Information Technology and Occupational Structure

Kenneth C. Laudon
New York University

Kenneth L. Marr
Hofstra University

April 1995

Presented at:
Association for Information Systems
Inaugural AIS Americas Conference on Information Systems
Pittsburgh, PA August 25--27, 1995

Working Paper Series
Stern IS-95-4

Information Technology and Occupational Structure

Kenneth C. Laudon, New York University

Kenneth L. Marr, Hofstra University

A central tenet of much popular and scholarly literature is that computers --and more broadly speaking "information systems"-- bring about significant change in organizations. Some scholars focus on changes in organizational structure-- the division of labor and its coordination through authority and power (Blau, 1976; Danziger, et. al., 1982; Laudon, 1976; 1986; Keen 1981; Kling and Iacono, 1984; Orlikowski and Robey, 1991; Robey, 1981; Walton, 1989; Barley 1986; 1990) . Others focus on IT induced changes in the design of work (Zuboff, 1984; Bikson, et. al., 1985: Kraut, et. al., 1987; Sproull and Kiesler, 1991; Turner, 1984; Iacono and Kling, 1987). Still others have argued that IT significantly alters occupational structure in organizations--the distribution of employment among occupations and skill classes of workers (Braverman, 1984; Kling and Turner, 1987; Berndt, et. al., 1992; Howell and Wolff, 1993; Cyert and Mowry, 1988; 1989). In general, the impact of IT on occupational structure of firms and organizations is a neglected area of empirical research despite the fact that scholars have strong opinions, and convincing theories, about such occupational shifts.

In this paper we report the results of a twenty year longitudinal study of occupational structure in three of the largest and most intensive organizational users of IT in the United States. For benchmarking purposes we also examine occupational change at the aggregate society level and in the federal government sector over a twenty year period. The results of our research question the claim that IT brings about significant change in occupational structure. While the organizations we examine did experience significant change in occupational structure during periods of intense computerization, these changes did not conform to theoretical predictions and they were inconsistent from one organization to another. We conclude that organizational occupational structures are quite stable in the face of massive IT change and claims that IT brings about "revolutionary" changes in organizational structure have little empirical foundation even though there may be isolated cases where such rapid and drastic changes do occur.

Theory and Research on Occupational Structure Impacts of IT

The view that IT transforms organizations and even societies in part by radically altering the mix of occupations is so widespread that it is difficult to find scholars in the IS field who hold even tentative views on the subject. Figure 1 summarizes the views of five major theoretical traditions in the IS literature on the issue of IT and occupational structure change.

In *micro-economic* theories, inexpensive IT capital substitutes for more expensive management, clerical, and blue collar labor in the production function (Solow, 1961; 1958; Arrow, et. al., 1961). According to Drucker, for instance, as firms learn how to use IT, "Almost immediately, it becomes clear that both the number of management levels and the number of managers can be sharply cut. The reason is straightforward: it turns out that whole layers of management neither make decisions nor lead. Instead, their main, if not their only, function is to serve as "relays"-human boosters for the faint, unfocused signals that pass for communication in the traditional pre-information organization." (Drucker, 1988, p. 47). While in the 1950's it was believed that computer controlled machine tools would devastate the blue work force, in the 1980s and 90s many scholars believed that IT would replace middle management and clerical workers.

In research using *transaction cost theory*, IT is seen as reducing the costs of participating in markets (Williamson, 1975; 1981). This has two impacts: firms can now buy in a competitive marketplace those goods and services which heretofore they made in-house; second, the size of the firms labor force can be reduced, especially those middle management ranks (and associated clerical support personnel) who in the past supervised a much larger labor force. As Malone argues: "we expect networks to lead to less vertical integration--more buying rather than making--and to the proliferation of smaller firms," (Malone, 1991, p. 131) and "people lower in the organization can now become enough informed to make decisions more effectively. At the same time, upper level managers can more easily review decisions made at lower levels." (Malone, 1991, 133). The implication of networks for transaction cost theorists is then that lower level workers will have sufficient information and knowledge to become self-managing, and senior managers will now have sufficient computing power to control the labor force without middle managers

Figure 1

Theories about IT and Occupational Structure

Theory	Core Concept	Dynamic	Occupational Structure Impacts
Micro Economic	Production function substitution	IT capital substitutes for expensive labor	Decline in middle managers and clericals
Transaction Cost	Transaction costs in markets	IT reduces market transaction costs	Decline in middle managers and clericals
Agency	Agents, principals and contracts	IT reduces agency costs	Decline in middle managers and clericals
Decision Control Theory	Decision making process and structure	IT replaces humans in the decision making process and structure	Decline in middle management decisionmakers
Institutional Theories	SOPs, politics, culture, social structure, history	IT reflects bureaucratic, political, and cultural forces	Impacts depend of relative strength of social forces. No impacts per se.

or support personnel. IT, and especially IT-based networks, will reduce the need for middle management and clericals in the transaction cost view.

Research using *agency theory* to describe the impacts of IT on organizations focuses on internal management costs. In agency theory, the firm is a nexus of contracts among self interested parties. The contractors are the owners of capital (the principals) and those who actually manage the firm and do the work--the agents. Because agents cannot be trusted, expensive monitoring, litigation, and policy-making mechanisms must be introduced to assure their performance according to the contracts they have struck with principals (Jensen and Meckling, 1976). For IT researchers like Ghurbaxani and Whang (1991), "Modern IT can reduce the costs of communicating information by improving the quality and speed of information processing and management's decision making, leading to more centralized management. At the same time, IT can also provide management with the ability to reduce agency costs through improved monitoring capabilities and performance evaluation schemes, inducing decentralization of decision making." In agency theory, as IT provides more powerful monitoring and communication ability, there should be a net reduction in overall organizational size measured by number of employees, and a decline middle management ranks and their clerical support staffs, which in the past performed the monitoring and surveillance function.[1]

A fourth major stream of IT research is based on *decision/control theory*. When applied to organizations, decision theory attempts to explain an organization's occupational and organizational structure in terms of the nature of decision making faced by the organization (March and Simon, 1958; Cyert and March 1963).

Decision/control theory sees organizations as primarily decision making structures which take in information from the environment to inform the decision making process of managers and others. Occupational and organizational structures arise over time to meet the requirements of decision making and the requirements for information processing in specific environments (Galbraith, 1979; 1983). In order to cope with uncertain environments, organizations build hierarchies, hire specialists and create specialized divisions, and develop an elaborate set of standard operating procedures--tried and true rules which guide organization members. Information is gathered by specialists who pass it along up the hierarchy to a central decision making group (senior management) who, with all the relevant information, and a complete understanding of organization-wide issues, and resources, make optimal decisions in a timely fashion and pass resulting commands down the hierarchy. In order to achieve economies--to keep the communications and information processing costs to a minimum-- standard operating procedures, standard information systems and data definitions, are designed to handle most situations for lower level workers, obviating the need for central decision makers to act or think.[2]

For decision/control theorists, IT has powerful and significant impacts on organizational structure, foremost, and by inference, occupational structure as well.[3] Huber argues straightforwardly that "Computers themselves are used to merge, summarize, filter and even interpret information from single or multiple sources, thus eliminating clerical workers, their managers, and the organizational units of which they are a part. These observations suggest that use of computer-assisted information processing and communication technologies would lead to elimination of human nodes in the information processing network." (Huber, 1990, p. 25). Leavitt and Whistler (1958), in very early research,

predicted that computer based systems would centralize information and decision making power in senior management, eliminating many middle managers. Continuing in this tradition, Applegate and Cash (1988) described two cases of organizational restructuring, and concluded that within weeks of installing a new system, 40% of management in one company was terminated: "...a sophisticated, on-line executive information systems was developed. It did the work of scores of analysts and mid-level managers who responsibilities had been to produce charts and graphs, communicate this information, and coordinate operations with others in the company. " In this and other examples, Applegate et. al. argue that "the companies reduced the number of middle managers, and the computer systems assumed many of the communication, coordination, and control functions that middle managers previously performed" (p. 129).

