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COMPUTERIZATION OF THE WORKPLACE

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ABSTRACT

Divergent conceptualizations of the recent changes in work organization that have accompanied computerization include neo-Bravermanian analyses, postindustrial analyses, and contingency analyses. To make sense of these differing views, the paper surveys sociological research on computerization and its impact on three analytically separate dimensions of the workplace: organizational restructuring, changes in worker skill, and power and authority relationships. The review reveals that computerized work organizations typically have fewer hierarchical levels, a bifurcated workforce, frequently with race and sex segregation, a less formal structure, and diminished use of internal labor markets and reliance instead on external credentialing. Variable patterns of centralization and decentralization occur, and workplace power relationships interact with technological change to produce variable political outcomes. With regard to worker skills, recent evidence suggests aggregate upskilling with some deskilling and skill bifurcation. Future research should more closely analyze the process of technological design and implementation.

INTRODUCTION

During the latter part of the twentieth century, the implementation of computerized technology and advanced information systems, in conjunction with related socioeconomic changes, has led to a fundamental restructuring of work organizations. Contemporary sociologists, trying to understand this "second industrial divide" (Piore & Sabel 1984), as nineteenth century sociologists

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tried to understand the first industrial revolution, have generated widely divergent conceptualizations. On the one hand, some social scientists have found that recent social and technological changes have created a centralized, neo-Taylorist work organization, deskilling of the labor process, and reduced worker autonomy (Braverman 1974, Feldberg & Glenn 1987, Kraft 1977, 1979, Noble 1977, 1984, Shaiken 1984, Zimbalist 1979). Conversely, other social scientists have concluded that the transformation of production has promoted a postindustrial or postbureaucratic work organization characterized by decentralization and reduction in hierarchy, upskilling of work and a centrality of knowledge workers, and democratization and increased worker autonomy (Attewell 1992, Bell 1973, Block 1990, Clegg 1990, Hirschhorn 1984, Piore & Sabel 1984). Still others have abandoned the search for general theory concerning the impact of technological change on the organization of production in favor of "contextualist" or "contingent" approaches that explore the microdynamics of workplace changes (Adler 1992b, Barley 1986, Cornfield 1987, Gallie 1978, Kelley 1990, Thomas 1994). These "contingency theorists" have argued that "the quest for general trends about the development of skill levels, or general conclusions about the impact of technologies, is likely to be in vain and misleading" (Wood 1989, p. 4; see also Vallas & Beck 1996, p. 341 ff for a good review).

We now have a considerable body of empirical research to help make sense of these divergent views. Can we substantiate any empirical or theoretical generalization concerning the impact of advanced technology on the workplace? If recent changes in the organization of production are contingent, can we begin to specify the contingencies? To answer these questions, this paper reviews recent sociological work on computerization and its impact on each of three analytically separate (although practically intertwined) dimensions of the workplace: organizational restructuring, changes in worker skill, and power and authority relationships. Although computerization is a global phenomenon, space constraints necessitate an emphasis here on US workplaces. I conclude with an analysis and interpretation.

ORGANIZATIONAL RESTRUCTURING

If it is true, as Salzman & Rosenthal (1994, p. 4) contend, that "workplaces are shaped by the design of the technology used," then we would expect work organizations centered around computerized systems of production and information to differ structurally from those utilizing other technologies. However, computerized systems are more flexible and variable than previous types of workplace technology; it is therefore not surprising to find variable patterns of implementation. Nonetheless, some trends are observable in the empirical literature.

