude the investigation of alternative theoretical, ideological, and practical spheres [p. 270].

In the context of organizational impacts of information technology, alternative perspectives lead to different dependent variables and suggest the use of different theoretical tools for the study of these impacts. Studies based on different perspectives have used different vocabularies and, as a result, often have talked past each other. A simple model for the impact of information technology is shown in Figure 2. The technology has an impact on organizational structure and process, thereby affecting organizational performance. This model defines three areas for impacts research: (1) the impact of information technology on organizational performance, (2) the impact of information tech-

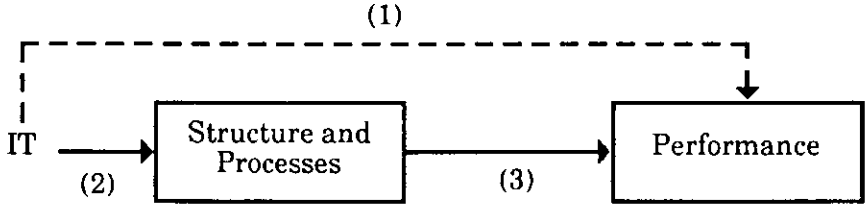

Figure 2. Areas for Impacts Research

nology on organizational structure and processes, and, (3) the impact of organizational process changes on organizational performance.

The general problem of the link between organizational structure, process and performance variables is best left to organization theorists. Information systems researchers may occasionally need to extend the available results in certain areas, but as Keen (1980) has emphasized, such research is worthwhile only when it makes a contribution to the underlying discipline of organization theory. The majority of impacts research will belong to one of the first two areas: impact of information technology on organizational performance and on organizational structure and processes. The difference between the two areas can be visualized as whether the structure and process box in Figure 2 is seen as a system that can be modeled and probed, or as a "black box" whose inputs and outputs are the only observable variables.

IDENTIFYING FIRM-LEVEL VARIABLES

In this section we review the literature on organization-level impacts of information technology and use the alternative perspectives on action (rational, constrained, and organismic) to identify relevant dependent variables.

Rational Approaches

Research employing the rational perspective has focused either on organizational performance or on structure and process variables. The major research problem is to identify the impacts of information technology on organizational structure and processes, and to determine how they can be predicted, controlled or mediated to fit organizational goals. Two major views have emerged in the non-political literature. Structural contingency theorists like Chandler (1962) postulate that *organizational structure* affects *organizational performance*, and they attempt to determine the nature of this relation. The information processing view focuses on the information processing capacity of organizations and their effort to cope with the constraints of individual bounded rationality and environmental uncertainty (Galbraith 1973; Tushman and Nadler 1978).

Political models of organizations generally assume rational, intentional action among organizational subunits to achieve their divergent goals and objectives. Coalitions of organizational subunits have been the main unit of analysis in political approaches (Cyert and March 1963). Two central organizational variables have been proposed: *coalition structure*, focusing on the process of their formation among eligible participants (Pfeffer 1978, 1981), and *coalition power*, most often defined in terms of the capacity to overcome opposition (Blau 1964; Salancik and Pfeffer 1977), or as the ability to influence organizational goals (Cyert and March 1963).

Environmentally Constrained (Evolutionary) Approaches

Population ecology is the major approach employing this perspective from a structural point of view. It focuses on the characteristics of environmental selection (evolutionary change). Its underlying assumption is that organizations are subject to environmental constraints to a much larger extent than the rational view will concede, leaving little room for rational action (Freeman 1982). Variables that have received attention are organizational type, such as specialist versus generalist; environmental characteristics, such as a fast or slow changing, finely or coarsely grained environment; degree of competitiveness, characterized by its institutional framework or by the resulting organizational mortality; and organizational adaptability, such as learning capacity.

