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Process as theory in information systems research[1]

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Process as theory in information systems research

Abstract

Many researchers have searched for evidence of organizational improvements from the huge sums invested in ICT. Unfortunately, evidence for such a pay back is spotty at best (e.g., Brynjolfsson, 1994; Meyer and Gupta, 1994; Brynjolfsson and Hitt, 1998). On the other hand, at the individual level, computing and communication technologies are increasingly merging into work in ways that make it impossible to separate the two (Gasser, 1986; Zuboff, 1988; Bridges, 1995). This problem—usually referred to as the productivity paradox—is an example of a more pervasive issue—linking phenomena and theories from different levels of analysis.

Organizational processes provide a bridge between individual, organizational and even industrial level impacts of information and communication technologies (ICT). Viewing a process as the way organizations accomplish desired goals and transform inputs into outputs makes the link to organizational outcomes. Viewing processes as ordered collections of activities makes the link to individual work, since individual actors perform these activities. As well, process theories can be a useful milieu for theoretical interplay between interpretive and positivist research paradigms. A process-centred research framework is illustrated with an analysis of the process of seating and serving customers in the two restaurants. The analysis illustrates how changes in individual work affect the process and thus the organizational outcomes and how processes provide a theoretical bridge between work at different levels of analysis.

Process as theory in information systems research

Many researchers have searched for evidence of organizational productivity improvements from the huge sums invested in information and communication technologies (ICT). Unfortunately, evidence for such payback is spotty at best (e.g., Brynjolfsson, et al., 1993; Meyer and Gupta, 1994; Brynjolfsson and Hitt, 1998). On the other hand, at the individual level, computing and communication technologies are increasingly merging into work in ways that make it impossible to separate the two (Gasser, 1986; Zuboff, 1988; Bridges, 1995). Examples of such pervasive ICT abound, from the mundane—telephones, Fax machines and ATMs—to the sophisticated—enterprise-wide resource management, financial trading and manufacturing control systems. The contrast between the apparently substantial impact of ICT use at the individual level and the apparently diffuse impact at the organizational level, often referred to as the "productivity paradox," is but one example of the problem of linking phenomena and theories from different levels of analysis.

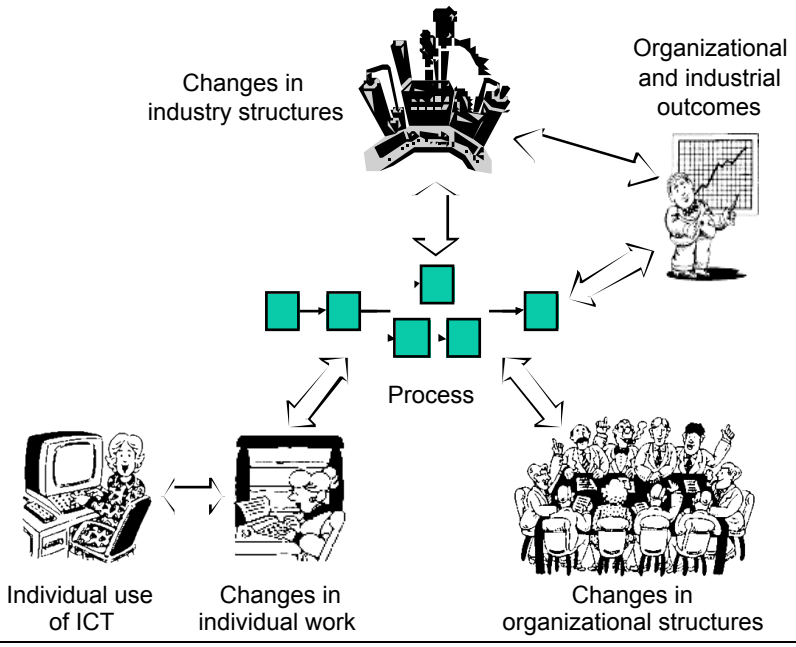
The goal of this paper is to show how individual-level research on ICT use might be linked to organization-level research by detailed consideration of the organizational process in which the use is situated. By process, I mean an interrelated sequence of events that occur over time leading to an organizational outcome of interest (Boudreau and Robey, 1999). Understanding this linkage is useful for those who study ICT, and especially for those who design them (Kaplan, 1991). As well, I will argue that process theories can be a useful milieu for theoretical interplay between interpretive and positivist research paradigms (Schultz and Hatch, 1996).

Processes as theory

Crowston and Treacy (1986) noted that linking the use of ICT to any kind of organizational-level impact requires some theory about the inner workings of organizations. Processes provide a possible bridge between individual, organizational (and even industrial) level outcomes of the use of ICT. This framework is shown pictorially in Figure 1. The framework acknowledges that ICT, by themselves, do not change organizations, nor are they merely tools of managerial intent. Rather, ICT use opens up new possibilities for individual work, and these changes in work in turn have implications for the processes and thus the organizations in which these individuals participate.

These work and process changes, in turn, may involve changes in organizational structures and outcomes (and vice versa). In other words, as individual workers incorporate various forms of ICT in their work, they alter both how they conduct their work and how they participate in the organization's structure, and thus indirectly how their organizations participate

Figure 1. The relationship between ICT-induced changes in individual work and changes in organizational and industrial structures and outcomes.



in the industry-wide value-chain. Conversely, there are organizational and industry-wide forces shaping how work is done. These forces also affect how individuals do their work. The interaction of these forces is what shapes the uses of ICT, new forms of work and new ways of organizing.

In the remainder of this section, I start with a brief review of the problem of cross-level analysis and the potential value of process theories. I next discuss the concept of a process to explain how processes link to individual work and ICT use on the one hand and to organizational and industrial structures and outcomes on the other. As well, I discuss the potential use of process theories as a milieu for interplay between research paradigms. In later sections, I illustrate the application of this framework in a study of the use of an information system in a restaurant. I conclude by sketching implications of my process perspective for future research.

The problem of cross-level research

Information systems research (I/S) has in recent years shifted its attention to organizational issues (Benbasat, et al., 1987). Organizational research in turn has historically been divided between micro- and macro-level perspectives. Micro-level research focuses primarily on the psychological attributes and behaviours of individuals or small groups in organizations (House, et al., 1995, p. 77), while macro-level research considers impersonal socio-economic aspects of organizations as a whole (House, et al., 1995, p. 75). A similar division can be seen in I/S between research focusing on individual use and organizational use of ICT.