Reduction in the Hierarchical Division of Labor

In contrast to the specialized division of labor with fine vertical gradations, characteristic of classical bureaucracy and many production workplaces, some researchers have found that computerization has correlated with fewer hierarchical levels and a "two-tier" occupational structure (Baran 1987, Colclough & Tolbert 1992, Kanter 1983, 1984, 1991, Hodson 1985, 1988, Noyelle 1987, Smith 1993, 1996, Wellman et al 1996, Zuboff 1988). Middle-level positions are reduced or eliminated, with a credential barrier typically separating the two sectors of the polarized corporation, with emphasis on external credentialing and recruitment from without (Kanter 1984, 1991, Burris 1983a,b, 1993). This trend appears particularly pronounced in high-tech firms (Kanter 1983, Hodson 1988). However, some observers disagree about whether this reduction in vertical hierarchy is causally related to computerization; Kling (1996a, p. 282) finds that what he terms "delayering" is also found in low-tech organizations and is more related to broader cultural and political changes than to computerization per se.

It appears that the extent and shape of the restructuring of the division of labor are dependent on several factors: the specific type of technology, managerial policies and choices, and the nature of the service or product (Salzman & Rosenthal 1994). When production of goods or services can be standardized and performed largely by the computer system, the workforce is likely to be more bifurcated into skilled technical workers and a smaller number of less skilled production or clerical workers, whereas when computerization is less extensive, the polarization may be less pronounced (Baran 1987, Barley & Orr 1997). With even more extensive computerization, "superautomation," comes a dramatic reduction in the size of the production workforce (Indergaard & Cushion 1987, Office of Technology Assessment 1984, Shaiken 1984).

One corollary associated with this polarization is that the organizational structure becomes less formal. In contrast to conventional bureaucracies, with their clearly defined chains of responsibility and communication channels, restructured bureaucracies rely more on ad hoc teams and task forces (Hodson 1988, Kanter 1983). What has been called an "adhocracy" (Mintzberg 1979) or "matrix organization" (Kanter 1983) emerges in some contexts: organic, integrative, flexible, adaptive, and innovative workplaces with a constantly changing internal structure. For expert-sector workers (managers and professionals), at least, bureaucratic constraints are relaxed to allow for creativity and flexibility (see Burris 1993). Indeed, occupational segregation appears sometimes to be accompanied by a pronounced bifurcation of working conditions. Hodson (1988) found that worker autonomy, input into decision-making, and salaries were dramatically different for high-tech engineers and workers.

A second corollary is that conventional internal labor markets tend to erode, along with mobility prospects for non-expert sector workers (Baran 1987, Hodson 1988, Kanter 1991, Noyelle 1987). External credentialing and promotion from without frequently substitute for in-house training and promotion. In some firms, diminished mobility prospects have translated into impaired worker motivation (Burris 1983a,b, Hodson 1988, Noyelle 1987); some firms have experimented with quality control circles and other worker participation experiments to compensate for the lack of training and mobility opportunities (see Noyelle 1987).

A final corollary of polarization has been the reinforcement of race and sex segregation in some firms (Burris 1989, Cockburn 1985, Colclough & Tolbert 1992, Hodson 1988, Noyelle 1987, Smith 1993). The erosion of internal labor markets has had special implications for women and racial minorities, as the organizational restructuring occurred during the 1970s and 1980s, a period of equal employment legislation and expanding social opportunities. The effect was to thwart legal and social reforms at the organizational level:

> …at the same time that EEO policies were gaining speed, other forces came into play that began weakening the role of internal labor markets across a broad range of industries. Hence a basic dimension of EEO strategy—aggressive internal promotion of women and minority workers—was undermined. Some women and minority workers continued to advance to higher echelons, but their progress became increasingly dependent upon a different set of factors, involving educational credentials. (Noyelle 1987, p. 15–16)

Quantitative analyses have confirmed this race and sex segregation (Colclough & Tolbert 1992, Glem & Tolbert 1987, Kraft 1987, Mahung 1984, Strober & Arnold 1987). More qualitative analyses have also documented the persistence of gender stereotypes that define femininity as antithetical to technical expertise (Cockburn 1985, 1991, Hacker 1989). However, this pattern of gender segregation may be changing; Wright & Jacobs (1994) found that computer support occupations (i.e. jobs that support other people's use of computer systems—computer programmers, systems analysts, computer and systems engineers) became less gender segregated during the 1980s, with all computer support jobs being 36% female by 1991.