The last theoretical tradition to consider are *institutional theories*. The theories we have described so far are all deductive: they begin with a few simple principles and deduce how the real world should behave when information technology is introduced. Institutional theories are generally inductive: they begin with empirical descriptions, observations, and historical narratives of real-world organizations and actors, and then inductively arrive at generalizations about how information technology in fact has affected organizational design and operation. From there it is a short step to predicting how future IT investments may impact organizations in the future.[4]

Institutional theories attempt to explain changes in occupational and organizational structure (as well as other organizational behaviors) as a direct result of the internal constituent forces resident inside organizations and external environmental factors to which the organization must respond and which the organization to some extent shape (Giddens, 1979). Organizations --in the neo-institutional view of contemporary sociology-- shape their environments by creating institutions as much as they reflect them (DiMaggio and Powell, 1983). Economic factors, the need to "be rational", are important factors, but not determinative (Laudon, 1986b). Non-economic factors--history, politics, bureaucracy, and culture-- which form the theoretical basis of reference disciplines like sociology, political science, psychology, anthropology, receive most attention.

In IT-related research, institutional researchers have concluded that "information systems do not cause structural changes in organizations," and that "Structural change may or may not accompany system implementation. When it does, the changes in structure appear as consistent companions to either rational management objectives, political strategies, or both." (Robey, 1981: 686). The impacts are co-produced by the organization's politics, bureaucracy, culture, and random behaviors, along with other environmental pressures produced by government, stockholders, management fashion, institutional ideologies, and general cultural expectations (Clement and Gottlieb 1987; Orlikowski and Robey, 1991; 1992). Technology is one factor in the production of "social impacts," but there is a large measure of managerial choice and decisionmaking, along with other non-choice social factors. Information technology per se imposes no necessary consequences (Laudon, 1974; 1986).

These results are replicated in a very large number of other studies, in a wide variety of situations, over many years (Laudon, 1974; Kling 1980; Kraemer, et al.). Other work in this tradition is much more deterministic, emphasizing the implacable influence of prior historical features and environmental forces. Kling's study of a welfare agency (1974), King and Kraemer's study of computing in local government (1985), and Laudon's (1986) study of computing at the FBI all paint a picture in which macro level environmental forces are operating to play a large--but not necessarily deterministic-- influence over the direction of computing and any social impacts which may result. (See also Danziger, et. al., 1982 and Laudon, 1974). More recent multi-national research documents the significance of institutional forces in shaping the pace and depth of IT innovation (King, et. al., 1994).

Institutional theorists predict therefore that the impact of IT per se on organizational and occupational structure will appear random. It is only by taking into account internal factors like chance, politics, culture, and bureaucratic features of the organization, as well as external institutional pressures, that computer impacts can be adequately described or predicted, and that patterns can be established.

IT and Occupational Structure: Empirical Evidence

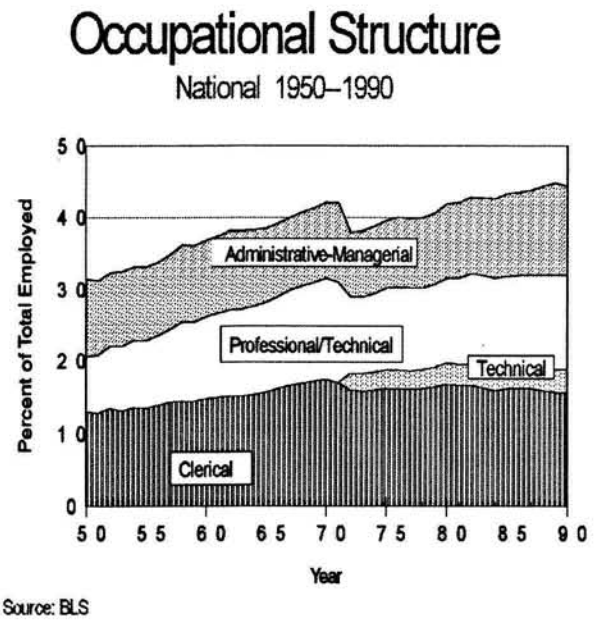
Most of the research relating IT to occupational structure is based on one or several case studies (Applegate, et. al. 1988; Clement and Gottlieb), pure theory supported by anecdotes (Malone et. al.; Drucker, 1988; Huber 1990). Economists have performed more systematic empirical research but often tangential to the topic of specific occupations and focusing more educational levels and capital investment. Griliches (1969) found that educated labor-- including managers and clericals--are complementary to rather than a substitute for certain kinds of modern machinery. Hi-tech investment then should lead to higher levels of managerial and clerical employment. Similar evidence for manufacturing industries was reported by Berndt and Christensen (1974) and by Morrison and Berndt (1981) who found that white collar workers and physical capital are complementary. Finally, in a study of two-digit U.S.

Figure 2

Year	Percent of Total Employment			
	Clerical	Tech.	Prof.	Manager /Admin.
1950	13.0	.	7.6	10.9
1955	13.5	.	9.3	10.4
1960	14.8	.	11.4	10.7
1965	15.7	.	12.5	10.3
1970	17.4	.	14.2	10.5
1975	16.2	2.5	11.5	9.4
1980	16.8	2.9	11.9	10.3
1985	16.2	3.0	12.7	11.4
1990	15.6	3.2	13.2	12.4

Source: Bureau of Labor Statistics

Figure 3



Source: BLS

manufacturing industries, Berndt et. al. (1992) found that investment in hi-tech capital was correlated with growth in white collar, non-production workers. The general view among empirical economists is that innovations in technology increase demand for better educated workers--white collar workers like middle managers and clericals--because better educated workers have a comparative advantage in implementing new technology (Bartel and Lichtenberg, 1987). This research runs directly counter to the case studies of Braverman (1974) and others who believed hi-tech capital investment would lead to a de-skilled work force.

But these empirical findings from economics are hardly decisive. Economists tend to be interested in the fate of white collar vs. blue collar workers, and the impact of education on wages and employment. There is no evidence on what happens to in-place managers and clericals when IT is rapidly expanded in existing white collar organizations, the kind of organizations which make up 70% of the gross national product. It is precisely in white-collar, knowledge and information-based organizations that we should be focusing our attention at this time.

Below we present empirical evidence on the relationship between IT and occupational structures. We begin by looking first at occupational change in the overall U.S. economy in the period 1970-1990. This provides a benchmark and a picture of the larger environment within which we can understand more subtle changes in specific industries and organizations. Second, we examine briefly the overall nature of occupational change in the U.S. Federal government in the period 1970-1990. Third, we examine the detailed occupational structure changes which occurred in three federal agencies in the period 1970-1990 during a period of intense computerization. Last, we carry the analysis a step further by examining the impact of intense computerization on specific micro-level occupations directly involved in computerization.

