Technological Innovation Studies Program

Research Report

THE EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS OF INDUSTRY

BY

STEPHEN G. PEITCHINIS, Ph.D.
Professor of Economics
The University of Calgary

April 1978

Rapport de recherche

Programme des études sur les innovations techniques

Industry, Trade and Commerce
Industrie et Commerce

Technology Branch
Ottawa, Canada

Direction de la technologie
Ottawa, Canada

THE EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS OF INDUSTRY

BY

STEPHEN G. PEITCHINIS, Ph.D.
Professor of Economics
The University of Calgary

April 1978

AUTHOR'S COMMENT

A report of the nature presented herein could not have been carried out successfully without the cooperation of the industries and institutions who supplied the information. I express my gratitude to all who returned a completed questionnaire and to the multitude who responded to my questions in writing. Also, I extend my appreciation to those who found it possible to allocate some of that scarce commodity, time, to rather lengthy interviews.

From amongst my direct associates considerable assistance was provided by Tom E. Clarke, Program Manager, Industry, Trade and Commerce, John W. Shepperd, Anthony E. Reinsch, Audrey E. Andrews, and Maureen M. Samuels. My gratitude to all.

THE EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS OF INDUSTRY

TABLE OF CONTENTS PAGE

Introduction 1

1. Definition of Technological Change 10
2. Methodology 12
3. Indicated Results and Conclusions. 16
4. The Impact of Technological Changes on the Sectoral Distribution of Employment. 24
5. Knowledge as Cause and Effect of Technological Change 38
6. Problems in Determining the Effects of Technological Changes on Educational and Skill Requirements of Industry 45
7. Predicting the Manpower Effects of Technological Change 49
8. Technological Innovation and High Level Manpower 54
9. Electronic Systems and Educational Requirements 57
10. Technological Innovations, Improvements in Technology and Manpower Implications. 60
11. Existing Levels of Education and Industry Requirements. 66
12. Technological Changes and Skill Requirements 73
13. Approaches to Adjustment--Human, Technological, Organizational. 83
14. An Overview of Technological Changes in Different Industries 87
15. The Effect of Technological Changes on Educational and Skill Requirements of Organizations: Results from the Questionnaire. 119

16. Policy Recommendations 150

17. APPENDIX A--Industries' Statements on
the Effects of Technological Changes
on Education and Skills. 155

18. APPENDIX B--Effect of Technological Innovations
on Occupational Skill Level and Educational
Requirements 163

19. APPENDIX C--Employment of Production and
Non-Production Workers by Industry 181

20. APPENDIX D--Questionnaire 195

21. APPENDIX E--Annotated Bibliography. 207

EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS

Introduction

Technology has been a major source of improvement in man's economic welfare and a major cause of man's economic and social problems. The rapid rise in living standards, the increasing efficiency in production processes, and scores of comforts in homes, at work and at play can be attributed largely to technology; equally, technology is largely responsible for the dislocation of communities, for scores of environmental problems, for the destruction of many work skills, and for most employment relocations.

Technological changes have had profound effects on the employment of the Canadian labour force: employment in agriculture has fallen gradually from 1.2 million workers in 1946 to about 450,000 currently, and the occupational composition of the agricultural labour force reflects the increasing use of science and technology, and the emergence of business enterprises in agriculture; employment in manufacturing and construction has remained an almost constant proportion of the labour force for more than twenty-five years; scores of occupations have disappeared from the market, and scores more have come into being; many occupations have become highly specialized, and equally as many have declined in importance. Finally, the service sector whose labour absorptive capacity has been largely responsible for the absorption of the rapidly rising labour force is now being increasingly computerized. Employment activities, such as retailing and wholesaling, warehousing, health services, clerical activities and such other, which were regarded as "labour intensive," and whose expansion meant almost automatically increases in employment, are no longer as labour intensive. So, the question arises how will employment be provided to the increasing labour force when the rate of increase in the absorptive cacity of the service sector deminishes further.

An aspect of these changes to which little attention has been focused is the human element: we have accepted them as a natural consequence of technological change, and expected those affected to accommodate the requirements of the new processes. If geographic mobility were required, workers are expected to move or lose their jobs; if retraining were required, they are expected to submit to it or lose their jobs; if relocation within the enterprise were required, they are expected to relocate at a moment's notice. Seldom has there been any question as to who would accommodate to what--people to technology or technology to people. It has always been taken for granted that the people, in their capacities of workers, consumers and citizens, will adjust to and accommodate the changes in technology regardless of its nature and magnitude.

It is generally recognized that the optimum utilization of new technology depends to a considerable degree on the availability of appropriately trained manpower. Yet, the manpower implications of technological changes do not appear to be given the degree of attention that is warranted. This is perhaps a manifestation of the primary concerns and orientations of those engaged in the search of technological innovations. The Vice-President in charge of technology and innovation of one of our relatively large public utility companies expressed the opinion that his responsibility was to search out for innovations in technology and processes which will increase efficiency, facilitate expansion, and reduce costs. He was not concerned with the social and manpower implications; that was the responsibility of the Personnel Department. But, the Personnel Department indicated that they were not informed about the nature of the new technology that was being developed and the precise nature of the manpower implications it would have until its pending installation and manning. This short notice they found to be inadequate for effective retraining, relocations and search of the market for new manpower.

It is recognized, of course, that frequently it is difficult to determine in advance of implementation the precise nature and magnitude of social and manpower implications. So, it is not the degree of accuracy in estimating the nature of effects that is being criticized; it is rather the apparent absence of detailed consideration of the nature of adverse effects, and the absence of joint labour-management and management-community committees to consider and formulate alternative accommodative arrangements. Commonly, technological changes are implemented and then efforts are made to accommodate the adverse effects on labour and the community at large. It is not uncommon for affected workers to be simply informed of the nature of accommodative decisions taken by management--who would be retrained, who would be transferred to alternative activities, who would have the option of early retirement in lieu of retraining or transfer, and who would be released from employment. Similarly, it is not uncommon for communities to discover suddenly unexpected adverse effects: families moving out, others moving in, pollution of water and environment, traffic congestion, and others.

The federal government has been aware of the problem, and has made a determined effort to eliminate it. In 1963 it established the Canada Manpower Adjustment Programme, which provides a means of bringing together management and unions to plan suitable adjustment programmes for workers affected by technological changes. But, participation is voluntary. All that The Canada Manpower Consultative Service (which administers the programme) can do is to indicate to the parties that the programme is available, that its service is at their disposal, and that under the Act establishing the programme the federal government will share in some of the adjustment costs. We have gained the impression that unions are more favourably inclined towards the service than management. There continues to exist an attitude amongst management officers that technological changes are a managerial prerogative, and adjustment to technological changes is a managerial responsibility.

Such an approach to the effects of technological changes has serious implications: neither labour nor communities will tolerate it for long. Traditionally, technological changes had been viewed as a managerial prerogative, to be implemented at management's discretion. The motivation was stated as increase in efficiency, expansion and reduction in costs. Adverse effects on labour, the environment and the community were the natural costs of technological progress. Any consideration of these as a pre-condition to the implementation of change was viewed as interference with industrial progress. There are many who continue to think in such terms.[1]

Yet, health and safety conditions are barbaric in many enterprises; what levels of inadequacy should be tolerated as a trade-off for productive efficiency? Is any trade-off necessary?

---

[1]One individual who has examined the subject of new technology and its implications wrote: "Efforts to stimulate engineers' interests in the social effects of their labours, even when made by knowledgeable and concerned people, often fall on somewhat passive ears." J. Scrimgeour, CAD/CAM and Its Significance to Canadian Industry, paper presented at the 1975 EIC Congress at Winnipeg, Manitoba, p. 8.

or is the claim for trade-off a lack of desire on the part of industry to do the possible?[2]

The adhoc approach to the accommodation of technology related manpower problems may be attributed to the relatively high levels of unemployment that Canada has had over the past 25 years, and the relatively easy access enterprises have had to foreign labour markets. As long as there is surplus labour in the domestic labour market, and industry has easy access to external labour market, there would be no incentive for manpower planning parallel to technological plans. Manpower planning becomes necessary when industry faces a tight labour market at home and restricted access to external labour markets--when management can no longer say, "if we can't find the skills we want in Canada we will send someone to Britain on a recruiting mission. We have never failed to get the number of qualified people when the need arose."

In Western Europe, where full employment has prevailed, employers are compelled by tight labour markets to carry out careful evaluations of the effects of technological changes on manpower requirements, and to introduce retraining and relocation programmes in an effort to retain their personnel. The experience

---

[2]A provincial inquiry into health standards in Quebec's asbestos industry recommended stricter health controls in the industry, and the Industrial Medical Association recommended a norm of two asbestos fibres per cubic centimetre of air. But the Quebec Asbestos Mining Association opposed the setting of an absolute limit, and recommended instead that "a standard be observed whenever it is technically possible in the plant." The implication being that health and safety standards should be determined on the basis of costs and technical feasibilities and not on the basis of the nature and extent of injury production processes may inflict on workers. Reported in The Labour Gazette, February 1976, p. 66.

of West European employers led Professor Arnold R. Weber to conclude: "The obstacles to an efficient reallocation of labour within a firm undergoing technological change undoubtedly have been exaggerated by American observers; the West European experience indicates that the problem can be handled without great difficulty when the appropriate incentives and administrative arrangements are available."[3] Therefore, to the extent that programmes designed to cope with the effects of technological change on manpower appear to be ad hoc in nature, it is largely because of the existence of surplus labour market conditions. If Canadian employers were to face tight labour markets, and were thereby to become concerned about losing their manpower, they, too, would probably carry out careful advance assessments of the effects of technological change and institute programmes for the retraining, upgrading and relocation of personnel.

Further evidence of the extent to which the adoption of new process technology is taken for granted is the apparent failure to evaluate its manpower and other effects after adoption has taken place. It would seem reasonable to expect that after a technological change has been implemented there would be an assessment of its costs and benefits relative to expectations:

---

[3] Weber, A.R. "Manpower Adjustments to Technological Change: An International Analysis," in International Labor, S. Barkin, et al (eds.), Industrial Relations Research Association Series, Harper & Row publishers, New York, 1967, p. 142.

what was expected in relation to efficiency and what was achieved; estimated costs versus actual costs; anticipated versus actual effects on manpower--relocations, retraining, lay-offs, dismissals; anticipated versus actual effect on society at large--pollution of environment, health and safety, effect on community services, and such other. Assessments of this nature either do not exist or access to them is denied. The common response to requests for such assessment reports has been: "Yes, people were moved around"; "some people had to learn new skills"; "some people found the new system difficult to adjust to, and left us"; "some new people were hired, with new knowledge and skills"; "some people elected early retirement"; "and a few had to be let go." There appears no recognition of any need for an examination of who those "some people" were, and an assessment of the adjustments made by the people affected. There is a disturbing degree of indifference on how these "some people" felt, and how they adjusted to their new conditions. The attitude appears to be that a technological change was instituted; it made necessary certain changes in plant, materials and labour; and the changes were put into effect in the most efficient way possible in the context of prevailing conditions; after the fact assessments would serve no purpose. Yet, one would expect an educational value in after the fact assessments, so that mistakes will not be repeated, and prior expectations will be either confirmed or negated. Furthermore, surely managers of enterprises have a social responsibility to ensure that the human and social costs of the technology they elect to use are kept down to a minimum. Recognition of this responsibility will ultimately be manifested in technology assessment studies and joint labour-management and management-community committees. The use of modern technology is too critical to society to be left at the sole discretion of enterprises and their engineers.

1. DEFINITION OF 'TECHNOLOGICAL CHANGE'

The nature of technology used in industrial, commercial and institutional enterprises varies significantly: in industrial enterprises it is largely related to the production of goods and to the handling of materials; whereas in commercial and institutional enterprises, it is largely related to office equipment and information handling. Hence, in our examination of the effect of technological changes on educational and skill requirements of industry it became necessary to use two definitions. For industrial enterprises, technological change was defined as:

> Change which involves the use of new and substitute products and services, new methods of materials handling, as well as new or modified production techniques and processes.

For commercial and institutional enterprises it was defined as:

> Change which involves the use of new or more efficient information handling systems, the use of new and substitute products and services, new uses of computer-control in transactions, as well as the mechanization of services previously provided mainly by personnel.

Although mechanization continues to dominate production processes generally, electronic systems are increasingly becoming the predominant form of technological change. From the standpoint of educational and skill requirements, there are two significant differences between mechanization and electronic processes: mechanization substitutes, supplements and complements human muscles, knowledge and skills, whereas electronic systems supplant, partially or totally, certain mental functions; and secondly, some of the fundamental knowledge required for electronics is not the same as that required for mechanics. For those involved on the technical side of operations, this means a change in fundamental knowledge.

2. METHODOLOGY

The information presented in this report was obtained by four methods: published and unpublished books, articles, reports and doctoral dissertations; a questionnaire; letters; and interviews.

The published and unpublished materials relevant to the study are presented as an appendix to this report, entitled Annotated Bibliography on the Effect of Technological Changes on Educational and Skill Requirements of Industry.

The questionnaire (appended to the report) was sent to 1200 industrial, commercial and institutional enterprises in September 1976. Enterprises were selected in four stages, on the following basis:

(a) All industrial and commercial enterprises with an annual revenue in 1975 of $10 million and over;

(b) All industrial and commercial enterprises with an annual revenue in 1975 of less than $10 million, but employing a labour force of 500 or more;

(c) Industrial and commercial enterprises which met neither the revenue nor the employment criterion, but whose operations were determined to have a relatively heavy technological basis; and

(d) Institutional enterprises, such as libraries, city administrations, hospitals, the St. Lawrence Seaway Authority, the Canadian Broadcasting Corporation, and such other.

The response to the questionnaire was the following:

(a) 104 (8.7 percent) completed questionnaires were returned.

(b) An additional 182 enterprises indicated by letter that they would not be able to participate in the project, but provided some useful general information about technological changes and their effects on manpower.
It is of interest to note some of the reasons given for the decision not to complete the questionnaire:

(i) An inordinate amount of manpower was being allocated to the preparation of reports for governments and government agencies (AIB, Statistics Canada, and other) and therefore they could not afford to allocate the required manpower to compile the information.

(ii) No technological change of consequence had taken place over the indicated period of 5 - 10 years, and none was anticipated.

(iii) Data of the nature requested were not available. Apparently, technological changes were being conceived, introduced, and the necessary manpower accommodations were made in the course of operations. Records did not exist on who was moved, from where to where, who was retrained, and so on.

(iv) Technological changes are continuous, and their effects on manpower are interrelated. It is not possible to separate from the continuum individual changes.

(v) It is not possible to separate the effects of individual technological changes from the effects of generally continuing changes in technology.

Technological Changes are Continuous

At the outset, we had approached the investigation with the assumption that individual technological changes and related changes in the educational and skill requirements of manpower are easily identifiable. It would appear that this is not the case with industry generally, although it may be possible in some industries.

In capital intensive industries, particularly those using relatively sophisticated technology, technological changes take place continuously. There are seldom sudden or complete replacements of entire production processes or substantial parts of production processes: a new machine may be introduced or a new product or a new process, but each is normally either an addition to what exists or a replacement for one that is phased out. Since such changes take place continuously, accommodative responses in the skill and education component of the labour force are managed simultaneously.

To enterprises which gave reasons (i), (iv) and (v) for failure to participate, we requested general information. In a follow-up letter to them the following request was made:

> "Without being specific about any particular technological change, could you identify the nature of changes in educational and skill requirements experienced by your organization over the past five years or so at all levels of the employment structure?"

(c) 46 enterprises responded to the communication; the majority of responses contain some valuable information, particularly in relation to effects on managerial, professional, administrative and such other high level employment categories.

3. INDICATED RESULTS AND CONCLUSIONS

1. The overall impression gained from industry responses to the questionnaire, to letters and in interviews is that technological changes have not caused any critical manpower problems; the levels of education possessed by the labour force are generally more than adequate for the nature of technological changes that are being introduced; few skills are being rendered redundant; relatively few workers are being displaced by changes in technology; and most of the workers that are displaced are accommodated into alternative employments, frequently after some relatively brief retraining.

2. A further impression is that the demand for additional labour has diminished significantly and that it will remain at a relatively low level for the near future. This is attributed in part to the increased productive capacity of new technology and in part to the general increase in the productive capacity of the economy relative to prevailing and anticipated demand over the short run.

3. A number of firms reported two significant outcomes of changes in technology: increases in output or increases in capacity to produce with virtually unchanged volumes of labour; and changes in the composition of their labour forces. One of them reported: "...in 1972 our management/professional staff numbered 1,086; 52% of whom were university graduates. At the end of 1975 the population was 1,261; 57.5% of whom were university graduates. During this period the total company population hardly changed at all."

4. Responses of the nature indicated above suggest that one of the micro effects of technological changes over the short run is a decrease in the labour absorptive capacity of industry. At a time when the nation's labour force is expanding, a decrease in the labour absorptive capacity of industry will result in unemployment.

5. New technology is being introduced in most industries, but particularly in service industries and the service side (office, finance, planning, control) of goods producing industries.

Heretofore many service activities were largely labour intensive. Not being conducive to mechanization meant increases in demand for services entailed increases in employment. But, activities which for a long time could not be mechanized are increasingly found to be susceptible to electronic technology. This has important implications for employment in service activities and for aggregate employment.

6. The implementation of the new technology does not require substantial amounts of technical manpower and generally does not take a long time. Usually the supplier of the new technology provides the manpower for installation and the training of staff, and assumes responsibility for supplies and maintenance. This is particularly the case with computers, which require a considerable amount of programming activity, and specialized peripheral equipment.

7. Employment does not appear to have been affected adversely on the aggregate, although the occupations and skills of employees working with the new technology, and of those whose activities relate to the functions performed by the new technology,

have been altered. Inevitably, some occupations are being eliminated, and some, such as computer programmers and other computer related occupations, are being added. Some employees are being displaced fully, while others are being trained in whole or in part to perform functions that relate to the new technology.

8. In relation to training and retraining, firms have shown a strong preference for on-the-job training. External training is not favoured, excepting the training programmes provided by suppliers of new equipment. Instances in which technical institutions were used, the training was done in conjunction with on-the-job training.

9. Retraining programmes and their duration vary from industry to industry, depending on the extent to which job functions are affected and on the nature of functions involved in the re-assigned positions. Training periods can be brief, provided largely on-the-job; or they can be lengthy, involving classroom instruction, demonstrations and training manuals.

9a. The number of workers who, for various reasons, could not be retrained was relatively small (1.9 percent of all workers affected by technological changes).

10. On the average, technological changes have not had any significant effects on educational and skill requirements: the majority of responding industries indicated no significant changes in fundamental knowledge requirements, and no substantive changes in technical knowledge requirements. Only 11 percent of affected workers required more or a different kind of fundamental knowledge, and 18 percent required more or a different kind of specific technical knowledge. But the aggregate hides some very significant variations amongst industries: whereas some industries indicated zero effect on their educational and skill requirements, in other industries all workers required more or different kinds of both fundamental and technical knowledge.

11. There is evidence of some "de-skilling" effects of technological changes, particularly in relation to specific job-related skills, acquired on-the-job.

12. Because most of the significant technological changes have been related to the introduction of electronics, their effects on education and skills appear to be greater on

intermediate and high level personnel than on wage-earning occupations. It is reported that electronic systems have accelerated production processes, and generally reduced the permissible margin of error previously available to senior management. This has necessitated more detailed planning, greater care in the derivation of cost estimates, and has generally reduced the permissible time-period for decisions. As a consequence, managerial, professional and supervisory personnel find it increasingly necessary to participate frequently in seminars, workshops and related interactive activities.

13. There is some evidence of scarcity of electronic systems-related technical and operative personnel, such as electronics technicians and engineers, systems analysts and programmers. The responses indicate that as a result of this manpower scarcity some new technology is not being utilized to optimum efficiency, and the implementation of some planned technology has been held back for periods ranging up to 120 weeks.

14. We have gained the impression that search for knowledge in relation to new products and processes is not given the priority that we believe it warrants. Allocations to research and development appear to be largely directed to "improvements" and "maintenance" rather than to innovation. This has implications, of course, for education and skills, and is reflected in the relatively low demand for high level scientific and technical manpower.

15. An examination of employment in goods-producing industries reveals that a significant number of industries seem to have reached a plateau in the employment of non-production workers--managerial, clerical, sales, and such other. While output has been increasing, and increases are recorded in the number of production workers, the number of non-production workers employed has remained relatively constant. We have not attempted to determine the possible causal factors. The increasing application of electronic technology in the office is one possibility; and contracting out of some professional, planning, clerical, marketing, advertizing and such other activities may be

another. Whether it is the former or the latter, there are important implications for aggregate employment. It is sugggested, therefore, that the issue warrants investigation. *

16. A potential problem is suggested by responses to the question about anticipated technological changes and their effects: heretofore the levels of technical knowledge appear to have been generally adequate to allow the relatively smooth introduction of most technological changes. But, for the near future organizations anticipate that 60 percent of employees will require an increase in technical knowledge (as opposed to only 18 percent in the recent past). Although this large amount of upgrading will no doubt take place through the retraining programmes of the organizations themselves (as in the past), a wider range of workers will be involved. This has implications for both the general level of fundamental knowledge possessed by workers, and the capacity of individual organizations to provide effective retraining to increasing numbers of workers.

---

*See Appendix C - Tables and Charts.

4. THE IMPACT OF TECHNOLOGICAL CHANGES ON THE SECTORAL DISTRIBUTION OF EMPLOYMENT AND THE OCCUPATIONAL STRUCTURE

Technological changes are an important element in the sectoral distribution of the labour force, and have a significant influence on the occupational structure. The absolute and relative reduction of employment in agriculture over the past thirty years, and the relative constancy of the proportion of the labour force employed in manufacturing are generally attributed to technological changes. Similarly, the very substantial changes that have been recorded in the occupational structure over time are generally attributed to the effects of changing technology on the functional content of jobs, and to the changes in knowledge and skills that such changes compel.

At the outset it is desirable to examine the meaning of the term 'occupation', and how occupations and occupational structures change.

An occupation (or employment classification) is a specified range of work functions related to a given process of production. An engineer's occupation is associated with a range of general engineering work functions and a range of specific work functions that are related to the engineer's specialization--mechanical, chemical, electrical, nuclear, and other. An engineering technician's occupation is associated with another range of work functions, some of which may overlap with the professional engineer's work functions.

Technological changes, whether they be in the form of new machinery and equipment or increase in technical knowledge, affect occupations through their effects on the work functions associated with them: some of the functions may be eliminated, new functions may be added and some functions may be transferred from and to other occupations. Such changes in the ranges of work functions have educational and skill implications: the new work functions, whether the result of innovations or transfers from related occupations, require the acquisition of new knowledge and new skills by the practitioners of the affected occupations.

Defining an occupation as 'a range of work functions' is closer to the reality of employment, than would be the traditional association of occupations with single work activities. The number of occupations and employment classifications that are limited to single work functions is relatively small. This is why adjustments to technological changes have become routine: when there is only one work function, the elimination of it means the elimination of the occupation; this would cause a major occupational adjustment; but, when there is a range of functions, the elimination of some of them does not eliminate the occupation; rather, it would cause a re-arrangement of work functions.

The occupational structure of a country is made up of the thousands of occupations and grades of occupations employed throughout the economy--managerial and administrative, professional, technical, sales, clerical, occupations employed in manufacturing, construction, transportation and communication, agriculture and in scores of activities related to personal and business services. Technological changes impact on the occupational structure through (a) the creation of new sets of work functions; (b) increases in the range of work functions of established occupations, requiring the separation and transference of some work functions to new occupations; (c) the substitution of technological innovations for manpower; and (d) the dilution of skills by complementary technological innovations.

