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information technology and information work

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This paper examines changes in information work in relation to investment in information technologies from 1970–1995. Though information work has been the primary source of employment growth since about the middle of the century, growth has slowed markedly since the early 1980s. Higher levels of investment in information technology are contributing to these slower rates of growth in information work. Information technologies tend to render routine information handling occupations redundant while simultaneously contributing to growth in non-routine information handling. Widespread use of information technologies facilitates occupational restructuring, the sum of which is slowing growth in information employment.

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The 'Information Society' concept in the USA is partially based on a shift in the economy from an emphasis on the production of goods to the production and distribution of information. Not surprisingly, this shift has been accompanied by a shift in employment. About mid-century, majority employment changed from industrial to information occupations, or occupations whose primary output is the production, distribution and manipulation of information. In the 1980s and 1990s, however, employment in information occupations has suffered several setbacks. Unemployment peaks, for the first time, reached into the ranks of white-collar workers. 'Downsizing' became a household word which appeared both to capture and explain the redundancies in information work. Ignored by this concept, however, has been the widespread adoption of information technologies. Real private fixed investment in information processing technology has risen dramatically since the mid-1970s. That information work has become progressively more vulnerable to high unemployment as heavy investment in information technology increases is hardly a coincidence.

The literature on technology and work is filled with both optimists and pessimists. The optimists believe investment in technology increases employment,[1] while the pessimists argue that technology ultimately replaces workers via deskilling and automation.[2] This article reviews changes in information work in the USA from 1970–1995 and links those changes to investment levels in information technology. I will argue that neither the optimists nor the pessimists are entirely correct. Indeed, the patterns predicted by each position appear to be occurring simultaneously. These simultaneous but divergent phenomenon are driving fundamental changes in the occupational structure of information work in the USA.

Trends in information work and information technology

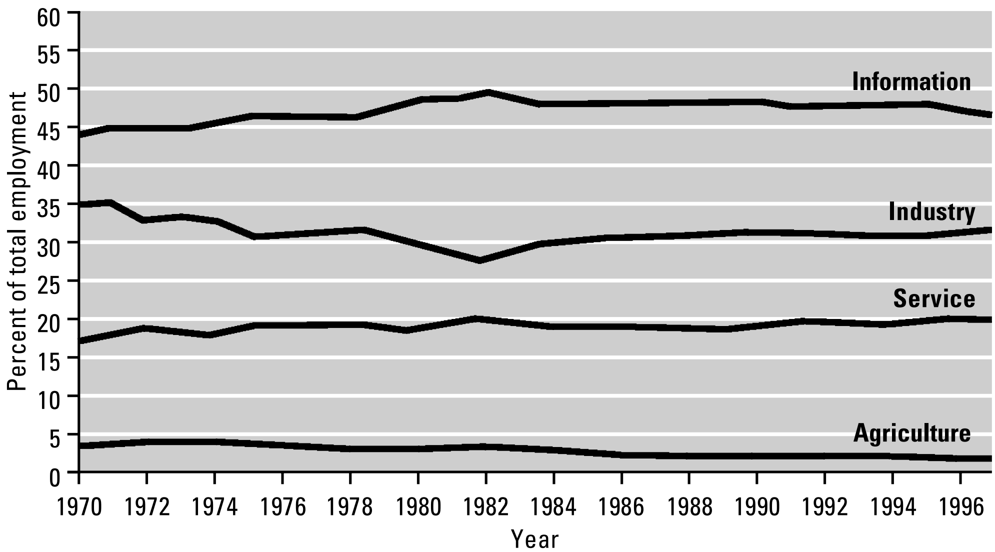
Machlup[3] was the first to identify information work. His seminal work, in combination with later research,[4] documents a large and growing information sector which employs the majority of workers in the USA today. Figure 1 displays Bureau of Labor data on employment. The data are broken down into four economic sectors: Agriculture, Industry, Personal Services, and Information. Of the four, only Information and Service have seen growth since 1970.

Agriculture represents less than 5% of all employment, while Industry dropped steadily until the early 1980s when it appears to have flattened out around 30%. Service, however, has grown from roughly 16% of all employment to 21%. The sector of most interest to this paper, the information sector, however, climbed steadily until the mid 1980s whereupon it flattened out at roughly 49%. Since 1994, the percentage has slowly dipped to 46%. Thus it appears that the information sector, which has been the largest employing sector over the latter half of this century, may be contracting.

Simultaneous to this trend in information employment has been a trend in investment in information technologies. Figure 2 documents growth in investment in information technologies since 1970.[5] Annual investment in information technology has skyrocketed, nearly doubling in the last ten years, and gaining more than a billion dollars a year from 1993–1996.