Patterns of Centralization and Decentralization

Traditionally, workplaces have been kept highly centralized, but with computerization come opportunities for new patterns of centralization and decentralization. Computerized numerical control (CNC), for example, can be used to facilitate end-user programming and editing (Noble 1984, Shaiken 1984), and personal computers can serve to link relatively autonomous satellite stations or work teams (Kanter 1991, Murphree 1984). However, the same technology

can be used to maintain centralized managerial control and even surveillance (see Office of Technology Assessment 1984, National Research Council 1986). In some contexts, the computer system may assume the form of visible, functional decentralization (e.g. a computer terminal in every office or throughout the shop floor) but with an underlying centralization of control (see Burris 1993, Prechel 1994).

Variable patterns of centralization and decentralization have been documented, as social and political choices interact with technical considerations and system design (Burris 1993, Kling 1996a, Noyelle 1987). Kling (1996a, p. 295–96) discusses two divergent approaches to system design and implementation: "business process reengineering [which] is usually applied by managers and consultants to streamline operations" and increase efficiency, and "sociotechnical systems design," which emphasizes people and their relationships with each other and the technology. The former typically implies more centralizd control, what Clement (1996) calls a "command and control culture," and the latter a more decentralized pattern, and one where end-users sometimes play a substantial role in redesigning their work practices (Kling 1996a, p. 299, Clement 1996). Despite the variable patterns of centralization, however, there is also evidence that traditional centralized patterns are the norm. The National Research Council (1986, p. 150) concludes from its survey of computer automation in diverse white-collar settings that "because innovations can be implemented in broadly different ways, the major determinant of the effects of innovation appears to be management's preexisting employee policies."

Some workplaces have experimented with geographical decentralization in the form of "telecommuting" or "telework." Although currently limited in scope, these experiments are significant and may become more prevalent in the future (Kling 1996a, Wellman et al 1996). A recent report by the Clinton administration (IITF 1994) cites numerous potential benefits from an expansion of telework: reduced automobile pollution and traffic congestion, improved quality of work life, smoother integration of work and family life.

Although research on telework has been limited, some evidence suggests that current telework experiments may also result in teleworkers being less visible to peers, less likely to be promoted, and more difficult to supervise (Forester 1989). Kling (1996a, p. 288) also points out that some employees may lack the self-discipline required to work at home amidst home-based distractions. Olson (1989) in a study of computer professionals working at home full-time found reduced job satisfaction and organizational commitment and higher levels of role conflict. Olson & Primps (1984) found that female teleworkers were particularly likely to assume greater housework and childcare responsibilities and to experience stress deriving from work/family conflicts. Wellman et al (1996) argue that telework may exacerbate workplace bifurca-

tion, for some studies have found that professional teleworkers tend to benefit from computerized social networks and expanded autonomy, whereas clerical teleworkers tend to become more isolated and often more stringently monitored (Olson & Primps 1984).

Telework highlights issues of centralization and control that are also pertinent to computerized workplaces more generally. Computerized systems of production are flexible, although not neutral, and the design of the software is critical. Salzman & Rosenthal (1994, p. 6) in their analysis of software production show in some detail how "technology both shapes and reflects the social matrix of organizations and socioeconomic systems, of which it is a part" and how a new technology can be either "assimilated" into existing organizational structures or "accommodated" by restructuring the organization (1994, p. 23; see also MacKenzie & Wajcman 1985, Thomas 1994). Although there has been a tendency to design and implement computerized technology in a manner consistent with centralized control, this is not inevitable and in fact may lead to organizational contradictions, worker dissatisfaction, and further change (Hirschhorn 1984, Kling 1996b, Noble 1984, Vallas 1990).