Unfortunately, many organizational issues are multi-level and thus incompletely captured by single-level theories. House et al. (1995, p. 74) specifically list status, leadership and

networking as examples of multi-level phenomena. ICT impact is clearly also multi-level, as the same ICT has discernable impacts on individuals, groups and organizations. For such topics, multi-level theories are preferable because they provide a "deeper, richer portrait of organizational life—one that acknowledges the influence of the organizational context on individuals' actions and perceptions *and* the influence of individuals' actions and perceptions on the organizational context" (Klein, et al., 1999, p. 243). However, multi-level research is difficult, so theorizing at different levels is often disconnected, leading to misleading theoretical conclusions. In information systems research, one specific symptom of this disconnect is the inability to link the huge effects of the individual-level use of ICT to organizational-level outcomes.

Crowston and Treacy (1986) noted that linking the use of ICT to any kind of organizational-level impact requires some theory about the inner workings of organizations. Klein et al. (1994, p. 196) similarly stress the primacy of theory in dealing with levels issues. However, multi-level work to date has been restricted to a few domains, such as climate or leadership (Klein, et al., 1994, p. 197). While the theories are certainly not irrelevant to I/S research, information and information systems are not first-order constructs in these theories. The lack focus of focus on information issues suggests that there is an opportunity and a need for multi-level theorizing on ICT use.

Processes as theory

Clearly there could be as many different multi-level theories as there have been single-level theories of ICT use. For example, researchers might consider group or organizational influences on individual decisions to use information systems or examine the impact of a new

ICT on individual, group and organizational productivity. These examples (and most other theories in organizational and I/S research) are examples of variance theories. Variance theories comprise constructs or variables and propositions or hypotheses linking them. Such theories predict the levels of dependent or outcome variables from the levels of independent or predictor variables, where the predictors are seen as necessary and sufficient for the outcomes. For example, a theory that states that "individuals' level of resistance to a new information system depends on their familiarity with technology and the designers' choice of implementation strategy" (to pick three constructs out of the hat) is a variance theory.

A multi-level variance theory is one that includes constructs and variables from different levels of analysis. House et al. (1995) call specific attention to the need to explicate the processes by which the levels of analysis are related (p. 73). However, in the framework of a variance theory, this explication takes the form of a series of bridging or linking propositions involving constructs or variables defined at different levels of analysis. For example, a theory of individual resistance might use group or organizational-level variables as predictors (e.g., implementation strategy might be defined at a group level). Within this framework, a lot of work has been done to clarify the nature of cross-level theories and the statistical issues in analyzing multi-level data (Klein, et al., 1994, p. 196). For example, Klein et al. (1994) highlight the importance of specifying the level of a theory and ensuring that data collection and analysis are performed appropriately.

Processes as theory

An alternative to a variance theory is a process theory (Markus and Robey, 1988). Rather than relating levels of variables, process theories explain how outcomes of interest develop

through a sequence of events (Mohr, 1982). These precursor events are necessary for the outcome, but not sufficient in themselves, and outcomes are therefore only partially predictable from knowledge of the process. For example, resistance might be conceptualized as the result of a sequence of events performed by the developers, the individuals and others.

Typically, process theories are of some transient process leading to exceptional outcomes, e.g., events leading up to an organizational change or to acceptance of a system. However, I want to focus instead on what might be called "everyday" processes: those performed regularly to create an organization's products or services. Such a process is also composed of events (the actions taken by key actors) leading to outcomes (the products or services).

A description of a process has a very different form from the boxes-and-arrows of a variance theory, but it is still a theory, in that it summarize a set of observations and predictions about the world. In the case of a process theory, the observations and predictions are about the performance of events leading up to organizational outcomes of interest. Such a theory might be very specific, that is, descriptive of only a single performance in a specific organization. More desirably, the theory might describe a general class of performances or even performances in multiple organizations. As Orlikowski (1993) puts it, "Yin (1984) refers to this technique as "analytic generalization" to distinguish it from the more typical statistical generalization that generalizes from a sample to a population. Here the generalization is of theoretical concepts and patterns." For example, a generalizable process theory of resistance might describe a typical sequence of events that seems to lead to resistance to or acceptance of a system. Similarly, a generalizable everyday process description would be a theory of how the organization (and perhaps others) create a particular product or service.

Processes as theory

Kaplan (1991, p. 593) states that process theories can be "valuable aids in understanding issues pertaining to designing and implementing information systems, assessing their impacts, and anticipating and managing the processes of change associated with them". The main advantage of process theories is that they can deal with more complex causal relationships than variance theories, and provide an explanation of how the inputs and outputs are related, rather than simply noting the relationship. Orlikowski (1993) argued for including "the action of key players associated with organizational change—elements that are often omitted in IS studies that rely on variance models and cross-sectional, quantitative data".

As well, I argue that process theories provide a link between individual and organizational phenomena and a milieu for interplay between research paradigms. However, to make this point, I will first describe the components of a process theory, in contrast to the variables and hypotheses of a variance theory. I conclude by sketching a process-centred research framework.

Components of a process

In this section, I discuss in more detail what I mean by a process to show how it provides a conceptual link between levels of analysis. In this section, I develop a series of increasingly elaborate process conceptualizations. I begin by discussing processes as wholes, and then as compositions of activities with constraints on assembly. The goal of this discussion is to understand the connection between processes and individual work, on the one hand, and processes and organizational outcomes on the other.

Processes as theory

Processes as ways to accomplish goals

A simple view is that processes are ways organizations accomplish desired goals. In fact, as Malone et al. (1999) point out, processes are often named by the goals they accomplish (for example, product development, order fulfillment, logistics management). Identifying a goal is an important part of defining a process. First, the goal identifies the desired result or output of the process, or the set of constraints the process satisfies (Cyert and March, 1963; Simon, 1964), which is necessary to link to organizational outcomes (i.e., how quickly or efficiently different process options meet the constraints and produce the output). Second, choosing the goal reaffirms the need to identify the customer of the process—that is, the person whose goal is being accomplished. By focusing more at the level of a process, I seek to avoid the problems outlined by March and Sutton (1997) who noted the instability of organizational performance.

Process as a transformation of input to output

A related view is that a process is a transformation of an input to an output. This view focuses on the resources that flow through the process. Input-output (I/O) operations are definitions of work activity common to all of the engineering sciences, in particular to industrial engineering (IE) and to electrical engineering (EE). The business process concept has strong roots in industrial engineering (IE) and its subfield of process engineering (Sakamoto, 1989). Other process concepts borrow heavily from operations research (OR) and operations management (OM), in particular, the design and control of manufacturing and product-producing processes of the firm. This view of a process is similar to the root definition (RD) of a system in Soft Systems Methodology (SSM) (Checkland and Scholes, 1990). A root definition expresses

the core purpose of a system. At its centre is a transformation: some input being converted into some output.