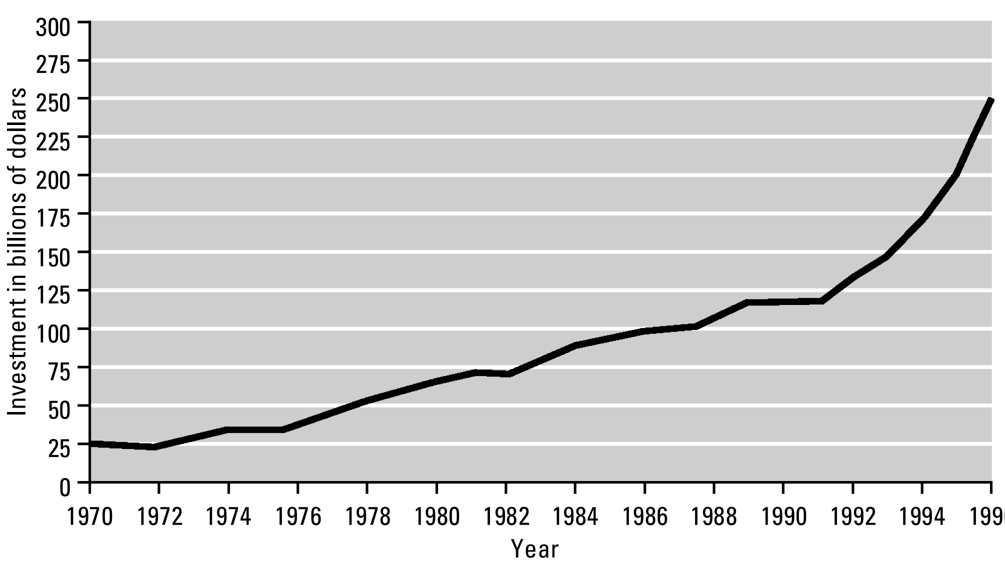
1. E. Ginzberg, N. Thierry and T. Stanback, *Technology and Employment*, Westview Press, Boulder, CO, 1986; *Micro-Electronics, Robotics, and Jobs*, Information, Computers, and Communication Policy Series No 7, OECD, Paris, 1982; *Trends in the Information Economy*, Information, Computers, and Communication Policy Series No 11, OECD, Paris, 1986; A. Hunt and T. Hunt, *Clerical Employment and Technological Change*,: W.E. Upjohn Institute for Employment Research, Kalamazoo, MI, 1986.
2. N. Colin, *Microelectronics at Work: Productivity and Jobs in the World Economy*, Worldwatch Institute, Washington DC,1980; D. Marschall and J. Gregory, Office *Automation: Jekyll or Hyde?*, Working Women Education Fund, Cleveland, 1983; F. Webster and K. Robins, *Information Technology: a Luddite Analysis*, Ablex, Norwood, 1986.
3. F. Machlup, *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, 1963.

Figure 1: Four sector aggregation of employment.



Source: All data on employment are from, *Employed Persons by Detailed Occupation, Sex, Race, and Hispanic Origin*, Table 11, available from the Bureau of Labor. The table is published regularly in *Employment and Earnings*.

Figure 2: Investment in information technologies 1970–1992 (chained to 1992).

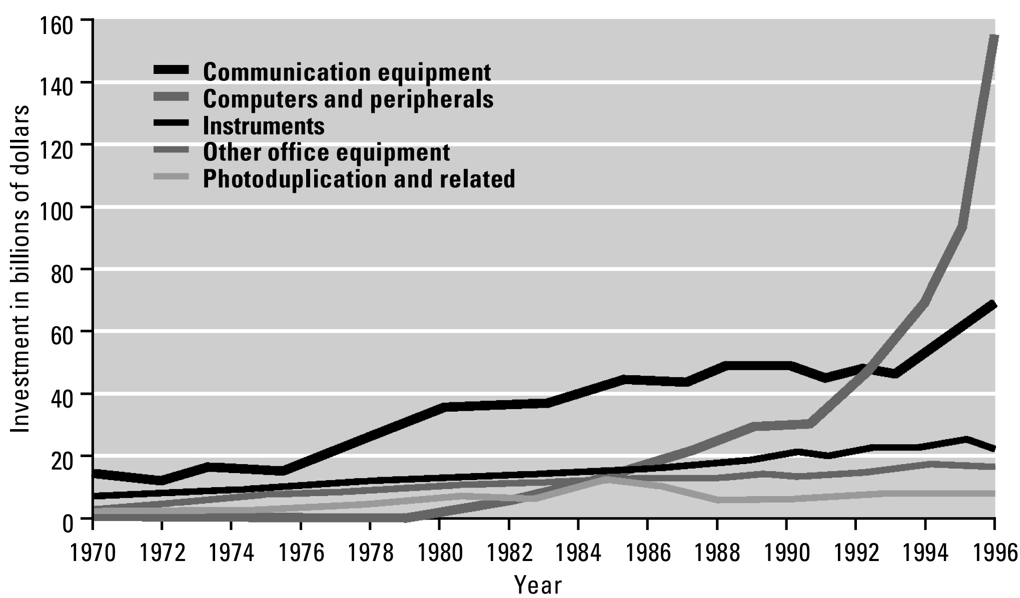


Source: National Income and Product Accounts, National Income and Wealth Division, Bureau of Economic Analysis.