Occupational Change in the U.S. Economy 1950-1990

This section describes the trends in the national occupational structure for the period 1950-1990. The focus is on occupational groups that are most similar to the occupational groups in the three agencies described later. Since "Sales"' is obviously a group that has essentially no federal government equivalency, this group is not included in these tables and charts.[5]

Figures 2 and 3, show the aggregate level changes in white collar occupations as a percentage of the national labor force from 1950-1990. During this period, the U.S. experienced the most intense growth in installed computer base of any society on earth. One would suspect that if IT leads to occupational structure shifts away from managerial and clerical work, that surely in this period one could easily observe such impacts.

Except for a blip in 1972 resulting from a re-classification of occupations by the Bureau of the Census, the trends for the period 1950-1990 are unmistakable: the distribution of employment in the U.S. during this period shifts towards clerical, technical, professional and managerial groups. Discounting the reclassification in 1972, managerial occupations increased from 10.9% to 12.4% of the labor force, and clerical occupations

Figure 4

Change in Selected National Occupational Groups: 1974--1991

Year	National Total	Clerical	Technical	Professional	Managerial/ Admin.
1974	86,794,000	13,870,000	2,096,000	9.5707,000	8,119,000
1991	116,877,000	18,334,000	3,794,000	16,058,000	14,954,000
Percent Change	34.7%	32.2%	81.0%	68.9%	84.2%
Annual % Change	1.8%	1.7%	3.7%	3.1%	3.7%

Table Notes:

1. Percent change: $(value_{1991} - value_{1974})/value_{1974}$
2. Annualized Percent change $\sqrt[17]{value_{1991}/value_{1974}} - 1$

increased from 13% in 1950 to 16.8% in 1980 and then declined to 15.6% by 1990. Professional workers nearly doubled and technical workers also expanded.

Figure 4 shows these changes over the period 1974--1990. This period was selected in order to make comparisons with the most reliable federal data introduced later which was not collected prior to 1974. Also the period 1974-1990 is more interesting because computerization was especially intense in this period when compared to, say, the 1950s or early 1960s. As Figure 4 illustrates, managerial employment grew at a whopping 84%, more than twice the rate of growth in overall national employment. Clerical employment grew at a slower rate than total national employment while the professional and technical groups grew at twice the overall national average job

At the aggregate societal level then, we see little evidence over long periods of time that intense computerization is reducing the share of managerial and/or clerical jobs in the U.S. economy. On the contrary, managerial job growth has been spectacular in the forty year time span 1950-1990, a trend which continues into the latest census reports which show managers now constituting 12.6% of the labor force.[6]

Occupational Change in the Federal Government 1974-1991

Aggregate data on the entire U.S. economy can muffle impacts of technology which is applied not to whole society, but to specific sectors. Early computing technology, for instance, was developed within the federal government to administer defense programs and social

Figure 5

Change in Federal Employment
By PATCO Occupational Groups: 1974--1991

Year	Occupational Groups					Total
	Professional	Administrative	Technical	Clerical	Other	PATCO
1974	283,464	340,432	257,959	441,268	107,475	1,430,598
1991	434,797	527,269	373,973	330,638	43,863	1,710,864
Percent Change	53.39%	54.88%	44.9P7%	-25.07%	-59.19%	19.59
Annual % Change	2.55%	2.61%	2.21%	-1.32%	-2.77%	1.06

Table Notes

1 Percent Change is calculated as $(value_{1991} - value_{1974})/value_{1974}$

2 Annualized Percent Change is calculated as $\sqrt[17]{value_{1991}/value_{1974}} - 1$

security and revenue collection functions. In the private sector, the financial services sector (banking, insurance, and real-estate) has historically been the most intense user of IT, followed by the telecommunications sector. Today, the single largest purchaser of computing equipment remains the U.S. federal government. If IT has occupational impacts, one would suspect they would be visible in data on federal government employment during a period of intense computerization.

Figures 5 and 6 show the absolute growth and relative share of the federal government labor force using the PATCO classification schema devised by the Office of Personnel Management. In this schema appropriate to a white collar labor force, occupational groups are classified into professional, administrative,

Figure 6

Change in Share of Federal Employment By Occupational Groups: 1974--1991

Year	Prof	Admin	Tech	Clerical	Other
1974	19.8%	23.8%	18.0%	30.8%	7.5%
1991	25.4%	30.8%	21.9%	19.3%	2.6%
Change in Share	+5.6%	+7.0%	+3.9%	-11.5%	-4.9%

technical, clerical and ther categories. This schema is used in the remainder of the paper.[7]

Figures 5 and 6 clearly show that clerical employment has decreased in the time period, while professional, technical and administrative employment have increased. In a period when total federal employment increased by 19.6%, clerical employment declines 25% administrative (management) occupations have expanded the most rapidly followed by professional and technical groups (Figure 5). Clerical employment has decreased both as a percentage share and also in absolute numbers falling from 31% (441,000 jobs) to 19% (331,000 jobs) (Figure 6).

All of the decline in clerical employment cannot be attributed to intensive use of IT. Some of the 110,000 clerical jobs "lost" in this period were in fact re-classified into higher paying "technical" titles. It is not known how much of the decline in clerical jobs were absorbed by growth in technical jobs, but based on interviews as many as half of the clerical workers were reassigned in this period to technical categories. Some clerical work was outsourced--especially in the Reagan era (1980-1988).[8] As in the private sector, outsourcing makes it extremely difficult to track the impacts of any policy or technology because management and clerical costs can be hidden under new budget categories.

The shifts in the occupational structure of the Federal government mirror those in the national occupational structure. Figure 7 compares the rate at which equivalent Federal and national occupational groups have increased in the 1974--1990 period. The graph in Figure 8 shows

Figure 7

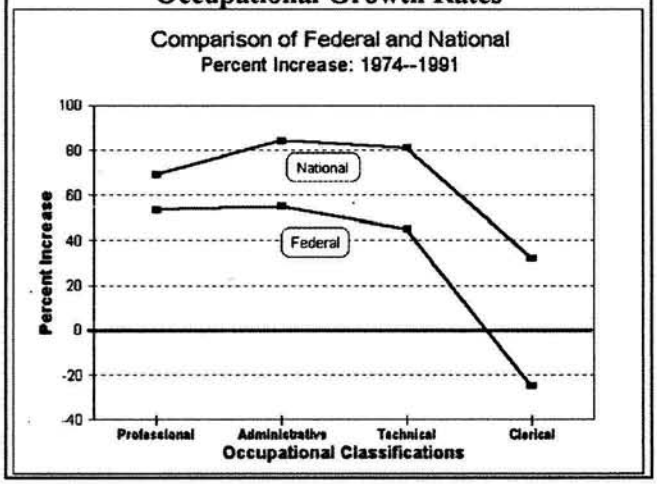
Comparison of Occupational Growth Rates: Federal and Equivalent National Occupational Groups

Occupational Group	% Increase	
	Federal	National
Professional	53.4%	69.0%
Administrative	55.0%	84.2%
Technical	45.0%	81.0%
Clerical	-25.1%	32.2%
Overall	19.6%	34.7%

these similarities even more strongly.

Despite the many significant ways that Federal government work differs from the rest of the national

Figure 8
Occupational Growth Rates



economy, the overall changes in occupational structure are quite similar. Managerial, professional and technical occupations expanded rapidly as a share of the labor force for both the private U.S. economy and the federal government in the period 1974-1991. Clerical positions in the private sector expanded about as fast as the overall expansion in employment, although in the federal sector clerical positions lost share.