A key point in SSM, to which I also adhere, is that there is not a single correct RD for a process. Instead, there can be several, reflecting different view of the process. For example, one RD might focus on the official rationale for the process and the concrete items created. Another might focus on the way the organization allocates resources to different processes. Yet another might focus on how employees are selected and rewarded for working on a process. Instead of arguing that whichever model chosen is a true representation of the work, I view the description as a discursive product, that is, as an artifact, with an author, intended to accomplish some goal. Checkland (1981) similarly describes models as "opening up debate about change" rather than "what ought now to be done" (p. 178). Descriptions are resources for action, that is, someone doing the work may find them useful as a reference or justification for particular actions. The implications of this perspective will be further discussed below.

Describing a process as a way to accomplish a goal or as a transformation of an input to an output establishes the link between processes and organizational outcomes. For example, at this level of detail the efficiency of a process can be stated as the process outputs divided by the inputs. However, at this level of detail, the link to individual work or ICT use is not yet apparent.

Processes as sequences of activities

To progress further, we need a more detailed view of processes that will allow us to say more about differences in how individuals contribute to processes and especially how the use of ICT might make a difference to these contributions. To do so, we draw on the definition of a process as a sequence of events, focusing specifically on events as activities performed by

individual or groups. To document a process then, we identify a set of activities that describe the observed performances of the process. Such a description will be a theory of the process in the sense that it summarizes a set of observations about what has happened when the process was performed in the past and a set of predictions about what will happen when the process is performed in the future.

Of course, developing such a description involves numerous choices. Many different sequences of activities are possible, and the exact sequences will likely differ from performance to performance. Indeed, the exact activities observed in a single instance of a process may never be repeated in all particulars. Even so, for many processes organizational participants have little difficulty in recognizing an abstract description that represents multiple instances of those specific activities, both those that have happened and those that might happen in the future. This feature of organizational life can be described as inducing a generalized process from a relatively small set of observed activities by fitting observed actions into mental templates that define more abstract process steps.

Such an abstraction will inevitably suppress some activities. For example, two people may start each interaction by spending a few minutes discussing last night's game, yet not include that activity when describing the process. In general, I would follow the informants' lead in choosing whether to include such activities in the process description. It may be that these interactions are viewed by some of the individuals as necessary to the smooth running of the process, in which case they need to be included; or it may be that they are considered as secondary, in which case I would probably also leave them out.

As well, activities can be represented at different levels of abstraction. Higher-level activities can be broken down into more detailed activities, forming a hierarchy of activities. For example, the waterfall model of software development breaks software development into steps such as analysis, design and coding, but each of these steps is in turn composed of many more detailed activities. Different levels of detail are appropriate for different purposes. One heuristic for knowing when to stop decomposing a process is when further decomposition is not useful for the analysis, i.e., a utility heuristic. Note that different parts of a process can be decomposed into different levels if this is useful. A second heuristic is to stop when the activity identified is one that is routine and unproblematic for the organization to perform. As before, this decision depends on the purpose of the analysis. At the most detailed level, it is important that all activities be something an actor can actually do (e.g., collect information or make plans), as opposed to the hoped-for outcomes of an action (e.g., lower costs) (Checkland, 1981, p. 235).

Representing a process as a sequence and hierarchy of activities provides insight into the linkage between individual work and processes, since individuals perform the various activities that comprise the process. As individuals change what they do, they change how they perform these activities and thus their participation in the process. Conversely, process changes demand different performances from individuals. ICT use might simply make individuals more efficient or effective at the activities they have always performed. For example, a manager using a spreadsheet to analyze a decision may be able to reach a conclusion more quickly or to consider more alternatives, thus improving the speed or quality of the process without changing the activities involved. A real estate agent might be able to search the database of house listings for each client every day.

Processes as theory

However, an interesting class of impacts involves changing which individuals perform which activities. Buyers might search real estate listings themselves, performing activities that the agent used to perform. ICT might be used to automate the performance of certain activities, thus changing the activities that comprise the process. Analysis of these possibilities requires an even more detailed view of the process, which I present in the following section.

Assembly constraints from interdependencies

I turn next to a discussion of constraints on assembling activities into processes. Understanding these constraints is important for understanding how changes in individual work might affect the process, since the constraints limit the possible arrangements and rearrangements of activities. The question I consider in this section is: "What constraints limit the range of processes that lead to a desired outcome?" Weick (1969) has argued that organizations construct processes from sets of "cycles" using "assembly rules" e.g., organizations build routines based on goal-directed rules and procedures, where rules are seen as constraints on action (Sandelands and Drazin, 1989). My approach compliments the views held by these authors, as I focus on the factors that limit or constrain which assemblies are feasible, rather than on the rules used to pick a particular assembly of activities.

I focus in particular on the implications of dependencies for process assembly. In focusing on dependencies, I both follow and diverge from a long tradition in organization theory. Thompson (1967) viewed subunit interdependency as the basic building block of organizational structure and behavior, in that the degree of interdependency in a given organization was associated with the degree of specialization and/or integration of its principal work units. Following Thompson, two basic conceptualizations of organizational interdependency have

evolved: resource interdependency, generated through exchanges between organizational members (e.g., people); and workflow interdependency, generated between organizational units located in the division of labor (Victor and Blackburn, 1987). In both cases, dependencies arise between individuals or groups.

In contrast to these earlier views, I believe that conceptualizing dependencies as arising between *activities* provides more insight into processes. In this view, dependencies between work units are the result of interdependent work activities performed by those units rather than being inherent in the units. This view makes it easier to consider the implications of reassigning work to different actors. In my view, the limits on the orders of activities arise from the flow of resources between them, that is, on resource interdependencies.

Malone and Crowston (1994) proposed two major classes of dependencies: *flow* or *producer/consumer* dependencies and *shared resource* dependencies. *Producer/consumer* dependencies arise when one activity creates a resource that is then used by another activity. *Shared resource* dependencies arise when two or more activities require the same resources. These dependencies have implications for changes to processes. Since the activities can not be performed without the necessary resources, the existence of the dependencies constrains how the process can be assembled. In particular, *producer/consumer* dependencies restrict the order in which activities can be performed. If activity B depends on the output of another activity A, for example, then only processes where B follows A are feasible. On the other hand, activities that are not involved in a dependency can be freely rearranged. Therefore, we can limit possible arrangements of the activities in analyzing existing processes or in designing new ones. For example, goods must be manufactured before they can be delivered to customer, so any feasible process will maintain this order of these steps. However, we might imagine moving the activity

of ordering products to different points in the process. For example, ordering might come before manufacturing (e.g., for customized products), after manufacturing but before delivery (e.g., ship to order) or even after delivery (e.g., ship to meet estimated demands or to maintain a stock at the customer's location from which orders are fulfilled).

