Computers and Employment

A. Borodin and C.C. Gotlieb
University of Toronto

The relationship of computers and automation to employment is part of the more general relation of technological change to employment. The most obvious effect is that increases in productivity due to technology can eliminate jobs. Technology affects the individual worker, in the nature and amount of his work, and in his attitudes toward that work. Technological change affects the occupational structure of the entire labor force. Because of the central importance of these effects, the impact of technology has been the subject of extensive study by economists, sociologists, political scientists, and psychologists. Even within a single discipline, studies are often contradictory, and conclusions are colored by political overtones. We wish to delineate some of the issues, and present arguments given to support different viewpoints.

Key Words and Phrases: employment, unemployment, social implications, attitudes, skills, obsolescence, technology, unions, displacement

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Authors' address: University of Toronto, Department of Computer Science, Toronto, Ontario, Canada.

1. Technological Change, Productivity, and Automation

The twentieth century has witnessed major changes in productivity and in the composition of the labor force, coincident with, and in large part attributable to, technological change. The commonly accepted index of technological change is the productivity or output per man-hour, measured in terms of some unit product or service.

Substantial changes in productivity, in conjunction with demands for new products and services, bring about significant changes in the composition of the work force. The most striking example of this is the steady decline, over decades, in the number of farm workers in North America, Western Europe, and other industrial nations at a time when technological change made it possible for output to increase. In the United States from 1947 to 1965, total farm employment and the number of farms decreased by 50 percent while net production increased by about 40 percent. This phenomenon can be accounted for by the dramatic 285 per cent rise in farm output/man-hour, contrasted with the substantial (but far less dramatic) rise of 82 per cent in nonfarm productivity during the same period. Other important changes in the makeup of the labor force can be readily observed, although one must be careful to distinguish between identifiable trends over an extended period and temporary fluctuations which may be reversed.

Let us define *service-producing* industries to include trade, government, finance, insurance, real estate, transportation, health services, education, and miscellaneous services (hotels, laundries, domestic). Economists commonly call these *tertiary* industries. *Primary* industries are those which produce basic items (food, clothing, etc.), while *secondary* industries are those which manufacture other products. These

last two are goods-producing industries. The development of an industrialized economy is characterized first by the shift from producing basics to the production of manufactured goods, and then by a shift to the provision of various services (culminating in what is often called the *post-industrial society*). Thus in 1971, there were approximately 49 million Americans in service-producing industries as compared to 22 million in goods-producing industries.

Of course not all changes are directly related to technology. Interrelated factors such as education, social and political attitudes, and the readiness to accept women in senior levels of employment affects the numbers of teachers, athletes, waiters, stockbrokers, etc. It is difficult to distinguish between those trends which are direct effects of technology and those which are coincident with technological development. In any event, we continue to witness the growth of those industries which employ mostly white-collar, professional, and technical workers. We find from 1947–1971 increases in professional and technical workers from 6.6 percent to 14.6 percent of the employed labor force, and in white-collar workers from 35 percent to 48 percent while blue-collar workers decrease from 41 percent to 36 percent. At the same time, the number of blue collar workers has decreased from 40.7 percent to 34.4 percent (although in the mid 1960's there was a temporary leveling in the percentage).

In spite of the high rate of technological change in the twentieth century and the resulting gains in productivity, the total labor force has increased throughout the period. The reason is, of course, that the demand for products and services (only partly due to increased population) has increased even more rapidly than productivity, so that more workers are needed. As is sometimes painfully obvious, there are severe fluctuations in the demand for labor. However, the data from the admittedly incomplete measure of unemployment rates suggests that high rates of technological change and increasing productivity do not, by themselves, sufficiently account for unemployment [16]. During the 1960's two opposing schools of thought emerged concerning automation and the underlying reasons for prolonged unemployment. One is that of the "structuralists," who believe that insufficient skill and education levels and other structural factors (age, sex, race, mobility) are the main obstacles to full employment.[1] On the other hand, proponents of the demand theory believe that while structural factors exist to some extent, insufficient demand is the main barrier to full employment. Between these opposing viewpoints there lie all shades of opinion.