Looking at the federal government data overall in the period 1974-1991 we find contrary indications for the relationship between IT and occupational structure. Contrary to the predictions of many theories, the administrative/management occupations increased despite that fact that the federal government is a far more intense user of computing equipment than the general economy, and despite the intensity of federal government

computerization during this period. However, clerical workers did actually decline in the federal sector, while continuing to grow in the private sector at the average growth of the U.S. labor force (32%).

Occupational Change in Three Computer-Intensive Organizations 1974-1991

The Social Security Administration (SSA), the Internal Revenue Service (IRS), and the Federal Bureau of Investigation (FBI) are among the largest and in some areas the most sophisticated users of information technology in the civilian economy of the U.S. SSA began developing automated large file handling techniques with IBM as early as 1940; the FBI began using digital computers in the mid 1950s. The IRS began using digital computers much later, in the early 1960s. SSA employs 65,000 workers to maintain earnings data on over 200 million American citizens who are current or former labor force participants, distributes 40 million checks each month, and administers a number of complex, earnings based social welfare programs the largest of which is the Old Age and Survivors Insurance program. SSA maintains a centralized organizational structure established in 1936, including a large centralized mainframe-based data center in Baltimore, Maryland, connected via satellite to 10 regional centers and 1300 local SSA offices throughout the country. Following the near collapse of its data processing systems in the late 1970s, SSA began a $2 billion program to rebuild its systems and re-design its organizational and work processes (SSA, 1994; OTA, 1986).

IRS employs 120,000 workers to maintain earnings data on 200 million working Americans and 4.4 million other reporting entities, and to administer the tax laws of the United States. IRS maintains a centralized organizational structure originally established in the 1920s including a large centralized mainframe data center in Martinsburg, Virginia, connected via a variety of telecommunications links to 10 regional service centers where paper tax returns are initially processed into computer tapes which are then transported physically to Martinsburg. Despite massive increases in computer processing power, by most accounts the IRS administrative systems neared collapse in the late 1980s. IRS systems have changed little since the early 1960s except for hardware upgrades, and the system is at the limits of its performance capability. The IRS is currently engaged in a $6-8 billion modernization program. (National Research Council 1992; GAO 1990).

The FBI employs 24,000 workers to investigate violations of federal statutes and provide criminal investigation and criminal history records to 58 local FBI offices and more than 64,000 state and local police agencies in the US. The FBI maintains a centralized organizational structure established in 1934, including a large centralized mainframe based data center in Washington D.C. (supported by three regional processing centers). The FBI maintains a database of over 200 million fingerprint records on civilians, and armed forces personnel, 86 million of which are criminal histories. 10 million of the criminal history records are fully computerized at the National Crime Information Center along with a variety of stolen property and warrant files. About 500,000 transactions per day are processed at NCIC. The FBI is currently engaged in a $100 million upgrade (NCIC 2000) involving significant enhancements to the central database and installation of 64,000 terminals around the country (U.S. Department of Justice, 1993).

Data

The findings reported in this section are based upon a larger study of long term historical trends in information processing at the three agencies in the period 1940-1994. The study is based on 155 interviews with agency management, users, and vendors at federal, state and local levels in the period, General Accounting Office investigators, members of Congress, and Congressional staff in the period 1985-1994. In addition we gathered detailed quantitative data from a variety of private, federal agency, federal budget, and Congressional documents on the following variables:

Employment: Total employed data is from Historical Statistics, Statistical Abstract of the U.S.; agency employment levels 1940-1990 are drawn from the Federal Budget (Office of Management and Budget); detailed occupational data for the period 1974-1991 are drawn from Central Personnel Data File maintained by the Office of Personnel Management who provided precise counts by occupational titles (over 600 titles exist) and PATCO categories for the five year intervals 1973, 1978, 1983, and 1988. This data was further supplemented and enriched by data obtained under the Freedom of Information Act by TRAC (Transactions Records Access Clearinghouse, Syracuse University). This detailed database provided us access to occupational and career data down to the level of individual employee for the years 1974-1991 [9].

Installed computer base: Detailed data on specific installed mainframe and mini computer machines, capacities (MIPS), and manufacturer. This data was gathered from GSA (General Services Administration Annual surveys, interviews, and agency reports).

Only the analyses concerning IT impacts on occupational structure are reported here. The analysis is limited to the period 1970-1990 because this period contains the most precise data, and it is the period of

intensive investment in IT. Forthcoming papers describe productivity impacts, patterns of IT budgetary growth, and patterns of technological advancement and diffusion.

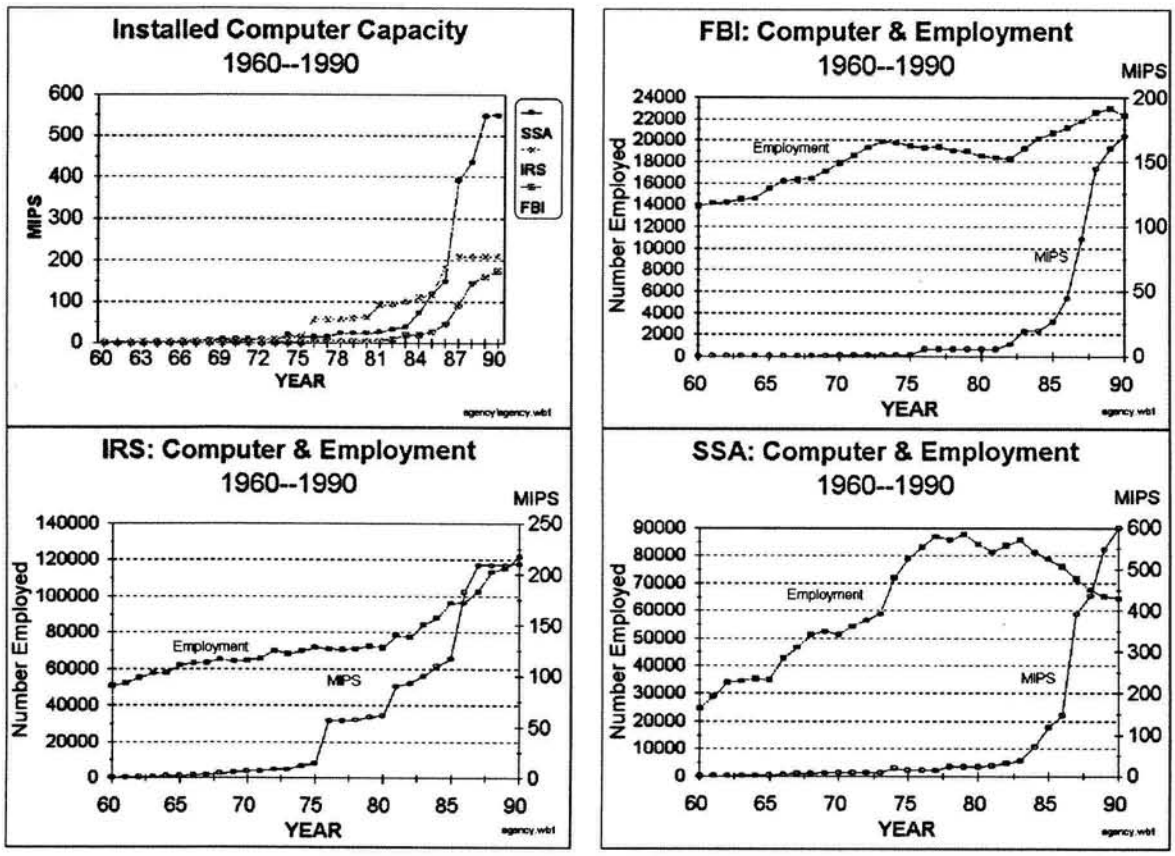
Intensive Computerization and Aggregate Employment Levels