CHANGES IN WORKER SKILL

Braverman and the Labor Process Tradition

Braverman's (1974) analysis of Taylorism and the capitalist labor process has been influential for over 20 years, despite some trenchant criticism (Attewell 1987, Friedman 1977, Stark 1980). Braverman analyzed the ways in which scientific management, under the guise of scientific neutrality and objectivity, promoted the interests of capitalist managers (1974, p. 86). Taylor (1913, p. 25) contended that "there is always one method … which is quicker and better than any of the rest. And this one best method … can only be discovered or developed through a scientific study and analysis." Braverman showed how Taylorism was implemented so as to deskill the labor process, separating conception from execution and transferring conceptual skills to technical experts and managers (see Burris in press for fuller discussion).

Braverman discusses computerization, a trend far from widespread in 1974, only in passing and in fact appears to see the logic of computerization as antithetic to the logic of Taylorism and capitalism, due to its potential to "re-unify" the labor process (see Braverman 1974, p. 328). However, neo-Marxist sociologists have often found that capitalist social relations tend to shape technological design so as to make computerization consistent with capitalist and managerial imperatives. Noble (1977, 1979, 1984), for instance, showed how numerical control of machining was chosen and implemented in accordance with capitalist and militarist imperatives toward centralized control (see also Shaiken 1984).

Other empirical studies in the labor-process tradition have also found that deskilling of workers results from computerization of production workplaces. Cockburn (1985), for instance, found deskilling, increased managerial control, and race and sex polarization in her study of the garment industry in England. The case studies in Zimbalist (1979) reveal evidence of deskilling in industries ranging from carpentry to coal mining.

Upskilling and Sociotechnical Design Perspectives

As Attewell (1987, 1992; see also Vallas 1990, 1993) points out, however, a contradiction exists between these qualitative case studies, with their evidence of deskilling, and more aggregate, quantitative analyses of the labor force, which have tended to find substantial upgrading due to an expansion of more skilled occupations (Adler 1988, Baran 1987, Spenner 1983). As Barley & Orr (1997, p. 3) demonstrate, since 1950 the fastest growing occupational group has been professional/technical workers, who comprised 17% of all workers in 1991. Wright & Singlemann (1982) and Barley & Orr (1997) discuss how overall occupational upgrading can coexist with deskilling of specific occupations, as the production workforce becomes bifurcated into skilled technicians and less skilled operatives.

In contrast to the neo-Bravermanian labor process literature, then, other empirical studies have found skill upgrading, "upskilling," to be correlated with computerization. The classic study in this tradition is Blauner's (1964) comparison of automation with earlier types of technology, in which he found that continuous-process operators were upskilled, had more opportunities to learn and grow on the job, were less isolated and often worked in teams, and in general were less alienated than workers in industries with less advanced technology.

The sociotechnical conception of work design (Trist et al 1963) emphasizes that the social and technological dimensions of work organizations must be designed to complement one another and that computerized production systems are capable of being designed so as to expand worker skill and autonomy. Sociotechnical analysts assume that advanced technology, expensive and vulnerable to technical problems, leads to a heightened dependence on operators to ensure productivity, cost-effectiveness, and quality control; therefore, to realize the potential of the technology, decentralization and teams of multiskilled workers who understand the total operation of the plant are needed. Hirschhorn (1984) analyzed the interaction between technology and the social organization of production in firms such as Olivetti, Fiat, and General Foods, and his findings are consistent with sociotechnical analysis: When work was organized around self-governing worker teams and worker learning, the result was better quality products and superior market position, whereas when

worker deskilling and alienation were the norm, workers were unable to effectively monitor and diagnose the complex technological system, making the operation vulnerable to technical breakdown and lost productivity. Hirschhorn & Mokray (1992, p. 16), in their study of a computer manufacturing plant, show how worker "[c]ompetence is shaped through the interaction of a worker's skills with the role he or she performs," making skill upgrading and worker autonomy necessary for optimal production.

Zuboff's (1988) case studies of the computerization of diverse workplaces is also consistent with the sociotechnical perspective. For Zuboff computerization fundamentally transforms skill by making work more "abstract" (see also Barley & Orr 1997, p. 5 ff, Hirschhorn & Mokray 1992, p. 23). Whereas earlier types of production involved manual skills and the interpretation of visual cues, working with computers involves "the electronic manipulation of symbols. Instead of a sensual activity, it is an abstract one" (Zuboff 1982, p. 145).