In the dynamic view, resource dependency theories focus on managing external dependencies. They are similar to rationalist political theories as they start from a coalition model of organizations, but the emphasis is on the type and importance of environmental dependencies. Power is assumed to accumulate to coalitions managing these dependencies, which may arise from environmental constraints, contingencies, resources, or uncertainties.

Organismic Approaches

The organismic perspective employs an emergent, almost random, process-constrained view of action and is not as homogeneous as the other two. There is no clear distinction between structural and dynamic views because conflict among subunits is not a central concept. The view of organizations as organized anarchies (Cohen, March and Olsen 1972; March and Olsen 1976), stresses the sequential, unfolding nature of organizational action. Behavior cannot be predicted either by the prefere-

nces of individual actors or by environmental conditions. Instead organizations are seen as "garbage cans" in which people, problems, solutions and opportunities for action are mixed together, the results largely depending on the *process* of interaction of the ingredients. Rationality and preferences are seen as emerging retrospectively from action, rather than guiding action (March 1978).

Cognitive perspectives see organizations as providing paradigms (models of the world), myths (perceptions of the world), and a common language that give meaning to the life of individual participants (Weick 1979). These approaches emphasize the importance of harmony between the technological and social components of an organization (Trist 1981) or focus on quality of work life issues. In this perspective information can be seen as a symbol rather than an instrument (Feldman and March 1981).

Table 1 summarizes the major structural, process and performance variables suggested by the rational and constrained perspectives, which are likely to be affected by information technology. The organismic perspective is too fragmented to allow us to abstract a concise set of variables, and although there is a substantial body of literature looking at the links between organismic processes and performance at the individual level, such as the relation between job satisfaction and performance (Vroom 1964), these results have not been extended to the organizational level. We are not trying to diminish, however, the significance of the constraints of social and organismic processes for the design and implementation of information systems, as several failed system implementations could attest to their importance.

Table 1. Organization-Level Variables

- structure
  - goverance mechanism
  - centralization/decentralization
  - integration/differentiation
  - coalition formation
  - power distribution
  - specialization, niche creation
- process
  - efficiency
    - production costs
    - coordination costs
  - flexibility
  - information processing capacity
  - political friction
    - coalition structure
    - coalition power
  - adaptability
- performance
  - economic returns
  - survivability

FIRM-LEVEL IMPACTS RESEARCH

In this section we address the problem of identifying dependent variables for the firm-level impacts of information technology. We look into three areas: organizational structure, organizational processes and organizational performance.

Organizational Structure

The impact of information technology on structural variables has received significant attention in the literature. Kling (1980) surveyed several theoretical and empirical studies of the relation between computers and organizational structure, primarily in the period 1970 to 1979. Most early studies, however, used information technology as the dependent variable as they tried to explore the factors influencing its adoption by organizations. Carter (1984) and Robey (1981) conducted studies using organizational structure as the dependent variable. They looked at authority relationships, centralization of control, differentiation, and horizontal relationships among departments, with generally inconclusive results. Attewell and Rule (1984) reviewed theoretical and empirical evidence on the impacts of information technology on centralization, differentiation of organizational subunits, and vertical and lateral communications. They concluded that the evidence was fragmentary and mixed. Kriebel and Moore (1982) suggested that the technology will affect the centralization of organizational structures and the mechanisms for control and resource allocation.

Thus no direct link has been established between information technology and organizational structure or performance, and the evidence from the organization theory and strategy disciplines suggests that any such link would depend on the particular organizational and environmental contingencies. This would explain the conflicting results of Attewell and Rule (1984) and Robey (1981), who reported that the technology is likely to either centralize or decentralize, differentiate or integrate,

and promote functional or less centralized hierarchies, a fact which organizational theorists pointed out several years ago (Zannetos 1970).

Organizational Processes

Process variables combine the advantage of a direct theoretical link to organizational performance, and the potential for study at the level of organizational subunits, subsequently aggregating the observed impacts. Unfortunately there is little empirical research in this area to guide us in building and testing specific theoretical hypotheses and in the operationalization of the underlying constructs. The role of information technology in relieving constraints in the storage, processing and communication of information caused by bounded rationality (Bakos 1985), and in increasing organizational flexibility (Malone and Smith 1984), can provide the basis for the identification of organizational variables susceptible to impacts from information technology.