Figure 9 summarizes the overall situation of the three organizations in the period 1960-1990. Beginning in the mid 1970s, each of the agencies entered a period of growth in installed mainframe computer base (measured in MIPS--millions of instructions per second). [10] These trends accelerated into exponential growth beginning in the 1980s. One agency, Social Security, had achieved an installed base in 1991 of roughly 65 times its 1980 installed base. The rapid growth of computerization in these agencies had many origins. The Reagan Administration in this period adopted a policy of computerization as an alternative to federal employment growth and as an expression of its "government as business" ideology, an inheritance of the Progressive tradition of good government. The systems at SSA were using code designed in the 1960s and many of its major applications in 1980 were literally breaking down for lack of computing capacity (OTA, 1986). IRS faced a similar situation. At the FBI computerization was more moderate but steady throughout the decade as it continued to expand on its policies of using nation-wide computer surveillance systems to apprehend criminals.

Aggregate employment at the IRS and FBI exhibited steady growth during this period (Figure 9). Both the FBI and IRS faced a favorable political climate in this period. As a collector of revenue in a government perpetually in deficit, the IRS was especially appreciated by both the Congress and whatever president was in power. This remained true throughout the period despite continual failures in computer system functioning. (GAO, 1990). The FBI had recovered from the loss of its aging leader, J. Edgar Hoover, and received wide-spread support from both the Congress and the President as the only federal agency that could "do something about crime" (Laudon, 1986).

At SSA, opposite political conditions obtained. SSA spends money--roughly 45 million checks worth $26 billion are sent out each month. As a major budget burden, SSA historically is under close observation by

Figure 9
Installed Computer Capacity and Employment



Presidency of Ronald Reagan, SSA found it had few supporters at the White House. During the period, employment rapidly expanded to over 80,000 until 1984. After 1984, SSA employment began a steady drift downwards to current levels of around 65,000. The reason for the abrupt decline in SSA employment was an arrangement among powerful institutional forces involving the Office of the President, Congress, and SSA management and unions (see Laudon and Marr, 1994). In return for huge investments in computer hardware, both Congress and the White House demanded a 25% cut in SSA employment.

Occupational Structure Changes 1974-1991

Figures 10-13 show the changes in occupational structure at the three organizations SSA, FBI, and IRS. For the IRS and SSA we have annual changes in detailed occupational titles, while for the FBI we have data in five year intervals. Figure 10 presents the information numerically, and Figures 11-13 present the same information in graphic form.

At the IRS, where computerization was more

Figure 10

IRS TRAC data by PATCO

	1975	1990	DIF
Prof	21.1%	16.8%	-4.3%
Admin	32.7%	23.0%	-9.7%
Tech	19.7%	29.0%	9.4%
Cleric	24.9%	31.1%	6.1%
Other	1.6%	0.1%	-1.5%
Total	100.0%	138.4%	38.4%

SSA TRAC data by PATCO

	1975	1990	DIF
Prof	1.8%	2.7%	0.9%
Admin	58.4%	52.6%	-5.8%
Tech	9.0%	18.2%	9.2%
Cleric	28.5%	26.2%	-2.3%
Other	2.3%	0.3%	-2.0%
Total	100.0%	100.0%	0.0%

FBI OPM_5yr data by PATCO

	1973	1988	DIF
Prof	0.1%	0.9%	0.8%
Admin	53.3%	51.6%	-1.7%
Tech	5.1%	16.8%	11.7%
Cler.	41.4%	30.6%	-10.8%
Other	0.1%	0.2%	0.1%
Total	100.0%	110.8%	10.8%

Figure 11

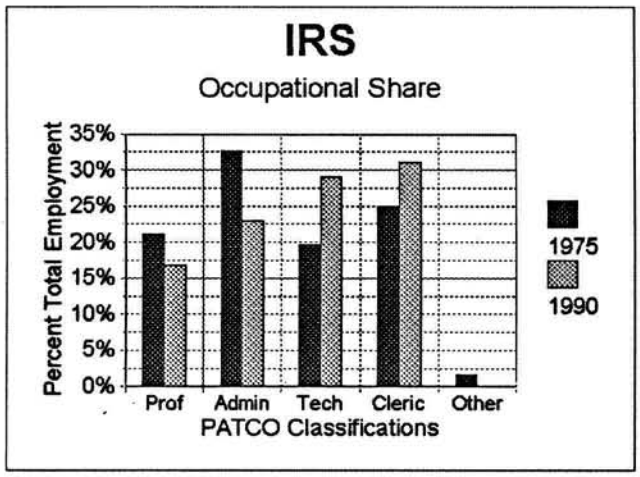


Figure 12

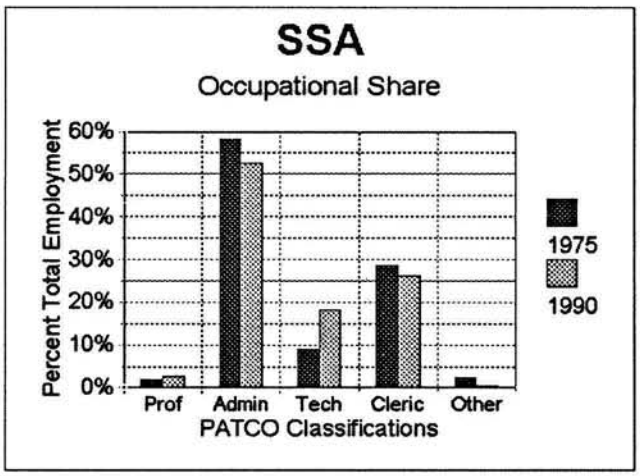
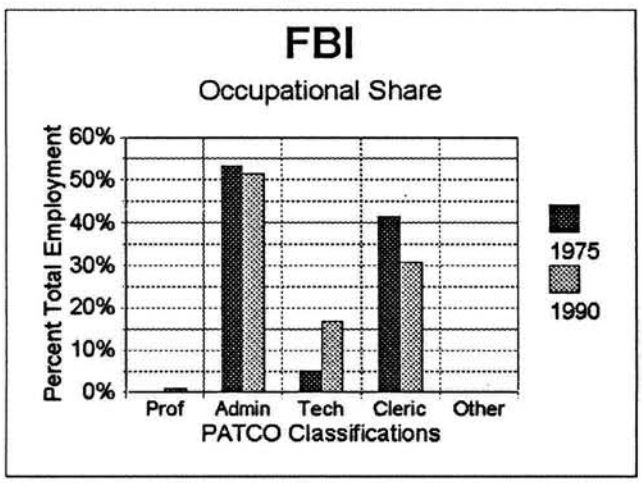


Figure 13



moderate (when compared to SSA) and there was no little external pressure to re-organize or become more efficient, the clerical employment expanded by 6%, while managerial workers declined by 10% during a period when overall IRS employment went up by 38%

At SSA, which experienced the most profound change in both computer intensity and great pressure from its organizational climate to re-organize into a more efficient organization, there was a 2% decline in clerical, and a 6% decline in managerial employees during a period when overall SSA employment declined by 17%.