If one believes that significant productivity increases will continue, then either demand must continue to increase, the labor force must shrink (at least relative to the population), and/or the hours worked must be reduced. There are many who believe that as our society matures and as its material needs are satisfied demand will begin to level. In light of environmental factors, a leveling in the demand for those goods which require a large consumption of resources is necessary for continued survival. But demand does not necessarily mean a demand for more and more gadgets and a glut of superfluous services. It is conceivable that we will direct our demand toward better housing, better transportation, and better health, education, and recreational services. In addition to these possibilities, the recycling of resources may necessitate a significant labor component.

Some of the most far reaching consequences of increasing productivity arise out of the possibility that leisure time will be increased significantly for a large number of people. This is a separate, important topic which will not be explored here.

Today technological change primarily means automation, and automation in the office means computing. Automation should be distinguished from mechanization[2] in that it implies automatic control and integration of a process. For example, a card sorter is a form of mechanization (where a machine replaces a human skill) as distinct from an airline reservation system which regulates the entire reservation process.

The advent of modern computing and of automatic process control in the factory understandably has caused a great deal of anxiety regarding the future of human employment. As early as 1950, Norbert Wiener [27] saw the possible end to full employment and the obsolescence of all but a small fraction of the work force because of computers. The argument is logical enough: if entire processes can be fully automated, then increases in productivity will be so great and so rapid that only a few individuals will be needed to monitor and repair equipment. Fortunately, the predictions have not materialized. This is not to deny that automation and computing have caused serious displacements in particular circumstances. Some studies [e.g. 13, 14] have revealed that there were reductions in staff (even during periods of business growth) directly attributed to the introduction of computers, but this has not been the usual case. Automation and computing are having measurable effects

[1] For some opinions on the "structuralists-insufficient demand debate" see [11, 22, 23], and for a summary of these positions see [16, Chap. 5]. There is actually a third major factor in unemployment: namely, the frictional unemployment rate for a given economy which is supposed to reflect the normal percent of unemployment in a fluid labor market. Thus full employment is achieved when the percent of unemployment equals the frictional rate. Of course, one may argue that a high frictional rate is symptomatic of structural unemployment.

[2] Mechanization is often called Detroit Automation, defined as the integration of machines, or linking together by means of automatic transfer devices of the machines of production. See [8].

on productivity and the labor force, but thus far the overall reduction in employment due to productivity growth seems to be still within manageable limits [16, 22, 23].

What are some of the factors that appear to have mitigated the impact of automation?

1. There are few manufacturing plants which have proceeded to full automation; essentially, control has remained in human hands. In general, most processes still need careful human monitoring and adjustment of parameters at several stages.
2. The replacement of sensory and manipulative operations as well as of decision making by machine is often beyond the present state of technology. Moreover, there is still a significant lag between scientific discovery and practical implementation.
3. Office work in service-producing industries requires interfacing with human customers. We may note that there are no immediate possibilities of having machines conduct the discourse required for normal customer inquiries.
4. In offices, typing and secretarial positions have been largely unaffected by computers. In both office and factory, decreases in direct labor may be partially compensated for by increases of indirect labor. *Direct labor* is that whose withdrawal would cause an immediate cessation of the work being done. *Indirect labor* is that whose withdrawal would result in a substantially rapid (but not immediate) delay in process performance. This includes maintenance, support functions (i.e. keypunching), and first-line supervision but excludes research and higher management. Many plants maintain a number of workers mainly as insurance against system failure.
5. Computers and automated process control are sometimes selected not for a reduction in labor but rather for improved accuracy or resource utilization. Also, only small gains can be expected when automation is applied to processes which are already highly sophisticated and have small labor requirements.
6. Years of planning and implementation are required for the installation of automatic equipment, especially in service-producing industries which cannot disrupt service for installation. This delay allows time for manpower planning and training, and normal attrition.
7. There are some companies which have deliberately slowed the introduction of automation to avoid large scale displacements. Sometimes this has occurred at the insistence of unions or to counter the threat of unionization. But many companies are simply aware of the dangerous effect on workers' attitudes and performance if a reasonably smooth transition is not achieved.