If we break the aggregate data down into its constituent parts (see Figure 3), it becomes obvious that this growth in investment is primarily due to two types of information technologies: communication and computer equipment. Indeed, from 1990 onwards, computer and peripheral equipment have dominated investment patterns.

Various theories have been put forward to explain why investment in information technologies rises so sharply at this particular juncture in history. Beniger[6] argues that the current emphasis on information handling technologies results from a long 'crisis of control', where our ability to move goods exceeded our ability to track the movement of those goods. Information handling technologies have evolved in response to the ever-escalating crisis of controlling complex information streams about products and markets. Jonscher posits a different genesis for the unprecedented investment in information technology.[7] He argues that the focus on electronic information technologies arose in response to the low productivity of the information handling sector.

Figure 3: Investment in information technologies by type (chained to 1992 dollars).



Source: Compiled from National Income and Product Accounts data, Bureau of Economic Analysis.[8]

He suggests that as productivity increases in manufacturing reached its maximum, further gains could only be found in information handling. Wide-scale adoption of information technologies in the 1980s resulted from heavy R&D efforts beginning in the 1950s. Finally, Garnham[9] argues that the unprecedented use of information technology results from capital's ever-restless need to find new markets. Information has become the latest in a long list of commodity goods. Information technologies are the mechanisms whereby information can be gathered, quantified, and priced. Each explanation (Beniger, Jonscher, Garnham) identifies a different genesis for heavy investment in information technology. Regardless of their differences, however, all three share an important assumption: the sharp rise in investment in information technology is but the beginning of an ever-upwards spiral.

4. M. Porat, *The Information Economy,* Vols 1–10, Department of Commerce, Washington DC, 1977; M. Rubin, *The Knowledge Industry in the United States* 1960–1980, Princeton University Press, Princeton, 1986; R. Katz, 'Measurement and cross-national comparisons of information workforce', *The Information Society*, Vol 4, No 4, 1986, pp 231–277; N. Sinha, 'Technological unemployment in the information age', paper presented to the 43rd Annual Conference of the International Communication Association, 27–31 May 1993; J. R. Schement and L. Lievrouw, 'A behavioural measure of information work', *Telecommunications Policy*, Vol 8, N0 4,December 1984, pp 321–334.

These simultaneous trends (increasing investment in information technology and changes in information employment) have not gone unnoticed by economists. Indeed, much energy has been spent trying to understand the 'productivity paradox' in the USA. Productivity, simply put, is the total output of goods and services divided by the personhours it took to produce those goods and services. If the output goes up (as it usually does when machines are applied to work tasks) without increasing the number of personhours, then productivity rises. This held in agriculture when mechanized farm equipment increased the productivity of the agriculture sector: more agricultural products were produced even as the number of employed persons went down. It has also been true of the industrial sector. Logic would predict, then, that investment in information technology should produce productivity increases in the information sector. Indeed, Jonscher's argument on the genesis of investment in information technology is predicated on just such an assumption. Such productivity increases, however, have proven illusive.[10]

Explanation for the lack of productivity gains are numerous. Gordon,[11] for instance, argues that current methods of measuring output in the sector underestimate real output and thus mask productivity increases. Attewell,[12] on the other hand, argues that productivity gains are cancelled due to 'goal displacement'. At multiple levels (individual, organizational, and intra-organizational) information technologies shift emphasis into better quality rather than more quantity production, and/or encourage investment in expensive technology which contributes to competitive market position, but not necessarily to productivity. Castells[13] argues that a complex and interlocking set of events (far more than technology alone) effect productivity. Thus, productivity increases associated with investment in information technology are hidden as their real impact is diffused through core sectors which are only partially considered in productivity measures of the service sector (such as manufacturing, telecommunications and financial services).

Castells also argues, however, that the lack of documented productivity gains does not mean that information technologies have no relationship to changing employment patterns in information work:

*What **tends** to disappear through …[the introduction of information technology] are the routine, repetitive tasks, that can be precoded and programmed for their execution by machines (p 242).*

He also points out that among the features common to informational economies are the 'rapid rise of managerial, professional, and technical jobs…[and] the relative stability of sales and retail jobs' (p 229).