At the FBI, where as at the IRS computerization was moderate and the environment supportive, clerical positions declined 11% and managerial positions 2% during a period when overall employment expanded by 11%.

Comparing these three agencies over a period of 15 years during which intense computerization efforts were underway we conclude that only very modest changes in occupational structure occurred. Even in organizations which undergo extremely high levels of computerization (SSA with a 65 fold increase), the amount of occupational structure change is unexpectedly small. A part, perhaps as much as 50%, of the observed shift in occupational structure is due to reclassification of workers.

In all three organizations, administrative/managerial workers fell by modest amounts (10%, 6%, and 2%). In two of three organizations clerical workers fell (2% and 11%), while in a third agency clerical workers expanded by 6%. At best one could argue there is some support for the hypothesis that computerization leads to declines in managerial and clerical employment, but the changes, even under unusually intense computerization periods, are not striking and must be understood within the overall environment of the organization.

[We do not report tests of statistical significance here because the data is population data and virtually any difference observable is statistically significant. The issue is the magnitude of change not its statistical significance].

A Closer Look: Micro Occupational Changes

Relying on broad occupational categories is efficient but perhaps blinding at the same time. These broad aggregates tell us little about fast-growth occupations and fast-shrinking occupations in periods of intense computerization. To get a closer look at fine-grained changes in the labor force during this period we divided the labor force into three categories:

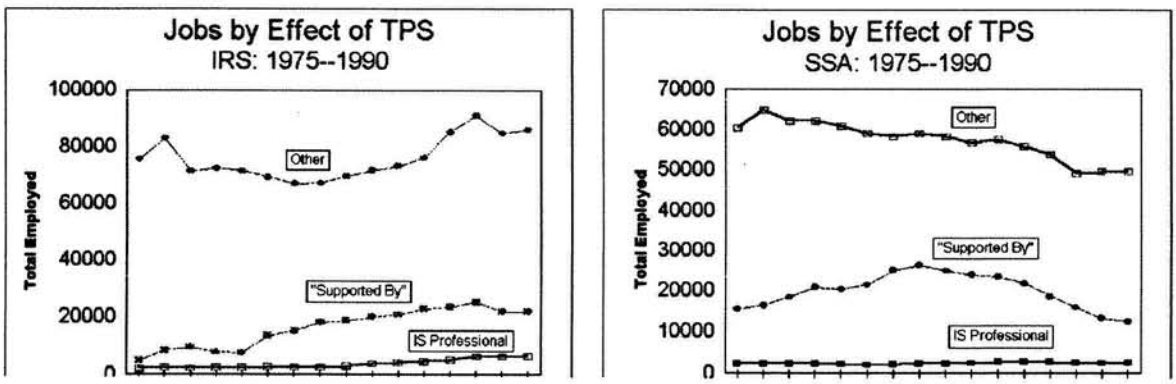
Hi-Tech Support Workers: in each agency we identified occupational titles which are directly involved in the support of transaction processing systems of the sort operated by these organizations. Job titles like mail and file clerks, data transcribers, voucher examination, budget clerical assistant, bookkeeping machine operation, and coding technician. We hypothesized that these occupations would decline as more advanced systems replaced the need for human computer operators and support personnel.

IS Professionals: in each agency we identified a set of occupational titles which would be required to install and implement the transaction systems built during this period. Titles like computer operator, computer specialist, equipment specialist, communication relay operations, computer clerk, systems analyst, programmer analyst, communication management, and system administrator. We hypothesized that these occupations would grow with intense computerization.

Other: all other occupational titles which are unlikely to be directly effected by the type of mainframe transaction systems being installed, including middle management, support staff, senior management, and professional case workers and investigators. We hypothesized that these occupations remain largely unaffected by computerization.

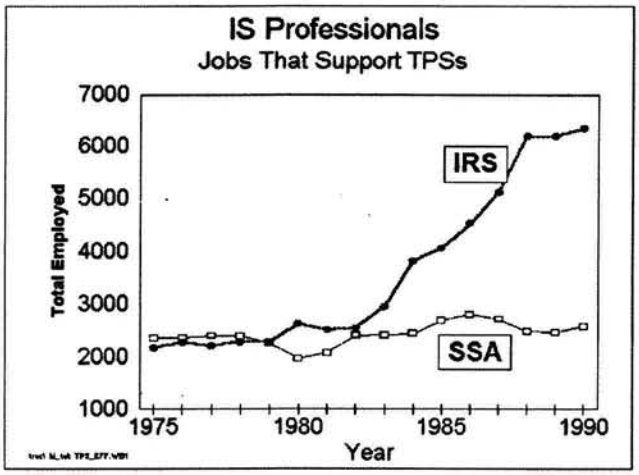
Figures 14 and 15 shows the results of this analysis for the IRS and SSA (the only agencies for which we had sufficiently detailed data). At SSA we see that Hi-tech support jobs rose in the 70's and early 80s to a high of 26,000 jobs and then went into a massive decline in the

Figure 14



late 80s down to 12,500. IS professionals expanded only slightly at SSA which is surprising given the huge increase in systems capacity. But also note that the Other category--those thought least likely to be affected by

Figure 15



systems improvement-- declined at SSA.

At the IRS, a different picture emerges. Here all jobs experienced growth despite significant computerization efforts. IS professional employment tripled as expected (Figure 15). By 1987 there appears to be some modest fall in Hi-Tech workers.

The results of this more fine grained analysis are therefore mixed. In one organization agency facing a budget ax, SSA, Hi-Tech occupations involving work of the sort easily replaced by advanced mainframe TPS systems certainly declined by 50%. But this occurred when employment at the organization overall declined by 25%.

At the IRS, an organization facing a similar production function [11], using similar technology, but facing a different external environment, intense computerization seems to have had little detrimental effect on "IT sensitive" jobs.

Conclusion

We have found that the relationship between information technology and occupational structure is far more complex and varied than heretofore imagined or theorized. At the aggregate level of the national economy, investment in IT seems to be complementary to managerial and clerical employment, and not a substitute for such employment. The reason appears to be that highly educated managerial and clerical workers are needed to design, implement, operate, and maintain advanced technology systems of all kinds. Within the federal sector, IT investment appears to be complementary to managerial employment and perhaps slightly substitutive of clerical employment (although the effect is quite small). At the organization level in our data, intense computerization shows small substitutive impacts for managers, but mixed results for clerical workers. At the micro-occupational level, the impact of computerization has mixed and variable results.

Our data are hardly definitive on the issue of IT and occupational structure. However our data should give caution to assuming a solid relationship between IT and occupational structure exists. The notion that middle managers are simply signal processors who can easily be replaced by workstations is simply unfounded and grossly misleading.

In general, we have found that knowing the nature and intensity of an organization's computerization efforts is by itself a poor predictor of that organization's occupational structure now or in the future. Many other factors mediate the relationship between IT and occupational structure. Chief among these other factors are management strategy, organization culture, pre-existing occupational structure, and surrounding environmental pressures.

References

Applegate, Lynda M., Cash, James, Jr., and Mills, D. Quin, Information Technology and Tomorrow's Manager, *Harvard Business Review*, November-December 1988, 128-136.

Arrow, K. J., and H.B. Chenery, B.S. Minhas, and R.M. Solow, "Capital-Labor Substitution and Economic Efficiency," *The Review of Economics and Statistics*, Vol. XLIII, No. 3, August 1961.