Activities to manage interdependencies in processes

As well as constraining the order of activities, interdependencies often require additional activities to manage them. According to Malone and Crowston (1994), the *producer/consumer* interdependency described above not only constrains the order of the activities (a *precedence* dependency), but may also require additional activities to manage the *transfer* of the resource between or to ensure the *usability* of the resource. (In other words, a producer/consumer dependency is really a bundle of three more specific dependencies, precedence, transfer and usability.) If the resource is needed by several activities, then additional work may be needed to provide the resource to one activity when it is performed. In other words, I can identify certain activities in a process as managing dependencies between resources and activities, which Malone and Crowston (1994) called coordination activities or coordination mechanisms. This approach expands Galbraith's (1973) list of generic, coordination mechanisms—teams, task forces, steering committees, review committees—to include specific coordination activities (e.g., notification, sequencing, synchronization) used to manage dependencies between activities and resources. In the remainder of this section, I will discuss coordination mechanisms that might be used to manage the two kinds of dependencies listed above. A more complete discussion of these mechanisms is given by Crowston (1999).

Managing producer/consumer dependencies. As discussed above, the first class of dependencies is producer/consumer dependencies, where one activity uses resources created by another. *Precedence* requires that the producer activity be performed before the consumer activity. This dependency can be managed in one of two ways: either the person performing the first activity can notify the person performing the second that a resource is ready, or the second can monitor the performance of the first. ICT may have an affect by providing a mechanism for cheap monitoring. *Transfer* dependencies are managed by a range of mechanisms for physically moving resources to the actors performing the consuming activities (or vice versa). For example, inventory management systems can be classified here. *Usability* can be managed by having the consumer specify the nature of the resources required or by having the producer create standardized resources expected by the user (among other mechanisms).

Managing resource dependencies. The second class of dependency is the dependency between an activity and the resources it requires. This dependency is managed by identifying what resources are necessary, choosing among available resources and assigning the resources to the task. Of course, within this framework are numerous variations, including hierarchical assignment and market-based mechanisms. For example, when a manufacturer requires some parts, it determines which suppliers can provide those parts, pick one of the suppliers (e.g., on the basis of bids) and contract with that supplier. This analysis can also be applied to the assignment of an individual to perform a particular activity. The person who wants the activity done first identifies who might be able to do, choose one person (e.g., whoever happens to be free at the moment) and asks that person to work on the activity.

In general, there may be numerous different coordination mechanisms that could be used to address a given dependency. Different organizations may use different mechanisms to address

similar problems, thus resulting in a different organizational form. Because these coordination mechanisms are primarily information processing, they may be particular affected by the use of ICT. For example, a key step in managing a resource dependency is identifying the set of available resources and choosing among them. In some settings, ICT might reduce the cost of these operations, e.g., by making it possible to broadcast requests or to automatically evaluate a large number of possibilities, allowing consideration of many more possibilities. This effect has lead to the prediction of an increased use of market mechanisms instead of hierarchies (Malone, et al., 1987). Indeed, the growing popularity of on-line auctions may reflect this trend.

Summary

In this section, I developed increasingly detailed conceptualizations of processes in order to explicate the linkage between processes, individual work and organizational outcomes. Viewing processes as the way organizations accomplish desired goals and transform inputs into outputs makes the link to organizational outcomes. For example, the efficiency of a process can be stated as the outputs divided by the inputs. Viewing processes as ordered collections of activities makes the link to individual work, since individual actors perform these activities. ICT use may allow individuals to perform specific activities more efficiently or effectively. It may also make different coordination mechanism more attractive, thus changing the way a process is coordinated.

House et al. (1995) argue that "micro and macro processes cannot be treated separately and then added up to understand behavior in, or behavior of organizations" (p. 73). They argue instead for a meso paradigm, which involves multiple levels of analysis. Processes provide such a view.

Processes as a milieu for crossing research paradigms

Developing a model of a process raises problems such as how activities are identified and determined to be relevant to the process and choosing an appropriate level of decomposition for the process description. These choices can be problematic because processes involve numerous individuals with possibly different interpretations of the process. Resolution of these choices raises questions about the theoretical assumptions underlying the theory.

Burrell and Morgan (1979) suggest a 2x2 categorization of social theories as a framework for discussing these underlying assumptions. One dimension of their framework is order-conflict. Theories of processes clearly focus on the ordering of society—stability, integration, functional co-ordination and consensus—rather than on conflict. (This is not to say that consideration of process might not be interesting for critical studies.) The second dimension is subjective-objective, which involves closely linked assumptions about ontology, epistemology, human nature and methodology. The combination of these two dimensions results in four distinct paradigms for research.

Burrell and Morgan (1979) present their four paradigms as incommensurable approaches to research. However, Schultz and Hatch (1996) suggest that paradigms can be crossed, that is, contrasted as opposed to integrated. They identify several ways research might cross paradigms, including sequential (e.g., Lee, 1991), parallel, bridging and interplay. Schultz and Hatch argue that interplay "allows the findings of one paradigm to be recontextualized and reinterpreted in such a way that they inform the research conducted within a different paradigm". In the remainder of this section, I will discuss the assumptions about ontology, epistemology, human

nature and methodology involved in the subjective-objective dimension to show how process theories might provide a milieu for such interplay.

Ontology. The first debate concerns the nature of social reality. Burrell and Morgan (1979) contrast two ontological positions: on the one hand, that social reality is external to individual cognition (realism), as is the case for physical reality, or on the other, that it is the product of individual consciousness (nominalism). A process description might contrast these two perspectives to achieve a richer description. The goals of a process might be viewed as real, such as a physical product, or symbolic. Activities performed might be real, as in stamping metal, or nominalist, as in many information processes. Flows of physical goods have a physical reality, though many interesting processes are largely information processing for which a nominalist position is more appropriate.

Epistemology. The second debate concerns the grounds for knowledge. Burrell and Morgan (1979) contrast two epistemological positions, positivist vs. anti-positivist. A positivist worldview seeks "to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements" (p. 5), while "for the anti-positivists, the social world is essentially relativistic and can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied" (p. 5). A researcher's epistemological assumptions are closely tied to ontology because if social world has an objective reality, than it makes sense to look for regularities, while if the social world is an individual product, then makes more sense to consider the point of view of the individuals.