Malone (1985) and Malone and Smith (1984) suggest that organizational technology can be characterized in terms of production and coordination technologies. Thus efficiency at the organizational level can be viewed as dependent on production costs and coordination costs. Frequently this distinction depends on the level of analysis employed, since what may appear as a production cost at a certain level of analysis can often be decomposed into production and coordination costs at a finer level of detail. Since coordination costs come from processing and communicating information, they provide a definite basis to establish a theoretical link between information technology and efficiency. The accounting discipline has addressed the problem of measuring efficiency gains of organizational subunits, but their approaches are geared toward the measurement of production costs. Research on impacts of information technology would greatly benefit from the systematic development of tools to help us assess coordination costs, since they seem to be a primary beneficiary of the technology, at least for some types of systems (Crawford 1982). Moving in this direction, Ciborra (1985) used transaction-cost theory to discuss the impact of the technology on the costs of coordination and control and on the organizational governance mechanism.

Organizational flexibility provides a measure of long-term efficiency in a changing environment. Malone and Smith (1984) defined it in terms of vulnerability (the cost of expected failures) and adaptability (the cost of adjustment). Williamson (1975) employed the related concept of asset specificity, i.e., the best alternative use of an asset outside its present economic engagement. We would prefer a definition comparing the expected efficiency in a stable (although not necessarily deterministic) environment with the expected efficiency under varying degrees of environmental uncertainty. The performance of flexible systems would be subject to less relative degradation as uncertainty increases. Using results from queuing theory, Malone and Smith were able to compare the relative efficiency and vulnerability of several simple organizational forms. Similar approaches could be used to derive theoretical predictions for the link between information technology and organizational flexibility (for a rational perspective) or adaptability (for an environmentally constrained perspective). In relation to adaptability, Argyris (1982) has pointed out the potential of information systems to reinforce different types of organizational learning.

The notion that information technology will increase the information processing capacity of organizations has probably been an *assumption* for researchers in the information systems discipline, and hence there exists no empirical research to test it. Malone and Smith (1984) looked at the impact of information technology on vertical and horizontal information flows, the structure of organizational networks, and alternative coordination mechanisms. Related measures could be provided by looking at the quantity and quality of decisions or other outputs of subunits and reaction times to expected and unexpected contingencies.

Theories on the determinants of organizational power have proposed a number of variables explaining the accumulation of power to certain organizational subunits, such as coping with critical uncertainties (Thompson 1967) or control of information or other resources (Salancik and Pfeffer 1977). Game theoretic approaches would suggest a focus on the goals and objectives of the individual participants, the structure of the payoffs under different outcomes, and the costs of coalition formation. Allocation of budgets, succession to administrative positions, policy decision patterns, and choice of information systems have all been studied as power-related dependent variables. In the MIS literature, Markus (1983) has pointed out the potential of information systems to affect the distribution of intraorganizational power and has

identified resource dependency considerations as relevant for the implementation of information systems.

A number of authors have adopted an organismic perspective in looking at the impacts of information technology. Kling (1980) reviews a number of articles with a similar "segmented institutionalist" perspective. Bostrom and Heinen (1977) focus on sociotechnical considerations in the design of information systems. Markus (1983) looks at the interaction between the information system and the organizational setting. Attewell and Rule (1984) cite controversial evidence on the role of information technology in the humanization or dehumanization of work.

Organizational Performance

Firm-level performance has been proposed as a dependent variable as well (Crowston and Treacy 1986). A number of MIS researchers have used dependent variables from the accounting literature for the assessment of economic performance, such as the productivity of the firm or the information system *per se* (Kriebel and Raviv 1982), return on assets and investment (Cron and Sobol 1983), or cost/benefit assessments of the value of information systems (Crawford 1982).