The data presented here to some extent corroborate Castell's assertions. The data suggest that instead of job growth (as the optimists argue) or job loss (as the pessimists argue), investment in information technology contributes to *slowing growth* in the information sector. Information technologies simultaneously make redundant the routine information handling workers, while creating more demand for non-routine information handling workers, the net effect of which is slowing growth for overall employment in information work. The exact mechanics of this, however, are somewhat unclear. Thus, we must examine more carefully how new information technologies influence changes in information handling, which in turn affects changes in overall trends in information employment.

5. Investment in information technologies is operationalized as the data reported by the National Product and Income Accounts on Information Processing and Related Equipment. These data are published in the *Survey of Current Business* in the table titled, 'Real private purchases of durable equipment by type'. The data used here (chained to 1992) are unpublished detail underlying the National Income and Product Accounts. It is available upon request from the National Income and Wealth Division of the Bureau of Economic Analysis.
6. J. Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society*, Harvard University Press, Cambridge, MA, 1986.
7. C. Jonscher, 'Information resources and economic productivity', Information Economics and Policy, Vol 2, No 1, 1983, pp 13–35.
8. Data chained to 1992 dollars are available for 1992-1995 inclusive in Table 5.4 or 5.5 of the January/February issues of *Survey of Current Business* for the appropriate year. However, data chained to 1992 dollars for years prior to 1992 are available from the Bureau of Economic Analysis upon request.
9. N. Garnham, *Capitalism and Communication: Global Culture and the Economics of Information*, Sage, London, 1990.
10. J. Triplett, 'The productivity slowdown, measurement issues, and the explosion of computer power', Brookings Papers on Economic Activity, 1988; P. Attewell, 'The productivity paradox', *Chronicle of Higher Education*, Vol 42, No 27, 1996, A 56; A. Filardo, 'Has the productivity trend steepened in the 1990s?', *Economic Review* (Federal Reserve Bank of Kansas), Vol, 80, No 4, , 1995, pp 41–59.
11. R. Gordon, 'Problems in the measurement and performance of service-sector productivity in the United States', *NBER Working Paper*, No 5519, March 1996.
12. P. Attewell, 'Information technology and the productivity challenge' in Rob Kling, ed, *Computerization and Controversy*, Academic Press, San Diego, 1996, pp 227–238.
13. Manuel Castells, *The Rise of the Network Society*, Blackwell Publishers, Cambridge, MA, 1996.

Information technology and information handling

The key to understanding the relationship between information technologies and information handling is to understand that skill is not equally distributed across all types of information work. Zuboff[14] provides an explanation for why skills are differentially available in white-collar work. She argues that at about the same time as scientific management began to rationalize manufacturing under Taylor's influence in the late 1890s, the task of running a business also underwent rationalization.[15] However, unlike manufacturing that *deskilled* the craftworker, rationalization in white-collar work left the owner-manager's skills intact:

> *Elements of managerial work most easily subjected to rationalization were 'carved out' of the manager's activities. The foundational example of this process is the rationalization of executive work, which was accomplished by ejecting those elements that could be explicated and systematized, preserving intact the skills that comprise executive craft. … [T]he most easily rationalized features of the activities at one level were carved out, pushed downward, and used to create wholly new lower-level jobs. In this process, higher level positions were not eliminated; on the contrary, they came to be seen more than ever as the depository of the organization's skills (p 98).*

The lower levels of a bureaucracy thus consist of occupations whose tasks have been 'carved out' of higher, more skilled positions. Indeed, the lower an employee ranks on the managerial hierarchy, the more routine the tasks and the smaller the body of knowledge necessary to perform them.

Zuboff also makes a distinction in types of skill. She divides work into acting-on and acting-with:

> *The new concept of … work [in lower managerial levels]… eliminated the… skill related to* **acting-with** *(that is, interpersonal coordination and communication) in favor of tasks that were wholly devoted to* **acting-on** *(that is, direct action on materials and equipment) (p 119).*

Acting-on work involves work where people physically handle objects, and/or whose labour involves working on or with objects as part and parcel of the job. In the case of information workers, this would involve people who type, file, answer phones, or otherwise shuffle paper for a living. *Acting-with*, on the other hand, is work in which people interact with other people to accomplish their jobs. In information-related work this refers to occupations like managers who keep teams working together smoothly, or sales clerks who impart information about various products to prospective buyers.