Again, a process theory offers a milieu in which to deliberately contrast these perspectives. On the one hand, viewing a process as a way to accomplish organizational goals implies a positivist conception of the process. On the other, focusing on individuals and their conceptions of their work implies an anti-positivist view of activities. A possible result of this contrast is to explicitly problematize the question of how individuals come to contribute to the higher-order goals. For example, even though individuals make sense of the world themselves, there must still be some degree of agreement among members of a group, e.g., about the meaning and nature of a shared process, such that individual perceptions are subjective without becoming completely arbitrary. Numerous researchers have investigated the nature of such shared cognitions and the social processes by which they are built (Walsh, 1995). For example, Weick and Roberts (1993) show how aircraft carrier flight deck operations are made reliable by the "heedful interrelating" of flight deck personnel.

Human nature. The third debate concern human nature. Burrell and Morgan (1979, p. 6) contrast two perspectives: individuals' actions are determined by their situations (determinism) vs. individuals have total free will (voluntarism). Burrell and Morgan note that most researchers adopt an intermediate position, which allows for aspects of both perspectives depending on the context. For process research, this intermediate position seems most reasonable. Individuals working in a group do not have total freedom in what they do if they are to contribute to the group, but are not totally constrained either. Again, consideration of interplay between these positions is possible. For example, Simon (1991) raises the question of why individuals adopt organizational goals in the first place.

Methodology. Finally, the three sets of assumptions above have implications for the choice of research method. Burrell and Morgan (1979, p. 6) contrast ideographic and nomothetic

approaches. Ideographic approaches rely on first-hand knowledge of the subject, while nomothetic approaches rely on systematic protocols and hypothesis formulation and testing. Clearly, interplay strategy suggests using both kinds of methods and contrasting research findings.

To summarize, the objective-subjective debate is often presented as a dichotomy, and a matter of prior assumption. However, as Schultz and Hatch say, "the assumption of impermeable paradigm boundaries reinforces and is reinforced by 'either-or' thinking. We believe that paradigm boundaries are permeable and claim that when paradigm contrasts are combined with paradigm connections, interplay becomes possible". Process theories provide a possible milieu for such interplay.

A process-centered research framework

Based on the discussion above, I propose a process-centred research framework for the linking individual and organizational-level research on the use of ICT. In this framework, shown in Figure 1, uses of ICT are enacted by individuals who, through their actions, change the conduct of their work in response to the availability of these technologies. For example, literature highlights changes in the way software developers use computer-aided software engineering (CASE) tools (Orlikowski, 1993) or electronic meeting systems (EMS) (Sawyer, et al., 1997), engineering technicians use computer-aided design (CAD) tools (Kelley, 1990), help-desk personnel use Lotus Notes (Orlikowski, 1995), and telephone operators use new information systems (Kraut, et al., 1989). Of course, changes in work also affect the use of ICT, as indicated by the double-headed arrows in the figure. The framework also acknowledges the value of studying the nature of an individual's interaction with the technology more specifically to

understand the relationship between ICT use and work changes. For example, I need to know more specifically what makes some systems more useful than others.

Individual-level changes in work lead in turn to changes in the organizations in which the work is done. These effects manifest themselves first as changes to *organizational processes* and eventually to changes in *organizational structures*. *Organizational processes* reflect the choice and sequencing of tasks to accomplish intended outcomes (discussed in more detail below) and *organizational structures* include how people are organized for reporting and dissemination of information. Changes in process also have implications for *industrial structures* and *value-chains* (Baker, 1990). *Industrial structure* includes the division of work among companies (i.e., the position of firm boundaries) and the *industrial value-chain* can be seen as processes extended across multiple firms.

In other words, as individual workers use various forms of ICT in their work, they alter both how they conduct their work and how they participate in the organization's structure, and thus indirectly how their organizations participate in the industry-wide value-chain. For example, Crowston, Malone and Lin (1987) described a company that introduced a computer-conferencing system to link plant human resource managers to the specialists at headquarters. This system made it possible for the first time for plant-level personnel to see questions asked by their peers and to participate in discussions. As a result, the firm was able to move an intermediate level of managers who used to answer these questions and instead have headquarters specialists interact directly with plant personnel. As a second example, toll free (1–800) telephone numbers and more recently, the World Wide web and electronic ticketing, enable airlines to sell their tickets directly to the public, bypassing travel agents and potentially reshaping this industry (Lewis, et al., 1998).

Processes as theory

Finally, changes to organizational processes and structures, arising in part from how individual workers use ICT in their work, lead to changes in *organizational* and *industrial outcomes* such as productivity or performance. Obtaining desirable outcome changes is the driving force behind the popularity of business process reengineering (BPR) (Davenport and Short, 1990; Hammer, 1990). For example, the use of electronic ticketing reportedly allows United Airlines to eliminate 14 accounting processes and their associated costs (Lewis, et al., 1998).

Conversely, there are organizational and industry-wide forces shaping how work is done. A new channel or business model in one industry may require changes to processes in that industry or related industries. For example, electronic ticketing requires changes to the processes for issuing tickets and checking in passengers at the gate, among others. These organizational and industry-wide forces also affect how individuals do their work. The experience of many companies with BPR efforts demonstrates that changes to processes have dramatic (sometimes negative) impacts on individual workers. Reflecting this duality, the arrows in Figure 1 run in both directions.

Rather than implying a strict model of causation or a particular set of variables or concepts, the framework discussed above captures my understanding of the interrelationship between individual work and organizational and industrial structures. In my view, it is the complex interaction of individual work, organizational and industrial forces that shapes the uses of ICT, new forms of work and new ways of organizing (Markus and Robey, 1988; Orlikowski and Robey, 1991). The implication of the chain of relations sketched above is that the use of ICT is not directly related to changes in organizational or industry-wide outcomes, nor mediated in a simple way. As a result, the eventual outcomes of new ICT use are impossible to predict in

general. Instead, analysis must be rooted in the context of a particular industry and organizational setting (see Abbott, 1995). For example, the fact that the relationship between airlines and passengers is being disintermediated as travel agents are driven out of the process (Lewis, et al., 1998) suggests examining changes in the work of other transactional intermediaries. However, I can not simply assume that the introduction of communication technologies that can link buyers and sellers will lead everywhere to disintermediation. Instead, to understand the ways ICT can and are changing work, this framework suggests the need to understand the individual, organizational and industrial levels and the processes that join them, simultaneously.

In the next section, I use this framework in the study of the use of an information system in a restaurant, shows how processes can provide a link between individual and organizational level phenomena.

Illustrative example: Service processes in two restaurants

To illustrate the use of this framework, I will analyze and compare the service processes in two restaurants, one with and one without a seating information system (Crowston, 1994). This example demonstrates how consideration of the process helps to link phenomena observed at the individual and organizational levels.