For Zuboff (1988, p. 9 ff), computerized technology can be implemented so as to either "automate" or "informate" jobs. When the informating strategy is chosen, information about the overall operation of the system is more available to workers, who are therefore able to learn and develop new skills and comprehensive understanding. In practice, however, Zuboff (1988, p. 252) found that such technological potential is often thwarted by managerial reluctance to share information and power: "Managers perceive workers who have information as a threat. They are afraid of not being the 'expert'" (see also Kanter 1983, Noble 1984).

Zuboff's work indicates general upskilling of production work, with the redefinition of jobs around more abstract skill, but limited expansion of worker autonomy. Similarly, Vallas & Beck (1996), in their study of pulp and paper mills, found significant upskilling of the jobs of manual workers as they learned the computerized system, but no evidence of any expansion of worker autonomy or discretion. Instead, they found a persistence of centralized managerial control in conjunction with increased reliance on degreed engineers as supervisors. Barley & Orr (1997, p. 19) found that the "emergent skills" of technical workers are often neither recognized nor rewarded; Creighton & Hodson (1997) found that technical workers in diverse settings were skilled but lacked power and autonomy. Vallas (1993, p. 184) in his study of AT&T found that "while the use of automated systems has at times increased skill requirements, its overall effects on levels of worker autonomy or responsibility have been far less beneficial…"; Iacono & Kling (1996) found that although "dramatic improvements in office technologies … have sometimes made many clerical jobs much more interesting, flexible, and skill rich … these changes, especially those involving increased skill requirements, have not brought commensurate improvements in career opportunities, influence, or clerical salaries" (Kling 1996a, p. 283).

The empirical literature on computerization and skill, then, is somewhat inconsistent and contradictory. Some have preferred to speak of "skill disruption" (Hodson 1988) or "skill restructuring" (Cockburn 1983), thus remaining agnostic on the deskilling vs. upskilling controversy. The more recent empirical work reveals aggregate upskilling, sometimes combined with the deskilling of a small number of jobs (Adler 1992a, Attewell 1992). At least three trends seem pertinent in explaining the increased salience of upskilling: 1. Computerized systems have become more sophisticated, with the development of advanced manufacturing technology and increased reliance on more skilled workers (Attewell 1992, p. 70; see also Hirschhorn & Mokray 1992). 2. The least skilled jobs have been disproportionately eliminated by the technology (Aronowitz & DiFazio 1994, Rifkin 1995). 3. More managers may be choosing to supplement their computer system with skilled workers to maximize productivity (reduce downtime) and quality control (Adler 1992b).

Professional Work

In recent decades professional work has also been transformed as the ideal type of the autonomous, self-employed professional has become the exception rather than the rule. As with other types of work, both empirical findings and conceptualizations of these changes have varied.

Some social scientists have concluded that "deprofessionalization" or "proletarization of the professions" is occurring (Derber 1982, Haug 1973, 1975, 1977, Larson 1977, Rothman 1984). Haug (1973, 1975, 1977), for instance, argues that such developments as rising educational levels among the general population, computerization and greater availability of knowledge, and a growing societal consciousness of the need for professional accountability have contributed to an undermining of professional power and increasing reliance on paraprofessionals. Larson (1977) focuses more on the trend toward professional employment in large bureaucratic organizations and on corporate pressures to maximize profits as leading to a more rigid division of labor, larger professional caseloads, and the routinization and standardization of professional work. She concludes that "technobureaucratic professionalism" results, as "professional status … no longer insures the incumbent against the predominant relations of production in our society" (Larson 1977, p. 233). Derber (1982, p. 21) highlights another dimension of proletarization: professionals' increased difficulty in owning and controlling their own means of production, making them more dependent on large institutions for their survival.