Attewell, Paul, "Technology Diffusion and Organizational Learning: The Case of Business Computing," *Organization Science*, Vol. 3 (1) February 1992.

Barley, S., "Technology as an Occasion for Structuring: Evidence from Observation of CT Scanners and the Social Order of Radiology Departments," *Administrative Science Quarterly*, (1986), 31, 78-108.

Barley, S., "The Alignment of Technology and Structure Through Roles and Networks," *Administrative Science Quarterly*, (1990) 35, 61-103.

Bartel, Ann P., and Frank R. Lichetenberg, "The Comparative Advantage of Educated Workers in Implementing New Technology," *Review of Economics and Statistics*, 69, 1, February 1987, 1-11.

Berndt, Ernst R., Catherine Morrison, and Larry S. Rosenblum, "High-Tech Capital Formation and Labor Composition in U.S. Manufacturing Industries: An Exploratory Analysis," Working Paper, Alfred P. Sloan School of Management, WP #3414EFA, 1992.

Berndt, Ernst R., and Catherine Morrison, "High-Tech Capital Formation and Economic Performance in U.S. Manufacturing Industries: An Exploratory Analysis," Working Paper, Alfred P. Sloan School of Management, WP #3419EFA, April 1992.

Bikson, Tora and Cathleen Stasz, and Donald Mankin, "Computer Mediated Work. Individual and Organizational Impact in One Corporate Headquarters," Santa Monica, California: Rand Corporation, R-3308-OTA, November 1985.

Blau, Peter M., Cecillia McHugh, William McKinley, and Phelps Tracy, "Technology and Organization in Manufacturing," *Administrative Science Quarterly*, v. 2 (March 1976).

Braverman, Harry. Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century. New York: Monthly Review, 1974.

Cash, J. I., and Benn R. Konsynski, "IS Re-Draws Competitive Boundaries," *Harvard Business Review*, March-April 1985

Cyert Richard M. and James G. March, *A Behavioral Theory of the Firm*, Englewood Cliffs, New Jersey, Prentice Hall, 1963

Cyert, Richard M., and David C. Mowery (eds), Technology and Employment: Innovation and Growth in the U.S. Economy. Committee on Science, Engineering, and Public Policy, National Academy Press, 1987.

Cyert, Richard M., and David C. Mowery, *The Impact of Technological Change on Employment and Economic Growth*. Ballinger Publishing Co., 1988.

Cyert, Richard M., and David C. Mowery, "Technology, Employment and U.S. Competitiveness," *Scientific American*, May 1989.

Danziger, James N., and William H. Dutton, Rob Kling, and Kenneth Kraemer, *Computers and Politics--High Technology in American Local Governments*, New York: Columbia University Press, 1982

DiMaggio, P.J., and W.W. Powell, "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," *American Sociological Review*, 48 (1983), 147-160.

Galbraith, J. R. , *Organization Design*. Reading, MA: Addision Wesley, 1979.

Galbraith, J. R., *Designing Complex Organizations*, Reading, MA: Addison Wesley, 1983.

General Accounting Office, Tax System Modernization. Washington D.C.: GAO, December 1990.

Ghurbaxani, Vijay and Kemerer, Chris F., "An Agent Theoretic Perspective on the Management of Information Systems," *IEEE*, 1989.

Ghurbaxani, Vijay, and Whang, Seungjin, "The Impact of Information Systems on Organizations and Markets," *Communications of the ACM*, January, 1991.

Giddens, Anthony, *Central Problems in Social Theory: Action, Structure and Contradiction in Social Analysis*, University of California Press, Berkeley, CA, 1979.

Griliches, Zvi, "Capital-Skill Complementarity," *The Review of Economics and Statistics*, 51:4, November 1969, 465-468.

Hammer, Michael and James Champy, *Reengineering the Corporation*, New York: HarperCollins, 1993.

Howell, David R., and Edward N. Wolff, "Changes in the Information Intensity of the U.S. Workplace Since 1950: Has Information Technology Made a Difference?", C.V. Starr Center For Applied Economics, New York University, March 1993. RR 93-08.

Huber, George P., A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making, *Academy of Management Review*, vol. 14, No. 1, January 1990.

Huber, George P., The Nature and Design of Post-Industrial Organizations, *Management Science*, vol. 30, No. 8, August 1984, 928-951.

Iaconono, Suazanne, and Rob Kling, "Changing Office Technologies and Transformations of Clerical Jobs: A Historical Perspective, " in *Technology and the Transformation of White Collar Work*, edited by Robert E. Kraut, Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1987.

Jensen, Michael C. and William H. Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs, and

Ownership Structure," *Journal of Financial Economics*, 3 (1976).

Keen, Peter G.W., "Information Systems and Organizational Change," *Communications of the ACM*, 24 (1) January 1981.

King, J.L., V. Gurbaxani, K. L. Kraemer, F.W. McFarlan, K.S. Raman, C.S. Yap, "Institutional Factors in Information Technology Innovation," *Information Systems Research*, 5, 2, June 1994.

Kling, Rob, "Automated Welfare Tracking and Service Integration, " communications of the ACM, 21 (6) 1974.

Kling, Rob and Turner, Clark, "The Structure of the Information Labor Force: Good Jobs and Bad Jobs", *Public Policy Research Organization*, September 25, 1987.

Kling, Rob and Susan Iacono, "Computing as an Occasion for Social Control", *Journal of Social Issues*, 40 (3) 1984.

Kraut, Robert; Susan Dumais, and Susan Koch, "Computerization, Productivity and Quality of Work Life", *Communications of the ACM*, (February 1989).

Laudon, Kenneth C. , *Computers and Bureaucratic Reform*, New York ,John Wiley, 1974.

Laudon, Kenneth C., *Dossier Society*, New York, Columbia University Press, 1986.

Laudon, Kenneth C., "Environmental and Institutional Models of System Development," *Communications of the ACM*, December 1986.

Laudon, Kenneth C. and Jane Price Laudon, *Management Information Systems: Organization and Technology. Third Edition*. New York, Macmillan, 1994.

Laudon, Kenneth C. and Kenneth L. Marr. "Productivity and the Enactment of a Macro Culture". International Conference on Information Systems. ICIS 1994.

Leavitt Harold J. and Whisler, Thomas L., Management in the 1980s, *Harvard Business Review*, vol. 36, No. 6, November-December 1958, 41-48.

Malone, Thomas W., and Joanne Yates and Robert Benjamin, "Electronic Markets and Electronic Hierarchies," *Communications of the ACM*, Vol 30 (6), June 1987.

Malone, Thomas W., and Kevin Crowston, "Toward an Interdisciplinary Theory of Coordination," Working Paper, MIT Sloan School, Center for the Study of Coordination, 1988, TR 120.

Malone, Thomas W. and John F. Rockart, "Computers, Networks, and the Corporation, " *Scientific American*, September 1991.

March James G., and Herbert G. Simon, *Organizations*, New York: John Wiley, 1958.

Morrison, Catherine J. and Ernst R. Berndt, "Short Run Labor Productivity in a Dynamic Model," *Journal of Econometrics*, 16, 3, December 1981, 339-365.

National Research Council, Review of the Tax Systems Modernization of the Internal Revenue Service. Washington D.C.: National Academy Press, 1992.

Office of Technology Assessment, "SSA and Information Technology," U.S. Congress, Washington D.C., 1986

Orlikowski, Wanda J. and Jack J. Baroudi, "Studying Information Technology in Organizations: Research Approaches and Assumptions," *Information Systems Research*, Vol. 2 (1) March 1991.