I have chosen a service example for several reasons, among them the increasing importance of service processes to the total economy, and the importance of both tangible (e.g., flow of physical goods) and intangible (e.g., relationships among personnel) factors in designing service processes. Moreover, information technology is frequently identified in practitioner literatures as an enabler of process innovation and, because of the importance of information in

service businesses generally and restaurant operations specifically, these businesses may be affected particularly by the increased use of information and communication technologies.

Restaurants have long been studied as important forums for coordination. The essential characteristics of restaurants—many customers, many orders, frequent deliveries, continuous monitoring of customers and of personnel in accomplishing work, and perishable products—makes them particularly illuminating for studies of logistical flows, information flows, and resultant needs for coordination. As Whyte (1948, pp. 18–19) noted "Failure of coordination is perhaps the chief enemy of job satisfaction for the worker. And the varying and unpredictable demands of customers makes this coordination always difficult to achieve." He noted further that in a small restaurant, everyone was in direct contact "and the problems of communication and coordination are relatively simple," while in a larger restaurant, "coordination must be accomplished through people who are not generally in face-to-face contact with each other" (p. 47). He noted also the importance of cordial relations between staff and customers for coordinating service, and equally important, the need for clear lines of communication, not only for orders, but also for complaints and information about order status (p. 75).

Whyte focused most of his analysis on the effects of differences in worker status on communication and coordination between parts of the restaurant. My analysis will focus more generally on how the two restaurants provide service, and compare different levels of information technology. While Whyte was less sure about the importance of technology in this setting—"mechanical devices are not an adequate substitute for face-to-face communications" (p. 60)—he wrote at a time when all orders had to be handwritten and delivered. The cost of any

such system—manual or electronic—was therefore high. Today, new IT makes such communications significantly cheaper, making the analysis of such applications timely.

In this example, the focus of the analysis will be on how the restaurant manages seats, because the management problem under consideration is what effect the seating system has on the process. Other questions would lead to different definitions of the system under study. For example, if the goal of the study was to improve the job satisfaction of the wait staff, the analysis would have to include how wait staff members are hired and details of how they interact with the kitchen staff.

The research setting

The two restaurants I compare both belonged to the same national chain. One was located in Lake Buena Vista, Florida and the other in Southfield, Michigan. Both were similar in size and had similar decor and menus. They differed significantly, however, in their use of information technology as I describe below. My description and analysis is based on observations of lunch and dinner service at the two restaurants, discussions with staff, and analysis of documentation describing the IT system provided by the software services company that developed and sold the system to the restaurant chain (Karp, 1994; Rock Systems, 1994).

The Southfield restaurant was a conventional sit-down restaurant, organized for high-volume operations. Seats were allocated by assigning entries in a conventional grease pencil-and-acetate record used by the hostess. Communications were face-to-face. By contrast, the Lake Buena Vista restaurant used an information system to track table status and to automate some communications between restaurant staff.

When I arrived at the Lake Buena Vista restaurant, the hostess consulted a computerized display of tables in the restaurant to select a table for us. If there were several free tables of appropriate size and in the appropriate section (smoking or non-smoking), the system was programmed to suggest a table in order to balance customers evenly among the restaurant wait staff. When the restaurant was busy or full, the system maintained a table waiting list. When a table became free, the system suggested which customers to seat based on the size and section of the table. Throughout, the system kept an up-to-date estimate of the current waiting time; as well, the system reported how long each table had been occupied, reportedly to allow hosts to predict how long it was until an appropriate table became available.

As I was seated, my hostess pointed out a button under the table. Pressing the button updated the status of the table in the information system, e.g., from free, to occupied, to waiting-to-be-bused, and finally back to free. As the button was pressed, the system confirmed that I had been seated. In addition to the "wired table," the restaurant information system included pagers carried by the wait staff. When the table button was pressed indicating I had been seated, the system paged the waitress responsible for the table, indicating there were new customers. Also, there was a button on the table with which I could page my waitress if desired.

Having received the page, my waitress arrived, took my order on a pad, and relayed the order to the kitchen. I believe, but did not observe directly, that food preparation was the same in both restaurants. However, because I did not observe the processes used by the two kitchens in preparing my food, I will not consider this part of process in my analysis. When my meal was ready, the kitchen used the pagers to inform the waitress my order was ready to be picked up and served. After I finished my meal, I paged the waitress to ask for my bill and paid it. When she collected the bill, she could page a buser to clean that table. I did not directly observe this part of

the process, but the system documentation indicates the page can be sent from a separate "buser" terminal or from the table, depending on the installation. Similarly, when the buser had finished, a message can be sent to inform the hostess (and the system) that the table is available and the next customer can be seated.

This system apparently had a significant practical impact: it is reported, for example, that "diners spend 15 to 30 minutes less time in the restaurant [after the installation of the system] because of swifter service" (Karp, 1994). At the Lake Buena Vista restaurant in particular, the system is reported to have decreased the waiting time for a table, "from one hour to 20 minutes", according to the manager. The system developers attribute this reduced waiting time to increased table utilization. According to the developers' analysis, increased table utilization can improve profitability by nearly $70,000 per year for a 250 seat restaurant (Rock Systems, 1994), allowing the system to pay for itself in as little as 10 weeks. As well, the developers list several other categories of benefit, such as increased customer satisfaction due to reduced waits, smoother flow of food and decreased labour costs. Quotations from restaurant managers suggest that the system also simplifies restaurant operations.