It should be realized, however, that empirical inquiry into the direct link between information technology and organizational performance is a particularly difficult task: there are too many confounding factors and sources of extraneous variance, necessitating accurate operationalizations of the independent variable, as well as use of methodologies allowing for controlled settings, such as field experiments. Carrying this sort of experimentation with entire organizations is next to impossible, therefore we must focus on the variables that will allow us to look at a finer level of detail, i.e., *organizational structure and process variables.*

IDENTIFYING INDUSTRY-LEVEL VARIABLES

Industrial economics and corporate strategy provide the theoretical disciplines for the study of the impacts of information technology at the industry level. The notion of conflict coming from the divergence in the goals and objectives of individual organizations, is central in this literature, and consequently this level of analysis is dominated by the rational and environmentally constrained perspectives, which pay attention to preferences, goals and objectives, and thus to potential conflicts. We shall use the more popular terms "industrial structure" and "industrial conduct" to refer to the structural and dynamic views as applied to the industry level.

Rational Perspective

Rational approaches have focused on conflict among firms in the study of industrial conduct, and the comparative dynamics of entire industries in the study of industrial structure. Economic theory has provided the primary reference discipline and some measure of economic returns relative to the rest of the industry or the rest of the economy is the prevalent indicator of performance. The existence of an underlying analytic discipline has led to a focus on explanatory and causal, rather than descriptive, variables. On the other hand, the validity and relevance of these variables, the related approaches, and the underlying assumptions have often been questioned (Kuttner 1985).

Three major concepts underlie the rational industry-level approaches: *efficiency*, *market power*, and *sustainability*, which appear both at the industrial structure and industrial conduct levels. Efficiency refers to the ability to maximize outputs for a given set of inputs. Power refers to the ability to resolve conflicting situations to one's advantage. Industrial economics has examined at length the link between comparative efficiency, power and superior economic returns for individual firms or entire industries. Sustainability refers to the ability to preserve these superior returns over time. The balance of power at the boundaries between entire industries is determined by the collective power of an industry against its customers (monopoly power), its suppliers (monopsony power), and the degree of collusion among industry participants (rivalry among industry competitors). The sustainability of superior economic returns is determined by the threat of substitution and by the barriers to new entry, such as the existence of potential entrants, the cost of entry, the likelihood and credibility of retaliation by current competitors (Porter 1980).

At the industrial conduct level, comparative efficiency refers to the ability of a firm to produce

a product using fewer inputs relative to other products considered as equivalent. Comparative efficiency can be achieved through improved internal (intraorganizational) efficiency or through the identification of interorganizational synergies. Market power reflects the ability of a firm to resolve conflictual situations against its customers and suppliers to its own advantage. The major related variables proposed in the economic and strategic literature are market share, power against suppliers, power against customers, unique product features, positional advantages, and asset specificity (defined as the best alternative use of a firm's assets). Variables that seem to determine the ability of some firms to sustain superior economic returns relative to their competitors include the capability for continued innovation, the ability to make credible threats of retaliation against acts that might erode their competitive advantage, and the quality and timing of their strategic moves. As discussed in the next section, several of these variables could be affected by information technology.

Constrained Perspective

This perspective has been underlying much of the traditional strategic literature, especially theories related to the identification of generic strategies. Population ecology and resource dependency theories provide the major concepts. Their theoretical imperative is that,in the long run, well focused, specialist strategies outperform unfocused, generalist ones and that firms strive for the control of critical environmental resources in an effort to negotiate the uncertainty and hostility of their environments.

At the industrial structure level, relevant variables that could be affected by information technology include the rate of environmental change, net mortality (births and deaths) of organizations, and changes in industrial boundaries to reduce uncertainties coming from the technology, *e.g.*, vertical information integration. At the industrial conduct level, variables likely to be affected by information technology include the ability to adopt major specialization strategies, such as low cost leadership, differentiation, or focus on market niches, the creation, restructuring or dissolution of organizations, and mergers, acquisitions, or strategic alliances to control critical information dependencies and to exploit opportunities created by information technology.