Of the studies relating to the effects of computers in office employment [2, 15, 17, 26], the results of a study in Great Britain are typical [5]. They show that up to 1964, in spite of the introduction of over 600 computers in offices, there was an 8 percent increase in the aggregate number of staff employed; it is estimated that there would have been a 13 percent increase if computing equipment had not been installed. The report also predicted that there would be no dramatic change in office employment over the next five years (a prediction subsequently confirmed), and because of the time required to plan and organize a computing installation, there would be adequate opportunities to redeploy staff. For the 70's, because of the growing requirements for office work and only a slow rise in the working population, the report predicted that computers would have to be used extensively to cope with the work load.

In the final summary of a series of reports on labor and automation published by the International Labour Office [18], an earlier conclusion concerning automation is repeated: "For various reasons, the introduction of automation in office has thus far not brought about any significant dismissal of personnel nor resulted in a decline in the general level of employment for office workers."

In spite of the reassuring conclusions about aggregate employment, to date, there are still serious concerns about the future. Early computers have now been replaced by much faster and larger machines. Input-output interfaces are undergoing major improvements; marked sense cards and remote terminals may spell the end of keypunching. Some processes are now fully automated. In one chemical industry a computer controls all the process variables for air liquefaction and separation. Some specialized jobs, such as typesetting are being eliminated. We could go on, but these are enough examples to warn against complacency.

Moreover, as suggested before, aggregate employment is not the whole story. Specific occupational groups, minority groups, and the young are affected disproportionally by unemployment (see [19]).

2. Automation and Skill Levels

The complexity of the relation between employment and the technological change brought about by computers can be illustrated by the following question: Do computers bring about an increase or a decrease in the skills required for jobs? Among the difficulties in attempting to carry out studies are:

1. The need to devise methods for measuring the skills required for a job. Here we must be careful to differentiate requirements from formal qualifications imposed as screening devices. Rising educational levels do not necessarily represent required skill levels.
2. The need to carry out experiments with good statistical controls, for instance, on comparable plants, one of which has been automated and the other has not.

3. The need to estimate the effects of other variables: changes in the economy, differences in attitudes, training, management, and the effect of unions.
4. The tendency to overestimate the difficulty of a new job. In initial studies exaggerations about the difficulty of doing jobs related to computers resulted in inflated reports of job upgrading. On the other hand, the occupational content can change significantly while the title remains the same.
5. The need to estimate the contribution of indirect labor.
6. The problem in distinguishing between skill and other aspects of a job, such as accuracy and responsibility, which are related but which are generally regarded as different.

Although many of the early studies on automation seemed to indicate a marked general upgrading of the skills required, after more than a decade of study the consensus is that skill levels are both increased and decreased and that the nature of the process has a greater effect than the technological change itself. For example, experience with numerically controlled machine tools has shown that the requirements for worker skill are often decreased with the advent of automatic control. A man tending an automatic machine may have a more routine job, with less opportunity to exercise control, than he would have on the same process nonautomated. The worker may be given more training so that he can better understand what he is doing, but how much of this training is required for carrying out the job effectively?

One thorough study, indicative of the many complex factors, can be found in the research of Crossman, Laner, and their associates [6]. They examined 18 cases of the application of digital computers or analogue automatic control in six different process types. The processes were: check processing and account posting in banking; annealing, galvanizing, and tinplating steel; machining aircraft parts; electric power generation; hydrocarbon cracking, and air liquefaction and separation; and an airline passenger reservation system.

The conclusions are:
1. Direct labor productivity increased in 13 of the 18 cases and was unchanged in the remaining 5. In the 8 cases where indirect labor could be assessed, 4 cases actually showed a small decrease in overall productivity. However, if one could measure product value, then the gains in the other 4 cases would probably indicate an overall increase in productivity due to automation.
2. In a majority of the cases, technological change increased the direct skill requirements and decreased the indirect skill requirements.
3. In only two of the six process types (demand deposit accounting and airline reservation systems) did the overall increase in mean skill level exceed 5 percent.
4. There were few changes in the man-hour requirements for skilled labor (operators and craftsmen) and some decreases in the requirements for semiskilled and unskilled labor. The overall tendency toward skill upgrading is largely accounted for by reductions at the semiskilled, and somewhat at the unskilled levels, with little contribution by increases in skill at higher levels.
5. New processes generally require a slightly better educated work force, but once again the general nature of the process has more effect than the technological change.