New sets of work functions (new occupations) are created by new products, new processes and increases in knowledge. In addition, increases in knowledge that relate to the activities of specific occupations may result in the formation of separate sets of work functions, and the creation of new occupations or different grades of the same occupation. In either case the number of occupational categories tends to increase. For example, a few decades ago, the nurse was responsible for duties which since have been taken over by x-ray technicians, laboratory technicians, dieticians, medical social workers, medical records clerks, physical and occupational therapists, respiratory technicians, surgical technicians, ward clerks, and others.[4]

---

[4]For a detailed examination of the subject, see: Technology and Manpower in the Health Service Industry 1965-1975, U.S. Department of Labor, Bulletin No. 14, 1967; and Stephen G. Peitchinis, Canadian Labour Economics, McGraw Hill, Toronto, 1970, Ch. 5.

But, it is well known that in many instances, knowledge renders knowledge redundant; which means that new knowledge can be equally a complement and a substitute to existing knowledge. To the extent that it is a substitute, it may cause the elimination of some occupations; to the extent that it is complementary it may dilute the skill component of the occupation and thereby facilitate the performance of work functions by relatively unskilled individuals. In such a case, the complementary knowledge causes the substitution of one occupation (relatively skilled) with another (relatively unskilled).

The three most outstanding employment features that characterize the development of the Canadian economy are:

1. the significant decrease in the number of workers employed in agriculture;
2. the very rapid increase of employment in service industries; and
3. the substantial increase in supply of professional and technical manpower.

The factors responsible for these shifts in employment have important implications for the educational and skill qualifications of the labour force. For example, the decline of employment in agriculture is associated with mechanization, consolidations, and the introduction of a scientific approach to farming. Inevitably these three factors would cause a change in the educational qualifications of the agricultural labour force:

consolidations and the emergence of agricultural business enterprises would be reflected in the number of farm managers and administrators; the scientific approach entails agricultural experimentation, testing and evaluation, which will be reflected in the number of agronomists, chemical and biological scientists, and other agricultural specialists; and mechanization would compel the acquisition of technical competence. Even the quality of the farm labourer would increase in response to requirements of processes that utilize increasingly complex and expensive capital equipment.

The comparative data given in Table 1 manifest the nature of changes in employment amongst sectors that are experienced by all countries in the course of economic development. A number of common experiences are evident: (1) employment in agriculture declined substantially in all countries, the average annual rate ranging between a low of 2.0 percent (Canada) and a high of 3.9 percent (Sweden); (2) all countries recorded increases of employment in services, the average annual rate ranging between a low of 1.2 percent in Germany and a high of 5.7 percent in Canada; (3) all countries, except Japan, recorded higher rates of increase in employment in services than in industry. Indeed, considering the relationship between technology and employment, it is significant to note that two of the countries, namely Germany and the United Kingdom, experienced an average annual decrease in industry employment over the period, one country (Sweden) experienced zero growth, and Switzerland recorded a mere 0.2 percent increase in

TABLE 1

CHANGES IN LABOUR FORCE AND EMPLOYMENT

BY SECTOR, 1961-1974

(Average Annual Rates)

Country	Rate of Growth in Labour Force	Rate of Growth of Employment in Agriculture*	Rate of Growth of Employment in Industry and Services	
			Industry	Services
Canada	3.6	-2.0	3.4	5.7
U.S.	2.1	-2.5	1.8	3.3
Japan	1.2	-3.7	3.3	3.1
France	0.9	-3.1	1.0	3.1
Germany	0.0	-3.5	-0.3	1.2
Italy	-0.6	-3.8	0.6	1.5
Netherlands	1.0	-2.5	1.9	2.5
Portugal	-0.1	-2.9	0.6	1.9
Sweden	0.7	-3.9	0.0	3.0
Switzerland	0.7	-2.7	0.2	2.5
U.K.	0.3	-2.7	-0.7	1.4

Source: OECD, Labour Force Statistics, 1961-74 (Paris, 1976).

*Including forestry, hunting and fishing.

industry employment.

There are a number of other exceptional experiences which warrant special reference: Canada stands out as the country which experienced the highest rate of increase in the labour force over the period. At 3.6 percent, the average annual rate of growth exceeded by far the second and third highest rates of 2,1 percent and 1.2 percent recorded by the United States and Japan respectively. This has important implications for the rates of increase in employment in industry and services, and for the rate of unemployment as well. The employment absorptive capacity of industry and services must expand at an exceptionally high rate to accommodate a 3.6 percent annual increase in the labour force and a 2.0 percent annual outflow from the agricultural sector. The rates shown in Table I demonstrate that the burden fell largely upon the service sector: the labour absorptive capacity of industry appears relatively limited, even though substantial relative to the rates of most other countries. As a result, Canada stands out as the country which experienced the highest rate of increase in employment in services. At 5.8 percent the average annual rate of growth exceeded by far the 3.3 percent recorded by the United States, and the 3.1 percent recorded by Japan and France.

The reference to the rate of unemployment is intended to suggest the possibility of a relationship between it and the rate of increase in the labour force seeking employment in industry and services. It is suggestive that the country which has been experiencing relatively high rates of unemployment is also the country which has been experiencing a very high rate of increase in the labour force. By contrast, countries which have been cited frequently for the absence of excessive unemployment, such as Sweden, Germany and the United Kingdom, have recorded relatively low rates of increase in their labour forces.

Over the past thirty years the service sector of the economy has been the main employer of the increasing labour force: retail and wholesale trade, clerical activities, hospitals and educational institutions, public administration, financial institutions, and such other were largely "labour intensive" activities--as they expanded, so did the number of people engaged in them. These activities remained largely labour intensive because many of the services performed in the sector were not conducive to mechanization. Where machines were used, improvements in them reduced the degree of labour intensity--improvements in typewriters facilitated an increase in the amount of typing services without the hiring of additional typists. But, for the scores of other service activities for which mechanical instruments could not be used, increases in demand for them meant increases in demand for the employees who performed them.

The advent of electronics is changing the labour intensity of the service sector. Activities which were not appropriate for mechanization and activities to which mechanization was applied to a limited extent only, are conducive to electronic technology. Indeed, electronics and electronic systems are not only facilitating the conversion of labour intensive processes into electronic processes, but are also substituting electronically automated processes for mechanical processes.

The implication of this for employment and unemployment is yet to be examined in the detail that it warrants. The Economic Council of Canada anticipated that "the demand for manpower will continue to shift towards the white-collar and related service industries, and their command of total employment will increase from 63 percent in 1974 to 68 percent in 1982."[5] We suggest this statement is based on past trends; not on current and anticipated technological developments in service sector industries.*

Heretofore, technological changes in production processes did not cause mass redundancies and notable difficulties with educational and skill requirements and qualifications because: (1) demand for goods and services increased rapidly, facilitating the retention or re-employment of most employees, after some retraining where required; (2) the general increase in demand for goods and services created demand for all kinds of non-production workers--clerical, sales, warehousing, administrative service and many other; (3) as incomes rose the ownership and use of durable goods increased, generating demand for maintenance and repair workers; and (4) although technological changes have been extensive

---

[5]Economic Council of Canada, People and Jobs - A Study of the Canadian Labour Market, Ottawa 1976, p.26.

*See Appendix C.

and somewhat revolutionary, the pace of their introduction has been relatively slow, facilitating necessary adjustments in educational and skill requirements.

The question now arises whether these positive offsetting developments will continue to be as effective in the future as they have been in the past. The first possible problem may arise from the radical nature of anticipated technological changes: the nature of technology that is being introduced, is virtually self-diagnostic in relation to malfunctions; and malfunctionings are frequently corrected by the simple process of replacing a card (module) on which the malfunctioning parts are imbeded. Thus, demand for repair and maintenance work, the two skilled occupations that expanded rapidly in recent decades, may be expected to begin a decline over the next decade, which decline is likely to accelerate in the second decade. Secondly, as indicated above, the increasing introduction of EDP* systems in the provision of services will reduce the labour absorptive capacity of service industries. For example, it is expected that an automobile will be driven through a diagnostic centre which will indicate which parts malfunction; the consumer will self-serve (computer assisted) at garages, gasoline stations, department stores, grocery stores, banks and other financial institutions, libraries, and other; typing services will be produced automatically while dictating into a receiver, and the telephone will record in-coming calls when the unit is engaged; and many routine diagnostic activities performed by physicians and other

*Electronic Data Processing.

health workers, such as the measurement of blood pressure, routine blood analysis, heart beat rate, sound of inhalation and exhalation will be performed automatically and more accurately by computer controlled equipment. The diagnostic functions that will remain with the competent physician will be those which require visual examination. Thirdly, the rate of technological change will likely accelerate. Knowledge of computer technology has increased dramatically in recent years, and the cost of computers has fallen to a range that indicates a substantial increase in demand. As their prices continue to fall, and their use requires less and less expertise, their utilization will become widespread--in homes, offices, shops, and industry generally.

In the course of this investigation we became aware of a general lack of appreciation of the nature of pending new technology, and the extent and speed with which new technology will be adopted. To the extent that some new technology is at the experimental stage, lack of precise knowledge about its potential would not be surprising; but some revolutionary new technology is being utilized in countries such as Germany and Japan, and competitive urgency suggests its careful examination.

J. Scrimgeour has outlined and commented on the implications of two such new technologies--Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM). It is anticipated that the two will be combined "into coordinated CAD/CAM systems (and thereby) make the concept of the automated factory, from product conception and design to final assembly and test, an actual reality."[6] In essence, the CAD/CAM system will integrate entire manufacturing processes, from design to production and distribution.

What are the implications of these prospective developments for the education and skill requirements of industry? A few can be deduced from the effects of currently implemented new technology: (1) large scale manpower displacement should be anticipated; although this will take place gradually, over a number of years, substantial retraining programmes will be necessary to re-equip with skills and re-employ the displaced workers. (2) The nature of the new technology suggests effects on workers that go beyond the shop floor; office employees will equally be affected, which suggests a wider range of retraining programmes. (3) The labour absorptive capacity of the service sector is being reduced. Considering that this sector has been absorbing almost three-quarters of the increase in the labour force, any reduction in its labour absorptive capacity has implications for employment and unemployment generally. (4) Canada's international competitive position dictates continuous innovative activity; Canadian industry cannot afford the luxury of awaiting developments in other countries and then seek to adopt the new technology implemented by their industries. To become and remain competitive Canada must allocate

---

[6] Ibid., p.2. Additional reference to this issue will be found on pp. 60-63.

resources to the research and development of products and processes. This suggests the development of high level manpower. (5) The new technology will have important social implications. The study and satisfactory accommodation of its effects will bear on its effective utilization. New technology cannot be utilized efficiently in an environment of social agitation. This suggests a need to study and analyse the implications of new technology for employees, consumers, public institutions and society at large, and to formulate plans outlining the alternative ways in which the effects can be accommodated.

The efficient functioning of automatic production processes depends on the knowledge and expectations of those who make use of them. Thus, the efficient use of computers was delayed many years by inadequate knowledge on the part of their potential users regarding what they can do, what their limitations are, and regarding the relationship between the nature of information provided and the nature of results received. The same principle applies to most technological processes: the rate at which they will be introduced and the efficiency with which they will be used will depend to a considerable degree on the knowledge of industry decision-makers. We have gained the impression, perhaps an erroneous one, that the search for knowledge in relation to new products and processes is not given the degree of priority that it warrants. Allocations to research and development appear to be largely directed to "improvements" and "maintenance" rather than to innovation. Yet, it is innovation that is needed for the strengthening of our international competitive position.

5. KNOWLEDGE AS CAUSE AND EFFECT OF TECHNOLOGICAL CHANGE

> Technology sets limits to what a country can produce at any given time with the land, labour and capital available to it. It also determines how production takes place. As the state of technology advances--either by drawing existing knowledge into use or by applying new technological knowledge--the production frontiers are extended.[7]

A cause and effect relationship exists between technological change and education, which is both direct and inverse: technological changes cause (require) changes in educational and skill qualifications; but certain educational and skill qualifications are necessary for technological changes to take place. The Economic Council of Canada put the issue in the following way:

> New knowledge must exist in the minds of men before it can be embodied in new skills, new machinery, new products and new processes. In order to maintain a high potential for technological change, Canada must have an adequate supply of scientific and technical manpower to serve as a basic source of inventions and innovation.[8]

The issue appears to be somewhat more complicated when educational

---

[7] Economic Council of Canada, Fifth Annual Review: The Challenge of Growth and Change, 1968, p. 35.

[8] Economic Council of Canada, Fifth Annual Review, p. 44.

requirements are related to specific sets of technological changes: educational qualifications, and to a surprising degree requirements too, vary from industry to industry, oftentimes in relation to the same technology and occupations.[9] Specific relationships appear to be limited to the strictly technical and scientific aspects of the technology and the manpower applied on it. This suggests that in relation to most economic activities there exists a possibility of substitution amongst levels of education, knowledge and skills. And when the possibility of substitution exists, each industry has the opportunity to choose that set of educational and skill requirements which suits it best.[10]

Commonly, the issue of the relationship between technological change and employment, and technological change, education, skills and the occupational composition of the labour force are examined from the standpoint of technological changes being the cause and changes in the other variables being the effect. The issue of the effect on technological changes--contemplated or implemented--of existing levels of education, skills, and the occupational composition of the labour force is not as frequently examined. Is there evidence of delays in implementation of

---

[9] See David Sewell, "Educational Planning Models and the Relationship Between Education and Occupation," Canadian Higher Education in the Seventies, Economic Council of Canada, Information Canada, 1972, pp. 45-74.

[10] Hollister examines this issue in A Technical Evaluation of the First Stage of the Mediterranean Regional Project, OECD, Paris, 1966, p. 34.

technological changes because of deficiencies in education and skills? Is there evidence of delays in the development of technological changes? Is there evidence of sub-optimal utilization of technological changes as a result of an inadequately prepared labour force?

We know that there has been a gap between inventions and their development and application in production processes; and we know also that the gap has been narrowing in recent times. Lynn identifies two initial periods:

1. "A period ... when little or nothing of a concrete nature occurs because although technical feasibility has been established, a number of missing elements must be supplied before the commercial potential becomes evident." He labels this the "Incubation Period."

2. "Once the commercial potential has been recognized, a period of commercial development ensues when a directed effort is made to convert the basic technology into a technically and economically feasible product or process." He labels this period the Commercial Development Period.[11]

Table 2 shows the incubation and commercial development periods of various innovations and demonstrates the extent to which the gap has tended to narrow in recent times.

---

[11] Frank Lynn, "An Investigation of the Rate of Development and Diffusion of Technology in Our Modern Industrial Society," Report of the U.S. National Commission of Technology, Automation and Economic Progress, Appendix, Vol. II, pp. II-39(1965).

TABLE 2. RATE OF DEVELOPMENT FOR SELECTED TECHNOLOGICAL INNOVATIONS.

Technological innovation	Start of commercial development	Lapsed time (years): Incubation period	Commercial development	Total development
Aluminum	1886	31	6	37
Motor vehicle transportation	1891	23	4	27
Air transportation	1903	6	8	14
Synthetic resins	1907	49	3	52
Radio broadcasting	1913	17	9	26
Electronic vacuum tubes	1914	7	6	13
Frozen foods	1916	74	9	83
Vitamins	1926	13	11	24
Synthetic rubber	1929	20	11	31
Television broadcasting	1933	22	12	34
Synthetic fibers	1936	6	3	9
Titanium	1936	26	14	40
Antibiotics	1939	11	1	12
Electronic computers	1944	15	6	21
Semiconductors	1948	7	3	10
Numerical control	1948	18	7	25
Synthetic leather	1950	12	14	26
Nuclear power generation	1954	11	3	14
Freeze-dried foods	1955	4	6	10
Integrated circuits	1958	2	3	5
Average		19	7	26

Source: Lynn, ibid., p. II-39. For additional examples see Appendix I. "A History of Recent Technological Innovations," by Frank Lynn, Thomas Roseberry, and Victor Babich.

It is quite appropriate to pose the question, to what extent, if any, is the invention-implementation gap related to the educational attainment of the labour force? Is it possible that the narrowing temporal gap of recent times is related to the fact that levels of education have been generally rising?

A.J. Jaffe and J. Froomkin write:

> An analysis of changes in the educational attainment of workers by growth in level of output per worker reveals that the speed of technological change has little, if anything to do with educational attainment ... even in those industries which apparently were undergoing the most rapid technological changes (as measured by changes in output per worker), one-half to three-quarters of the manual workers had less than a high school education. These data clearly prove that modern advancing technology does not necessarily require workers to have more formal schooling.[12]

The authors state that their observations apply equally to the educational attainment of nonprofessional white-collar workers.[13]

These findings are in general agreement with those of Bright[14] and Fine,[15] who concluded that workers generally did not need additional schooling to fill jobs in highly mechanized processes. In some instances periods of training tended to be a little longer than for previous changes in equipment, but these were a matter of a few weeks on the job.

---

[12] Technology and Jobs - Automation in Perspective, Frederick A. Praeger, Publishers, New York, 1968, pp. 87-89.

[13] Ibid., p. 89.

[14] James R. Bright, Automation and Management, Harvard Business School, Boston, Mass., 1958, Chapter 12.

[15] S.A. Fine, The Nature of Automated Jobs and Their Educational and Training Requirements, Human Sciences Research Inc., McLean Va., 1964.

Lynn makes no reference to education as a possible factor in the gap. He attributes it instead to three other factors: (1) the nature of the application--whether for the consumer market or for the industrial market. Apparently, consumer market innovations have had a narrower gap than industrial market innovations. (2) The source of development funds--whether private or public. Apparently the financing of developments by governments in recent times has been an important factor in the narrowing of the gap. Particularly so in relation to innovations that have implications for defence and space exploration. (3) Patent protection. The rationale here is that when patents are held by the public authority and development of the innovations is open to competition, faster development and application can be expected than when patents are privately held.

Mansfield,[16] too, fails to make any reference to the education and skills of the labour force. He has examined the relationship between the size of firms and the development of innovations; the relationship between the application of innovations and the relative increase in the firm's economic advantage; the uncertainty associated with development of innovations;

---

[16]Edwin Mansfield, "Innovation and Technical Change in the Railroad Industry," in Transportation Economics, NBER, 1965; "Size of Firm, Market Structure and Innovation," Journal of Political Economy, Dec. 1963; "The Speed of Response of Firms to New Techniques," Quarterly Journal of Economics, May 1963; "Intrafirm Rates of Diffusion of an Innovation," Review of Economics and Statistics, Nov. 1963.

the financial commitments required in attempting development; and the potential profitability of the investment.

To conclude this discussion, the evidence appears to suggest that technological innovations and their application are not likely to be held back by the educational and technical preparation of the labour force. Although without doubt the inventive and developmental activity in advanced economies is related somewhat to the existence of highly educated individuals and a technically competent labour force, there is no evidence of the existence of a direct relationship between the rate of technological change and the education level of the labour force.[17] To the extent that there exists a relationship between levels of education, innovation and technological development, it is likely to be found in connection with R & D activity. If there is a close relationship between R & D activity and technological change, and there is a relationship between R & D activity and employment of high level manpower, then a relationship can be deduced between technological change and the education level of the labour force.

The foregoing relates, of course, to the Canadian labour force and it is in the context of the technological structure of Canadian industry. It does not apply to countries which are not technologically advanced.

---

[17]Sven Moberg, Under Secretary of the Swedish Ministry of Education makes reference to this issue in "Technological Change and its Implications for Education," Proceedings of an International Conference on Automation, Full Employment and a Balanced Economy, The American Foundation on Automation and Employment Inc., 1967.

6. PROBLEMS IN DETERMINING THE EFFECTS OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS OF INDUSTRY

It is difficult to determine precisely the effect of technological changes on the educational and skill requirements of industry: we know that some technological changes are substitutes for education and skills; some are complementary to education and skills; and some are partly substitutes and partly complements. The difficulty arises when we attempt to determine the degrees of substitutability and complementarity in relation to individual occupations and employment categories.

The fundamental problem appears to be the existence of only vague relationships between educational requirements and the range of work-functions that are associated with individual occupations. Although most work-functions require some specific knowledge, that knowledge is not necessarily related to the level of education that is set as a minimum qualification for the position that is identified with those work-functions. Disagreements between educators and employers on the relevance of the contents of educational programmes are commonplace. Although employers insist on a university degree, a college diploma, senior or junior matriculation, there is evidence that they are willing to substitute experience for any of them. "Experience" relates to the work-functions involved, which may not necessarily be related to the educational content of the relevant educational programme.

Excepting professional and specific technical qualifications, the requirements of degrees, diplomas, senior or junior matriculation must be taken to constitute a general standard, and not an educational content related to the work-functions to be performed.

Even with professional occupations there exist differences between educational qualifications and the specific knowledge required for the performance of specific work-functions. But, the professional is presumed to have sufficient high level fundamental education in the subject of the profession to be able to grasp the specifics of application without difficulty and long training. Nevertheless, a problem does exist in establishing a proper relationship between educational qualifications and the specific knowledge requirements of work processes.[18]

The problem is compounded by the existence of related occupations whose education and work-knowledge are closely related. There is much overlap in work-functions between professional occupations and occupations related to them in the work-process: the work-functions of engineers overlap with some of the work-functions of engineering technicians; some of the work-functions of dentists overlap with some of the work-functions of dental hygienists; physicians perform some work-functions which in other countries (and in some areas of this country) are performed with equal efficiency and competence by nurses.

---

[18] See detailed discussion on this subject in U.S. Department of Labor, Work Force Adjustments in Private Industry - Their Implications for Manpower Policy, 1968, pp. 104-106.

Overlapping work-functions provide some desirable flexibility in work processes: they become the adjustment mechanism that brings about equilibrium when surpluses and scarcities of related occupations coincide. For example, when there is a scarcity of engineers and a surplus of engineering technicians, the latter can assume the overlapping work-functions performed by the former. Such a transfer of functions from one occupation to another has the same market effect as an actual increase in supply of and demand for the occupations involved. In the case of the engineer-technician relationship, by transferring some functions to the technician the engineer will be able to perform some functions whose performance was precluded by the shortage in supply. Clearly, the transference in functions has the effect of an increase in supply of engineers. Similarly, the increase in work-functions to be performed by engineering technicians would represent an increase in demand for engineering technicians. Thus, given a shortage of engineers and a surplus of engineering technicians, the transfer of work-functions from the former to the latter would tend to move both occupations toward positions of market equilibrium.[19]

But, the flexibility in work-processes that over-lapping work-functions afford, complicate the effort to determine the proper relationship between technological changes and educational and skill

[19]Mention should be made to the fact that such transfers result in an increase of the average level of the work-functions performed by each of the occupations involved. When increases in wages and salaries accompany such adjustments, they are as much related to the increase in average value of the work-functions performed, as they are to the forces of demand and supply.

requirements. Additionally, the work-functions of most occupations (grades of occupations and employment categories) change continuously in response to changes in knowledge regarding the processes to which they are applied, changes in procedures and techniques, changes in demand for and supply of occupations (and those of occupations potentially utilized as partial substitutes), and changes in wages and salaries. Any and all of these cause adjustments in work-processes and redistributions in work-functions amongst occupations and employments.