Table 2 shows the major variables in the literature used to characterize the structure of industries which may be affected by information technology. Table 3 shows the five major variables identified as determinants of a firm's conduct within an industry.

Table 2. Industrial Structure Variables

- efficiency
  - production economics
    - economies of scale
    - economies of scope
    - economies of specialization
  - internal efficiency
    - production costs
    - coordination costs
  - interorganizational synergies
    - coordination costs
    - transaction costs
- market structure
  - market form
  - market efficiency
  - market power
  - competitive rivalry
- sustainability
  - barriers of entry
  - threat of substitution
  - credibility of retaliation
  - rate of innovation
- survivability
  - net mortality
  - strategic alliances
  - M&As, vertical information integration
- performance
  - economic profits
  - excess returns

Table 3. Industrial Conduct Variables

- comparative efficiency
- market power
  - market share
  - unique product features
  - customer and supplier switching costs
  - asset specificity
  - positional advantages
- sustainability
  - product and process innovation
  - threat and credibility of retaliation
  - timing
- survival strategies
  - niche creation
  - differentiation
  - cost advantage
- control of critical resources
  - strategic alliances
  - vertical information integration

As discussed earlier, the former three come from rational (economic) approaches, while the latter two are suggested by environmentally constrained (evolutionary) perspectives.

INDUSTRY-LEVEL IMPACTS RESEARCH

Identifying the industry-level variables which are likely to be affected by information technology, and understanding the nature of these impacts, is at least as difficult as the corresponding problem at the organizational level.

Industrial Structure

The main focus of the traditional MIS literature has been on efficiency-related impacts of the technology. As Kriebel and Moore point out (1982), information technology will affect industry-wide efficiency through its impacts on the economics of production, most likely by changing the economies of scale, scope, and specialization. Another type of efficiency-related impacts is likely to come from interorganizational synergies, primarily through coordination efficiencies (Cash and Konsynski 1985; Malone 1985) and reduced transaction costs (Ciborra 1985).

More recently, Ives and Learmonth (1984) and Beath and Ives (1986) used the efficiency of internal processes as their dependent variable. Parsons (1983) pointed out the potential impact of the technology on competitive forces (buyers, suppliers, substitution, new entrants, competitive rivalry) and industry-wide economics of production, Cash and Konsynski (1985) elaborated on Parsons' variables to suggest a more detailed set (capacity, cost structure, prices, entry barriers, quality, services, competition), and Bakos and Treacy (1986) identified search costs, unique product features, switching costs, bargaining power, internal and interorganizational efficiency as variables which could be affected by the technology.

Furthermore, information technology can affect the monopoly or monopsony power of an industry or the competitive rivalry among industry participants, e.g. by requiring substantial non-recoverable investments, changing the costs of exit, and altering the relation between fixed and variable costs. It can also affect the sustainability of superior economic returns enjoyed by an industry with market power. All four variables in Table 2 related to sustainability (barriers to new entry, threat from substitute products, likelihood and credibility of retaliatory action against new entrants, and rate of innovation in the industry) are potential candidates. At this level of analysis the net effect of the technology is uncertain and highly dependent on industry characteristics and thus more detailed variables will be necessary for a normative model of the relevant impacts. Empirical research beyond the case-study level is suspect because of confounding variables, extraneous variance, and difficulty in the operationalization of the underlying variables.

From an evolutionary perspective, information technology is likely to affect variables related to the ability of an industry to survive and evolve in a changing environment, as well as the rate of environmental change faced by that industry. Related variables include net mortality, strategic alliances to meet the challenges introduced by information technology, and restructuring or merger and acquisition activity directed toward the control of critical information resources, such as vertical information integration. Although there is a lot of anecdotal evidence on these impacts, there is little rigorous research in the area.