The Crossman-Laner study, with its careful attempt to differentiate process types and to assess job categories and skill ratings, clarifies some of the apparently contradictory findings of earlier studies. For example, Helfgott [13, p. 509] found significant upgrading in the composite skill level in the introduction of data processing to banking and insurance, and suggested that increased productivity due to computing might have been responsible for the low growth rate of clerical positions in the early 60's. On the other hand, Bright [4] observed a decline in skill requirements with the introduction of automation to metal working industries.

Some comments on the structural versus demand theory debate on unemployment are relevant here. Although there has not been an explosive impact on skill levels, many questions remain. Will a continuing shift to service producing industries increase the importance of the rising skill levels observed in banking and insurance? Will there be a continuing rise in the number of professionals? What are the job prospects for domestics, attendants, waiters, delivery men, and other relatively unskilled service workers? Will the unskilled components of office work tend to disappear? What if automatic control proves so dependable that there will be more risk than insurance in human monitoring?

The change to automation in certain processes, while not significant in its effect on the immediate labor requirement, has made the process more *labor static*. That is, once the marginal operating requirements are met, an increasing demand for the resulting product does not require a proportional increase in the labor component. It follows that demand directed at labor static industries will not alleviate unemployment. Even more disturbing, it is possible that with advancing technology, processes which are labor elastic become labor static, and thus perhaps require zero or near zero labor increases once they are launched. If it is mainly the higher skilled social and personal service industries which are more elastic, then cutbacks in the less skilled segments of the economy will present serious structural problems which will be very difficult to overcome by conventional job retraining.

3. Automation and Attitudes

What differences in worker attitudes are brought about by introducing automation and, in particular, computers? To answer this we must ask, to what extent is one's work interesting? How do we measure alienation? Attempting to assess attitudes is even harder than analyzing skill levels; in particular, the problems of performing statistically controlled experiments come up again.

Yet the importance of this question about worker attitudes has been recognized from the beginning of industrialization. Karl Marx was one of the first to proclaim productive and satisfying labor as a necessity of life. It is not surprising that every study of technological impact returns to questions of attitudes and job satisfaction. Management reports on introducing computers into companies repeatedly emphasize the need to prepare employees long in advance of the computer's arrival. There is a deep-rooted fear of being displaced by computers, and this fear necessarily influences attitudes. A number of recent books have been entirely devoted to the question of the impact of automation on the nature of work, and resulting attitudes.

In the study by Shepard [21] (which is strongly influenced by the research of Blauner [3] and Faunce [10]) alienation among factory workers is compared with similar attitudes of office workers: in particular, the attitude of factory workers in an auto plant and in an oil refinery are compared with those of clerical workers, operators, and programmers within EDP installations in insurance companies and banks. Shepard makes a clear distinction between craft production systems (where the worker is basically an "artisan" using a tool), mechanized production systems (where the worker operates a machine which performs a specific function, i.e. the assembly line worker), and automated production systems (where a large process is being automatically controlled, and the worker performs monitoring or design functions). Given these definitions, the conclusion can be anticipated: automation reverses the historical trend (observed during mechanization) toward increasing alienation for both office and factory workers.

Among the aspects of alienation identified by Shepard are *powerlessness* (the lack of control over the process, the work content, and schedule), *meaninglessness* (the inability to identify the purpose of one's work with respect to the process and/or the society) and *normlessness* (the lack of confidence in proper recognition and fair rewards). The given definition of automation implies a greater emphasis on the entire process, more centralization and better integration within the system. This in turn usually results in a less specialized division of labor, job enlargement, and a great degree of interdependence between jobs. It is not surprising then that those in automated production and craft production jobs score better (i.e. lower) with respect to the meaninglessness scale than those in mechanized jobs. Meaninglessness is the aspect of alienation most clearly related to functional specialization. It is also reasonable that craft workers suffer least from powerlessness while mechanized workers suffer most. Of course, these broad job categories do not tell the complete story. Computer operators contrasted with programmers feel significantly more impotent because they are tied to the machine. In fact, except for programmers and systems analysts, the work pace in automated production appears to be as uniform as in mechanized production.