These developments lead to the following general conclusion: the higher the levels of education relative to the requirements of work-processes, and the greater the flexibility in transference of work-functions among related occupations, the lesser would be the dislocative effect of technological changes. To the extent that the work-functions normally performed by some occupations are below the educational and skill qualifications of those who perform them, the introduction of technological changes which require higher level qualifications would result in the optimal utilization of existing qualifications. Therefore, from the standpoint of the efficient utilization of technological changes and efficient accommodation to technological changes, it would be desirable to maintain levels of education and skills that are somewhat higher than what production processes require at current periods.

7. PREDICTING THE MANPOWER EFFECTS OF TECHNOLOGICAL CHANGE

The fundamental problem in predicting accurately the manpower effects of technological change is our inability to measure accurately the outcomes of dynamic interactive relationships between all of the economic, technological and social factors that become involved. It is one thing to construct a model which explains static causal relationships between all the factors, and quite another, to determine and measure quantitatively the outcome of dynamic interactions between all factors over specified time periods.

In the absence of technology, there would exist a direct functional relationship between labour input and output; and the labour input-output ratio would tend to be relatively stable over time. Fluctuations about an average would take place, but over time general stability would prevail, mainly because of the tendency of workers to abide by group established norms.

Technology breaks this direct functional relationship between labour input and output; it introduces varying degrees of variability in the labour input-output ratio. When an instrument is placed into the hands of a worker, the resulting output no longer reflects the knowledge, experience and efficiency of the worker; it reflects the knowledge, experience and efficiency of the worker and the quality and efficiency of the instrument. Indeed, depending on the nature of instrument that is being introduced, it may render redundant some or all the knowledge and experience that the worker possesses, and may require the worker's native intelligence only. Hence the introduction of instrumentation creates considerable uncertainty about the knowledge, skill and experience that is required of workers.

The function of capital instruments is not limited to one of complementarity to labour; instruments are also labour substitutes. Indeed, their role as labour substitutes gives rise to considerable apprehension and discussion.

The effect of technological changes on manpower appears to be six-phased: (1) They complement the manual and semi-mechanized work-functions of personnel, thereby enabling them to perform a larger quantity of work; (2) they increase the efficiency of processes; (3) they facilitate the performance of some work-functions which could not have been performed in the absence of the new technology; (4) they create new categories of labour; (5) they displace labour and (6) they reduce the employment intensity of production processes.

The effect on employment on the aggregate depends upon demand and the consequent increase in output: where demand and the volume of output increase faster than the rate of increase in productivity, employment should increase; where output increases proportionately to the increase in productivity, employment, on the aggregate, can be expected to remain unchanged; and where demand and the volume of output increase by less than the increase in productivity employment should decrease.

Whatever the effect on employment on the aggregate (i.e. increase, unchanged or decrease), some work-functions are likely to be redistributed amongst occupations and employment categories, and some new occupations and employment categories are likely to be created (mainly related to the technological change). The redistribution of work-functions and the change in occupational mixes have, of course, implications for education and skills. But, the implications vary from technological change to technological change, depending on its nature, and on the change in employment on the aggregate. Thus, if the technological change represents a radical departure from existing production processes, it will likely cause the employment of appropriate technical occupations; similarly, if demand for the goods and services is increasing faster than the increase in productivity, necessitating an increase in employment generally, there will likely be additions to professional, managerial and supervisory personnel. This leads to the general conclusion that major technological changes in organizations facing rapidly increasing demand for their goods and services will have an upward effect on educational and skill requirements. Where demand is rising proportionately to the increase in productivity, production personnel will likely remain the same, but the increase in volume of goods and services will cause an increase in administrative and professional personnel, in addition to the technology related manpower. This too, will have an upward effect on educational and skill requirements.

Based on this analysis, the only situations in which a downward effect on education and skills is likely to be experienced would be where there is an actual decrease in demand for goods and services. The introduction into such a situation of a productivity increasing technological change will likely cause redundancies amongst both production and supervisory personnel. Although some technology-related employment may be created, which would suggest an upward effect on the skill composition of the labour force, the effect on educational requirements will likely be neutral.

In the three situations to which reference is made above, a positive relationship is assumed between output and employment. There are instances in which such a relationship does not exist: employment in totally or largely automated plants may be entirely insensitive to fluctuations in output.[20] The number of personnel employed and the number of man-hours worked are more likely to be related to the operation of the equipment than to the output produced by it. Similarly, in situations in which equipment is underutilized, it may be possible to increase output without any effect on employment. In relation to the first, appropriate examples would be automated petroleum refineries and automatically controlled electricity-generating plants; while the second can be found wherever equipment is not utilized to capacity.

The introduction of technological changes into such situations may have no perceptible effects on the skill composition

---

[20] E.R.F.W. Crossman, Automation and Skills, (Problems of Progress in Industry No. 9), H.M. Stationary Office, London, 1960.

and educational requirements of the labour force. This statement is based on the assumption that the technological change, whatever its nature and complexity, is nevertheless, based on the same scientific, mathematical and mechanical principles as that which it replaces. To the extent that the technological change is based on different fundamental scientific, mathematical and mechanical principles, changes in the skill composition and educational requirements of the labour force would be necessary. For example, the change from mechanical to electronic processes, and the change from the use of coal fixed electrical generation stations to nuclear powered generation stations, will necessitate changes in both the skill and education of the labour forces involved.

8. TECHNOLOGICAL INNOVATION AND HIGH LEVEL MANPOWER

A fundamental characteristic in the relationship between educational requirements and job knowledge is that they are substitutes: generally educational requirements tend to rise when knowledge about a job or a process is limited, and they tend to fall when knowledge increases. This would suggest a tendency for educational requirements to rise in periods of widespread research and experimentation, and to fall on the downside of the research cycle.

An appropriate illustration is provided by the development and use of computers. During the initial phase of their introduction, computers were demonstrated by electronics engineers, and computer programmers were required to have degrees in engineering or mathematics. But, over time, as knowledge about the nature and operation of computers increased, the level of education of computer sales representatives decreased, and high school graduation became adequate qualification for training in computer programming.

This has important implications for education and society at large: a cycle is introduced which parallels the cycle of innovation. When these are stimulated, whether in quest of perfecting armaments or by international industrial competition, demand for education will rise to search for and make the unknown known. As long as knowledge remains imperfect the quest for its improvement will sustain demand for relatively high levels of education. When knowledge so improves as to require relatively little education to understand and use the products of research, then both the level and specialization of education would tend to diminish.

A study of the relationship between education and technological innovations over their lifetime concluded:

> ...highly skilled scientists and engineers are required for development of a product and production process before high volume production can occur. Engineering inputs reach a maximum during installation of high-volume production lines. Less highly skilled engineers, and fewer of them, are needed later for cost-reducing improvements and for problem solving associated with production. As they age products move to organizations with progressively lower average skill levels. Great emphasis is placed on transfer of information from early to later production organizations. The primary function of highly skilled labour in product innovation thus appears to be acquisition of knowledge.[21]

This finding has important implications for highly skilled labour: the demand for it is directly related to the level and range of innovative activity. Research related to improvements in established innovations does not appear to require the level of expertise nor the numbers required in the course of searching for distinctly new products and processes. The computer provides another relevant example: subsequent to its initial introduction a series of

---

[21] F.O. Setzer, Technological Change Over the Life of a Product: Changes in Skill Inputs and Production Processes, Unpublished Ph.D. Dissertation, Yale University, 1974.

important improvements were introduced; but important as they were, the established labour force was able to cope with them after only minor instruction. Therefore, if it is important to society to have a pool of highly skilled labour, it would be necessary to maintain a continuous program of innovative research activity. High level education and skills cannot be sustained on the repair and maintenance of established or imported innovations.

9. ELECTRONICS SYSTEMS AND EDUCATIONAL REQUIREMENTS

The increasing use of EDP systems has opened up a new field of employment for a rapidly expanding number of new occupations and new employment categories. Mass production of electronic products and systems has brought down the prices of hardware, and the reduction in prices made hardware accessible to larger numbers of potential users. This created employment both at the level of production and at the level of operations.

At the level of production, demand has risen for engineers, technicians and scientists to research, design, develop, test and produce the hardware. In addition, specialists in these same occupational categories are required to research, design, develop, test and produce the software.

Hardware and software are complimentary products--one cannot produce without the other. The extent to which the hardware will perform the functions they are designed to perform will depend upon the design of the software. Hence, software may be viewed as the more important element in the complementary combination.

There prevails a view in the organizations engaged in research, development and production of hardware and software that the main thrust over the next decade or so will be in R & D of software. The rationale appears to be founded on the belief that existing hardware can perform efficiently a wider range of functions than they are presently performing; and the reason for not performing to capacity of potential is the inadequacy of software. An example to which frequent reference is made is the landing of man on the moon and the landing of robots on Mars. This is held as evidence that existing hardware can perform highly complex functions if instructed and directed properly. The instruction and direction is contained in the software.

What are the implications for employment, education and skills of increasing advances in EDP hardware and software? "With robots already manning factories, and computers beating us at chess, will people be relegated to the sidelines?"[22]

Technologically we are rapidly moving towards a self-operational system. Production processes will be self-evaluative, self-corrective, and self-operational. The role of experts will be limited to the consideration of alternative instruments, processes and products; and the role of today's maintenance worker will be reduced to one of replacing the indicated deficient instruments.

This suggests a concentration of human effort at the conceptual phase of production processes. Whatever human participation will be required at the operational phase it will likely be of the "trouble-shooter" nature, which, by implication, will likely involve individuals with high level fundamental knowledge of systems and operations. It is important to note the scope of the operational phase: it is not limited to industrial production processes. Rather, it will cover the entire spectrum

---

[22] M. Sanderson, "People may Suffer Unless We Modify Attitudes Toward Systems and Automation," Computer Data, September 1976, p. 50.

of technology use. For example, diagnosticians, whether they be specialists in human or mechanical systems, will be presented with the possible causal factors of indicated maladies, and alternative remedies. It will be their function to deduce which are the causal factors of the specific maladies and which corrective measures to take.

This suggests a different kind of knowledge than has been required heretofore of many specializations. Specific knowledge will have to give away to fundamental knowledge; and unit knowledge will have to give away to systems knowledge.

10. TECHNOLOGICAL INNOVATIONS, IMPROVEMENTS IN TECHNOLOGY AND MANPOWER IMPLICATIONS

The current wave of technological change has its beginning in the mid-1950's. Its impact on the educational and skill requirements of industry was significant at the beginning since in many instances it required new knowledge and the mastery of new concepts. But, once the revolutionary phase passed, and the new technology became established in production processes, subsequent "innovations" have really been improvements rather than inventions or as it is commonly referred to "nuts and bolts" innovation. The impact of improvements in technology on educational and skill requirements is of a supplementary nature, not in the nature of substitutes: it is adding to basic knowledge, not necessarily replacing basic knowledge.

An appropriate example is provided by computer technology: when computers were introduced in the mid-1950's, the emphasis was on engineering and mathematical computations. Generally, the computer was regarded as an automatic high speed calculator, with a memory facility. From the standpoint of education and skill, the significance of it was not in what it could do, or in what it was generally thought it could do, but rather in the new technological, conceptual and operational principles that it introduced. An innovation was introduced which constituted a significant departure from existing technology; a new language was being introduced; and a set of new operational principles were being suggested.

During the early phases of the innovation, perhaps in the first decade of its implementation, the implications for education and skills were very significant: a new set of technical knowledge had to be mastered; there were new concepts; and a new set of operational knowledge had to be grasped. The new knowledge caused the emergence of new occupations and changes in employment classifications.

Subsequent to the initial phase of its introduction, computer technology found application in a wide range of additional activities without any significant additions to fundamental knowledge or occupational qualifications. The new applications, although revolutionary in nature, were mere extensions of the fundamental principles incorporated into the initial theory and technology. It became evident, for example, that in addition to its computational potential (the ability to perform lengthy calculations at high speed), the computer had logical potential--the ability to make programmed decisions, to examine multiple cases, make selections and optimize; it had memory--the ability to receive information, store it in memory banks, and provide it to users upon request; and it had graphic potential--the ability to provide the information in a variety of configurations, such as tables, charts, drawings and lines.[23]

Only the last of these is expected to have some significant implications for occupational knowledge and employment: it is widely expected that it will have a negative effect on the employment of traditionally-trained draughtsmen.

The same results are in evidence in manufacturing: the most notable changes in manpower qualifications were recorded during the initial introduction of computers. Even though initially computerization was limited to accounting functions--accounts receivable, accounts payable and payroll--specialized manpower had to be employed for the operation and utilization of the computers, and equally important, most of those whose work became affected directly or remotely by the introduction of the computer had to acquire some new knowledge. Subsequent extensions in the application of computers to production planning and inventory control, and the current extension to the control of numerically controlled machine tools, have not had any dramatic effects on manpower, knowledge and skills. The effect now is largely supplementary and in some instances complementary; it is additions to a base of knowledge, skills and manpower established during the initial phase.

---

[23] A good analysis on the actual and potential application of computer technology to industrial activity will be found in a paper by J. Scrimgeour entitled "CAD/CAM and its Significance to Canadian Industry," presented at the 1975 Annual Congress of EIC, in Winnipeg, Manitoba (September 30-October 3, 1975).

The question arises whether any significant changes in knowledge, skills and manpower should be anticipated as computer technology is applied more extensively in the manufacturing sector--to the factory floor. To date, technological changes in manufacturing have been in the nature of improvements in materials and electromechanical technology. The most advanced technological innovation introduced in recent years has been the numerically controlled machine tool. A firm employing "high technology" processes indicated:

> ... tool bits are harder, machine speeds are faster, cutting oils are better. Techniques for deep hole drilling are improved ... Metals have become harder, stronger and lighter, and techniques and tooling have had to evolve to keep up.
>
> Machines have also improved with faster set-ups, tape controls, easier maintenance, and greater speeds. They are available with digital readouts, convertible from English imperial units to metric.

Regarding manpower, the same respondent wrote:

> The men who operate these machines are trained in-house, or by equipment builders ... If we require an N/C programmer, we hire one. If the newly-hired programmer is unfamiliar with our programming language, he is sent to a service bureau for training.
>
> . . .
>
> Perhaps the real challenge has rested with management, who have had to develop new markets, reduce inventory levels, reduce supplies and materials costs, reduce down-time, improve safety, and optimize scheduling techniques, in order to remain competitive and profitable. The level of management skills has had to rise faster than any other group.

Manufacturing is entering a new phase in its technological development, which will have significant implications for manpower, particularly manpower at the factory floor. There prevails a general view that within the next decade manufacturing processes will become as computerized as are information processes today. The first step in the process of computerization is to link groups of numerically controlled machine tools to a single computer. Such a link facilitates the coordination and control of various related activities, such as, materials routing and transfers, product assembly, testing and inspection, and such other.

The second step would be to establish interconnected computer systems which will encompass the entire process, from conception/design through to testing and shipment. Scrimgeour[24] visualizes the following automatic process:

- Computer graphics for the design and drafting of the product, with the "design" held in computer memory rather than by drawings and blueprints.

- Computer generated parts lists, vendor ordering, production scheduling and inventory control. More and more these are becoming real time transaction oriented rather than batch systems.

- Computer controlled stacker cranes for automatic movement of material in and out of raw materials storage, work in progress inventory and finished goods inventory.

- Computer controlled delivery of components to machining centres and assembly areas employing robotics.

- Direct computer control of numerically controlled machine tools, inspection and automatic test equipment.

---

[24] *Ibid.*, p. 3.

The manpower implications of the computerization of factory processes can be deduced from the nature of manpower employed in automated refineries, telephone systems and chemical plants: engineering and other technical personnel and management will develop greater facility in the use of computers as aids in design, production control, testing, and other pre-production, production and post-production (inventory control, consumer relations) activities; shop floor labour, such as machine attendants, product inspectors, machine repair and maintenance will gradually be rendered redundant.

11. EXISTING LEVELS OF EDUCATION AND INDUSTRY REQUIREMENTS

The past twenty years have recorded a progressive and general increase in the levels of education of the Canadian labour force. The proportion with only primary school education has more than halved; and the proportions with high school, some post-secondary education, and university degrees have increased substantially.

It has been difficult to ascertain the extent to which the recorded increases were demand-induced, i.e. the result of actual and anticipated increases in the educational requirements of production processes and of the socio-economic environment at large, and the extent to which they were the result of an autonomous general increase in the levels of education of the population at large, motivated by a general desire for more education and facilitated by rising incomes.

The predominant opinion appears to support the latter proposition. Yet, it is instructive to recall that in the early 1960's widespread concerns were expressed about the relatively low levels of education of the labour force, and young people were urged to remain in school longer. Rising levels of unemployment, particularly amongst the young, were attributed to inadequate education; and prevailing opinion had it that unless levels of education and training were raised substantially, people would find it increasingly difficult to find and retain jobs in an increasingly techno-scientific economy. Concerns were expressed also about the possibility of an inadequately educated labour force becoming an obstacle in the implementation and effective utilization of modern technology. Thus, education came to be viewed as an important means to employment security, in an ever changing techno-scientific work environment.

Therefore, the current opinion that the increase in the levels of education of the labour force has been the result of the general increase in levels of education of the population at large, and that the motivation for more education has been personal-social rather than economic-industrial, may not be founded on an accurate interpretation of past developments. General assertions of positive relationships between education and employment, education and income, education and advancement within the occupational structure, and expressions of concern about lifetime employment in an increasingly diverse and complex techno-scientific economic environment have had considerable influence on the quest for more education.

These conflicting relationships have important implications for education, skills and employment. As indicated above, in the context of technologically advanced economies, most technological changes do not appear to require higher than the prevailing levels of education. Indeed, in relation to the labour force at large, and the nature of modern technology that is being employed, the prevailing levels of education may be higher on the average than what is required. Although most industries do require somewhat higher levels of completed formal education today than they did five or ten years ago, the extent to which that is a requirement of their new processes of production and the extent to which they are a response "to the fact that a greater number of educated and trained people are available in the market" has not been ascertained. Undoubtedly, some new processes require higher levels of education and skills; and some other require different educational and skill content than the processes they replaced (i.e. electronics instead of electro-mechanical knowledge and skills); but, most processes do not appear to require any substantially different levels than the range of levels possessed by their current labour forces. The overwhelming majority of industries that responded to our enquiries indicated that the educational levels of their labour forces were adequate for the efficient utilization of existing and known technology.

Responses to our questionnaire, to letter enquiries and to questions posed during interviews convey the impression that there have been no manpower problems in relation to technological changes-- neither in relation to the accommodation of technological changes nor in relation to labour force adjustments to technological changes. Some scarcities of specialized manpower do exist, particularly in computer-communications systems and in skilled trades, but there are no problems with levels of education, knowledge and skills. The responses indicate that whatever deficiencies in knowledge and skills may have emerged from time to time in the process of accommodating some technological change, retraining and refresher courses corrected the problem.

But, perhaps wider implications are suggested: the evidence from this study indicates that on the average about 85 percent of the labour force affected by technological changes did not require any change in fundamental knowledge, and 78 percent did not require any change in specific technical knowledge. This can be interpreted in two ways: either that the new technology did not require any more or a different kind of fundamental and technical knowledge than the technology it replaced, or that the labour force had higher educational qualifications than was required for the old technology. Information provided by personnel managers lends support to the latter proposition.

There prevails a general view that increasing numbers of workers possess more education than is necessary for the efficient performance of their present job-related work functions. Scores of cases were brought to our attention of individuals with high school, college and university education engaged in full-time work activities that required considerably lower educational qualifications. But, explanations for the apparent requirements-qualifications imbalance varied: some saw it as a general desire of society at large for more education, regardless of the requirements of production processes; others attributed it to quest for employment security in the long run--the ability to accommodate anticipated changes over time; some saw it as a manifestation of the absence of coordination between the sources of demand for labour (industrial, commercial and institutional employers) and the suppliers of education and skills; and still others viewed it largely as a manifestation of the freedom of choice that people can exercise in a free market.

Those who postulated the last explanation made reference to individuals who elected employment that required lower qualifications than they possessed, because they did not want to move, or because the pay was higher, or because it provided greater employment security. In each of such cases it becomes a matter of individual choice whether to sacrifice some of the educational qualifications for higher pay, greater employment security, and the convenience of not having to move, or to sacrifice some or all of these for an employment position suited to the individual's educational qualifications.

A 1969 report by the Harvard University Program on Technology and Society concluded:

> The enhanced importance of education as a prerequisite to employment ... a product of both social and technical factors ... Given the value placed upon education in our society and the ease with which educational credentials may serve as a screening device, employers will often prefer to hire the more educated, even though the intrinsic requirements of the job do not call for such education.[25]

---

[25] I. Traviss, and W. Gerber, Technology and Work, Harvard University Press, 1969.

Therefore, if the educational qualifications of the labour force exceed the educational requirements of production processes, it is because supply conditions of educated people are favourable.

It should be recognized, of course, that occasionally employers prefer to hire the more educated because of scarcity of less educated with demonstrated high level ability. The requirements of the job may be for a good honours B.Sc. But, experience has it that good honours B.Sc.'s proceed to graduate studies. Therefore, the choice becomes one of hiring someone with a B.Sc. who is less than good or hiring someone with an M.Sc. to get the good B.Sc. By implication, when demonstrated academic ability is a dominant criterion in the selection of applicants and the academically proficient tend to seek higher levels of education, employers will hire those with more education and pay for it even though the jobs to which they are assigned may, at the outset, not require it.

Two areas of employment stand out as the ones which in recent years have required progressively higher levels of education and specialized knowledge: finance and computer systems. In the past, finance personnel were for the most part instructed on-the-job. Normally, their academic preparation was at the level of high school graduation or a general B.A. degree. The requirements have now risen to a B.Comm. degree with specialization in finance or with a C.A., C.G.A., or R.I.A., certification. In relation to computer systems personnel, notable variations in requirements have taken place over the relatively brief period of their existence. Initially the requirements were relatively high--electronics engineers for sales positions and honours mathematics or engineering graduates for programming. As knowledge of the nature and operation of computers increased, the required basic educational qualifications were adjusted downward. But now, with system-wide application of computer technology, and the emergence of computer-communications systems, demand is rising for highly specialized system analysts.

12. TECHNOLOGICAL CHANGES AND SKILL REQUIREMENTS

Do advances in machine technology demand an increasingly educated labour force, or do they lower educational and skill requirements?

Generally, it is thought that advances in technology require increasingly high levels of education and skill. But, it would appear that the relationship between technological changes and educational and skill requirements depends on the nature of technological changes: there is some evidence that in highly mechanized and automated processes workers experience diminishing opportunities to use their education and skills.[26]

A 1967 British study concluded that: "Within a broadly defined skill group such as skilled operatives, in some cases new technology 'de-skills' operations, while in others it increases the skill required."[27] The most recent manifestation of the de-skilling effects of high technology has been the employment by highly mechanized industries in West Germany of thousands of immigrant workers from Greece, Turkey, Italy, Yugoslavia, Egypt and other countries-- unskilled, some uneducated, and the majority unable to

---

[26] James R. Bright, "The Relationship of Increasing Automation and Skill Requirements," Appendix II, Report of the U.S. National Commission on Technology, Automation and Economic Progress, 1966, pp. 207-221.

[27] Sir Denis Barnes, "Technological Change and the Occupational Structure," Proceedings of the International Conference on Automation, Full Employment and a Balanced Economy, The American Foundation on Automation and Employment Inc., 1967.

read or speak German. Had these workers been employed in agriculture, mining and logging no question would arise about education, skills or the ability to communicate in the language of the host country. But, they are employed mainly in manufacturing industries, which are traditionally associated with the employment of skilled tradesmen and semi-skilled operatives.