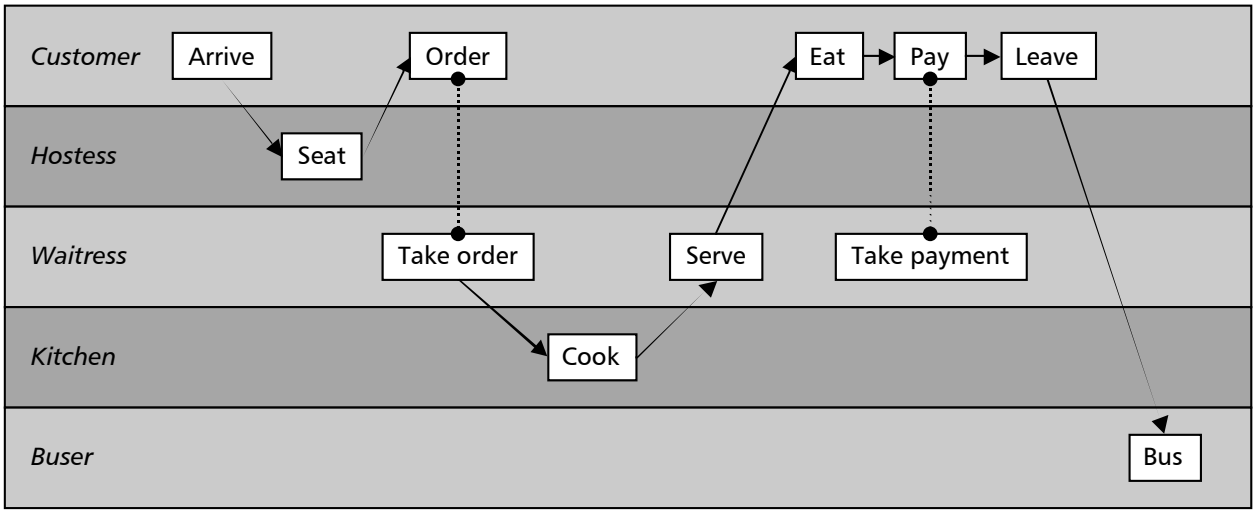
The question I wish to answer is, why does the system have such a profound impact on organizational performance? This question can not be answered by a single-level theory. On the one hand, focusing on individual use of the system can not explain how the system has an effect on the overall performance of the organization (short of assuming that the performance of the organization is a simple sum of the performance of its members). On the other hand, considering only the organization as a whole (e.g., by comparing a number of organizations with and without systems), quantifies but does not illuminate how the system provides benefit.

Analysis

In this section, I provide an analysis of the process of seating and serving customers in the two restaurants that illustrates how changes in individual work affect the process and thus the organizational outcomes. The changes in individual work have been described above: use of an information system to track table status and to communicate between individual employees. The organizational outcomes have also been described: reduced waiting time and increased table turns and profitability. The question I address here is how consideration of the process can clarify the link between these phenomena.

The first step in this analysis is to develop a description of the activities involved in the process. A simple description of these steps is shown in Figure 2. This figure shows actors on the left and activities performed by each across the page in time-order. Activities performed jointly are connected by dotted lines. While there may be some disagreements about details, I believe that most people will recognize the sequence of activities as representative of a restaurant. I

Figure 2. The restaurant service process. Actors are shown down the left side, activities performed by each are shown in order across the page. Activities performed jointly are connected with dotted lines.

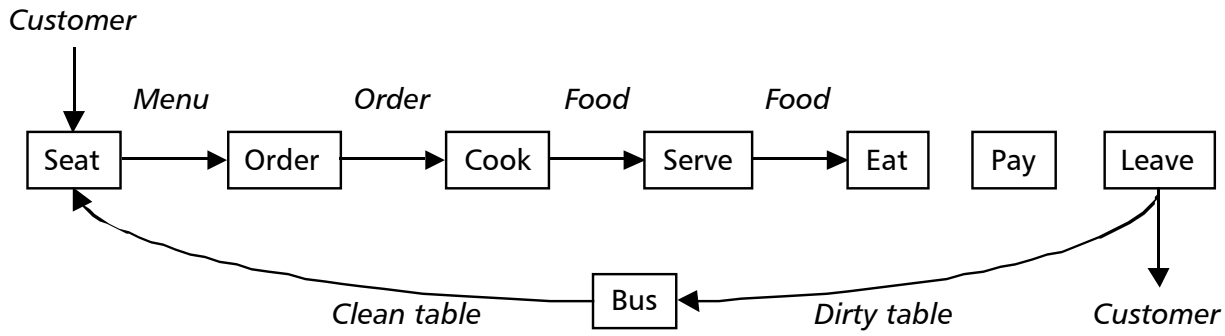


argued above that process descriptions should be viewed as resources for action rather than as necessarily valid descriptions of reality. In that spirit then, I will bracket discussion of the validity of this model and instead focus on the insights possible from the analysis.

In the case of these restaurants, a particularly important type of dependency is the producer/consumer dependency between activities. These dependencies can be easily identified by noting where one activity produces something that is required by another. These resource flows and the dependencies between activities are shown in Figure 3. For example, the activity of cooking creates food that can then be served and eaten; customers' departure produces a table ready for busing; and busing and resetting a table produces a table ready for another customer.

This distinction clarifies the role of the information system used. Recall that in Malone and Crowston's (1994) analysis, such a dependency can be managed in one of two ways: either the person performing the first activity can notify the person performing the second that a resource is ready, or the second can monitor the performance of the first. Employees in Southfield can not be easily notified that they can now perform an activity. They must instead spend time monitoring the status of the previous activity. For example, a bused table, ready for a customer, waits until the host or hostess notices it. In Lake Buena Vista, by contrast, the paging system notifies the host or hostess that a table has been bused and is ready. Similarly, the wait staff can monitor the kitchen to notice when an order is ready or, if using the system, the kitchen can page the wait staff to notify them that it is. Similar changes can be made at all stages of the process. The appropriate waiters or waitresses can be paged when customers arrive at their tables; a buser can be paged when the table has been vacated in is waiting to be bused.

Figure 3. Flow of resources between activities and resulting dependencies in the restaurant service process.



The effect of these changes is to slightly reduce the interval between successive activities. The improvement likely comes from increasing the pace at which the restaurant employees work. Since there are many such intervals, the result of the system can be a noticeable decrease in the interval between successive customers or alternately, a higher number of table turns and increased utilization of the restaurant's tables. (Of course, this analysis assumes that there are a large number of customers waiting to be seated and that these customers are not seeking a leisurely dining experience, both factors that were true of the restaurants I studied.)

Viewing the process in terms of producer/consumer dependencies also makes clear that the wait staff act as intermediaries between the kitchen and the customer, taking an order which is then transmitted to the kitchen or taking food prepared by the kitchen and delivering it to the customer. There are clearly alternative methods for managing these dependencies. At the restaurants I studied, a different actor sometimes performs the second function; drinks and food ordered are often delivered by a "runner" instead of the wait person who took the order. (The system can even page the appropriate wait person to meet the runner at the table to actually present the food, thus hiding the participation of the runner from the customer.) The system is

also involved in the first function: wait staff enter their orders on a computer system that transmit them to the kitchen and calculates the bill. Some restaurants already provide their wait staff with wireless terminals that transmit the order directly from table to the kitchen. One could imagine providing such a terminal to the customer; orders would be directly transmitted to the kitchen and delivered when they are ready, thus eliminating the role of the waitress or waiter, i.e., disintermediation of the relationship between kitchen and customer (Benjamin and Wigand, 1995).