Information technologies are particularly well suited to performing *acting-on* kinds of tasks and particularly ill-suited to handling *acting-with* tasks. Jobs that involve a great deal of acting-on type tasks are more likely candidates for mechanization via information technologies than jobs which require a great deal of *acting-with* tasks. Because it involves human interactions, *acting-with* requires interpretation, or 'giving meaning' to symbol systems (such as facial expressions, body gestures, etc). These symbol systems are also often embedded in other sets of meanings (such as power differentials between men and women, or bosses and workers), which may vary slightly or greatly from culture to culture. In spite of recent advances in information processing systems, information technologies still have limitations.

Information technologies are not capable of higher-order thinking. From a functional perspective, information technologies are not 'creators' of information in the same way that human beings are creators. Nor can information technologies synthesize meaning the way human beings can.

14. S. Zuboff, *In the Age of the Smart Machine*, Basic Books, New York, 1982.
15. E. Lupton, *Mechanical Brides: Women and Machines from Home to Office*, Princeton Architectural Press, New York, 1993; M. Davies, *Woman's Place is at the Typewriter: Office Work and Office Workers*, 1870–1930, Temple University Press, Philadelphia, 1982.

Though undoubtedly information technologies 'create' streams of data in the normal performance of information handling, this 'creation' is bound by rigid rules. Hofstadter[16] argues that one of the main distinctions between minds and machines is that minds can 'step out of the system' of rules while machines cannot. Writing a sentence, for instance, is a process for which there is a system of codified rules embodied by grammar and spelling. Hofstadter points out that programmable information technologies can write grammatically correct sentences, but are unable to step out of their rule-bound system to evaluate whether or not the sentence is meaningful – something even young children are able to do. In other words, machines 'create' information only by a set of highly rigid rules and are unable to engage in meaning making. To the extent that a job involves *acting-with* rather than *acting-on*, the job will also require human participation and intervention.

So, what, then, can information technologies do? First, information technologies are able to distribute information. Indeed, one of the primary functions of information technology is to move information from its origination point to its destination. In the case of broadcast information technologies, for instance, the purpose is to distribute television and radio programming from an origination point to many destinations. Telephony and telegraph distribute information on a point-to-point basis. More recent technologies like computer networks, real-time video conferencing, online data bases, and the internet distribute information both point-to-point and point-to-many.

Information technologies, however, are more than distribution mechanisms. They are also eminently capable of transforming information. Modems, for instance, transform information from an analog format to a digital format. Optical character readers and scanners take printed material and digitize it for computer manipulation, while computer printers transform complex series of ones and zeroes into a graphical symbol system readable by humans. In short, while information systems may be designed to distribute information, select components of those systems are designed to transform information in order to facilitate distribution.

Information technologies also process information according to sets of rules. These sets of rules can range from the very simple (as in directing incoming phone calls via an automated voice answering system) to the extremely complex (as in performing real-time analysis of the stock exchange and issuing buying/selling instructions based on given parameters). At the simplest level, the processing of information according to strict rules is obvious. If a caller dials a company and pushes '1' for accounts payable, and '2' for sales, the rule-boundedness of the system is easily recognized. However, at more complex levels, information technologies begin to take on the semblance of intelligence. As Hofstadter[17] points out, though artificial intelligence still eludes us, we are able to code complex decision making algorithms that approach discriminatory judgment. We must not lose sight, however, of the underlying nature of what occurs. Though the set of rules by which a machine processes information may be extremely large and complex, the processing is still limited by the ability of the (human) computer programmer to specify the codified rules and their interrelationships. In short, this processing is still 'mechanical' in that the information technology is not able to make creative leaps or synthesize meaning.

The functional nature of information technologies, then, means that the technology will be far more adept at performing *acting-on* rather than *acting-with* tasks. *Acting-on* and *acting-with* tasks, though to some extent available in all information occupations, are generally divisible into either routine or non-routine information handling. The bulk of tasks in routine information handling (like filing, data processing, directing phone calls, etc) are *acting-on*, while the bulk of jobs requiring *acting-with* are non-routine information handling

16. D. Hofstadter, *Goedel, Escher, Bach: Eternal Golden Braid*, Vintage Books, New York, 1979.
17. *Ibid*.

occupations (lawyers, administrators, counselors, etc)[18] Furthermore, routine information occupations' *acting-on* tasks are more likely to consist of highly codified and rule-bound activities while non-routine information occupations' *acting-with* activities will involve non-codified or non-rule bound activities like creativity, synthesis, and meaning making. Thus, it is possible to posit a complex relationship between information technology and information work: where information jobs are highly rule-bound, routine, and/or primarily *acting-on* activities, the occupation will very likely be subject to the redundancy effects of the adoption of information technologies. Conversely, where information jobs involve non-rule bound information handling and/or a great deal of *acting-with* activities, the occupation will not likely suffer redundancies from the adoption of information technologies. Indeed, some non-routine information work will actually be in greater demand. As information technologies proliferate, so will the need for workers to create and organize content (such as writers, actors, web page designers, and other creators of information).