Industrial Conduct

Research on efficiency-related impacts at this level would focus on comparative efficiency, seeking to establish that technology adopters show efficiency gains relative to their competitors, and on interorganizational synergies, attempting to establish efficiency gains at the boundaries between organizations. Despite the similarity to the study of efficiency impacts at the organizational level, the need for a comparative emphasis, the consideration of inter-firm transaction costs, and the extension of the unit of analysis beyond a single organization, complicates the problem of the design of appropriate studies.

Although some of the variables underlying market power or sustainability have been the subject of econometric studies (e.g., market share), and thus have existing operationalizations, the majority requires the development of both theoretical models for the impact of information technology and adequate measures. Similarly, although the potential of the technology to promote strategic alliances or mergers and acquisitions and to affect the ability of a firm to adopt specific strategies is well recognized, we are not familiar with any efforts to

theoretically predict or empirically establish the nature of these impacts.

MEASURING THE DEPENDENT VARIABLES

Measurement and operationalization of theoretical variables is a self-contained problem, as the development of appropriate instruments is closely related to the theoretical and construct validity of the models tested. A discussion of these issues extends beyond the scope of this paper, but Bagozzi (1979) provides an excellent discussion for the interested reader. In the remainder of this section we review representative measures for the dependent variables identified earlier which may be applicable to the study of organizational impacts of information technology.

Firm-Level Variables

A number of structural variables at the firm level have been used in empirical studies. Organization theory provides classification schemes for organizational forms, such as functional *versus* product hierarchies *versus* matrix forms. Vertical integration has been measured as the ratio of value added to sales, although this measure is biased towards raw materials producers. Several measures of centralization have been used based on the locus of decision making, such as profit *versus* cost centers, budgetary authority, and number of reporting levels. The number of job titles has been used as a measure of differentiation. Diversification measures in the strategic literature are primarily based on the ratio of dominant product line sales to total sales.

Process efficiency has been measured by using frontier analysis or DEA (data envelopment analysis) on production cost data, which at closer scrutiny often include coordination costs as well. Stabell and Foresund (1983) and Chismar and Kriebel (1985) conducted representative studies in the MIS literature. Other process variables do not have existing operationalizations and thus empirical researchers will have to start from the reference discipline of organization theory and the MIS literature surveyed in the previous sections.

There are several performance measures in the literature, ranging from financial returns on investment and assets to the value added as reflected by a firm's market valuation to direct cost/benefit assessments of the value of information systems. These measures have the advantage of high validity but, as discussed earlier, confounding factors and extraneous variance make the task of establishing an impact due to information technology extremely difficult.

Industry-Level Variables

Internal efficiency at the industrial structure level can be measured similar to firm-level efficiency. Comparative measures of the efficiency of multi-product and different size firms have been used to estimate the economies of scale and scope for individual industries, while inter-process inventories, delivery times and purchasing costs have been used as a measure of interorganizational synergies.

The study of the structure and efficiency of markets has been an area out of the mainstream of economics and organization theory. Market power and the degree of collusion have been studied extensively, however, with empirical proxies such as concentration ratios, existence of price wars, price stability, ability to price over marginal costs, and competitiveness in advertising. Yet recent advances in industrial economic theory have cast doubt on the ability of these measures to capture tacit collusion.

Industrial organization theory is actively developing new theoretical models for the barriers of entry, substitution and the role of reputation, which may lead to related empirical measures. The rate of innovation has been typically measured by patent counts and the number of new product introductions, measures often unreliable and inappropriate for inter-industry comparisons. Macroeconomic data is available on firm mortality in different industries and on mergers and acquisitions, while industry performance measures are similar to the ones used for individual firms. Once again, while the measures available are quite reliable, they are not sensitive to the impact of information technology.