As well, the wait staff delivers the bill and collect payment. My analysis suggests that there is no necessary dependency between paying and the other activities. As a result, the bill can be paid at any point in the process (e.g., before ordering, as in an "all you can eat" buffet, after ordering but before serving, as in fast food restaurants, after serving but before eating, as in most cafeterias, or after eating, as in most sit-down restaurants). Of course, in some restaurants, the amount of the bill depends on what was ordered or the quality of the service, in which case there would be a producer/consumer dependency between these steps and paying. My analysis also suggests that there is no dependency leading into leaving, in other words, customers can potentially leave at any point in the process. As a result, restaurant processes are sometimes designed to minimize this opportunity (e.g., by requiring payment up front or motivating wait staff to monitor customers closely).

It is also clear which problems a seat-allocation or order-entry system does not address. It does not appear to address processes in the kitchen; in both cases I was seated immediately but had to wait for my orders, presumably due to the time required to produce it.

Summary

This example demonstrates how examination of the process helps to link phenomena observed at the individual and organizational levels. The changes in individual work include use of an information system to track table status and to communicate between individual employees. The organizational outcomes include reduced waiting time and increased table turns and profitability. My analysis of the process suggests that the system allows individuals to change how they manage precedence dependencies, from noticing to notifying, thus decreasing the interval between activities, and overall, increasing table turns and profitability for a certain class of restaurant.

Recommendations for process research and practice

I have argued above that a focus on processes makes contributions to the study of ICT use and organizations. Of course, many other researchers have explicitly or implicitly used the approach recommended in this paper. For example, Sauer et al. (1999) discuss the potential of ICT use to restructure the value-chain in the Australian construction industry, using a process-focus to link change in individual firms to the overall industry structure.

Overall, it seems reasonable to urge adoption of a process perspective when investigating the many organizational problems that have an ICT component. Five specific recommendations are outlined below for incorporating processes in ICT research and practice.

Develop richer process analysis and design techniques

First, researchers need to develop richer process analysis and design techniques. Analyses of processes must include more than simple sequences of activities. As discussed above, a

process analyst must also consider the flow of resources, the dependencies created by these flows and how these dependencies are managed (Crowston and Osborn, 1998). Therefore, I suggest that researchers in these areas consider how their instruments can be adapted for broader usage. A more difficult challenge is developing a meta-theory for processes that matches the well-defined and well-understood set of terms and concepts for variance theories, such as "construct", "variable", "proposition", "hypothesis", "variance" and "error". Researchers developing variance theories have a rich set of statistical tools for expressing and testing hypotheses. Is there a process theory equivalent of a regression? The framework developed in this paper is a small first step towards such a meta-theory.

These tools should be useful for managers undertaking process redesign. Perhaps more helpfully, a range of feasible new designs can be developed by systematically varying the coordination mechanisms used (Crowston, 1997), though practitioners should keep in mind that process descriptions are theories, rather than unproblematic and precise descriptions of reality. Broader consideration of these mechanisms is especially useful given the capabilities of modern information technology to process and communicate information, allowing new approaches to coordination and monitoring.

Use processes as a unit of analysis

Organizational theorists have found it problematic to develop generalizations that hold for entire organizations, reflecting the diversity of activities and micro-climates found in most modern organizations. Mohr (1982) describes organizational structure as "multi-dimensional—too inclusive to have constant meaning and therefore to serve as a good theoretical construct". Processes provide a useful level of analyses to narrow the study of organizational

form (Mohr, 1982; Abbott, 1992). As Crowston (1997) states, "to understand how General Motors and Ford are alike or different, researchers might compare their automobile design processes or even more specific subprocesses" (p. 158). Within this finer focus, it may be possible to reach more meaningful conclusions about a range of theoretical concerns (Price and Mueller, 1986).

For example, March and Sutton (1997) note the difficulties in studying antecedents of organizational performance due to the instability of this construct. However, it may be meaningful to consider performance at the level of a process. Similarly, it is probably not meaningful to measure the level of centralization or decentralization of an entire organization (Price and Mueller, 1986), but such measures may be quite appropriate and meaningful within the context of a single process.

Develop the theory of organizational processes

More research is necessary to properly establish processes and the various constraints on process assembly as valid theoretical constructs. For example, research methods need to be developed or adapted to operationalize activities, resource flows and dependencies and to validate models built around these constructs. Development of these research instruments will also be useful for practice, as discussed above, but I do not believe that the current applied techniques are suitable for use in rigorous research.

As well, additional research is needed to characterize the range of possible dependencies and the variety of coordination mechanisms possible and in general, to document the assembly rules used in organizations. Work already done on work design and agency needs to be adapted to the general process perspective. Most importantly, research is needed to characterize the

tradeoffs between different mechanisms. Ultimately, such work may allow some degree of prediction of the performance of a selected configuration of activities.

Expand to richer contexts

Consideration of organizational processes has been used primarily in an applied fashion, and as a result, its use has mostly been restricted to processes in companies, often with the intent of designing a more efficient process, employing fewer workers. Certainly, I do not believe that this is the only or even most interesting application of these ideas. Therefore, I recommend that the use of organizational process analysis be expanded to a richer and more complex range of contexts.

One example of this approach is the work of Malone et al. (1999), who are collecting examples of how different organizations perform similar processes, and organizing these examples in an on-line "process handbook". The handbook is intended to support practitioners in analyzing and redesigning processes and to provide a framework to facilitate sharing knowledge about different types of organizations.

Use multiple theories

Cannella and Paetzold (1994) argued that use of multiple theories is a strength of organizational science. Following their argument, I recommend the use of a process perspective with complementary theories, resulting in a multi-level and multi-paradigm understanding of the organization. One example of this approach is an ongoing study of the use of ICT in the real estate industry (Crowston, et al., 1999; Crowston and Wigand, 1999; Sawyer, et al., 1999). The research project asks how the pervasive use of information and communication technologies

(ICT) in the real estate industry changes the way people and organizations in that industry work. To accomplish the objectives of this research, the researchers synthesize several theoretic perspectives to integrate findings from multiple levels of data collection. Specifically, at the individual level, they draw on theories of *work redesign* and *social capital*. At the organizational and industrial levels, they apply *transaction cost* and *coordination theory*. Linking these theories is the real estate sales process.

Conclusion

In this paper I argued that individual-level research on ICT use can be linked to organization-level research by detailed consideration of the organizational process in which the use is situated. Viewing a process as the way organizations accomplish desired goals and transform inputs into outputs makes the link to organizational outcomes. Viewing processes as ordered collections of activities makes the link to individual work, since individual actors perform these activities. As well, process theories can be a useful milieu for theoretical interplay between interpretive and positivist research paradigms (Schultz and Hatch, 1996). A process-centred research framework was illustrated with an analysis of the process of seating and serving customers in the two restaurants that illustrates how changes in individual work affect the process and thus the organizational outcomes.

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