Others have interpreted recent changes in professional work as more consistent with Weberian bureaucratization, rationalization, and formalization. Freidson (1984, 1986), for instance, argues that conceptualizations such as deprofessionalization and proletarization are exaggerated in that professionals

continue to enjoy high status, prestige, and occupational power (see also Derber et al 1990). Computerization may not adversely affect professionals, since "it is the members of each profession who determine what is to be stored and how it is to be done, and who are equipped to interpret and employ what is retrieved effectively" (Freidson 1984, p. 8). Freidson sees the professions as becoming "formalized," as a certain internal stratification into an administrative elite, a knowledge elite, and rank-and-file professionals occurs (Freidson 1986).

Abbott (1988) also focuses upon the increasing systemization and rationalization of the professions and the ongoing redefinition of professional categories and jurisdictional boundaries within the system of professions in recent years owing to technological and organizational changes. Like the deprofessionalization school, Abbott also highlights the "commodification of knowledge," the competition from computerized diagnostic systems, and the ensuing routinization and degradation of some professions (Abbott 1988, p. 126 ff).

Certainly we have seen the creation of many paraprofessional occupations in the last few decades, for instance, in the health care field (McKinlay 1982). Medical diagnostic systems have also been developed, although not widely implemented (Dreyfus & Dreyfus 1986). However, physicians have retained considerable occupational power and workplace autonomy. In fact, some evidence suggests that computerized technology may be enhancing, rather than undermining, the work of the physician (Burris 1993, National Research Council 1986, p. 159).

Similarly, the legal profession and the judiciary have undergone internal stratification and systemization (Heydebrand & Seron 1990, Spangler & Lehman 1982). Heydebrand (1979) speaks of a "technocratic restructuring" of the judiciary in response to a crisis of the judicial system, with increased reliance on computerized data banks, role integration of professional and administrative functions, and more circumscribed and specialized judicial discretion. Others have found that judicial discretion has been enhanced and expanded, even as the judiciary has been reorganized and systematized (Aaronson 1977, Freidson 1984).

Some researchers have found polarization of certain professions. Shaiken (1984), Kraft (1987), and Kunda (1992) all found polarization within the ranks of computer professionals and engineers. Kunda (1992) documents a division between "central" and "marginal" engineers, with cultural normative control characteristic of the central, exempt engineers and more coercive and utilitarian control characteristic of the nonexempt sector.

In sum, it appears that technological changes and other rationalization measures appear to have differential effects on professional work, depending on the relative status of the profession and of the professional within a given profession. Professionals within elite professions may lose a certain degree of

autonomy as they become more integrated into complex administrative systems, but discretion over professional work is generally retained (or even expanded). Ideologically and economically, they may be more subject to capitalist and bureaucratic imperatives, but not deprofessionalized. Less elite professionals and paraprofessionals (health care technicians, nurses, teachers, computer programmers) may be more vulnerable to professional rationalization. In some instances they may be deprofessionalized: their work deskilled, their caseloads increased, their contact with clients routinized. For such workers, professionalism may be little more than a legitimating ideology (see Burris 1993, p. 142 ff).

POWER AND AUTHORITY RELATIONSHIPS

Increased Salience of Technical Expertise

With the increased salience of professional and technical workers, it appears that traditional rank authority is deemphasized in favor of technical expertise (Burris 1993, Ilchman 1969). Kanter (1983, p. 55 ft), for instance, found that in the high-tech firms she studied "traditional authority virtually disappears; managers must instead persuade, influence, or convince" (see also Hodson 1988, Kunda 1992). Burris (1983a, 1993, see also Zuboff 1988) found that "conspicuous expertise" and new forms of politicking, centered around expertise, emerge.

Knowledge and information become important sources of power. Zuboff (1988) found that computer conferencing, along with computerized information generally, was restricted to expert-sector workers through the use of passwords, account numbers, and "closed status" designations. Kraft (1977) found that conflicts over the locus of authority occurred between experts and managers, and that these were exacerbated when managers had limited technical knowledge; similarly, Hirschhorn (1984) found that managers of utility companies were sometimes threatened by engineers' expertise and perceived threats to managerial authority. In other contexts, experts and managers have formed unified coalitions, and conflicts between workers and technical experts have been more common (Burris 1993, Zuboff 1988).