However, proliferation of information conduits also means a proliferation of information itself, which in turn drives the need for well-trained workers to analyse, synthesize and re-communicate increasing amounts of information. For instance, word-processing and document preparation software have increased the efficiency with which research grant proposals can be prepared, including the ability to modify or duplicate the same proposal for different funding agencies. Information technologies have thus increased the productivity of grant writers. However, information technologies have not necessarily increased the productivity of proposal evaluators. Evaluation of proposals still requires significant human investment. Thus, information technologies that facilitate productivity in some information occupations (thus driving *down* the need for those workers) drives *up* the need for workers in other occupations (specifically those who winnow and render information useable).

Finally, the proliferation of information technologies drives the need for highly trained workers who design and maintain the information systems themselves. Computer systems analysts, computer programmers, and computer systems designers are but a few job titles that have seen impressive growth since 1970.

In order to assess changes in information work in relation to information technology, it is necessary to provide a rubric for types of information work. This article divides information work into the conceptual scheme developed by Machlup:[19]

- A *transporter* will deliver exactly what he has received, without changing it in the least;…
- A *transformer* changes the form of the message received, but is not supposed to change its contents…
- A *processor* changes both form and contents of what he has received, but only by routine procedures which subject different pieces of knowledge received to certain operations, such as combinations, computations, or other kinds of rearrangements, leading to definite results, independent of the processor's tastes, moods, or intuition, dependent solely on conventions concerning such processing rules…
- An *interpreter* changes form and contents of the messages received, but has to use imagination to create in the new form effects equivalent to those he feels were intended by the original message; for example, the translator of subtle speech or sensitive poetry in a foreign language.
- An *analyser* uses so much of his own judgment and intuition in addition to accepted procedures, that the message which he communicates bears little or no resemblance to the message received.

18. This is not to say that there are no *acting-on* tasks in non-routine information handling or no *acting-with* tasks in routine information handling. Upper management certainly physically manipulates information just as lower level positions engage in communication. Indeed, it is this exact complexity of skill combinations that makes it difficult to predict with precision which jobs will be affected in what ways. I will return to this complexity of skills later in this article.
19. Machlup, *op cit*, Ref 3.

- An *original creator*, although drawing on a rich store of information received in messages of all sorts, adds so much of his own inventive genius and creative imagination, that only relatively weak and indirect connections can be found between what he has received from others and what he communicates (p 33).

Implicit in this scheme lies a continuum of the kind of mental activity required to perform the range of information handling tasks. Jobs in the first categories (ie transporters, transformers and processors) are the jobs most likely to have formalized rules by which to handle information. Furthermore, these are also most likely to engage in *acting-on* tasks. Conversely, those in the last categories (interpreters, analysers and creators) are the least likely to have codified rules and the most likely to engage in *acting-with* tasks.

Occupational trends in the information sector

Slowing growth in information employment results from the synergy of the elimination of jobs towards the routine *acting-on* end of the spectrum, while simultaneously contributing to growth in the non-routine *acting-with* occupations. Table 1 charts the percentages of each of the six different types of information work for all information workers (see Appendix A for a list of coded occupations).

The more routine occupations (transporters, transformers and processors) have lost share in the information sector since 1970 while non-routine occupations (interpreters, analysers and creators) have consistently gained.

Table 1: Six types of information work as percents of all information work.

Year	*Transporters*	*Transformers*	*Processors*	*Interpreters*	*Analysers*	*Creators*
1970	13.69	22.83	30.08	6.04	19.90	7.46
1980	12.04	21.74	30.32	7.42	20.09	8.39
1990	13.00	18.52	29.75	7.73	22.06	8.94
1995	12.52	15.97	29.14	8.91	24.36	9.10
1997	12.68	5.20	27.99	8.98	25.41	9.74

Source: S. Martin, *Information Technologies and Information Employment 1970–1995; Gender, Technology and Work in the Information Society*, PhD dissertation, Department of Radio-TV-Film, University of Texas at Austin, 1977.

These numbers, however, are comparative in nature. In other words, though we can document that routine information handling is in decline vis- -vis non-routine information handling, it is still possible for routine information handling to be gaining in overall employment. Therefore, it is important to look at absolute numbers to know whether or not the structure of work is the result of shifting percentages among the types of information work, or the result of actual decline/growth.