For variables specific to industrial conduct, market power has been measured in terms of market share, excess profits, and ability to price over marginal costs. A number of empirical studies have looked into asset specificity and customer switching costs in specific settings to test the predictions of transaction cost theory, but we are not aware of any generally applicable measures. Measurement of innovation and vertical integration were discussed earlier, and we are not familiar with applicable

measures for the remaining variables in Table 3. Interested researchers will have to develop appropriate operationalizations starting from the theoretical literature.

CONCLUDING REMARKS

Not enough of the existing literature on the impacts of information technology at the organizational and industrial levels consists of rigorous theory building or empirical studies. Research results are fragmented and conflicting (Attewell and Rule 1984). Most important, we cannot claim substantial progress in our understanding of the organizational and industrial impacts of information technology and in our ability to establish their existence and quantify their nature, compared to early work in the organizational and strategic disciplines (e.g., Zannetos 1968, 1970). We believe that an agreement on the appropriate dependent variables will make a contribution to research in this area. The underlying theoretical disciplines of organization theory, microeconomics and industrial economics can provide us with sets of organizational variables, among which the ones relevant to information systems research can be identified. We used the framework shown in Figure 1 to organize the major firm and industry-level approaches in these reference disciplines and to propose appropriate variables.

By choosing appropriate explanatory theories from the underlying disciplines, information systems research can focus on the process-related impacts of the technology, relying on existing theory to link these impacts to organizational performance (see Figure 2). There are a few salient characteristics of information technology that can be used as the basis to study its process impacts and to identify these variables that the technology is most likely to affect. It has been proposed that bounded rationality can provide such a basis from a rationalist perspective of individual and organizational action, while organizational flexibility is most relevant from an evolutionary perspective.

Weick (1984) pointed out the importance of proper methodology in studying the impact of information technology on organizations, but he also cautioned us about the dangers involved in trying to distinguish between independent and dependent variables. In particular, as Markus and Robey (in press) explain in detail, there are many bi-directional interactions in organizational systems. Causal models will be inadequate if they do not include the appropriate feedbacks and cross-sectional data will be unable to show the interactions among the variables; hence longitudinal approaches will be necessary.

As the level of analysis becomes more general (from the organizational unit to the industry, to the economy and society as a whole), the links between independent variables related to information technology and the dependent variables of interest become more indirect, introducing a large number of confounding variables and extraneous variance that reduce our ability to observe the impact of information technology. In most industries the participant firms employ similar types of information technology, thus reducing the variance of our independent variables. Furthermore, several empirical studies in the past were based on data from the impact of older technologies, such as accounting or payroll systems, whose impact on organizations and industries is likely to be quite different from modern user-friendly applications emphasizing analytical tools, communications and specialized areas of strategic importance.

Developing valid operationalizations and instruments for *any* of the variables proposed in this paper is a formidable task by itself. Providing empirical research guidelines for the entire set we identified goes beyond the ambitions of this paper; our goal was to point in the right direction. We conclude with a list that may prove useful in addressing the complexities of empirical research into the organizational and industrial impacts of information technology:

- We need to build a cumulative research tradition on the impacts of information technology on different organizational variables and at different organizational levels.

- We need more sophisticated theories (models) and methodologies (instruments) to overcome the problem of confounding variables; industrial economics can suggest appropriate models, but to this date organization theory does not offer sufficient assistance, as it is not able to provide adequate operationalizations for several of its constructs.

- We must identify the variables on which the technology is likely to have more direct impacts, e.g., variables that are closely affected by

bounded rationality at the individual and organizational levels.

- We should use methodologies that allow us to control or compensate for the contextual variables when it is feasible; thus we can hope to better isolate the impacts of information technology.

- We should study technology innovators and collect longitudinal data so that we can achieve more variance in our independent variables.

- Finally, we should study organizations in which information technology is closely related to their core technology, and thus is more likely to result in impacts easier to observe, as is the case in several service industries.

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