Worker Autonomy or More Stringent Managerial Control?

As we have seen, postindustrial analysts have argued that the fundamental logic of advanced technology is most consistent with increased worker autonomy and democratization (Hirschhorn 1984, Piore & Sable 1984, Zuboff 1988). Conversely, some have found that managerial control has been intensified and extended by computerized systems (Applebaum & Albin 1989, Prechel 1994).

Worker participation experiments have been implemented in many workplaces (Applebaum & Batt 1994, Smith 1996, US Department of Labor 1994);

more ambiguous is the significance of these experiments and whether they are causally related to technological change. Some have found the level of worker autonomy and input into decision-making to be minimal, and the significance of the experiments to be largely ideological, a form of "hegemonic" or "consensual" control (Burawoy 1979, 1985, Hodson et al 1993, Vallas 1993). Smith (1996), however, argues that this interpretation, although not without validity, misses the fact that the low-level white-collar workers that she studied perceived the new system of worker participation to be personally beneficial, promoting the acquisition of social/relational skills and "a new step on a constrained mobility ladder" (Smith 1996, p. 177; see also Hodson et al 1993). Kling (1996a, p. 299) also highlights examples of more significant types of worker participation, where workers reorganized the way in which computerization was implemented so as to create more flexible and less regimented jobs for themselves.

Computerization promotes not only production but also social networking (see Wellman et al 1996 for a good review). Office computers can be used for recreation, private "conversation" with other workers, nonwork friends, or family members, and work-related interaction. In some workplaces, computer-mediated communication, with its diminished social presence and greater anonymity, can be used to cross status and power boundaries, promoting a more democratic type of workplace interaction and culture (Wellman et al 1996, Zuboff 1988). For relatively autonomous computer conferencing and collaborative work, now potentially global in scope, computerization can greatly enhance the work process; as Wellman et al (1996) point out, this computerized augmentation of collaboration is more salient among professionals and academics.

Computerization is also consistent with more sophisticated and intensified systems of managerial control. Zuboff (1988), for instance, found that computerization can be implemented so as to promote centralized managerial control by making workers more visible and vulnerable to supervision, a technologically advanced version of the "Panopticon." Others have addressed the issue of computerized monitoring of workers, although there is little consensus about the extent of this practice (Attewell 1987, Kling 1996a, p. 286 ff, Garson 1988, Marx 1996). Management sometimes monitors not only level of productivity and errors, but also the type of on-line activities to ensure "appropriate" use of the technology (Orlikowski et al 1995, Zuboff 1988).

Prechel (1994) found that the large steel corporation he studied, in response to global competition and economic crisis, has implemented a "neo-Fordist" strategy of "hypercentralization," "hyperquantification," and "formalized control"' (Prechel 1994, p. 737 ff), a system that reduced or eliminated the former autonomy of managers and instituted a sophisticated neo-Taylorist system of production control where the "one best way" of doing something is con-

sistently utilized. Prechel's case study demonstrates how a firm can flatten its hierarchy, utilize the computerized system to achieve functional decentralization and flexibility, yet also strengthen centralized managerial authority over production and decision-making.

Another recent conceptualization of changes in managerial control systems is that of "algorithmic" control (Applebaum & Albin 1989, Vallas 1993), which Applebaum & Albin (1989, p. 252) define as the reduction of "decision-making as much as possible to a set of self-contained rules (algorithms) implementable by a computer." Vallas (1993), in his study of AT&T, shows how management, through algorithmic control, can simultaneously upgrade worker skills and extend managerial control over production by "placing information systems at the directive nodes of the productive circuitry and progressively removing workers to more peripheral locations in the labor process… [so that (in the words of one manager)] 'there are no decisions to be made [by workers]'" (Vallas 1993, p. 187).