A study for the U.S. National Commission on Technology, Automation and Economic Progress reached a similar conclusion to that of the British Study:

> The overall or net change in the skill requirements of occupations in these industries (slaughtering and meatpacking, rubber tires and tubes, machine shop trades, medical services, and banking) was remarkably small, despite the fifteen years covered. One industry had on balance an increase, one a possible decline, but in each case the shift was modest. Moreover, substantive changes in occupational content were not common, ... the small net change in skill levels was the product of numerous offsetting changes in the various abilities needed for individual occupations in an industry. There was considerable change in occupational requirements and content, but on balance it was either inconsequential or inconclusive with respect to overall skill levels.[28]

These findings are in conflict with generally accepted expectations that technological changes (or more specifically 'mechanization') will require the upgrading in skills and higher levels of education.

---

[28] M.A. Horowitz, and I.L. Herrnstadt, "Changes in the Skill Requirements of Occupations in Selected Industries," Appendix II, Report of the U.S. National Commission on Technology, Automation and Economic Progress, 1966, p. II - 287.

It is generally assumed that:

1. Semi-automatic and automatic machinery and equipment require higher levels of skill and education than does conventional machinery.*

2. Semi-automatic and automatic machinery and instruments require a higher degree of worker specialization for maintenance.*

3. The design, production and installation of automatic machinery requires more specialized engineers and technicians than does conventional machinery.*[29]

4. The change from conventional to automatic machinery is so radical and so fundamental as to make it either very difficult or impossible for workers to shift from the one process to the other.

5. Even where the average worker is not deficient in skill relative to the skill requirements of the automatic machines, it is alleged that he feels instinctively inadequately prepared for the work environment of the automatic process. It is this sort of reasoning that is at the foundation of the prevailing view that high level technology

---

[29]*James R. Bright, "The Relationship of Increasing Automation and Skill Requirements," Appendix II, Report of the U.S. National Commission on Technology, Automation and Economic Progress, 1966, p. II - 208.

will require high levels of education and skills.[30]

But, generally accepted expectations and beliefs do not appear to find support in the reality of work processes. James R. Bright writes:

> I was startled to find that the upgrading effect had not occurred to anywhere near the extent that is often assumed. ... I found frequent instances in which management's stated belief that automation had required a higher caliber of work force skill was refuted when the facts were explored.[31]

This does not mean that automation does not create new skills and does not require educational and skill upgrading. It means rather that on the average the extent to which skill upgrading is required as a result appears to have been exaggerated. Indeed, Bright concluded: " ... automated machinery tends to require less operator skill after certain levels of mechanization are achieved. ... automation does not inevitably mean lack of opportunity for the unskilled worker."[32] This is confirmed by

---

[30] A significant relationship between education and the capacity to adjust successfully to changes in machinery was found by a number of investigators. See Eva Mueller et al., Technological Advance in an Expanding Economy, Institute for Social Research, The University of Michigan, Ann Arbor, 1969.

[31] James R. Bright, "The Relationship of Increasing Automation and Skill Requirements," Appendix II, Report on the U.S. National Commission on Technology, Automation and Economic Progress, 1966, p. II - 208.

[32] loc. cit.

the findings of Jaffe and Froomkin who write: "Our broad-based statistical findings confirm ... that the workers generally needed no additional schooling to fill a job which became highly mechanized."[33]

As indicated elsewhere in this study, our findings provide general support to such a conclusion: a considerable majority of workers employed in establishments which introduced significant technological changes experienced neither excess nor deficiency in technical knowledge. Where tools and processes became automatic and manual adjustments were eliminated, machinists became or were replaced by worker-monitors; and where processes were replaced by ones founded on different principles, as in changes from mechanics to electronics, technicians had to acquire some new fundamental knowledge. But, in both instances a significantly smaller proportion of workers were affected than the proportion who did not require any change in education and skills.

Another automation related effect to which frequent reference is made is the alleged mental strain it imposes on workers. Charles R. Walker studied changes in a steelmill operation and found a substantial increase in the mental effort required of workers.[34] Telephone operators[35] who changed from manually operated switch-boards to automatic ones alleged a considerable increase in mental

---

[33] A.J. Jaffe, and J. Froomkin, Technology and Jobs, Frederick A. Praeger Publishers, New York, 1968, p. 91.

[34] Toward an Automated Factory, Yale University Press, 1957.

[35] At British Columbia Telephones.

strain.

But, neither the steelmill operation studied by Walker nor the telephone switchboards were truly automatic. What happened in reality was that the operations became semi-automatic, and the operatives, who continued to be required, lost "control" of some aspects of the operations. The increase in mental strain appears to have been related to increases in the speed of operations, and to the loss of control over the rate of operation. In both cases, it was not automation that increased the mental strain; it was inadequate automation. As the level and scope of automation increases, and less and less critical functions are left at the discretion of the operator, both skill and mental strain will inevitably be somewhat reduced. Bright illustrates the relationships in the following exhibits.

EXHIBIT 1. - LEVELS OF MECHANIZATION AND THEIR RELATIONSHIP TO POWER AND CONTROL SOURCES

INITIATING CONTROL SOURCE	TYPE OF MACHINE RESPONSE		POWER SOURCE	LEVEL NUMBER	LEVEL OF MECHANIZATION
FROM A VARIABLE IN THE ENVIRONMENT	RESPONDS WITH ACTION	MODIFIES OWN ACTION OVER A WIDE RANGE OF VARIATION	MECHANICAL (NONMANUAL)	17	Anticipates action required and adjusts to provide it.
				16	Corrects performance while operating.
				15	Corrects performance after operating.
		SELECTS FROM A LIMITED RANGE OF POSSIBLE PRE-FIXED ACTIONS		14	Identifies and selects appropriate set of actions.
				13	Segregates or rejects according to measurement.
				12	Changes speed, position, direction according to measurement signal.
	RESPONDS WITH SIGNAL			11	Records Performance.
				10	Signals preselected values of measurement (includes error detection).
				9	Measures characteristic of work.
FROM A CONTROL MECHANISM THAT DIRECTS A PREDETERMINED PATTERN OF ACTION	FIXED WITHIN THE MACHINE			8	Actuated by introduction of work piece or material.
				7	Power tool system, remote controlled.
				6	Power tool, program control (sequence of fixed functions).
				5	Power tool, fixed cycle (single function).
FROM MAN	VARIABLE			4	Power tool, hand control.
				3	Powered hand tool.
			MANUAL	2	Hand tool.
				1	Hand.

James R. Bright, "The Relationship of Increasing Automation and Skill Requirements", Appendix II, Report of the U.S. National Commission on Technology, Automation and Economic Progress, 1966, P. II - 210

STUDIES: EMPLOYMENT IMPACT OF TECHNOLOGICAL CHANGE

Exhibit 2. - CHANGING CONTRIBUTION REQUIRED OF OPERATORS WITH ADVANCES IN LEVELS OF MECHANIZATION

WORKER CONTRIBUTION[1] OR SACRIFICE TRADITIONALLY RECEIVING COMPENSATION	MECHANIZATION LEVELS			
	1 - 4	5 - 8	9 - 11	12 - 17
	HAND CONTROL	MECHANICAL CONTROL	VARIABLE CONTROL, SIGNAL RESPONSE	VARIABLE CONTROL, ACTION RESPONSE
PHYSICAL EFFORT	INCREASING-DECREASING	DECREASING	DECREASING-NIL	NIL
MENTAL EFFORT	INCREASING	INCREASING-DECREASING	INCREASING OR DECREASING	DECREASING-NIL
MANIPULATIVE SKILL (DEXTERITY)	INCREASING	DECREASING	DECREASING-NIL	NIL
GENERAL SKILL	INCREASING	INCREASING	INCREASING-DECREASING	DECREASING-NIL
EDUCATION	INCREASING	INCREASING	INCREASING OR DECREASING	INCREASING OR DECREASING
EXPERIENCE	INCREASING	INCREASING-DECREASING	INCREASING-DECREASING	DECREASING-NIL
EXPOSURE TO HAZARDS	INCREASING	DECREASING	DECREASING	NIL
ACCEPTANCE OF UNDESIRABLE JOB CONDITIONS	INCREASING	DECREASING	DECREASING-NIL	DECREASING-NIL
RESPONSIBILITY[2]	INCREASING	INCREASING	INCREASING-DECREASING	INCREASING, DECREASING, OR NIL
DECISION MAKING	INCREASING	INCREASING-DECREASING	DECREASING	DECREASING-NIL
INFLUENCE ON PRODUCTIVITY[3]	INCREASING	INCREASING-DECREASING OR NIL	DECREASING-NIL	NIL
SENIORITY	NOT AFFECTED	NOT AFFECTED	NOT AFFECTED	NOT AFFECTED

Source: Ibid., p. II - 214

[1]Refers to operators and not to setup men, maintenance men, engineers, or supervisors.

[2]Safety of equipment, of the product, of other people.

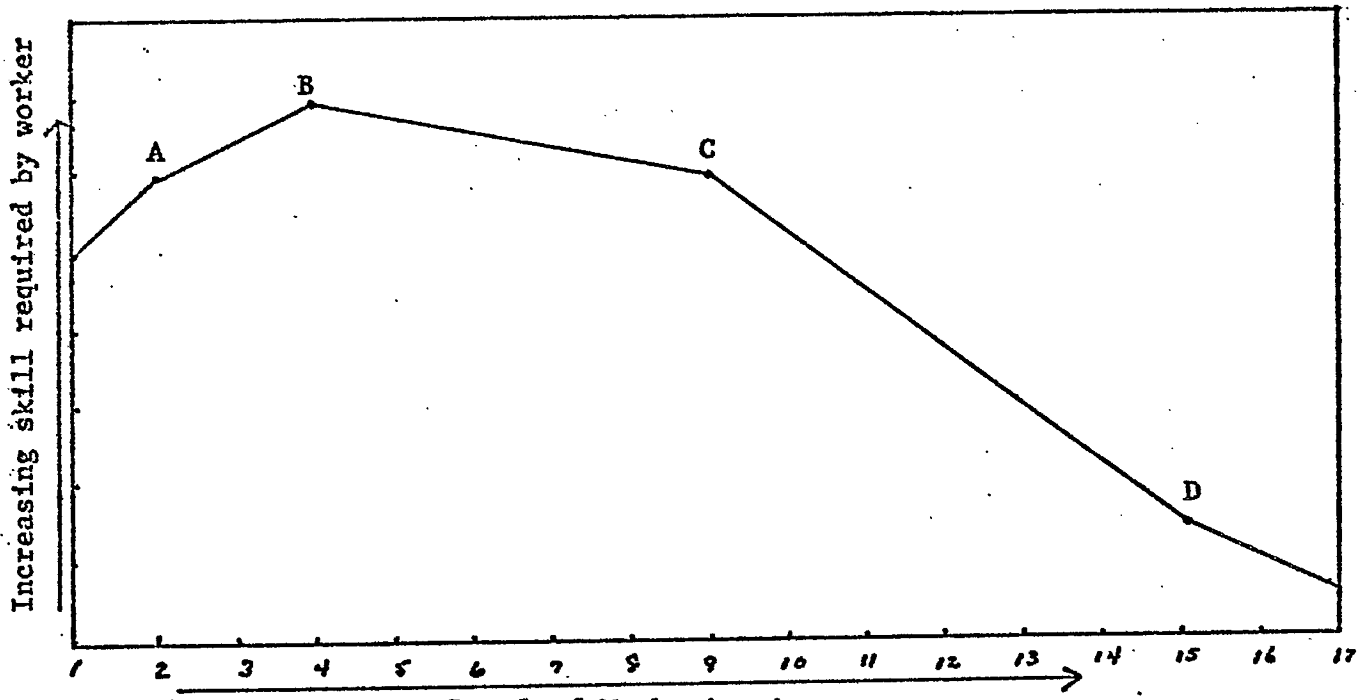
[3]Refers to opportunity for the worker to increase output through extra effort, skill or judgment.

Upon examination of the relationship recorded in Exhibits 1 and 2, Bright concluded:

> ... automation does not necessarily result in an increase in skill requirements. In fact, automation often tends to reduce the skill and training required. ... The curve of skill requirement (worker contribution) rises with lower levels of mechanization, and then falls off at high levels.[36] (Exhibit 3).

EXHIBIT 3

Mechanization - Skill Relationship:



Level of Mechanization
Increasing degree of automatic operation --→

---

[36] J.R. Bright, Ibid., p. II - 217

Exhibit 3 illustrates the mechanization-skill relationship: where the mechanization of a work activity is raised from level 2 to level 4, skill requirements will be raised from level A to level B. But, if the work activity is mechanized to level 9, the skill requirement will drop to point C; and further increases in the levels of mechanization will result in progressive reductions in the level of skill required.

Examples of such relationships abound: we noted how improvements in computer technology reduced the required education and skills of those engaged in computer operations; similarly, it is well known that each new aircraft model contains more automatic and computer controlled features, thereby reducing the range of work-functions required of pilots, navigators and other crew members; laboratory technicians, bank tellers, machinists and scores of others increasingly find some of their skills built into new equipment.

What are the implications of this for education? The progressive decrease in work related skills will perhaps require more education than if the level of skills were to be rising; for the erosion of skills compels shifts to new jobs, search for new opportunities, readiness to learn, and adaptability to new situations. Education makes all of these somewhat easier.

13. APPROACHES TO ADJUSTMENT - HUMAN, TECHNOLOGICAL, ORGANIZATIONAL

"Change the person, change the job, or change the environment.

- If a job calls for new qualifications and the incumbent is both willing and able to learn, provide the necessary training.
- If the job has clearly outgrown the incumbent's ability to handle it, try to restructure it and leave the incumbent in charge of those components that he or she is competent to handle.
- If the incumbent is clearly beyond his depth and it is impractical to restructure the job, re-assign him to some other position, even if it means a demotion. The change of environment and the satisfaction of doing a manageable job may outweigh feelings of humiliation."[53]

Workers whose job duties have been affected by changes in technology have for the most part been retrained and re-assigned to new positions. The retraining has been carried out by the firms themselves, although in some cases the supplier of the new equipment has participated, and in some, educational and training institutions participated.

The length of time involved in retraining and the nature of retraining depends, of course, on the extent to which job functions were effected and on the nature of functions involved in the re-assigned positions: the training can

---

[53] James W. Westcott, "Employee Obsolescence: A Shared Responsibility," The Labour Gazette, May 1976, pp. 242-243.

be brief, provided largely on the job; or it can be lengthy, involving classroom instruction, demonstrations and training manuals.

Reports on manpower adjustments to technological change indicate that most workers adapt to minor innovations as easily and successfully as do new workers brought in from the external labour market.[54] Normally, the engineers and supervisors who become knowledgeable of the new technology during the planning, production and installation stages, provide some training in operational fundamentals, and then allow operators to develop their skills to the requirements of the new technology. Even where the new technology is a fully automated process, requiring of operatives the observation of signals and the pressing of certain keys, the knowledgeable engineer-supervisor is limited in his instructional function to the presentation of signals, signs and fundamentals: the operatives' effectiveness and efficiency in performance of tasks will be developed gradually by the operatives themselves.

In most situations the effects of technological changes on manpower are akin to plant expansion, and the adjustments required of labour in such instances are akin to in-plant

---

[54]For discussion on the subject of internal and external labour markets and adjustments to technological change, see Peter B. Doeringer, "The Determinants of the Structure of Industrial Type Internal Labor Markets," Industrial and Labor Relations Review, January 1967; and Work Force Adjustments in Private Industry - Their Implications for Manpower Policy, U.S. Department of Labor, Manpower Administration, Monograph No. 7, Washington, D.C., October 1968.

relocation amongst departments and jobs.[55] The work-knowledge required by transferred workers is commonly acquired through instruction by supervisors initially, and thereafter workers become teachers of workers. Therefore to the extent that technological changes are extensions of existing processes the majority of workers can be expected to be able to acquire the additional work-knowledge required without undue difficulty.

Adjustment difficulties are commonly encountered when technological changes involve a significant jump in technology. In such instances workers may require some fundamental scientific knowledge--theoretical or/and technical--that is different from that which they possess. For example, the nature of mathematical principles required for mechanical operations are fundamentally different from those required for electronic operations. Hence, technicians knowledgeable in mechanical and electromechanical operations, repair and maintenance of equipment require a change in their fundamental mathematical knowledge, if they are to become knowledgeable about electronic operations.

Adjustment difficulties do not appear to arise where skills can be transferred, in whole or in part, from one process to another; and where the adjustment process involves the addition

---

[55] U.S. Department of Labor, Monograph No. 7, Ibid., p. 102.

of new knowledge unto existing knowledge. Difficulties arise where existing skills cannot be readily utilized in the new processes; and where the new knowledge is not a continuation or extension of existing knowledge. This is, difficulties of adjustment arise where innovations manifest the discontinuance (the end) of a given body of knowledge, and the initiation (the beginning) of a new body of knowledge. In such instances there cannot be a transfer of knowledge and skills; acquisition of the new knowledge and skills is necessary, and that process often requires a beginning from the beginning--the acquisition of new fundamental principles, which often means the employee must go back to the classroom. The successful acquisition of fundamental principles, and the successful adjustment to technological changes founded on new knowledge, appears to depend on the nature of basic general education possessed by workers.

Most establishments with technologically advanced processes appear to have a variety of formal and informal educational and training programmes for their personnel: some of these relate to on-going work functions which workers would have to perform upon transfer; some relate to equipment whose installation is pending; and some involve higher level knowledge and are used as screening processes for the selection of personnel for promotion.

14. AN OVERVIEW OF TECHNOLOGICAL CHANGES IN DIFFERENT INDUSTRIES AND THEIR MANPOWER IMPLICATIONS

Technological transformation is characteristic of our epoch: some industries have undergone considerable technological transformation, whereas in others changes have been rather moderate. In manufacturing, there has been considerable and varied transformation; in the energy sector, the transformation has reached the level of automation; whereas in certain parts of the building industry the transformation has been pedestrian.

MANUFACTURING: In manufacturing, technological changes are predominantly in the nature of servomechanisms: the mechanization in existence prior to the advent of electronics required human monitoring of production processes. The advent of electronics has facilitated the introduction of monitoring instruments: temperature measurements, pressure, analysis of chemical compositions, all are now increasingly performed automatically; and in addition, machines respond automatically to signals from monitoring devices and change the rate and direction of production processes without human intervention.

Automatic control processes are now operational in such industries as steel, chemicals, power, petroleum refining, and cement, and are advancing in stages throughout the manufacturing sector. In metal-working, numerically controlled machine tools are being used which can be programmed to change from one job to another with a minimum of operator assistance. The linkage of such tools by a computer, creates a fully automatic assembly line. In such a setting three kinds of workers are required: those who design the control instructions; those engaged in the production of instruments; and those required for supervisory and maintenance functions.

The transformation of operations from manual materials handling and assembling to automatic and semi-automatic machine handling, line feeding and assembling has generally tended to have positive employment effects on inspectors and skilled tradesmen, negative employment effects on production process operators, and hardly any effects on factory service personnel. There is some evidence of a tendency to inflate the numbers of service personnel with displaced long service production process operators, but this is viewed as temporary adjustment to the transformation process.

Whatever specific knowledge and proficiency production process operators may have acquired regarding materials handling, line feeding and assembling of component parts becomes redundant with the transformation to automatic and semi-automatic processes. Workers retained in employment with the new processes, such as product inspectors and skilled tradesmen, are generally required to acquire a higher level of fundamental knowledge and a higher level of specific technical knowledge. For this purpose most establishments have retraining programmes, involving both theoretical and practical instructions over periods generally ranging between three and six weeks.

In addition to effects on production process workers, technological changes have varying effects on the employment, education and skills of the non-production labour force--management, professional, technical, clerical and other. Mechanical and electronic technologists and engineers are required for production technical services, system and design activities; programmers, analysts, operators, and service personnel are required for the computers; and management must acquire some fundamental and technical knowledge about the new operations. Industries have encountered varying degrees of scarcity in all of these specializations. There are indications that in some companies the rate of technological change has been held down by the lack of adequate supply of specialized manpower, and in some the utilization of modern equipment has been below capacity because of the scarcity of specialized operating manpower.

TEXTILES: Technological changes have revolutionized the textile industry during the past two decades: new raw materials, synthetic fibres and non-woven fabrics have caused significant changes in machinery and production processes. The structure of textile and ready-made clothing has been particularly affected, with varying degrees of automation and mechanization in both branches of the industry. Also, the increasing shift to non-woven materials will undoubtedly cause further changes, the most important of which is the replacement of sewing with vulcanization of garment seams.

The technological structure within the industry is very uneven. This is attributed largely to the nature of the product, which lends itself to 'cottage' operations.

ENERGY: In the energy sector all processes are characterized by automated or semi-automated technology: the production of electrical energy, whether by water, coal, oil or gas has attained a high degree of technological sophistication; oil refineries have become increasingly automated; and nuclear energy processes are largely automated.

CONSTRUCTION: In the construction industry, some processes, such as materials handling on construction sites have become highly mechanized--cranes, excavators, lifts, and concrete mixers--but other, such as prefabricated building components have been held back. Should prefabrication be permitted, traditional small scale operations will be phased out and replaced with large scale mechanized construction operations. Such a change will have very significant implications for the nature and employment of construction trades.

PETRO-CHEMICALS: The petro-chemical industry sector is expected to have a relatively stable labour force, but changes are anticipated in its skill mix:

- improvements in instrumentation are expected to sustain a relatively high demand for technologists;
- increasing deployment of EDP systems will sustain the relatively high demand for systems related occupations;
- increasing involvement by governments as regulatory agents will sustain the relatively high demand for people who can relate to governments, government agencies and the community at large.
- on the negative side, demand for high level specialized manpower will likely remain at a low level as long as fundamental research continues to be a low priority activity; and
- increasing competition in foreign markets, and our decreasing competitive advantage may induce expansion of branch plant facilities in other countries, which would have an adverse effect on employment at home.

AGRICULTURE: The technological transformation of the agriculture sector is well known: the tractor, the combine harvester, mechanical equipment for fodder collection and storage, the mechanization of livestock care, new farming methods, fertilizers, chemical control of pests, soil analyses, plant, seed and livestock selection, and scores of other 'technological' innovations transformed farming operations from largely labour intensive to largely capital intensive, and changed the organizational structure of the agricultural sector from predominantly individual family units to predominantly large business enterprises. The transformation reduced the number of farms from 623,091 in 1951 to 366,128 in 1971 (the acreage remaining virtually unchanged), drove out of agriculture almost 500,000 workers, and changed significantly the skills and knowledge of those who remained in the agricultural sector.[37]

Technological changes in agriculture are likely to continue in four areas: in labour-saving machinery and equipment; in the application of fertilizers, insecticides, weed killers, and other chemicals; in the use of biological agents for pest control; and in the implementation of plant and animal genetics.[38] Each of these areas of technological development will require specialized high level manpower, and because of the inter-relatedness of the four areas, it would be necessary to organize cooperative

---

[37] Canada Census 1971; and Robert W. Crown and Earl O. Heady, Policy Integration in Canadian Agriculture, The Iowa State University Press, Ames, Iowa, 1972.