Finally, with regard to normlessness, automated workers scored best in this respect, and again the mechanized worker is least confident of fair recognition. A number of studies have found that most workers in automation-related jobs perceive greater responsibilities, more deadlines, and a greater need for accuracy in their work. To the same extent then, the worker will feel that his performance is more easily judged and, given a fair employer, that good performance will be recognized. On the other hand, several studies have found that clerical workers associated with automation often feel that promotion chances have been decreased. They feel that the middle steps in the promotional ladder (jobs involving coordination of specific functions, and some supervisory positions) are disappearing. Moreover, promotion into higher level jobs for computing is based on training and aptitude and not on experience in lower levels. So while workers may tend to believe that the system is fair, they may simultaneously be resigned to limited upward mobility, and hence experience a higher level of normlessness.

The work of Elizur [9] on attitudes is particularly interesting because of its in-depth survey. A series of detailed questionnaires was given to 450 employees of two organizations in The Netherlands. One organization was responsible for payroll administration in the government; the other was a bank in the public sector. Both organizations have computerized and non-computerized departments, so that a comparative study of the attitudes of employees directly involved with computers and of those who were not involved (but might be later) could be carried out. Even though the work force differs in important ways from comparable workers in North America (men form the majority of clerical workers, and there is a high rate of stability for such positions in The Netherlands), the observations are quite similar to North American studies. Some of the observations were as follows.

Initially:

1. There was appreciable resistance to the introduction of the computer from supervisors and middle management as well as from rank and file.
2. Many expressed anxiety about the future of their work, about the possibility of dismissal or transfer,

about their difficulties, and about their concern that the work will be less interesting.

After the computers are introduced:

3. The majority liked the presence of the computer, more so in the computerized departments than in the noncomputerized departments.
4. Substantial changes were reported in the computerized departments: most felt that their work demanded more knowledge, accuracy, regulations, and an increased workload.
5. Most felt that the work was more varied, interesting, responsible, and productive.
6. The majority were satisfied with job security, social relations with their colleagues, the work, and the organization. Attitudes were more pessimistic, however, in the noncomputerized departments.
7. Many disliked how the change was introduced; in retrospect, it appears that little information or traning about the new systems was given, even to those in the computerized departments.
8. The majority were concerned about opportunities for promotion and felt that upward mobility had been decreased. There were divided opinions on opportunities to show ability and exert influence.

Although the conclusions about computers, automation, and attitudes expressed by Elizur are plausible and generally supported by other studies, it must be emphasized that quite different results can occur in particular situations. The organizational structure, the quality of supervision and management, and the manner in which changes are introduced exert a strong influence on attitudes. The conclusions about the variety and interest of work are not as generally accepted as those concerning increased responsibility, accuracy, and amount of work. As an extreme example, Gruenfeld and Folman [12] report on the rejection of an EDP system by employees to the extent that unreliable information was supplied by supervisors, eventually resulting in the system being withdrawn.

There are a number of disturbing questions. As the novelty, prestige, and innovative features wear off, will attitudes approach those associated with mechanization? Shepard [21] observes that the really important thing about technology and automation may be that independent workers (e.g. craftsmen) are disappearing at all levels of employment. While automation appears to have reversed the trend of alienation invoked by mechanization, to what extent can we say that work is a significant part of our lives?