Finally, Burris (1993) highlights a neo-Taylorist "technocratic" ideology that rests on the increasing centrality of technical expertise and the assumption that technical and system imperatives have displaced traditional workplace politics: that there is one best technical solution to any problem, which can be found only by technical experts. This ideology, in conjunction with the mystique of computers and a sense of technological determinism and progress, serves to legitimate the power and privilege of technical experts, to obscure existing workplace politics, and to promote consensual control of workers (see also Collins 1979).

DISCUSSION AND CONCLUSIONS

Although the trends discussed above appear to correlate with computerization, causal inference is made problematic by the fact that computerization is embedded in a constellation of factors: the internalization of the division of labor, intensified worldwide competition and a corresponding emphasis on innovation, expanded need (and capacity) to manage complex organizations and systems and to perfect long-range planning. Technology interacts with social preferences and political choices in complex ways, making generalization difficult (Thomas 1994). The challenge is to assess the impact of computerization, avoiding both the Scylla of technological determinism and the Charybdis of technological indeterminism.

While there are many contingencies concerning computerization, there are also observable trends in the empirical literature. This review has revealed the need to separate analytically the three dimensions of the workplace examined here: organizational restructuring, worker skill, and power and authority relationships. One pitfall of existing theories has been the tendency to assume correspondence among these dimensions. Thus, postindustrial analyses have

tended to assume flatter hierarchies, a more skilled workforce, and worker empowerment to be coterminous. Neo-Bravermanian analyses, on the other hand, have tended to assume that more stringent centralization, worker deskilling, and reduced worker autonomy coexist and reinforce one another.

Recent empirical work indicates, however, that these dimensions do not always line up. We have seen, for instance, that technically skilled workers often do not enjoy autonomy or responsibility on the job (Baran 1987, Barley & Orr 1997, Creighton & Hodson 1997, Iacono & Kling 1996, Vallas & Beck 1996, Zuboff 1988). A reduction in levels of hierarchy does not necessarily imply a more egalitarian workplace; delayering appears more often to result in a polarized, "two-tier" workplace and dramatically unequal working conditions between the two sectors (Baran 1987, Colclough & Tolbert 1992, Kanter 1983, 1984, 1991, Hodson 1985, 1988, Noyelle 1987, Smith 1993, 1996, Zuboff 1988). In some workplaces, centralized decision-making, embedded in the computer system, can be combined with a considerable degree of functional decentralization and flexibility (Burris 1993, Prechel 1994). With regard to the deskilling/upskilling controversy, it has become apparent that both trends can coexist, depending on the unit of analysis: aggregate upskilling with some skill bifurcation, some deskilling, and considerable skill disruption (Adler 1992, Attewell 1992, Barley & Orr 1997).

Rather than abandoning the search for general theories about workplace change, we need to search for more complex and nuanced theory, multidimensional and multilevel theory, to understand both the generality and the contingency of contemporary workplaces. The new types of work and organization emerging along with computerization do not readily conform to existing theories, but this does not imply that they cannot be theorized.

In addition to more relevant theory, we also need more objective research. As a subdiscipline, the field of the sociology of work has tended to be highly politicized, with some researchers influenced by managerial perspectives and others by solidarity with workers (see Abbott 1993). In researching computerization, some have taken the situation of expert-sector, professional workers to be generally representative of working with computers and have therefore emphasized the positive side of computerization; conversely, others have focused upon the situation of non-expert sector workers and have therefore emphasized the negative side of computerization (see Burris 1993). Each perspective is partially valid. One salient contingency in assessing the impact of computerization on contemporary workplaces is one's position within an increasingly bifurcated workforce.

Future research in this area needs to analyze more closely the process of technological design and implementation within work organizations so as to better specify the interaction between existing power relationships and computerized systems (Salzman & Rosenthal 1994, Thomas 1994). We need to un-

derstand better not only the impact of computerization on work organizations, but also the impact of work organization on computerization. Only with this more comprehensive understanding can we promote intelligent choices about the workplaces of the future.

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