Orlikowski, Wanda J. and Daniel Robey, "Information Technology and the Structuring of Organizations," *Information Systems Research*, Vol. 2 (2) June 1991.

Orlikowski, Wanda J., "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science*, Vol. 3 (3) August 1992.

Robey, Daniel, "Computer Information Systems and Organization Structure", *Communications of the ACM*, (24)10 October 1981.

Social Security Administration. Information Systems Plan. Baltimore, Md., 1994.

Solow, Robert M., "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics*, (August 1957).

Solow, Robert M. "A Skeptical Note on the Constancy of Relative Shares," *American Economic Review*, 1958, 618-631.

Solow, Robert M., "Capital Labor Substitution and Economic Efficiency," *The Review of Economics and Statistics*, (August 1961).

Sproull, Lee and Kiesler, Sara, "Computers, Networks, and Work," *Scientific American*, September 1991, 116-123.

Steele, Christine E., "Occupations of federal white-collar and blue collar workers". U.S. Office Personnel Management. Washington, D.C. Sept. 1991

Turner, Jon, "Computer Mediated Work: the Interplay Between Technology and Structured Jobs," *Communications of the ACM*, 27(12) December 1984.

U.S. Department of Justice. Annual Report of the Attorney General of the United States. Washington D.C.: Department of Justice, 1993.

Walton, Richard. *Up and Running: Integrating Information Technology and the Organization*. Boston: Harvard Business School Press, 1989.

Williamson, O.E., *Markets and Hierarchies*, Free Press, New York, 1975.

Williamson, O.E., "The Economics of Organization: Transaction Cost Approach", *American Journal of Sociology*, 87 (1981).

Zuboff, Shoshana, *In the Age of the Smart Machine*, New York: Basic Books, 1984.

End Notes

[1] Ghurbaxani and Whang are undecided on the issue of whether or not IT will actually lead to a decline in management agency costs. They argue that more IT will empower lower level workers to act on their own, decreasing the need for intense management and lowering management costs. However, they argue that decentralization of the decision locus will lead lower level actors to pursue their own interests leading to the need for more intense surveillance systems. Therefore, they argue, one has to examine the culture and politics of specific organizations before one can assess that computerization will lead to lower management costs or to the decline in management positions.

[2] A variant of decision theory--popular in schools of management-- can be called control theory (Deutcher). Here the emphasis is on senior management control and how to design organizations and reporting systems so that senior managers can command and control them. For control theorists, the occupational structure of organizations reflects top management efforts to structure the organization so as to maximize the likelihood that lower level employees carry out management's will. Although there are differences among the two theories--decision and control theory-- for our purposes we will treat decision and control theorists as a single group.

[3]We tend to forget that the IS field originated in part within the field of accounting. IS was seen from very early on as a tool for management accounting and control.

[4]We are, for the sake of exposition, lumping together a number of different disciplines like sociology, political science, social history and anthropology which share a common thread. The common thread shared is the view that there are both voluntaristic and deterministic aspects to social behavior of all kinds, that organizations and individuals shape their environments and tools, creating social structures everyday, while at the same time these actors must cope with and adapt to social structures and environments created in the past.

[5]The basic source of national employment data is the Current Population Survey (CPS) conducted by the Bureau of Labor Statistics (BLS). More details about the data are contained in the Appendix. One important detail is that BLS made major a revision to its employment estimates. These revisions affect the 1972 data and produces a noticeable change for several of the occupational groups in the following data tables and graphs.

[6]Statistical Abstract of the United States, 1993. Table 644.

[7]Throughout the remainder of this paper we use the Federal government's PATCO (Professional, Administrative, Technical, Clerical, and Other) classification to characterize the occupational structure. The PATCO classification corresponds to the subdivisions of White-collar used by the Bureau of Labor Statistics (BLS) in the previous section. Formal definitions of the five PATCO classes can be found in Office of Personnel Management publications (Steele 1991, pp188-189).

The primary source of Federal occupational data is the U.S. Office of Personnel Management. Established in 1973, OPM started reporting Federal employment by the PATCO categories in 1974. There are two salient facts that should be recognized. First, although no detailed occupational data is available that goes all the way back to the time of the first computers in the Federal government, OPM's data covers the Federal civilian labor force since computers were but a very minor part of the Federal Government. Second, the classification scheme used by OPM is applied through out the Federal Government and data is available for the three target

agencies as well as the whole government. Nothing in this detail is available for any other part of the economy.

[8]The large decline from 1975 to 1976 in Other occupations was due to reclassifications. Apparently in the initial start up of OPM, Other was used for jobs whose classification was not easily determined. Many of those jobs were eventually reclassified to Technical; since 1976, Other has accounted for less than 4% of employment. At present, Other is used mainly for training and student aid jobs associated with Technical, Professional, or Administrative titles.

[9]The OPM and TRAC data reported here is far more detailed than would be available in the private sector. Our thanks to scholar and reporter David Burnham (Washington D.C.) and Professor Susan Long, Director of TRAC, Syracuse University. Our thanks also to the Center For Research on Information Systems (CRIS) and NYU's Stern School of Business for providing funds to purchase the TRAC data sets.

[10]Computing power is measured in MIPS (millions of instructions per second). Although MIPS is not without its problems as a metric of computing power it is the most widely used (Ein-Dor 1985 and Ein-Dor 1994). When used to compare computers within the same class running similar operating systems, MIPS is a good surrogate for computer capacity because as the MIPS rating of a machine increases, the other components will generally also be faster and of higher capacity. For the three agencies, all the computer capacity is mainframe computers, mostly running IBM's MVS operating system or the roughly equivalent operating systems for Univac mainframes so MIPS is a good measure of the computer capacity in all three agencies.

In 1973, the FBI had less than 1 MIP of mainframe power. The first large increase occurred in 1975 when the FBI increased its computing power to 5.3 MIPS; it entered 1990 with 160 MIPS. The IRS had been adding computing power relatively steadily so that in 1973 it had 8.65 MIPS, which was an increase of about 2 MIPS from 1970, and it added 2 more MIPS the next year (1974). It added computing power about every two years so that by 1990 the IRS had 209 MIPS. In 1973, SSA actually had slightly less computing power than IRS, about 8.4 MIPS. As the graph shows, SSA had about the same computing power as the FBI until 1983, at which point, computing power was added at a nearly exponential rate. In 1987, SSA's computing capacity surpassed the IRS and the SSA entered 1990 with 548 MIPS of mainframe computing power. Comparing mainframe computing power in 1973 with that in 1989, the FBI went from 0.87 MIPS to 160.1 MIPS, approximately a 180 fold increase; the IRS went from 8.65 MIPS to 209.26 MIPS, approximately a 24 fold increase; SSA went from 8.41 MIPS to 548.23 MIPS, approximately a 65 fold increase.

These figures, while obviously impressive, are consistent with the increases of computing power in information processing industries such as banking and insurance. Although each agency started 1960 with approximately the same amount of computing power (less than .25 MIPS) and they have taken different expansion paths, all three agencies have had a history of significant IT use that is comparable with the largest corporate IT users during this time frame.

[11]In a separate paper analyzing the production functions of the SSA, IRS, and FBI, it was found that these agencies face an identical production function. See Kenneth C. Laudon, Kenneth L. Marr, and David N. Sessions, "Management Strategy, Information Technology, and Productivity," working paper, Center For Research on Information Systems, 1995.