4. Technological Obsolescence

Statistical and aggregate studies do not convey the full impact of automation on employment; technological displacement is a continuing and often harsh occurrence. Unions attempt to protect their members from the negative effects of technological innovation and often come into conflict with management over such issues. Many engineers and other professionals, who are not unionized, face a different type of displacement—the job remains, but the older engineer may become less capable of performing it satisfactorily. Just as a low unemployment rate does not preclude displacement because of technology, the constancy of average skill levels does not preclude people becoming *obsolete*. Through what Armer [1] calls the "Paul Principle" (in allusion to the "Peter Principle"), "individuals often become, over time, uneducated and therefore incompetent at a level at which they once performed quite adequately." The people Armer has in mind are those in the "knowledge profession," especially scientists, engineers, and management in technologically oriented industries. In 1970, there were already 1.6 million scientists and engineers employed in the United States, and this class continues to grow.

There is some evidence that the Paul Principle is having its effect. Dalton and Thompson [7] have studied the performance of 2500 engineers in six organizations (performance as perceived by both management and the engineers). Because of management practices and constant changes in the "state of the art," the years of high performance are starting and ending sooner for many engineers. And the same holds true for the computing professions. Industry views those under forty, and especially those in their early thirties, as being the most valuable. This viewpoint is reflected in performance ratings, challenging work assignments, and salary increases. The engineers themselves agree, although they tend to think one's peak occurs in the late thirties.

It is hard to judge how much of this phenomenon is induced by management practices, as differentiated from the continual increase in knowledge. Engineering firms have long been known to give the best raises to the younger employees who are most apt to change jobs. Locked-in pension plans coupled with the usual decrease in mobility leave the older worker more dependent on the firm, which then responds with decreasing salary incentives. Once job adaptation is discouraged, even small changes in skill requirements can produce obsolescence. The problem becomes critical in the rapidly changing fields of computing, electronics, and aerospace where up-to-date information can be more important than experience.

How can the talents of older and more experienced workers be fully utilized? Many of the psychological aspects of the problem might be alleviated by im-

proved management practices. In Canada and the United States, the universities have transferable pension programs and, although they are more costly, such programs could be instituted in all industries. Salary practices must be restructured in order not to automatically discriminate against older workers. And new projects must be distributed as much as possible among all age groups.

With respect to the knowledge and skills required for a job, continuing education in a variety of forms is a necessity. In the occupations most affected by rapidly changing technologies, part-time re-education is not enough. Many engineers are dismayed by the prospect of spending one or two nights at classes every week for the rest of their careers. Companies will have to contribute time if they are seriously committed to maintaining performance and enthusiasm. There is a growing feeling that periodic retraining sabbaticals ranging from six months to two years may sometimes be necessary. Presently, only a few select companies can afford to look beyond immediate competitive demands and institute more concentrated educational programs. As Armer [1] sees it, the solutions are so costly that substantial support from the federal government is a prerequisite. Estimating a one-year average educational stipend of $8,000 for 5 percent of the United States work force, Armer derives a $30 billion per year cost figure. Depending on one's orientation, this figure represents about 3 percent of the GNP or less than 50 percent of the defense budget. Moreover, Armer cautions that such a program might even be self-defeating in that it would further accelerate a knowledge explosion.

At this time, most segments of the work force are not in occupational need of educational sabbaticals, and Armer's estimate of 5 percent of the total labor force (approximately 3.5 million people) appears to us as an exaggeration to emphasize the point. But on the other hand, the provision of such programs is consistent with the need to distribute employment opportunities evenly and maintain a flexible work force. For the immediate future, however, programs which enable an employee to spend one work day per week in either university or company courses can be effective and perhaps acceptable to industry.

5. Summary

In industrialized countries, the present evidence indicates that computing has not had the unsettling effect on employment forecast by many. The conclusion of the previous sections is that the effects have been similar to those accompanying other technological innovations. The nature of the work force does change, and productivity continues to increase, but at a gradual rate. Thus far, increased consumer demands have kept pace with productivity increases, and employment in the aggregate sense has stayed relatively stable. When indirect labor is considered, the skill levels required within various industries have both increased and decreased. And while alienation is still present, the introduction of automation and computing may have improved work attitudes when compared to the effects of earlier mechanization. But it is not possible to be complacent about the effects of computers and automation on employment. Even if changes continue to be gradual, we must expect that the accumulated effects will come to have a profound impact on the nature and meaning of work.

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