Net decreases in absolute numbers are almost all located in the most routine of information handling (see Table 2). Though the numbers are small in relation to all employment, we can clearly see absolute decline in transporters and transformers. Transportation has lost a net 497 000 jobs and transformation has lost 466 000. Deskilling and automation of these jobs are taking their toll.

Table 2: Information occupations with a net decrease in absolute numbers.

	1970	*1997*	*Loss*
Transporters			
Cost and rate clerks	135 000	47 000	88 000
File clerks	360 262	295 000	65 262
Records processing, nec	21 492	10 000	11 492
Office machine operators	165 396	105 000	60 396
Comm. equip. ops, all	427 800	185 000	242 800
Sched. and distribution, nec	25 800	16 000	9800
Radio operators	28 041	9000	19 041
Transformers			
Stenographers	128 539	104 000	24 539
Typists	979 997	555 000	424 997
Payroll clerks[a]	155 715	155 000	715
Press/type setters[b]	316 493	301 000	15 493
Interpreters			
Drafting	291 829	222 000	69 829
Totals	3 036 364	2 004 000	1 032 364

Notes: [a] The loss of jobs here is misleading. Payroll clerks reached a maximum of 245 000 in 1978. Since then the occupation has undergone steady decline. In actuality, this occupation has lost 90 000 jobs.
[b] As with payroll clerks, the printing trades have had significant job loss not shown here. Printers, not listed in this chart, reached a maximum of 459 000 in 1982. Since then the occupation has undergone steady decline to evenly match the 1970 point.
nec = not elsewhere classified.

In terms of net increases, gains are primarily in non-routine information handling. Table 3 lists the occupations which have experienced higher than average percent gain in employment since 1970. Not surprisingly gains in absolute numbers are heaviest in non-routine information handling occupations. The average percentage gain since 1970 was 230%.[20] Sixty-eight percent of jobs experiencing better than average gain are in non-routine information handling. Interpreters account for 13%, analysers for 41%, and Creators the remaining 13.6%.

Configured this way, the data indicate clearly that there is both proportional and absolute loss in routine information handling as well as proportional and absolute gain in non-routine information handling. This may oversimplify the phenomenon, however. The relationship between information technology and changing occupational structures in information work is complex precisely because both *acting-on* and *acting-with* skills, as well as codified routines and non-codified activities, are available to varying degrees in all levels of information handling. Middle managerial positions are particularly complex combinations of skills and activities.

Zuboff's[21] argument about 'informatting' – that information technologies make information about how a company is performing more readily visible across hierarchical levels – may also account for the contracting of employment in the information sector as information technologies particularly target middle managerial jobs that require a combination of skills. Bureaucratic levels were designed to handle the flow of information from the shop floor to management and back again. Information technologies cut through these levels of bureaucratic hierarchy. Because information technologies can make the same information simultaneously available at multiple physical sites, and because information technology gathers and distills information with reduced human intervention, there is less need for a management chain to perform this task. Take, for instance, Wal-mart's use of 'just in time' (JIT) inventory. Clerks scan bar codes at checkout which

20. Average rate of growth was figured as the net gain in employment divided by the total number of employed in 1970.
21. Zuboff, *op cit*, Ref 15.

are transferred to a data base that keeps a constant running inventory for the store. Loading dock clerks also scan bar codes as products enter the loading dock. At the end of each day, the status of the store (products sold, products delivered, payroll, money taken in, etc) is immediately available to local management and is also sent via microwave to Wal-mart's central management. The information about any particular store is not only immediately tallied and assimilated, but it is also available virtually simultaneously at multiple sites.

Before computers, bar codes, and microwave relays, Wal-mart would have had to employ a larger staff of middle managerial workers to perform all the information handling necessary to process and share this information. Thus, to the extent that a middle manager's job is mostly about recording, compilation, and communicating routine reports, that job is at risk to information technologies. However, to the extent that a middle managerial job is not about *acting-on* information but about *acting-with* people, the job will be more resilient to the effects of information technology. In short, informatting of the process of the managerial chain, the business of knowing how a company is performing, flattens managerial hierarchies as we need fewer employees to perform the *acting-on* activities and the remainder can more efficiently handle the *acting-with* activities.

Table 3: Information occupations with an above average increase in employment.

	Total gain 1970–95	*% gain over 1970*
Transporters		
Dispatchers	113 376	311.23
Computer operators	197 578	309.03
Transformers		
Health records technicians	7023	484.69
Processors		
Admin., protective services	18 927	299.60
Legal assistants	57 008	819.35
Air traffic controllers	287 888	1 113.87
Misc. admin. support, nec	216 425	2 210.00
Interpreters		
Eligibility clerks, soc. welfare	16 268	7 031.41
Social workers	207 024	312.85
Teachers aides	57 698	385.67
Analysers		
Inspectors, construction	64 863	264.77
Management analysts	216 519	832.35
Sales, securities and financial	272 742	304.54
Mgrs, advert. and public relations	426 311	243.52
Administration, education	289 515	232.92
Administration, health	131 260	673.14
Lawyer and judges	683 390	234.67
Math and computer specialists	815 006	641.17
Managers, financial	1 292 689	409.67
Creators		
Numerical tool programmers	27 690	1 104.40
Social scientists	207 024	312.85
Computer programmers	389 867	237.68

Notes: nec = not elsewhere classified.