[38] Edgar Weinberg, "Technological Change and Education," The Encyclopedia of Education (9), p. 115.

approaches to the research and implementation of technological changes. Indeed, it has been asserted that "prospective advances depend increasingly on cooperation among specialists from different scientific disciplines. Controlled-environment facilities for starting and growing crops, for example, require teams of plant physiologists, horticulturists, and agronomists ... the mechanization of fruit and vegetable harvesting, involves the collaboration of engineers who design harvesting machinery with plant breeders and geneticists who tailor plants such as tomatoes, to withstand mechanized handling."[39]

PULP AND PAPER: In the pulp and paper industry the past twenty years have recorded some dramatic changes in operation, both in the woods and in the mills. Felling operations, loading, and the removal of limbs and tops all have become highly mechanized. Improvements have been introduced in methods and processes of transport from woods to mills, and a variety of improvements have taken place in processing operations.

The most dramatic effect on the labour force has been recorded in woods operations: the number of workers has been reduced substantially; sharp seasonal variations in operations have decreased, removing the sharp seasonal fluctuations in employment; and educational and skill requirements have been

---

[39] _Ibid._, p. 115.

raised considerably. The change is described in the following way:

> The original semi-mechanized method of wood harvesting had been developed by gradual progression over a considerable period of time from a purely manual system using, in some cases, horses for skidding of wood to the roadside. In many cases, it was a logical extension of farming operations requiring the same skills and the same or similar equipment. Many of the people employed had been working in the woods all their lives and, although the degree of productivity varied widely from man to man, most of the skills had been self-acquired over a period of time. Any training courses provided emphasized safety and general work methods rather than specific technology. In virtually all cases, payment was by the piece work method.
>
> The new operation involves 10 - 12 relatively sophisticated pieces of mechanical equipment working on a fairly closely coordinated basis together as a logging system. Machine operators require considerable manual dexterity, sufficient mechanical knowledge to appreciate the limitations of the equipment they operate and the motivation to work as part of a team. Most of the work is shift work and can be monotonous if not properly organized, but on the other hand, most of the operators work in machines with heated and air conditioned cabs. The mechanics involved have to do most of their work with the machines in the bush (rather than in a work shop) and at the same time, must be knowledgeable of diesel motors, hydraulics, pneumatics and electrical systems. It has been our experience that many of the traditional woods workers just cannot adapt to this type of operation and in fact that with new entrants one has to make a careful selection as to susceptibility to motivation, adaptability, etc., quite apart from whether or not they have the particular skills required. In fact, with many of the machine operators, we have found it is preferable to hire a person with minimal skills who can be motivated and train him on the job rather than use someone who already possesses skills.

> We see continuing and expanding requirement for people with basic technological education at the high school and/or technical institute level. This education should concentrate on the training of basic skills such as the ability to write and read English, basic maths, basic knowledge of internal combustion engines, mechanical technology, hydraulics, pneumatics and electrics. Also there should be concentration on teaching the fundamental methodology of problem analysis. We do not believe it is worthwhile to teach more than the basic skills in regular high schools and technical institute courses because we require people with sound background knowledge. We have found it much better to educate in specific skills related to specific machines or processes either on the job or through special courses arranged by manufacturers or educational institutions at the specific request of our company or a group of companies.[40]

Evidently, what the industry requires for its woods operations is relatively broadly educated unskilled workers. Whatever skills may be required will be provided on the job.

In the administrative-office area of activity external hiring of specialized manpower appears to be limited to that which is traditionally supplied by universities and technical institutes. Specialized knowledge specific to the industry is generally provided on-the-job. Even in relation to computer operations, external hiring appears to have been limited to the initial period following installation of their systems. Computer operations staff have now become part of the internal operation, and their training has become part of the general administrative process. Positions such as Data Processing Manager, Computer Analyst, Key-punch Operator, Micro-film Storage Supervisor, EDP Manager

---

[40] Communication from a Pulp and Paper Company.

have become common in-office operations "something unheard of prior to late '50's."

The computerization of pulp and paper manufacturing activity is in its infancy. As it expands, initially in relation to individual specific processes and eventually system-wide, more computer related manpower will be required. But, since computerization is rather slow, the manpower needs will continue to be met through internal training. There is no reason to expect that the industry will increase its demand for specialized manpower from the external labour market.

The occupational structure has changed significantly, and indications are that it will continue to change. The proportion of non-production workers has been rising steadily, whereas the proportion of service workers, labourers and operatives has been falling. It is anticipated that employment of managers, sales workers, professional and technical workers, and clerical workers will increase, whereas the employment of operatives will continue to fall. For example, the introduction of computer control in paper-making operations will result in the computer setting and manipulating production variables, such as temperature, pressure, and flow rates. The machine tender's function will be limited to monitoring duties; which means, of course, that fewer of them will be required. Similarly, where materials handling and continuous processing technology has been introduced, the work functions of workers have changed from the manual movement of materials and the manipulation of machinery to the oversee of an increased workflow and the regulation of operations by pushbutton control.

MINING: In the mining industry technological changes have been widespread throughout the industry and over all phases of mining operations. Significant improvements have been introduced in drilling equipment; the equipment used in loading and hauling ore has generally increased in size and in efficiency; and notable changes have taken place in processing methods.

The increase in size and efficiency of loading and hauling equipment has been in response to the increasing scarcity of mine-workers. It became necessary to increase substantially the volume of output loaded and hauled away by the limited labour force.

In processing, in addition to improvements in traditional methods of operation, new methods have been devised which made possible the exploitation and processing of low grade ores. Process control computers with associated analytical equipment are being introduced, which provide almost instantaneous readouts of the various parameters of the controlled operation. Where computerization is not in effect, samples are taken manually in the course of processing, assays and determinations are also carried out manually, and the information is relayed to operators. Computerization, with the almost instantaneous readouts of information required for the control of various feed and production rates, facilitates closer control of the operating parameters, and eliminates delays inherent in manual collection, analysis and transmission of information.

Scarcity of specialized manpower will continue to be a serious problem in the industry, particularly in coal mining. The relatively depressed state of the industry over a period of about 20 years reduced the inflow of young people in the industry, and reduced the numbers of those who sought specialization in coal mining. As a result, the current mining labour force contains relatively large proportions of older workers. The retirement of these workers is expected to create even greater scarcity at the time when demand will be rising.

Another potential obstacle to substantial expansion in coal mining activity is the scarcity of safety engineers and inspectors. Increasing pressures on governments to legislate stringent health and safety regulations for industry generally would worsen an already grave labour market situation. Therefore, a recommendation was repeated a number of times by industry spokesmen that action be taken to increase the supply of qualified safety engineers and industrial health inspectors.

TELEPHONES:* In the telephone industry technological changes have revolutionized operations: Stored Programme Controlled Switching Machines, Automated Toll Switchboards, and Interactive Computer-

---

*Most of the information contained in this section was provided by Alberta Government Telephones.

Communication Systems have virtually eliminated manual operational activities.

The change from electro-mechanical wired logic technology, to a complex solid state stored programme switching equipment involved very significant operational changes: it provided automatic self testing, diagnostic and assisted fault location; the use of more reliable components and duplications of critical elements reduced maintenance; increased operating information regarding traffic flows; provided remote monitoring, alarm reporting, and remote control; provided capability for automatic testing of facilities external to the switching machine; and facilitated modular replacement servicing. By contrast, the electro-mechanical system required significantly more maintenance, its hard wire logic elements made it considerably less flexible, and contained few of the automatic features of the programmable computer control design, with electronic switching control elements.

The change to stored programme switching technology has had important implications for both managers and craftsmen: the relatively high technical complexity of the system forced a substantive change in the job content of lower management levels. The technical content of their managerial functions decreased, whereas broader managerial functions, such as budget, performance, productivity and employee development increased. The technical aspects became the responsibility of specialists. The job content of craftsmen changed, too: the change was described as a "shift from a 'physio-motor' type of problem analysis to a 'psycho-cognitive' type of analysis." Because of the delicate nature of components in the system--higher component operating speeds, and a large number of simultaneous operations going on within the central processor--craftsmen can no longer interact with components for examination and detection of equipment faults. To effectively deal with the relatively abstract software sequences within the machine, craftsmen must now apply greater mental effort.[41] Modular packaging of components with plug-in inter-connections facilitates the removal and replacement of faulty modules, thereby reducing the amount and nature of routine maintenance work. Furthermore, the duplication of critical elements and automatic rerouting around faulty areas tends to reduce the pressure for immediate repair or the need for continuous supervision and inspection of equipment.

Evidently, the craftsman's workload in terms of repair and maintenance has decreased significantly. He no longer manually investigates what is wrong and repairs; rather, he reads print-outs, analyses the messages and determines what is malfunctioning. But, the workload in the form of knowledge of the functional inter-relationships within the system has increased equally significantly. The location of malfunctions has become

---

[41] One telephone company reported that an eight week training period is required to transfer a fully qualified technician from mechanical switching to electronic switching. Amongst those retrained, one in fifteen could not cope with the change.

more difficult, and effective repair, without mistakes, more critical. Although it is expected that in time software will be designed to assist in pinpointing the location of malfunctions, and thereby remove one of the most difficult tasks that craftsmen face currently, for the immediate future the successful shift in functions from 'psycho-motor' to 'psycho-cognitive' will require a substantial upgrading of craftsmen in electronic circuiting and computer logic concepts. It would appear that the introduction of stored programme switching machines has increased both fundamental knowledge and specialized technical knowledge requirements of all operating and maintenance personnel.

In addition to the increase in fundamental and specialized technical knowledge requirements, technological changes have generated new employment positions: higher educational and training requirements created demand for more instructors; emerging difficulties in locating and solving problems created demand for "troubleshooting" specialists; the new technology required groups of engineers and technicians with formal education in electronics and logic fundamentals.

Another technological change that has had widespread effects throughout the telephone industry is the Computer Assisted Toll Switchboards. Prior to this change all telephone calls were directed to operators who made connections manually through a plug-in type switchboard. The operator's work functions involved asking and recording the called number and the calling number, making the required connection manually, dialling the number, monitoring and recording the time spent on the call, and whenever requested, determine the charge, and call back to inform the caller. A number of variations to this sequence of steps existed, depending on the nature of calls, whether the caller had a number, whether the call emanated from a coin telephone, and so on.

The Computer Assisted Toll Switchboards have eliminated many of those work-functions: operators are now brought into the circuit only when they are needed to receive or transmit relevant information. Unless operator involvement is required or requested, calls are automatically routed to a central computer which automatically records the called number and the calling number, and stores them for billing purposes. The computer monitors and records the time, and transmits the information automatically to the automatic message accounting equipment for billing. On coin calls and when callers wish to know the cost of a call, the calculations are done by the computer, and flashed on a readout panel almost immediately after a call is completed.

It is evident that the work functions of operators have changed significantly: under the old system they were responding to the demands of customers, and performing the required functions; under the new system their work is oriented to meeting the demands of the computer. The former system afforded them greater freedom and flexibility in relation to the number of calls they processed. The new system compels continuous alertness and attention to the computer; operators do not have much control over the number of calls that are handled, have less personal contact with customers, and do not have much control or knowledge of how calls are progressing.

The nature of change in work functions has been such as not to require any increase in fundamental knowledge or in specific technical knowledge. The new system facilitated a substantial increase in the volume of calls, with essentially an unchanged number of operators.

The third major technological change in the telephone industry has been the area of Interactive Computer-Communication Systems. This involves the application of such concepts as Time Sharing Systems, Teleprocessing Networks, Distributed Processing Applications and Interactive Data Base Systems. These are expected to have significant implications for education and skill requirements. Consider, for example, the collection of traffic data: prior to the introduction of mini computers, such data were collected in offices, recorded by cameras on film, and sent for manual processing. Scores of people were engaged in "form handling": "errors were many; corrections and changes were laborious; and transmittal of information between departments required multiple copies and was time consuming." The initial introduction of a computer reduced some of these activities, but the considerable keypunching and other manual operations before the information was put in a form suitable for use by the computer continued to require laborious manual work. Under the new system, the data were collected by mini computers, which also perform validation checks, and produce reports for middle management. The collected data are then put on magnetic tapes and forwarded to a central computer where further analyses take place and reports are prepared for senior management.

At the initial introduction of computer technology there was no interactive computer assistance, and considerable manual labour continued to be used. In the new system, interactive computer assistance is provided throughout the process: forms are filed in the computer in an interactive mode from remote terminals and stored in the computer memory; transmission of messages between departments is carried out automatically by the computer; information for billing purposes can be obtained automatically from a data base within the computer memory; the system has capabilities for the collection and reformulation of data for special studies.

The potential of the system is considerably greater than what is being utilized. The limiting factors are scarcity of specialized manpower: computer software specialists, systems analysts and programmers are scarce throughout the industry. In addition, there are educational (knowledge) implications for all who use the system in the decision-making process: people have access to information that was not available in the past, and as a result alternatives have become more apparent; job pressures are greater as a result of increased awareness of the consequences of wrong decisions; the increase in information about functional relationships has made jobs more complex, and more challenging; and there is almost automatic evidence of how successfully jobs are being done.

LIBRARIES: At the extreme, "it is possible to store an entire library in a shoe box."[42] The function of libraries is to centralize information and to make it available to users. The effective performance of this function requires an effective and efficient system of cataloguing and retrieval. Thus, while technology has made it possible to store large quantities of information in relatively small spaces, it has not yet introduced effective and efficient ways in taking the information out of storage for examination and use. As a result, the implementation of technological changes is still at the infancy phase, limited largely to technical processes cataloguing, ordering and circulation control.

The effect on educational and skill requirements to date has been limited to (a) a few new occupations related to the novel equipment and processes, such as systems analysts, data bank clerks, information systems officers; and (b) relatively brief periods of instruction to professional and semi-professional staff on the operation of equipment. But, upon reflection many of them admit to realization that their work-functions are changing

---

[42]Robert Presthus, Technological Change and Occupational Response: A Study of Librarians, U.S. Department of Health, Education, and Welfare, Washington, D.C., 1970, p. 11.

significantly more than the brief periods of instruction on the fundamentals of new technology would indicate. The elimination of routine clerical and mechanical functions permits the allocation of more time to higher level functions, such as the acquisition of in-depth knowledge in individual subject-matter, and to more interaction with users of library services.

This shift in work-functions, from the routine clerical and mechanical to the intellectual and interactive, is potentially beneficial to both librarians and libraries: librarians are increasingly finding their work ineffectual and lacking in challenge, and increasing numbers are developing interests in other fields of endeavour; as a result, libraries are finding it increasingly difficult to find and retain in employment adequate numbers of qualified and competent staff.

A 1970 survey of librarians in certain U.S. cities found that 38 percent of male librarians and 41 percent of female librarians had become disenchanted with their library careers and had become interested in new fields of endeavour: 34 percent did not find their work "a real challenge"; and 66 percent indicated they would not choose library work as a career if they had to do it again.[43]

This is not the sort of professional attitude that will stimulate an increase in supply of qualified librarians. Hence,

---

[43] Robert Presthus, *Ibid.*, p. 69.

to the extent that technological changes will eliminate the routine clerical work-functions from the range of work-functions, and thereby facilitate the allocation of more time to high level intellectual activities and to interaction with users of library services, interest in professional library work may be stimulated. But, any shift in work-functions requires an appropriate parallel shift in educational preparation. Involvement in higher level intellectual activity, and allocation of more time to interaction with users, can only contribute to the more effective rendering of services if librarians were to specialize in specific areas of study and if they were to become information specialists.[44]

BANKING: Central to the new technology implemented in the banking industry is the change to electronic data processing (EDP). Reader-sorters and the computer are the key elements in the new system: the reader-sorter reads, sorts cheques and other documents and transmits the information to a computer to be recorded on tape: whereas the computer stores the information transmitted to it, processes it on demand, balances accounts, computes average balances and service charges, and performs scores of other functions.

Three basic factors appear to have stimulated the process of change in technology in the banking industry: (1) growth in operations and range of activities; (2) quest for stabilization or reduction in operating costs; and (3) need for information on the

---

[44]There are indications that librarians recognize this requirement. See Presthus, Ibid., p. 102.

nature and range of operations that could not have been had under conventional systems of recording and storing information.

Canada's chartered banks have recorded a phenomenal rate of growth in the past decade: in December 1965 their total assets amounted to $26,233 million; by December 1975 they stood at $108,378 million--a fourfold increase within the relatively brief period of one decade; their loans increased from $9,124 million to $41,520 million or four-and-a-half times; their Canadian deposits increased from $18,594 million to $66,873 million or about three-and-a half times; and their personal chequing accounts increased from $207 million to $2,539 million or about twelve times.[45]

Some of this growth is, of course, a manifestation of rising money incomes; between 1965 and 1975 the average money income of families and unattached individuals increased from $5,799 to an estimated $14,500 or by 150 percent. As a result, in the absence of any changes in the nature of banking operations, deposits could have been expected to increase proportionately or one-and-a-half times. The increase of three to four times indicates that there has been a very significant real growth in the banking industry.

Expansion in operations of the magnitude experienced by the industry within the relatively short period of one decade

---

[45]All statistical information is from the Bank of Canada Review, May 1976.

imposed serious strains on the organizational structure and management of the industry. The mechanization process and experimentations with alternative organizational systems and managerial configurations are responses to the pains of growth, and a manifestation that the then existing operational procedures and managerial structures and practices could not accommodate the rapid rate of growth.

The technological processes implemented to date contain a potential for achieving significant reductions in operating costs. In addition, existing and potential technology will facilitate substantial additional growth and integration of operations. Whether significant reductions in operating costs will in fact be achieved, and whether operations will be integrated successfully, will depend upon the effectiveness and efficiency of the organizational structures and managerial configurations of individual banks. It can no longer be said that the operational system cannot cope with rapid growth and diversity in service activities. The onus now rests with management.

An important aspect of the growth process has been a broadening in the range of activities in which banks have engaged. Hence, the flow of information that paralleled the growth process was itself growing in volume and mix. The storing and processing of this increasing volume and variety of information could not have been handled efficiently without the nature of equipment that has been and is being implemented.

The introduction of electronic data processing equipment should manifest itself in two employment effects: (1) there should be a reduction in the rate of increase in employment; and (2) there should emerge a number of new employment categories.

It has been established that conventional methods of operation were becoming an obstacle to substantive increases in the volume and diversity of operations. The conventional system would not have been able to handle the volume of work entailed in a fourfold increase in operations. Therefore, had the new technology not been adopted the rate of expansion in operations would have been arrested. This has important implications for the potential and actual increase in employment.

It is commonly asserted that in the absence of modern technology employment would have expanded faster. In relation to banking, where conventional methods of operation were largely labour intensive, it appears logical to hypothesize that a fourfold increase in operations would have generated a proportionate increase in employment. But, such an assertion would have been based on the doubtful premise that such an increase in operations would have been possible in the absence of the new technology.

Technology reduces the labour-output ratio, but by increasing output substantially beyond the level that would have been possible in its absence, employment may in reality increase more than it would have increased under conventional methods of operation. Between 1965 and 1975 the total domestic employment of banks increased from 75,728 to 123,567 or by 63 percent.

The industry has recorded an accelerated rate of increase in employment in recent years, which is attributed to the rapid expansion in banking services during a period when the data processing systems were being phased-in, and personnel were being employed for the data centres. It is expected that as data transmission becomes more rapid, and as transmission is extended in space, the volume of paper float will diminish, and up-to-date information will become available instantaneously on all aspects of banking operations. The effect of this on related low-skill routine employment activities would be to eliminate them.

But, while employment in routine low-skilled activities may decline, employment in high-level positions is likely to continue its upward climb: computers retain into storage information that is deposited into them, and release information on demand in whatever forms they are instructed to release it; furthermore, while computers can release information in minute detail and configuration, they must be instructed on the nature of detail and configuration appropriate for individual decisions. For such, and many other related functions, increasing numbers of high level manpower will be required.

The specialization of the high level manpower that would be required will be of an analytical nature, not narrowly technical: individuals broadly knowledgeable of the economy, society, industry and finance will be needed, to examine, analyse and design the available information into forms that are appropriate for the ends to which the information is intended. If the information released by a computer is inadequate, imperfect or inconclusive it is because the computer has been given inadequate information or has been inadequately or imperfectly instructed. The implication of this for specialized manpower in information design and analysis is self-evident.

In summary, increasing utilization of electronic data processing equipment in banking operations will affect employment in the following ways: (1) Total employment will continue to increase, but at a substantially lower rate than that recorded over the past decade; (2) the introduction of increasingly rapid transmission of data, and the automatic and continuous recording of deposits, withdrawals, charges, sorting and other routine functions will cause a decrease in employment in occupational classifications associated with relatively unskilled routine activities; (3) the effective and efficient utilization of the costly electronic networks will require high level personnel with broad knowledge of the technology and its potential, as well as of the economy, society and finance. The design and analysis of information inputs and outputs will be the core activity of such personnel; (4) substantial increase in employment can be anticipated in classifications associated with the use of equipment, such as, encoders, programmers, data control clerks, reader-sorter operators, and a score of supervisory personnel.

This pattern of employment adjustments is likely to take place regardless whether banks limit the range of their service activities to those which they now perform, or expand into additional activities. Should they undertake additional activities, such as for example, accounting and billing services for small enterprises and professional practitioners, total employment will increase somewhat faster, but the distribution into employment categories is not likely to be altered significantly.

The undertaking by banks of accounting and billing services for small enterprises and professional, trade and other practitioners will, of course, have employment implications for the economy as a whole: demand will decrease for the services of clerks, bookkeepers and accountants who now provide the accounting, billing, collecting and such other services. On balance, a decrease in employment may be anticipated. To the extent that accountants provide financial counselling to small enterprises and independent professional and other practitioners, they or their counterparts employed by banks will continue to provide such a service; but, the routine functions now performed by clerks and bookkeepers will be performed by the electronic system, with some input from a data control clerk and from an information designer-analyst.

The foregoing suggests an average upgrading in the skill mix of banking personnel. Whether such upgrading will in fact take place, and the extent to which it will take place, will depend upon whether and the extent to which banks respond to the evident need for information designers and analysts. If they do not so respond, and limit their hiring to what is needed for the operation of the equipment, i.e., technicians, programmers, encoders, data control clerks, and such other, the average skill mix will not change significantly. But it is unlikely that bank management will commit such an error, its cautious conservatism notwithstanding. Should they so respond, their costly electronic networks will be utilized fully, but neither effectively nor efficiently.

Employment related to the use of electronic systems has been commonly underestimated in magnitude and misestimated in occupational structure. Indeed, there is evidence that many enterprises fail even to count such personnel as part of the change in employment associated with the change in technology. It would appear that many enterprises using automatic electronic systems have not yet integrated their systems into the scheme of their operations. For example, when we asked a bank what were the employment effects of the electronic data processing system, we received in response information and opinion of all of the effects on employment related to the traditional operations of the bank, i.e., the effects on activities and numbers of tellers, accountants, branch managers, supervisors, inspectors, senior decision-makers, but no information at all on employment at the data centre. Subsequent enquiries on the matter revealed that the centre was viewed as something separate, an invisible organization somewhere out there, which receives all the information that is relayed to it and gives out information that is instructed to give.

Responses to our enquiries indicate that most enterprises and institutions using electronic systems have found it necessary, within relatively short periods after commencement of operations, to employ many more systems related staff than originally estimated. Most such unplanned additions are attributed to two variables: (a) inadequate knowledge on the part of management regarding what "automatic" equipment can do, and (b) the dynamic nature of electronic systems, which is manifested in continuous improvements in technology and software.