Conclusion

This article has argued that wide-scale investment in information technologies is contributing to slowing employment growth in the information sector as information technologies simultaneously make redundant routine, *acting-on* information occupations while driving the need for *acting-with*, and/or complex information handling occupations. This trend, however, has only recently been visible in the data. It would be wise to continue to monitor this into the early part of the next century.

If this trend continues to hold, then we may see disproportionate job loss across the working population. As women's employment (especially minority women's) has largely been in routine information handling occupations, and as these occupations are the most 'at-risk' to technological redundancy, it is probable that this portion of the working population will see more rapid impact from the wide-scale investment in information technology. As employment data is monitored in the future, it will be important to break the data down by gender, class, and race.

Last but not least, the results of this research are concerning for economic health overall. If each previous round of investment in technology caused workers to shift into another industry (as happened with mechanization of agriculture and mechanization of industry), then the question arises as to where workers displaced from the information sector will find re-hire. The fourth sector, personal services, is a sector notorious for low skill, part-time, and low-wage occupations. We must question what role (if any) entities such as federal and state governments, labour unions, and educational institutions have to play in maintaining a strong economy as large portions of the workforce make the transition from information to personal service sector employment.

Appendix A: Information occupations as types of information work.

Transporters	*Transformers*	*Processors*
Radio operators	Health records technicians	Admin, Protective services
News vendors	Sales, retail	Personnel & Labour rel mgrs
Demonstrators	Cashiers	Managers, Purchasing
Computer operators	Stenographers	Post masters
Receptionist	Typists	Managers, nec
Cost and rate clerks	Interviewers	Accountants, Auditors
Library clerks	Hotel clerks	Technicians, mathematical
File clerks	Personnel clerks, exc payroll	Technicians, electrical
Records processing, nec	Records clerks	Technicians, clinical lab
Billing machine ops	Information clerks, nec	Technicians, industrial
Office machine ops, nec	Order clerks	Technicians, biological
Telephone and telegraph ops	Payroll clerks	Technicians, chemistry
Comm equip ops, nec	Billing clerks	Science technicians, nec
Photocopy operators	Shipping and receiving clerks	Legal assistants
Mail carriers	Stock clerks	Air traffic controllers
Mail, not postal	Weighers, checkers and samplers	Pilots
Messengers	Bank tellers	Sales, insurance
Postal clerks, mail	Data entry	Sales, real estate
Dispatachers	Printing press operators	Sales, advertising and related
Sched & % distribution, nec	Typesetters	Auctioneers
Meter readers, utilities	Stereo- and electrotypers	Sales reprs, manufact
Account collectors	Engravers and photoengravers	Office supervision
General office clerk	Photoprocessing operators	Secretaries
Bookbinders	Announcers	Ticketing agents
		Book keepers
		Expediters & production controllers
		Adjusters and investigators, Insurance
		Adjusters and investigators, not ins
		Statistical clerks
		Misc admin support, nec

Interpreters	*Analysers*	*Creators*
Purchasing managers	Administrators, public	Architect
Underwriters	Managers, financial	Engineers, all except sales
Buyers	Financial officers, other	Chemists
Sales engineers	Mgrs, advert. and public relations	Biological and life scientists
Chiropractors (50%)	Management analysts	All other scientists
Dentists (50%)	Administration, education	Sociologists
Veterinarians (50%)	Administration, health	Economists
Pharmacists (50%)	Sales managers	Psychologists
Physicians (50%)	Inspectors, not construction	All other social scientists
Podiatrists (50%)	Inspectors, construction	Dancers
Social workers	Computer systems analyst	Musicians and composers
Clergy	Operations & Systems Analysts	Painters and Sculptors
Drafting	Computer specialists, nec	Photographers
Counsellors, edu & Voc	Actuaries	Editors and reporters
Teachers aides	Mathematicians	Authors/writers
Eligibility clerks, soc welfare	Statisticians	Technical writers
	Teachers, college	Designers
	Teachers, not college	Actors and directors
	Librarians, archivists, and curators	Public relations specialists
	Lawyers	Surveyors
	Judges	Computer programmers
	Sales, securities and financial	Numerical tool programmers