Inadequate knowledge about the nature and potential of electronic systems has led many to the erroneous conclusion that the system will perform scores of activities at the push of a button. But, experience increases knowledge and knowledge exposes faulty assumptions. The push of a button will, indeed, cause information to be produced rapidly, but the usefulness of the information for decision-making purposes will depend on the nature of information deposited in the system, the format in which the information is sought, and the interpretation given to the information that is produced. All these qualifications mean that the effective and efficient <u>use</u> of modern electronic equipment requires the employment of scores of specialized personnel. It is important to note that the emphasis is on use, and not on the technical aspects of operation and maintenance. The most substantial increases in systems related employment have been related to the use of the systems: thus, in addition to the now well known occupations of programmers and keypunch operators there have emerged the occupations of encoders, data control clerks, systems development officers for each area of activity (i.e. finance, inventory, marketing, materials, transportation, etc.), applications consultants, tape librarians, workstation employees, information designers, information interpreters, supervisors, data managers, and many other. Yet, as indicated above there is a general tendency to disregard these additions to personnel, and refer only to the employment effects in the areas of operational activity to which the systems are linked.

Two employment positions that are most commonly associated with banking operations are those of the Branch Manager and the teller. Indications are that both are being affected significantly by electronic data processing systems. As the day-to-day operations of branches are transmitted automatically to central, branch managers are no longer required to prepare weekly detailed financial reports on the operational state of the branch. Instead, their efforts are directed increasingly to customer relations, the examination and analysis of causal factors that bear on the volume and nature of operational services, and the efficiency and effectiveness with which services are rendered. A change in managerial functions of this nature, will undoubtedly cause a change in the nature of educational qualifications and personal characteristics that will be required of candidates for such positions.

The extent to which managerial activities will actually change will depend, of course, on the extent to which senior management will allow flexibility and diversity in operations amongst branches. Were senior management to opt for standardization in operations, which has been the traditional characteristic of risk-minimizing senior management, then branch managers can be moulded into whatever shape tradition requires, and programmed to perform a set of specified standardized functions. In such cases, the educational qualifications and personal characteristics of candidates will be related to what is required for the successful moulding and programming of a standard branch manager. On the other hand, were senior management to opt for flexibility and diversity in operations, and were branch managers to be given considerable latitude in the nature and scope of operations, a different set of educational qualifications and personal characteristics would be required. The individuals involved would require knowledge that extends beyond the intricacies and mechanisms of banking operations; they would have to become knowledgeable of industry, social structure, the economy, government, business-government relations, and all other variable forces that bear on operations.

The basic functional activities performed by tellers, namely, the acceptance of deposits and the honouring of withdrawals, continue to be performed by tellers, but the performing process has changed. As tellers' stations are linked to data processing centres, the activities performed by tellers are automatically transmitted to the centre, and immediately following the transmission of a deposit or a withdrawal a reverse transmission takes place from the centre to the teller's station indicating the resulting balance. The implications of this process for the teller can easily be deduced: (1) the manual recording of information on deposits and withdrawals is eliminated; (2) to the extent that the functional activities of tellers involve the processing of information on deposits and withdrawals, that too, is eliminated; (3) to the extent that tellers' functions after "banking hours" are related to their manual functions during banking hours, the elimination of manual functions eliminates the need for them after "banking hours." This suggests two possible effects on tellers: (1) they will have access to more information about customers' accounts, which they will be expected to use effectively in answering customers' questions and in giving advice. A considerable upgrading of tellers is suggested. (2) The elimination of "paper work" from the tellers' functions, suggests the possibility of extending banking hours to a full day's work or employing part-time tellers to provide services during banking hours only. The trend appears to be in the direction of the first, i.e., extension of banking hours to the full extent of a day's work. Ultimately, when the use of the "Instabank" system becomes more widespread, and customers can deposit, withdraw and transfer funds from one account to another automatically, the services of tellers will no longer be required.

15. THE EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATION AND SKILL REQUIREMENTS OF ORGANIZATIONS: RESULTS FROM THE QUESTIONNAIRE

INTRODUCTION

The purpose of the questionnaire was stated in its preamble (see appendix 1). In short, the intention of the questionnaire was to discover the effects of technological change on labour with special reference to the educational and skill requirements.

The criteria by which the organizations were selected to receive this questionnaire, and the somewhat disappointing nature of the response, have been detailed elsewhere in this report. This section will confine itself to a description and analysis of the 104 useable questionnaires returned, always bearing in mind, of course, that the returns received may not necessarily be representative of the original larger group selected.

It is obvious from the questionnaires that were returned, that certain problems were encountered by the organizations in completing them. Two main difficulties were apparent. Firstly, the questions were designed on the implicit assumption that technological change is discrete; that is, that it is possible to isolate a single change and identify the effects that flow from this well defined event. This preconception, which is in sympathy with the theoretical discussion of the subject, was found to be largely incorrect. Many respondents indicated that technological change is an on-going process ("a way of life" said one), continuously occurring with continuous effects.[46] Thus they had difficulty identifying the cause-effect relationship which the questionnaire sought to explore.

A second cause of difficulty which the respondents seemed to encounter was that of quantifying the effects of a change as it applied to their employees. Questions 4, 6, 7, 8 and 10 all required that a certain number of people be identified in some way. Many organizations would not, or could not, identify a specific number of people, and often filled the spaces with vague terms such as "many," "few" or "all." Obviously this increases the difficulty of performing statistical analysis on the replies.

Beyond these two specific problems, there are other difficulties associated with such a questionnaire which is mailed to organizations. On some of the questionnaires, questions that were applicable were simply left blank. On others, the answers given were qualified in separate letters or in notes written on the questionnaire itself. On yet others, answers were inconsistent. One striking example of this is where the number of workers identified as "displaced" in question 6(d) is not equal in the aggregate to those identified as "displaced" in question 8.

---

[46] One explanation for this may be that the amount of investment each year is not great enough to allow for more than a partial replacement of existing capital. See L.C. Hunter and P.J. Robertson, Economics of Wages and Labour, (Macmillan and Company, 1969), page 380.

In the question by question analysis which follows, these problems have been largely ignored. To a great extent they are inherent in this method of collecting data. Thus, some caution is advised in interpreting the specific detailed statistics derived. We do feel, however, that the trends identified throw considerable light on the phenomenon of technological change, and that the conclusions drawn are supported by the statistics presented below.

QUESTION 1 - TECHNOLOGICAL CHANGES INTRODUCED WITHIN THE PAST FIVE YEARS

This question most clearly showed one of the problems mentioned in the Introduction--that of considering technological change as being discrete. Many respondents noted that they could not answer this question meaningfully, and so left it blank. Of those that did answer, there were three types of response:

(a) some took one well-defined but significant technological change, and answered the rest of the questionnaire with regard to this single change. Thus they would give the answer "1" to this question, even though there had been many changes in the appropriate time period.

(b) some adopted a different approach to the same problem. They stated that they had instituted many changes, and tried to answer the questionnaire with all the recent changes in mind. Thus several respondents answered "5+" to this question even though this is not a formal option on the questionnaire.

(c) there were some organizations which have had between 0 and 5 technological changes and therefore could answer the question in a straightforward way.

From the point of view of analysis of the responses, a further difficulty was encountered. Many organizations returned several questionnaires, each answering "1" to this question.

In view of the problems encountered with this question, and the fact that some respondents gave the answer "5+," thus leaving the exact number of technological changes indeterminate, no statistical analysis was attempted. This is not to say that the question served no purpose--we clearly found that for most organizations, technological change is an on-going process, which we consider to be an important conclusion.

As a final point, it is interesting to note that four respondents answered "none" to this question. We believe this to be a valid response and have included these four in the useable questionnaires.[47]

QUESTION 2 - NATURE OF TECHNOLOGICAL CHANGES

Part (a) - Description of Main Technological Changes Introduced

The answers to this question were as varied as the

---

[47]This does not imply that the rest of the questionnaire will not be completed, as questions 11 and 12 are still applicable.

organizations themselves. Some changes were very idiosyncratic to the organization involved. For example, one firm changes its production line from ordinary to radial tires. Retail outlets are introducing more sophisticated cash registers. A chemical plant introduced charcoal filters to cut down on the emission of noxious fumes. And so on. However, there was a common link between many of the changes introduced. Over half of the technological changes were, in some way, computer related. In almost every industrial category, computers were being utilized in some way. In manufacturing plants, computer control and testing systems are being introduced. Computerized "on-line" banking is a major change in that area. Newspapers now do their typesetting with the aid of a computer. Libraries keep track of their books by computer. In every area where large amounts of information have to be processed, computers are being used. This emerged as one of the dominant themes of the questionnaires, and is constantly reflected in the answers to later questions (which types of manpower were in short supply, for example).

Part (b) - Nature of Considerations Entering Decisions to Introduce Technological Changes

For the purpose of analysing this, and later questions, each of the respondents was placed into one of fifteen industry groups, shown in Table 3. The figures tabulated in Table 3 show the percentage of respondents who mentioned those reasons listed as being responsible for introducing the technological change.

From both the totals, and the figures for different industry groups, it is apparent that the categories of "cost saving" and "more efficient" were almost equally the most important factors. That the two categories are almost equal in the total figures is not surprising, as many respondents mentioned the two together. This may well be valid. If a process is more efficient it no doubt reduces costs, and vice versa. Indeed, cost saving is often the criterion by which efficiency is judged. Some respondents however, clearly could distinguish between the two concepts, as often one or the other was mentioned separately. This may simply be a reflection of the outlook of the person who answered the questionnaire. Efficiency to an engineer may be cost saving to a manager.

"Present methods inadequate" ranked third in the aggregate, although the distribution between industry groups varied greatly. However, on examining those groups in which the reason seemed prominent (manufacturing, distillers and bottlers, communications media and utilities) some general considerations do emerge. Firstly, these groups mentioned their comparatively high rates of growth as being a factor in making the present methods inadequate. This was most apparent in the information handling systems where, due to the growth in the amount of data involved, manual data processing was becoming unwieldy. Thus computerization was introduced.

Secondly, it is in these groups that the fastest rate of technological change is observed. Whether the processes

TABLE 3:* CONSIDERATIONS ENTERING INTO DECISIONS TO INTRODUCE TECHNOLOGICAL CHANGES

INDUSTRY GROUPS	SCARCITY OF QUALIFIED MANPOWER	COST SAVING	MORE EFFICIENT	PRESENT METHODS INADEQUATE
Manufacturing (General)	6.25%	75%	75%	50%
Manufacturing (Construction)	10%	80%	60%	20%
Pulp and Paper	25%	75%	75%	0
Mining and Smelting	18%	63%	72%	0
Oil and Gas	0	50%	75%	25%
Distillers and Bottlers	0	100%	100%	33.3%
Agriculture		Insufficient data		
Food Processing		Insufficient data		
Retail Sales	0	80%	80%	20%
Banking and Financial Services	0	66.6%	66.6%	16.6%
Communications Media	0	71.4%	85.7%	42.8%
Utilities	25%	50%	62.5%	37.5%
Libraries and Cities	0	60%	70%	30%
Transportation	0	50%	50%	25%
Publishing and Printing	0	100%	100%	0
TOTALS	7.69%	67.3%	70.19%	24.03%

*Totals do not equal 100% as many respondents gave more than one reason.

involved in these industries lend themselves well to innovation, or whether competition is so severe that innovation is a necessary condition of survival, is not clear. But technological change is comparatively more rapid in these groups, and thus current methods become obsolete more quickly.

With regard to the scarcity of qualified manpower, the aggregate totals suggest that this was a minor problem. Two industries did seem to experience difficulties in this area however--pulp and paper, and utilities. In pulp and paper, the problem was most severe in the woodlands operations, especially with the skilled mechanics needed with the advent of mechanized tree harvesting. To a large extent this seems to be a locational problem. With the utilities, it was the telephone companies who raised this issue. The high rate of growth of the telecommunications industry has made the manual operation of systems close to a physical impossibility. One respondent stated that in the absence of automation it is "unlikely that there would be enough man or woman power to do the job." Thus here it is less a shortage of qualified manpower, but simply a forecast shortage of people *per se* to perform the tasks manually.

QUESTION 3 - FUNDAMENTAL DIFFERENCES IN TECHNOLOGY

This question was to a large extent redundant. The answers were usually an elaboration of those given to question 2(a). Indeed, some respondents did not elaborate but simply referred back to what they had written earlier. As such, the information gained from this question merely supplements and reinforces that gained previously. There was an immense variety of answers which literally defies description, but computer related technological changes predominated.

QUESTION 4 - ON DELAYS IN IMPLEMENTATION OF TECHNOLOGICAL CHANGES

Part (a) - On Whether Technological Changes Were Delayed by Lack of Qualified Personnel

Approximately 24% of the respondents stated that implementation of technological changes was delayed by lack of qualified manpower.

Part (b) - Nature of Personnel Scarcities Causing Delays in Implementations of Technological Changes

Table 4 lists the occupation and number of people involved in causing the delay in implementing the technological change being considered.

TABLE 4: SCARCE OCCUPATIONS CITED FOR DELAYS IN IMPLEMENTING TECHNOLOGICAL CHANGES

Systems Analysts	20+*
Computer Programmers	63+
Electronic Technicians	3+
Computer Operators	6+
Word Processing Stenographers	4
Mechanics	38+
Engineers	7
Implementation Officers	13
Chemical Analyst	1
Spinner	1
Foremen	?*
Pipefitters	?

*Both "+" and "?" are caused by the fact that some respondents indicated a shortage of qualified manpower, without specifying the exact number of positions involved.

Because of the dominance of computer related technological change over the last five years, it is only to be expected that delays in the implementation of these systems should be due to shortages of systems analysts, programmers, etc. Very few respondents completed the section "Educational and Skill Qualifications" in the table of question 4(b), and so it was impossible to draw any conclusions from this.

<u>Part (c)</u> - <u>On Duration of Delays Caused by Manpower Scarcities</u>

The average length of the delay caused by these shortages was 8.45 weeks. However, there was a large range of reported delays, from 6 weeks to 120 weeks. The long 120 week delay was for control room operators in a cement plant. Delays of 104 weeks were reported for systems analysts, terminal operators, and systems engineers. As is obvious from the figure of 8½ weeks average delay, these 2 year (or more) delays were exceptional. However, the effect of such long delays on the organizations involved would be considerable, and as such their importance outweighs their number.

Part (d) - Occupations That Caused Most Serious Delays

This turned out in practice to be a repeat of Part (b), and as such yielded no extra information.

Part (e) - Measures Designed to Resolve the Manpower Scarcity Problem

The responses to this question are tabulated in Table 5. This table shows the percentage of respondents who mentioned the methods listed for resolving the personnel scarcity.

TABLE 5: COPING WITH MANPOWER SCARCITY

Upgrading existing personnel	76%
Retraining	48%
Professional development	8%
Changes in equipment	4%
Hired new employees	76%
Internal transfer of personnel	24%

"Hired new employees" and "Upgrading existing personnel" ranked equally first. The former is an expected response--firms will react to personnel scarcity by attempting to acquire new staff. However, the latter of these two, together with the third and fourth most popular options (retraining and internal transfers) indicates that organizations place a great deal of reliance on their own internal labour market for filling new positions. There are several advantages to the firm in doing this. The expenses (and uncertainty) of advertising for, processing, interviewing and hiring new personnel are avoided. Also, if the employee is retrained, this training can be made very specific,[47] thus hopefully ensuring the efficient performance of the job function.

Part (f) - Main Causes of Manpower Scarcity

The above relates directly to the responses given to this question, tabulated in Table 6. This table shows the percentage of respondents who mentioned the reasons listed as being the main causes of the personnel scarcity.

TABLE 6: MAJOR CAUSES OF MANPOWER SCARCITY

Inadequate supply at prevailing salaries	16%
Salaries demanded too high	16%
Inadequate supply at any price	36%
Inadequately qualified manpower	92%

[47] See the results to Questions 7(b) and 7(c).

The overwhelming problem seems to be the inadequate qualifications of the people available. Often it was stated that the job was so specific to one system or piece of equipment, that it was futile even to look for people qualified in this job function. Given this fact, it becomes logical for organizations to opt for upgrading their own staff rather than to look for new employees.

QUESTION 5 - IMPACT OF NEW TECHNOLOGY OF WORK ON MANAGEMENT AND WORKERS

There was a great variety of answers to this question, often with very specific changes being linked to very specific jobs. However, here, perhaps more clearly than elsewhere, several general themes did emerge from the perspectives viewed.

Part (a) - Impact on Management

Many technological changes have led to managers receiving better information much more quickly than before. As two fairly representative respondents put it:

> "Accurate, updated information on the process units performance enables better planning and control of unit operation." (Oil Company)

> "Areas of weakness in operation highlighted." (Manufacturing)

Thus the potential has been created for more efficient management--more efficient as they work in the light of greater information. More than that however, speed has become more important. Managers are expected to be more efficient as information is received faster, and thus decisions are expected to be made more quickly. Obviously because of this potential for more effective management, there has been considerable pressure on managers to live up to this expectation. A final element of pressure is added by the fact that technological change is, in itself, expected to increase efficiency or reduce costs.[48] Thus they are living with the preconceived notion that costs will be reduced, productivity increased etc., despite any extra performance on the managers' part.

Finally, the problem was raised that some managers may know less about the particular technological change than their workers. One respondent (in a telephone company) called this "blind management":

> "With the advent of electronic switching the managers find themselves in the novel position of knowing very little technically of the equipment we now install. This phenomenon, which I call 'blind management', is probably quite common in other industries and we must learn to live with it."

Part (b) - Impact on Workers

The general theme which dominated this section was that technological change tends to reduce the amount of manual labour involved in most jobs. Many respondents mentioned an increased need for "brain power" or "mental effort" as opposed to physical

---

[48] See the results to Question 2(b).

toil. Two things should be noted about this. Firstly, it does not necessarily mean that the job is more interesting or meaningful to the worker. Sometimes this appeared to be the case, other times, however, the job was reported as being more repetitive and tedious after the change. There was no clear concensus on this point. One should also bear in mind, however, that this answer involved managers writing about workers' jobs, and as such some answers seemed too good to be true. For example, a pulp and paper company gave the following reply concerning the effect on the workers of a particular change:

> "Happier employees - work pain has disappeared - freedom from boredom maintained - seasonality of work removed - reasonable financial security."

One can only wonder if the workers would agree that "work pain has disappeared." Other respondents implicitly admitted that they were uncertain about the effects on the worker--"hopefully more meaningful work" was the more doubtful reply of a utility company.

Secondly, the trend from physical to mental effort does not necessarily imply that higher levels of skill of either the fundamental or technical type (as defined on page 8 of questionnaire) are needed. This indeed may be the case, but often the work is greatly simplified, or a hard-earned manual skill is replaced by a machine process.

A final often mentioned consideration was that technological change increased the responsibility placed on the worker. He is now more often working with a faster process, and with more expensive equipment. As such, mistakes can now become more costly. The burden of responsibility is therefore increased.

QUESTION 6 - IMPACT ON EMPLOYMENT

Part (a) - Numbers Employed Prior to Technological Change

In total 24,938 people were reported as being directly or indirectly employed in the old (pre-change) process. It should be noted, however, that some respondents could not, or would not, give an accurate reply to this question.

Part (b) - Occupational Classifications of Employees

Given the large number of people involved (see part (a)) this question yielded a very large variety of answers. Thus, no analysis was attempted on this part.

Part (c) - Effects of Technological Changes on Skills and Knowledge

This was, no doubt, the most important question on the questionnaire. It seeks to answer the very basic query about technological change which is posed in the preamble to the questionnaire: does technological change increase or decrease the required levels of education and skill of the workers involved? Intuitively, one can imagine cases of change which would support the notion of a decrease or increase. Indeed, it would be easy to draw many examples supporting either notion from the survey itself. The intent of this question, however, is to enable us to move away from discussing particular changes to viewing the aggregate effect of technological change on education and skill requirements.

In analysing this question, the industry groups mentioned in question 2(b) were utilized again. Both individual industry replies and aggregate figures are shown in Table 7. The concept of fundamental and technical/specific knowledge, and the coding of -1, 0, +1 are both explained on page 8 of the questionnaire. The total number of workers reported as being affected by the change in this section was 23,279. This is approximately 7 percent higher than the equivalent total reported in question 6(a).

From the totals for "fundamental knowledge," we see that the vast majority required no extra knowledge. Very few (4 percent) required less fundamental knowledge--whereas more than twice that number required more. With regard to "technical knowledge," the percentage requiring less is almost identical. The difference is that there has been a movement of people from the "same" category to the "more" category, requiring a higher level of technical skill. So, for technical knowledge, there are four times the number requiring more than less. Generally, therefore, we find that technological changes do not, on the average, necessitate a change in required levels of knowledge. But for that minority of workers for whom a change is required, it is more likely that that change will be in the direction of an

TABLE 7: EFFECTS OF TECHNOLOGICAL CHANGES ON FUNDAMENTAL KNOWLEDGE AND ON SPECIFIC TECHNICAL KNOWLEDGE

INDUSTRY GROUP	NUMBER OF COMPLETED QUESTIONNAIRES	FUNDAMENTAL KNOWLEDGE			TECHNICAL/SPECIFIC KNOWLEDGE		
		LESS (-1)	SAME (0)	MORE (+1)	LESS (-1)	SAME (0)	MORE (+1)
Manufacturing (General)	16	0	75.95%	24.05%	0.75%	69.45%	29.8%
Manufacturing (Construction)	10	0.54%	70%	29.46%	4.03%	68.37%	27.60%
Pulp and Paper	8	0	90.83%	9.17%	0	21.90%	78.10%
Mining and Smelting	11	0	100%	0	0	94.53%	5.47%
Oil and Gas	4	0	13.88%	86.12%	0	0	100%
Distillers and Bottlers	3	0	75.51%	24.49%	0	75.51%	24.49%
Agriculture	1	Insufficient Data					
Food Processing	2	Insufficient Data					
Retail Sales	5	0	100%	0	0	99.34%	0.66%
Banking and Financial Services	12	10%	87.79%	2.21%	0	94.27%	5.73%
Communications Media	7	13.16%	85.41%	1.43%	31.10%	36.12%	32.78%
Utilities	8	0	48.18%	51.82%	40%	8.18%	51.82%
Libraries and Cities	10	0	46.31%	53.69%	0	26.16%	75.84%
Transportation	4	0	14.29%	85.71%	0	14.29%	85.71%
Publishing and Printing	3	0	82.91%	17.09%	0	4.27%	95.73%
TOTALS	104	4.00%	85.15%	10.85%	3.99%	78.37%	17.65%

increase rather than a decrease, especially where technical knowledge is concerned. However, these general observations ignore a great variety within individual industries.

We shall now consider some of the major characteristics and differences found within the industry subgroups:

Although manufacturing was split into two subgroups--general and construction--the results are very similar.[49] Generally, there has been more upgrading of skills in this group of industries than on the average, with fewer people in the "less" or "same" categories than in the aggregate. Both of these groups are so diverse that general explanations are difficult, but certainly the rate of technological change in those industrial categories is greater than on the average.

Pulp and paper is notable for the difference between the figures for the two types of knowledge. "Fundamental knowledge" requirements show very little change, whereas the amount of technical knowledge required seems to have increased substantially. This industry has, for a long while, been heavily mechanized. The trend at the moment is to larger machines, especially in the woodlands operations. Thus, people already used to operating heavy equipment are now being trained to use still larger machines.

---

[49] In a U.S. study which looked at the effects of technological change on skill requirements in the manufacturing industry, it was found that 68% of those workers studied required no change in technical skills. The comparable result for this study is 68.91% (derived by combining both manufacturing groups). See New York State Department of Labor, Manpower Impacts of Industrial Technology, Publication B172 (1969), p. 40.

Therefore, there is little need for a change in fundamental skills, as there has been no change in the basic operation at hand. However, the use of the larger, more sophisticated machinery does require more technical knowledge on the workers' part.

Mining and smelting, and oil and gas, illustrate opposite trends. The technological changes that have occurred in mining and smelting have been largely extensions of existing technology. As a result, there has been virtually no change in knowledge requirements.* Oil and gas however is very different, with a great deal of competitive innovation leading to a large increase in fundamental knowledge, and a remarkable 100 percent increase in technical knowledge required. Most of the reported innovation in the oil and gas industry was concerned with computer control techniques.

Retail sales is a fairly exceptional case--quite a large amount of technological change was reported, but there was little change in either type of knowledge requirements. This may be explained by the nature of the change, which has largely been toward more efficient cash registers. These registers are internally more efficient and collect more data, but their operation is substantially the same as the older type. Banking and financial services show a similar trend, with such innovations as "on-line" banking which, the banks judge, does not require any increase in knowledge requirements.

The main technological change in the field of printing and publishing has been from "hot metal" to "cold metal"

---

*Efforts are being made in some sectors of the industry to cope with occupational health and environmental problems, which may manifest themselves in both the general and technical knowledge of the labour force, but at present no such effects are indicated.

typesetting. The effect on fundamental knowledge has been minimal, 85 percent of affected workers requiring neither more nor less of it. The technical-specific knowledge has been affected to a greater extent: almost one-third of affected workers required less of it, and one-third more.[50]

The industry has been undergoing some rather radical technological changes: computers for justification and hyphenation, photocomposition equipment, optical scanning equipment and phototypesetting machines have revolutionized the processes of composition, assembly and printing. In the course of change jobs have been eliminated and jobs have been created: linecasting machine operators became keypunch operators; journeymen typesetters acquired photocomposition skills; and employees with the necessary fundamental knowledge became computer programmers. All affected employees require some change in technical knowledge.

The information relating to "libraries and cities" was heavily influenced by returns from libraries, some of which have gone into computer technology in a rather substantial way.

The transportation industry, too, has utilized extensive computer technology, both in the financial-administrative

---

[50] A U.S. study found that this type of technological change required more technical skills. See P. C. Brennan and B. Burdetsky, Outlook for Technology and Manpower in Printing and Publishing, U.S. Department of Labor, 1973, pp. 22-23.

area and in traffic scheduling and control. The effect on employment is manifested in additions of computer-related occupations and in the retraining and relocation of employees.

Part (d) - Employees Displaced by Technological Changes

In all, 3,087 workers were displaced by the change. This is 13¼ percent of the total number of workers affected. However, almost half of these were accounted for by one large retail company, which reported that it accommodated this displacement with natural attrition and a reduction in part-time employment.

QUESTION 7 - UPGRADING AND RETRAINING OF EFFECTED EMPLOYEES

Part (a) - Numbers Retrained and Upgraded

Of the 23,279 workers reported as being affected by the change (question 6(b) total), 16,661, or 71.5 percent, had to be retrained or upgraded in some way.

Part (b) and (c) - On the Nature of Retraining

Table 8 correlates the answers to parts (b) and (c).

TABLE 8: RETRAINING: DURATION AND PLACE

TYPE OF RETRAINING	LENGTH OF RETRAINING (WEEKS) 1	2	3	4	5	6	6+
IN HOUSE (ON-THE-JOB)	9	12	4	12	1	6	11
EXTERNAL TO COMPANY	1	0	0	0	0	1	2
COMBINATION OF BOTH	1	5	3	4	0	1	9

Any element in the matrix shows the number of respondents who chose that combination of type and length of training. With regard to the type of retraining, the options on the questionnaire were "Inhouse" and "External to the company." However, so many respondents indicated that a combination of both had been employed that this was tabulated as a third option.

Table 8 illustrates two important conclusions. Firstly, most of the training is done on the job, and therefore, is, no doubt, of a very specific nature. Secondly, the training period is quite short, with most of the replies indicating a time period of four weeks or less. Purely external training (which is probably of a general nature) is not favoured. If firms are going to use external training it is more likely that they will do so in conjunction with on-the-job training. Typically therefore, the training is short, on the job, and occasionally supplemented with outside courses.

Part (d) - Failure to Retrain

This question related to those workers who for various reasons could not be retrained. The responses indicated that a mere 318 workers, or 1.9 percent of the numbers affected by technological changes could not, or would not, be retrained. Thus the strong conclusion is that of those workers who were not displaced, a relatively small number experienced trouble in retraining.

On reflection, this is not a surprising conclusion. It has already been established that 85 percent of the workers needed no increase in fundamental knowledge, and 78 percent no increase in technical knowledge. Thus, inadequate knowledge on the part of the workers is at worst a minor problem. Also, because the training is typically short and job related (see parts (b) and (c) above), it was no doubt more easily accepted by the people involved than, for example, long external training would have been.

With regard to the 318 (1.9 percent) workers who were not retrained, the following distribution of reasons was given (in percentage terms):

Inadequate Fundamental Education	10.7%
Too Old	70.55%
Too Old and Inadequate Education	9.12%
Workers did not wish to be retrained[51]	9.74%

Thus the most likely reason for a worker not being

[51] The fourth option on the questionnaire was "other." However, all those respondents who used this "other" category did so for this reason.

retrained is that he is too old. Rationally, for a worker to be retrained, the discounted benefits of the training over his expected working life with the company are compared to the present cost of the retraining. If the former exceeds the latter retraining is a profitable proposition from the point of view of the organization. However, the shorter the remaining working life of the employee (i.e., the older the person involved), the less likely is the calculation to yield a positive result.

QUESTION 8 - RELATING TO DISPLACED AND NON-RETRAINED WORKERS

In Question 6(d) it was ascertained that 3,087 workers were displaced by technological change (13¼ percent of the total affected). This question seeks to discover what happened to them. Here however, slightly fewer workers were reported as being displaced--2,907, or 5.83 percent less than the previous total. The figures below are based on the latter total. In percentage terms the workers fell into the following categories:

(a) transferred to other positions without retraining - 10.56%

(b) retrained for other positions - 15.55%

(c) released from employment - 73.89%

However, these figures were heavily influenced by one large retail company (see Question 6(d)), which by attrition accounted for over half of those classified as "released." If this one firm is ignored, the figures then become: (a) 19.10%

(b) 28.13% (c) 52.77%.

These revised figures show that about one half of those displaced became unemployed. However, several other employers also noted that this reduction in employment was achieved by natural attrition. One should not interpret this as implying, however, that technological change does not cause unemployment. If employers use natural attrition to decrease the size of their workforce, they obviously will not hire (so many) new employees. Thus the unemployment will occur indirectly as workers, most likely new entrants to the labour force, cannot find jobs.

QUESTION 9 - RELATING TO NEW EMPLOYMENT POSITIONS

Approximately 51 percent of responding establishments indicated that technological changes created additional management, technical and professional employment positions.

QUESTION 10 - RELATING TO THE NATURE OF EMPLOYMENT POSITIONS CREATED BY TECHNOLOGICAL CHANGES

A total of 609 new positions were created at this higher level, specifically in the following categories:

TABLE 9: MANAGEMENT, PROFESSIONAL AND TECHNICAL POSITIONS CREATED BY TECHNOLOGICAL CHANGES.

Computer programmers	104
Systems analysts	48
Computer operators	84
Engineers	38
Technicians	85
Installers and Trainers	57
Librarians and Library Assistants	11
Managers	26
Supervisors	26
Control Analysts	10
Mechanics	102
Data Processors	3
Chemists	3
Biologist	1
Draftsman	1
Assayists	10
Total	609

Nearly 40 percent of these new positions are in the first three categories, which are directly computer related. Indeed this is an underestimate of such positions, as some of those employed as "technicians," "installers," etc., would also be working with computers.

QUESTION 11 - RELATING TO ANTICIPATED CHANGES IN TECHNOLOGY OVER THE NEXT FIVE TO TEN YEARS

Approximately 85 percent of the respondents said that they did expect significant technological changes in the next five to ten years. Of the 15 percent who replied "no," 40 percent were in the mining and smelting industry. This is a group which has experienced very little technological change in the past five years.

QUESTION 12 - RELATING TO THE NATURE AND EFFECTS OF ANTICIPATED CHANGES IN TECHNOLOGY

Part (a) - Nature of Anticipated Changes

This question produced a great variety of answers and no assessment was attempted.

Part (b) - Anticipated Effects on Educational and Skill Requirements

The answers to this question were quantified in a way comparable to Question 6(c); that is, the two types of knowledge (fundamental and technical) were graded from -1 to +1. The following results were obtained:

FUNDAMENTAL KNOWLEDGE			TECHNICAL/SPECIFIC KNOWLEDGE		
-1	0	+1	-1	0	+1
3.5%	72.1%	24.4%	5.8%	33.7%	60.5%

These figures can be compared directly with the totals of Table 7 which show the same evaluation of knowledge requirements over the past five years. We see that with regard to fundamental knowledge, employers expect that there will have to be slightly more of an upgrading than was witnessed in the past. As Table 7 shows, over 10 percent of the employees affected required more fundamental knowledge; in the future one can expect that figure to more than double. However, the greatest change apparent in comparing past figures to the expected future ones is in the required amount of technical knowledge. In the future, 60 percent of the people affected will require greater technical knowledge--only 17 percent required upgrading in the past.[52] With neither type of knowledge is the figure for a reduction in knowledge (the -1 category) significantly different from the historic figure. Thus one would expect to see a much greater emphasis on retraining in the future, and an increase in the number of employees needing more technical knowledge.

CONCLUSIONS

Despite the vast range and diversity of the answers to the questions posed, some general observations can be made concerning the effects of technological change on the manpower involved.

---

[52] In reviewing analytical models used for forecasting future skill levels, Alan Fechter found no clear concensus on whether future technological change will increase or decrease required skill levels. See Alan Fechter, Forecasting the Impact of Technological Change on Manpower Utilization and Displacement: An Analytical Summary, (Washington, D.C., The Urban Institute, 1975) p. 31.

The technological changes introduced have typically been small and frequent. They have probably been computer orientated, and were introduced in order to increase efficiency and reduce costs. The majority of firms have not experienced any shortages of skilled personnel, but about one quarter of them did find the implementation of the changes delayed due to a lack of qualified people. Where this problem was encountered, the delay was roughly two months, although it could be as long as two and one half years. The reason for the shortage was simply that the people available were inadequately trained to deal with the new technology, and the problem was most often solved by retraining employees from within the organization. This training was short (a month or less) and on the job, perhaps supplemented with outside courses.

The effect of the change on the job function was to increase the complexity of the manager's job, but also to open up the potential for more effective management. The workers experienced a reduction in the amount of manual labour they had to perform, hopefully making the job more interesting. Generally, the workers affected needed no change in either fundamental or technical knowledge, although nearly a fifth of them did require greater technical expertise. This varied considerably by industry.

Retraining of workers was not a problem, though some workers were too old to be retrained. About 13 percent of the workers involved were displaced in some way--about half of these became unemployed.

With regard to the future, a large majority of the respondents expected some technological change in their industry in the next five to ten years. They expect that the effect on the required levels of fundamental knowledge will follow the pattern of the past. However, employers are anticipating a very large increase in the level of technical knowledge required. If this is indeed the case, greater problems in the areas of shortages of qualified manpower, retraining, and possibly redundancies can be expected.

16. POLICY RECOMMENDATIONS

1. A major conclusion of this investigation is that technological changes do not appear to create any serious manpower problems. They do often facilitate increases in productivity and thereby affect employment in the industries involved, but that is not the issue under investigation. The issue is their effect on educational and skill requirements, and the evidence indicates no problem: employees seem to possess levels of fundamental and technical knowledge which enable them to adjust to new processes with comparative ease; and the majority of organizations assist in the adjustment process through a vast array of retraining programmes.

2. But, a potential problem is suggested by responses to the question about anticipated technological changes and their effects: heretofore the levels of technical knowledge appear to have been generally adequate to allow the relatively smooth introduction of most technological changes. But, for the near future organizations anticipate that 60 percent of employees will require an increase in technical knowledge (as opposed to only 18 percent in the recent past). Although this large amount of upgrading will no doubt take place through the retraining programmes of the organizations themselves (as in the past), a wider range of workers will be involved. This has implications for both the general level of

fundamental knowledge possessed by workers, and the capacity of individual organizations to provide effective retraining to increasing numbers of workers.

3. Therefore, it is recommended that consideration be given to the question of government participation (sharing in the cost of) in retraining programmes. Also,

4. Governments are cautioned to ensure that academic institutions emphasize general concepts and ideas which stress the importance of logical thinking. Many organizations indicated that they were quite prepared (indeed, many indicated a preference) to train new employees. What is required is a sound fundamental education such that students can easily grasp new concepts and ideas. People with high degrees of _specific_ technical knowledge are going to be rendered increasingly obsolete. Therefore, the ability to grasp new ideas and flexibility to adapt to new knowledge are paramount requirements.

5. Furthermore, in periods of rapid change in technology, it is imperative that educational institutions remain continuously aware of the nature of changes occurring in occupations and processes, so that their programmes will reflect those changes. This suggests a closer link between academia and the world of work than has existed heretofore. If the fundamental knowledge acquired by new entrants into the labour market is to be of value

to them, and not to be obsolete in whole or in significant part even before they find a suitable job, the purveyors of that knowledge must be up-to-date on it, in itself and as it relates to processes in which it is applied.

6. Notwithstanding the often heard assertion that Canada's labour force possesses on the average higher levels of education than what production processes require, it is important to bear in mind the relationship between education and adjustment to changes in industrial structure and work-functions. High levels of education facilitate greater flexibility in the transference of work functions amongst related occupations, and make adaptability to industrial and social change somewhat easier. Therefore, it is recommended that governments continue to place education high on the social policy priorities list.

7. An equally critical issue, and one which has given rise to considerable discussion, is the specific relationship between education and work activity. How much specific work-activity related knowledge should be incorporated into educational curricula? How much <u>can</u> be incorporated? Is it possible to establish optimum combinations of education and training for each job? Only rarely would one find situations in which a given output can only be produced efficiently by a labour force of specific educational content. While it may be possible to establish optimum combinations

of trained workers (skilled and semi-skilled) for each job, it is very doubtful whether optimum combinations of educational content can be determined. This suggests a possible misconception on the part of those who propagate specific education for specific work. Excepting component parts of educational programmes which are specifically related to specialized knowledge, it would be a disservice to students and society at large to limit the educational content of their programmes to that knowledge only which has immediate application in the world of work. Considering that in periods of rapid change in knowledge, applied knowledge becomes redundant rapidly, application oriented knowledge will disappear, leaving its possessor with no foundation on which to build new applied knowledge.

8. An examination of employment in goods-producing industries reveals that a significant number of industries seem to have reached a plateau in the employment of non-production workers--managerial, clerical, sales, and such other. While output has been increasing, and increases are recorded in the number of production workers, the number of non-production workers employed has remained relatively constant. We have not attempted to determine the possible causal factors. The increasing application of electronic technology in the office is one possibility; and contracting out of some professional, planning, clerical, marketing, advertizing and such other activities may be another. Whether it is the former or the

latter, there are important implications for aggregate employment. It is suggested, therefore, that the issue warrants investigation.

9. There is evidence that Canadian industry has opted out of fundamental research. This has had serious negative effects on the employment of high level manpower, particularly amongst physicists and chemists. The long run implications of this for high level manpower, the creation of knowledge, and innovative activity do not appear to have been given the critical examination that they warrant. An investigation should be undertaken to determine the reasons for the decision to opt out of fundamental research.

10. Specific attention is warranted to conclusion No. 12 (pp. 20-21). Evidently, intermediate and high level management personnel are under intensive pressure to respond rapidly to the requirements of a rapidly changing market environment. Many industries have sought a partial solution to the problem by purchasing the expert services of consultants. But, consultants are problem-project oriented; they do not provide the continuity in knowledge that the enterprise may require. It is recommended, therefore, that the government initiate consultations with industry and the universities for the purpose of developing a series of programmes for intermediate and high level management personnel, to be offered continuously at a number of institutions.

APPENDIX A

17. INDUSTRIES' STATEMENTS ON THE EFFECTS OF TECHNOLOGICAL CHANGES ON EDUCATION AND SKILLS

....

"While a general grade 10 education may once have been adequate, current candidates for apprenticeship are required to have completed a grade 12 in technical subjects. ... Technological change has introduced the need for new in-plant training. ... In the area of research and development, more than anywhere else, the accelerating speed of technological change has an impact on educational requirements. Much of the advanced scientific work has become the preserve of younger men. Re-training and self-development, from technicians to Ph.D's becomes increasingly important."

....

" 'Technological Changes" occur primarily in small increments, in products and processes, and continuously. Seldom does one see a major change in direction, and yet products today are very much improved over products of even 5 years ago, even though they may bear the same label. ... Lack of skills is evident in relation to major capital installations. The skills involved are key trades, primarily electricians and pipefitters. The lack of these skills ranks with the 'capital crunch' as the main factors limiting growth in the petrochemical industry. ... Training programs are continually carried out by the Company using modular trades training at the local College of Applied Arts and Technology. In-house training is supplied from time to time at the trades level and at the first-line supervisory level. ... In summary, technological change is continuous and for the most part comes in small increments. The educational system is, by and large, adequate to supply trained people."

....

"In some of the larger plants we have, however, with some success, drawn upon the inherent intelligence and skills of many people by training them to identify and solve many operating problems themselves which previously were left to the professional staff to cope with. This greater involvement has, in turn, been a form of motivation which has increased productivity. ... In 1972 our managerial/professional staff numbered 1,086; 52 percent of whom were university graduates. At the end of 1975 the population was 1,261; 57.5 percent of whom were university graduates. During this period the total Company population hardly changed at all. These figures illustrate, in a global way, the kinds of changes that have occurred."

....

"Head Office Personnel: computerized accounting and general information generating procedures has forced all levels of personnel to become more precise and less qualitative in their work. Executive levels now have more data at hand to make decisions so there is less 'seat of the pants' activity."

....

"Because we are well aware, not only of the effects of technological change on manpower but also of the effects of changes in organizational and managerial techniques and style, we select personnel with sufficient educational base which, supplemented by in-house and external training and education, enables them to adapt to change."

....

"During the time period which you mention, we have continued to increase the number of computer and computer-like equipment installations in our operating departments. These units are involved mainly in process and production control systems. As a result, we have two groups of employees whose knowledge and skill levels must adjust; i.e., those who operate the equipment and those who maintain and service it."

....

"Many, many changes and improvements have been incorporated over the years but they have been gradual, not involving personnel problems of any serious or significant value."

....

"... our organization is more or less geared to technological change, and in the case of our Systems Analysts and Customer Engineers, these people average a technical upgrading course every six to nine months."

....

"With this expansion our instrumentation equipment has doubled, creating a need for more skilled Instrument Technologists who are hard to find. We have advertised across Canada with minimal results. ... As to other levels of educational requirement changes, there have been no changes of significance in the last five years."

....

"In Western Canada there is a continuing shortage of skilled personnel so that it is necessary to retrain and adapt existing personnel to the maximum."

....

"... we have always found that given a sustained hiring effort, we are able to attract competent people in the number required. ... the proportion of our population which holds scientific degrees has increased and we expect that this trend will continue. It is generally conceded that we expect the universities to produce a science or engineering graduate who is cognizant of the fundamentals of his trade and who has some acquaintance with state of the art techniques. Considerable on the job training is required and we are willing to provide this training ourselves."

....

"To provide the necessary changes in skills to cope with the technological change, we not only do a large amount of on-the-job training but we operate three separate training schools. Lack of qualified personnel is seldom a delaying factor because through long experience we have learned to make the retraining and development of the personnel required an integral part of the planning of the technological change."

....

"While planned change through improved client services is certainly a major activity in our organization, its nature is such that the gradual and deliberate upgrading of our employees'skills through 'on-the-job' and 'in-house' training is sufficient to meet the demands of these changes."

....

"Shortage of qualified personnel if any, is not due to technological changes but to market variation."

....

"We have never been aware of technological change being a major problem. We have always had on-going in plant trade development programs as a result of attrition and normal upgrading."

....

"It is not our practice to separate people but rather to upgrade, retrain and, in many cases, relocate our employees. This applies to people at all levels and in all occupations."

....

"... we did have difficulties to attract qualified N/C operators and programmers. However, we have overcome this problem by upgrading our own personnel through training courses at Community Colleges, in-house training and courses conducted by our machinery suppliers."

....

"... we believe the rapidity of development of new techniques and ideas will require considerably higher levels of abilities in the very near future."

....

"Perhaps the real challenge has rested with management, who have had to develop new markets, reduce inventory levels, reduce supplies and materials costs, reduce down-time, improve safety, and optimize scheduling techniques, in order to remain competitive and profitable. The level of management skills has had to rise faster than any other group."

....

"Part of the changes in education and skill level requirements for new employees is due to the fact that a greater number of trained people are available in the market place .. . Regulatory agencies have added to our work load and in so doing have placed higher education and skill demands on our organization."

....

"If we could be fully selective, we would hire only those people who had had at least two years of training in electronics after high school graduation. Unfortunately, the number of such individuals is limited and our requirements for manual skills is so great, we must still accept regular high school graduates who have had no subsequent training. Obviously, to raise such people to the desired level of ability is more costly."

....

"The only change in the area of manual jobs, skilled or unskilled is the increase in educational preference which has risen from roughly Grade 9 to the present level of High School education. This continues to be a preference rather than a requirement but a significant change has occurrred in this area over the past 5 years."

....

"We have gone thru considerable change in our processes, incorporating computers, terminals, photocomposition and many other new pieces of equipment. We have retrained our previous staff to use this new equipment and they are operating quite successfully. Therefore the educational requirements have not changed because these older employees have not added to their basic education in any way. ... With regard to new employees, we find that the standard of education (or the level reached before seeking employment) has risen. New employees adapt to the techniques and skills required very quickly. It is not difficult to fit a new employee into many types of jobs, because they seem to be so adaptable and willing to try anything. They have no fear of failure, of inability to perform, and will wade into anything they are given."

....

"In summary, the impact is a higher level of the same skills and a greater depth of knowledge and more specialized education in all of the areas the Corporation is concerned with."

....

"I would say that in the past five years the greatest educational requirement has been a knowledge of micro and macro economics; and with it the ability to comprehend requirements of changes in world economics and also the discipline imposed by regulatory bodies, such as the Anti-Inflation Board. ... The greatest skill requirement is in the use of mini-computers; not the ability to understand the theory, but the skill to apply mini computers to the accounting problems."

....

"We have found that because of the many computer aids developed in the last two decades, many engineering problems are resolved more quickly. Because they can generally handle each problem in a shorter time, engineers need to have a broader repertoire of skills so that they can handle a wider array of assignments than previously."

....

"... we require higher skills to-day than we did five years ago. With employees now using more sophisticated equipment, checking out customers, ordering merchandise, etc., educational requirements must be higher. ... There is no question but what employees are coming out of educational institutions with higher academic standards."

....

"In summary, a substantial upgrading of the formal educational component in almost all jobs and functions. This may, in part, be due to the fact that many more people are available with the formal qualifications. However, we are equally convinced that we need them to perform the tasks required in today's business organization."

....

"If we were to wait until these educational and skill requirements were processed through the educational system, we would find ourselves many years behind the other employers who need these particular educational or skill requirements, and hence, we resolve the problem internally."

....

"I can identify one major skill requirement that has developed in the last several years. It is the skill required to motivate people through participatory type management in virtually every level of management. ... The day of the arbitrarily stated demand of the supervisor will not be adequately carried out without involvement. Therefore, the understanding of many of the theories put forth in recent years having to do with the nature of man, is becoming of critical importance."

....

"During the last three years we have experienced great difficulty in finding engineers and technicians with coal mining expertise between the ages of 35 and 55. ... However, I can be sure of my facts when I say that the other area of 'people' concern is the shortage of well qualified safety engineers. The professional engineer who has made safety a career is simply not to be had and to my knowledge there is no institution, apart from Humber College, which provides for this training."

....

"We have found that succeeding technological changes have tended to reduce the number of jobs requiring the least education and skill. ... As processes and controls and equipment are automated the remaining positions require a higher degree of comprehension, skill and education. As a result we have had to organize training, for employees who would be taking on new duties, to a greater degree than in past years."

....

"It is true there has been shift from brawn to brain, and this probably affects hiring practices but seldom disqualifies the man who was already there."

....

"I can not think of a single instance where we have held up changes because of the lack of properly trained people. Certainly changes do require on occasion new skills and it is our general practise to provide this training ourselves, and where outside help is required we find it is generally readily available through a variety of sources. ... we have a greater problem over education rather than a shortage of trained people. ... Far too many people are coming to us with inadequate skills in reading and writing and too many of them have difficulty with simple arithmetic when the batteries of their pocket calculators fail."

....

"... we have merely seen an upgrading of former requirements, at all levels, generally corresponding to the greater quantity of better educated people who now come onto the labour market. This hiring of personnel having a better level of education will hopefully lessen the need for extensive internal retraining to cope with future changes. ... we have seen few, if any, specific changes in our requirements over the past few years outside of a general upgrading of the educational level of personnel hired at all but the professional level."

APPENDIX B

18. EFFECT OF TECHNOLOGICAL INNOVATIONS ON OCCUPATIONAL SKILL LEVEL AND EDUCATIONAL REQUIREMENTS

This section contains projections of changes in occupational skills and educational requirements for selected occupations. The information was obtained from the professional and trade journals of the indicated occupations.

(1) ACCOUNTANTS AND AUDITORS

Employment of accountants and auditors rose over the period 1961-71 from 29,121 to 103,020. The trend to 1980 is for continued absolute increase in employment, but a lower overall growth rate as computer systems take over many accounting functions.

The increasing utilization of electronic data processing (EDP) systems has relieved the accountant of the tedious and repetitive book-keeping requirements of the profession. As a result, there has been a shift in educational emphasis away from procedures and details and towards theory and concepts. The accountant requires a higher order of analytical ability, with specialization in sophisticated mathematical and quantitative techniques, and ability to apply them to operations research, forecasting, and other areas of business analysis.

Established accounting programmes have not changed sufficiently to fulfill adequately emerging requirements. As a result, consideration is being given to recruitment of non-accounting undergraduates, particularly from the fields of economics and engineering.

(2) ARCHITECTS

Employment of architects increased during the period 1961-71 from 2940 to 4040. Increases in job openings are expected to continue as computer-based project analysis increases the speed and efficiency of design work, allowing more projects to be undertaken per year.

The advent of a system called multiple contracting and fast-rack scheduling, has resulted in a modular-type construction approach allowing structural and interior design integration, which greatly reduced the time required for project completion. In order to meet the resultant increase in architectural demand a computerized system of Logical Sequencing (LS) has been developed. Project design and specifications are fed to a computer which anticipates problems and timing sequences, and presents them in a graphically simple flow chart of the project concerned.

This novel technique has forced the architect to replace the traditional bar chart planning skills with a sound knowledge of computer programming and data processing. This represents an upward-skill level change, as all previous skills are still required in order to identify specifications of design for computer feeding. A technique is presently being perfected by which a computer can interpret the architects' specifications, design the product, and produce detailed lists of materials needed to produce the object. Incorporation of this system will result in a radical shift in architecture education requirements away from traditional skills and toward a more solid background in computing science and programming.

(3) DRAFTSMEN

Many of the tedious and repetitive functions of this occupation are being increasingly performed by new computerized equipment. Photo-reproduction and electronic drafting aids allow more time to be spent on design, and erasable drafting paper allows modifications to be made without extensive redrafting.

The occupation of draftsmen will likely be eliminated by the 1990's for all but a highly qualified few. Automatic drafting equipment, which until recently was considered too difficult to integrate into the existing system, is now being incorporated as complementary equipment to the Logical Sequencing systems. The new equipment, capable of designing and drafting functions from specification data, will replace all but a few draftsmen who will remain as systems monitors and 'proof-readers' of equipment printouts.

(4) ENGINEERS AND RELATED OCCUPATIONS

Professional engineers experienced a rapid growth in employment over the period 1961-71, increasing from 43,066 to 76,880. The widespread automation and computerization of the industrial sector will continue to have highly positive effects on the growth of the engineering profession, with demand for qualified engineering personnel increasing in many new areas.

The demand for quality control and computational engineering skills has declined as automation replaced these functions, resulting in a general increase in occupational skill-level requirements and a radically altered educational demand. The increasing complexity of industrial organizations, and the increasing technical sophistication of production processes (and of some products), have created demand for managers and administrators who can fill the double role of technical expert and business administrator. This role is being increasingly filled by engineering graduates trained in theoretical and technical operations design as well as economics and business management.

Although the emphasis is still on advanced mathematics, physics, and process design, increasing numbers of programmes are incorporating course work in management and economics as central to the engineering degree.

(a) Engineering Technicians

The shift in emphasis from the technical to the conceptual and theoretical has created a gap at the work place between the engineer and the craftsman. That gap is being filled by the engineering technician. The engineering technician performs many lower level engineering functions. With a combined technical-theoretical educational background, the technician acts as an information 'interpreter' between the engineer and the tradesmen.

In the early 1960's, when the engineering technician occupation was first established, the majority of practicing technicians had high school diplomas with some initial university engineering training. By 1975, most of them held technical certificates in electronics or computing science, or bachelors' degrees in mathematics, computing science or engineering. The main reason for this educational upgrading has been a progressive increase in the level of work-functions. In addition to the original tasks of calibration and equipment operation, they have assumed work functions in production operations, material and product specification, and basic design work.

Educational requirements for engineering technicians are expected to remain static over the next few years, while employment is anticipated to increase from 70 to 80 percent per year as a greater proportion of industries convert to computer processes and control systems.

(b) Chemical Engineers

The utilization of computer technology in such operations as data fitting and analysis, pilot plant monitoring, distillations, column control, and so on, has changed the chemical industries' demand for professional specializations from operations knowledge to programme preparation and analysis of results. This trend favours the chemical engineer over the chemist or technologist, whose functions tend to be deskilled by the incorporation of computer control in laboratory analysis.

Educational concentration in mathematics, chemistry and physics remains a central part of the engineer's curriculum, but special courses in computing science, economics and process design and control are also required in order to qualify the engineer for the managerial and design functions demanded by industry. As the number of chemical engineers engaged in R and D declines, greater stress is placed on economics and problem-solving techniques, skills which are better suited to the industrial demand.

(5) CHEMISTS: LABORATORY AND RESEARCH

Chemists experienced a relatively rapid rate of increase in employment over the 1961-71 decade, increasing from 4051 to 10,211 or by 152 percent. It is anticipated that this trend will continue over the next decade; but laboratory chemists are expected to experience a negative rate of employment growth.

The ease of adaption of chemical processes to automation and computerization will continue to have a deskilling effect on the laboratory chemist. New laboratory equipment is self-regulating in some form or another and to varying degrees. Semi-continuous operations or non-automatic continuous operations, the most prevalent laboratory technique heretofore, involve continuous control of machine functions by the chemist. This method of operation is being replaced by the closed-loop computer operation, which features computer calculation and data evaluation as well as automatic optimum control setting and error evaluation and correction. The use of this new technology, combined with the growing number of chemical technologists specifically trained in laboratory equipment operations and maintenance, greatly reduces the demand for laboratory chemists. Those affected have the option of performing the lower-skill technologist functions, or obtaining additional educational training required for research chemist positions.

Automation of many of the technical functions previously performed by the chemist and the associated increase in quantity and accuracy of laboratory analysis made possible by the new equipment, has resulted in a growing demand for theoretical and design chemists. Rapid advances in chemical analysis necessitate periodic upgrading of skills and area knowledge, with greater stress placed on the theoretical aspects of chemistry and physics. The position of research chemist, unlike many other occupations, will require a greater degree of educational specialization within the area, in order to properly assimilate the rapidly expanding information output resulting from laboratory computerization.

(6) MANAGERS AND ADMINISTRATORS

The number of self-employed managers (proprietors) is expected to continue its downward trend as the trend towards larger business enterprises continues. The increasing complexity of business, in the context of government regulations, financial markets, scientific and technological developments, raises the need for trained management specialists. Therefore, it is expected that increasingly managers will emanate from the ranks of professional occupations. Distribution of employment amongst sectors will, of course, follow the anticipated developments in the sectors: smaller increase in manufacturing than in communications industries, smaller in communications than in service industries, and so on.

(7) CLERICAL WORKERS

Clerical and kindred workers recorded the fastest growth during the 1950's and 1960's. Between 1961 and 1971 their numbers increased from 833,156 to 1,373,565 or by almost 65 percent.

Developments in electronic technology--computers, office equipment, communications devices--are expected to retard the employment of clerical occupations and stimulate the employment of occupations related to the operation of the new equipment. For example, the employment of file clerks and office machine operators is likely to decline as computers are used more extensively in arranging, storing and transmitting information. Such a development will mean, of course, an increase in employment of occupations related to the operation of the computers. Similarly, advances in mail processing equipment will likely have an adverse effect on the rate of employment growth of postal clerks, and the increasing use of dictating machines will continue to reduce the need for stenographers. By contrast the employment of secretaries and receptionists is not likely to be affected adversely by technological changes because (a) their functions involve a considerable degree of personal contact, and (b) demand for their services will continue to grow in the expanding sectors of the economy, such as, services to business, medical and other health services, and professional services.

(8) RETAIL SALES WORKERS

The increasing use of labour-saving merchandizing techniques, such as self-service and automated check-out counters, will moderate the rate of increase in employment of retail sales personnel. But, because of the relatively slow pace of conversion to electronic technology, the retail industry does not expect any problems in relation to redundancies, the training of workers, and generally in adjustments to the new processes. The prevailing view is that some of the employees who possess the relevant level and nature of education will be trained to perform computer related functions, and other employees will be relocated to general work functions associated with the anticipated increase in retail activity.

(9) EMPLOYMENT IN WHOLESALING

Warehouse operations lend themselves easily to both automation and computer process control. Incorporation of conveyor systems and automated floor-to-floor handling and assembly have increased the speed and efficiency of warehousing duties, at the expense of labour and operative employment. By 1980, two-thirds of all wholesaling firms will have computerized their in-house accounting and inventory control tasks. Larger firms are incorporating systems which allow orders to be placed directly with the computer, which automatically invoices, posts accounts receivable, and adjusts inventories by reordering depleted stock from the manufacturers.

The newest innovation in wholesaling is the fully automated warehouse: remote computers control storage, order pick-ups, process information on orders, reorder items, locate items, and determine destination and frequency of delivery.

The effect of computerization on employment has been favourable for non-production workers such as salesmen and professional personnel, but very unfavourable for production workers, such as operatives, service workers, and craft workers, who are either being displaced or reduced to monitoring functions.

(10) FARMERS AND FARM WORKERS

The number of persons employed in farming declined over the 1961-71 period: the number of farm owners fell from 393,406 to 234,010 or by about 40 percent; while the number of farm labourers decreased from 222,331 to 202,185 or by about 10 percent. The decline is attributed to the amalgamation of small farms, and to the use of larger and more efficient machinery.

The availability of larger and more complex farm implements, equipped with monitors designed to indicate deviations from optimal operation conditions, combined with improved fertilizers, feed, and seed, have resulted in productivity and yield per acre increases throughout the farming sector. The rapid growth of the Agribusiness service industry and the accompanying expansion of technical information has served to reduce the production risks inherent in farming operations.

These innovations have necessitated a substantial increase in the educational requirements of farmers. On-the-job training, while necessary, is no longer sufficient training to ensure a successful farming operation. Growing numbers of farm owners and workers are entering agricultural colleges and university programmes in agrology and agricultural economics, in order to upgrade and acquire knowledge in marketing, farm operations, economics, business management, accounting, and technical skills related to the operation and servicing of farm implements.

(11) LIBRARIANS

Technological innovation in library services has been concentrated on standardization and automation of library processes. The public library system is moving toward bibliographic computer control and standardization of serials and test listing on a provincial and national level, in an attempt to make the total information resources more readily available. Within the education system, libraries are making increasing use of microform reproduction, 'learning carrels' equipped with desk-top calculators and recording machines, and minicomputer terminals.

The increasing utilization of computer technology for cataloguing, information processing and subject-search is eliminating many of the repetitive functions of the librarian. Automation has resulted in a change in skill level requirements from manual ability in stocking, controlling and sorting, to remote control board operation, equipment monitoring, keyboard operation, and basic programming skills. Librarianship is attracting personnel with strong data processing backgrounds and a continued trend toward technical ability in computer applications is expected.

(12) MACHINISTS

Following a period of rapid growth in the 1950's and 1960's, the demand for machinists has dropped off sharply in the early 1970's, with the 1971 employment figure of 37,315 only slightly above the 1961 figure of 34,552. The major reason for this decline in demand has been the advent of numerical machine control, a technique of automatic machine operation by means of coded instructions implanted on magnetic tape. The incorporation of numerical control has adversely affected the number of machinists employed as job setters, and the increased accuracy provided by computer control has reduced the demand for inspectors and production machinists. The replacement of machinists by less-skilled machine operators has reduced the overall education requirements from post-high school technical education to three to six weeks on-the-job training background.

The one exception in skill-level change is the maintenance machinist. The new equipment, composed of electronic and hydraulic systems as well as traditional mechanical systems, requires the machinist to have an understanding of electronics and computer operations in order to maintain the machine and control process. Advances in metal-cutting equipment, such as chemical and laser machining, will further upgrade the technical education and skill requirements of the maintenance machinist.

(13) MACHINE TOOL OPERATORS

Automation and computerization, in the form of numerical machine control and automation of job set-up and processing, have had a cumulative deskilling effect on the machine tool operator. Where prior to these innovations the operator was required to set-up, recalibrate and readjust the machines for tooling, these functions are now controlled by continuous-loop computer control tapes, which allow increased speed, accuracy, and efficiency of operation. The operator is responsible only for monitoring the highly automated process; malfunctions are reported to a maintenance machinist for repair, rather than the operator performing the required adjustments himself. These innovations will result in negative employment growth over the next decade.

The downward skill requirements of the operator have been accompanied by lower education requirements. Technical training is being replaced by short duration on-the-job training in monitor operations, and automatic materials transfer equipment substantially reduces the manual labour requirements of the occupation.

(14) SCIENTIFIC DATA PROCESSING TECHNICIANS

The scientific data processor is the newest entry to the technician category. The field, in existence since the early 1960's, is presently the fastest growing of the technician occupations. Job functions include simulation techniques, statistical programming, inventory control, and programming for mathematical models.

The traditional education requirements involve a solid background in statistics, supplemented with linear programming, algebra and economics. With the extension of EDP systems into increasing numbers of industrial firms, the educational requirements of the processor will become more specific. Coupled with fundamental computer knowledge, the processor will require a more intensive background in the specific field of employment, involving university level training in economics, business management, and industrial organization.

(15) TOOL AND DIE MAKERS

This occupation has traditionally been considered the 'elite' of the craft trades, requiring a high degree of precision and manual dexterity. The craftsman required several years of technical training and experience, either through formal apprenticeship or equivalent on-the-job training, prior to receiving a license. Occupational tasks involved the use of handtools for fitting and assembling tools, guages and equipment, and the ability to read and interpret blueprints.

The use of computers for measurement, calibration and assembly has eliminated most employment positions for tool and die makers. Affected workers either accept lower skill positions such as machine operators, or obtain additional technical education in mechanical drawing and tool design to qualify as design machinists.

19. EMPLOYMENT OF PRODUCTION AND NON-PRODUCTION WORKERS,

BY INDUSTRY, 1961-1974.

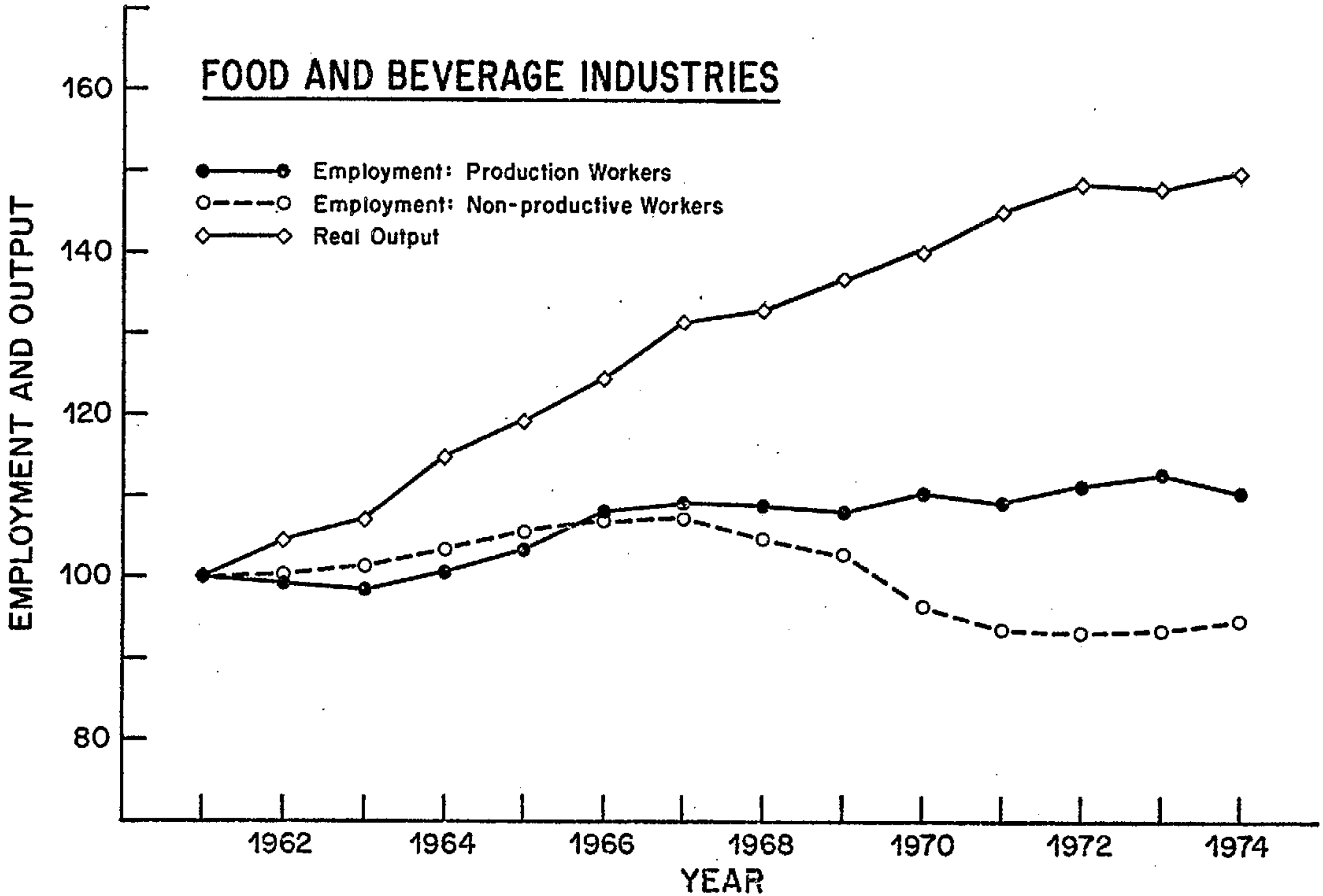
INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

FOOD AND BEVERAGE INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	99.3	100.6	104.4
1963	98.5	101.5	107.2
1964	100.9	103.8	115.1
1965	103.9	105.9	119.2
1966	108.3	107.0	124.7
1967	109.4	107.2	131.9
1968	109.0	104.9	133.5
1969	108.1	103.4	136.9
1970	110.4	96.9	140.8
1971	109.6	93.9	145.4
1972	111.6	93.4	148.9
1973	112.8	93.8	148.2
1974	110.9	95.0	150.1

* Real Value of Shipments based on 1971 prices.


FOOD AND BEVERAGE INDUSTRIES
Employment: Production Workers
Employment: Non-productive Workers
Real Output
EMPLOYMENT AND OUTPUT
160
140
120
100
80
1962
1964
1966
1968
1970
1972
1974
YEAR

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

RUBBER AND PLASTICS INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	109.6	94.7	120.9
1963	118.0	98.6	130.1
1964	122.9	98.3	130.6
1965	127.2	106.6	157.3
1966	136.9	109.6	174.9
1967	128.6	113.2	185.9
1968	114.4	112.5	183.2
1969	118.2	109.8	196.5
1970	112.2	106.2	186.9
1970**	227.3**	155.4**	306.3**
1971	227.9	160.6	324.3
1972	252.3	173.1	367.9
1973	280.7	189.3	439.0
1974	277.7	192.4	458.3

* Real Value of Shipments based on 1971 prices.

** Standard Industrial Classification changed.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

LEATHER INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	101.7	86.2	103.6
1963	101.8	80.3	105.5
1964	101.6	76.8	109.3
1965	101.9	78.4	110.9
1966	101.1	82.6	109.2
1967	97.2	82.3	109.2
1968	98.1	82.3	115.8
1969	94.5	81.2	117.6
1970	88.2	69.7	111.8
1971	88.1	63.7	114.8
1972	85.7	63.8	110.1
1973	85.5	64.3	112.4
1974	82.9	62.9	114.1

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

TEXTILE INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	105.3	103.9	110.4
1963	109.8	104.6	122.6
1964	117.3	107.4	132.9
1965	120.4	112.0	141.4
1966	119.2	120.1	149.5
1967	119.7	119.3	156.5
1968	115.0	106.7	166.8
1969	118.5	109.3	184.9
1970	113.4	108.1	171.2
1970**	109.7**	100.9**	179.7**
1971	109.7	98.5	187.1
1972	117.6	104.9	213.8
1973	121.8	108.2	222.2
1974	118.9	109.9	207.8

* Real Value of Shipments based on 1971 prices.

** Standard Industrial Classification Changed.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

KNITTING MILLS

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	102.6	90.8	106.9
1963	104.2	77.4	116.4
1964	106.3	77.8	126.8
1965	112.0	78.5	142.1
1966	109.8	77.4	148.1
1967	110.9	52.0	148.1
1968	110.4	80.2	169.5
1969	115.6	77.7	183.1
1970	110.7	76.5	192.1
1971	118.8	75.4	205.6
1972	116.5	74.1	217.2
1973	122.4	75.3	195.8
1974	120.1	77.5	229.8

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

WOOD INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	101.1	105.1	107.6
1963	104.8	111.9	114.1
1964	109.7	104.6	121.0
1965	113.6	100.3	124.9
1966	113.8	101.8	129.4
1967	111.4	99.1	129.6
1968	111.7	100.7	135.3
1969	114.5	102.6	136.7
1970	108.2	100.4	138.6
1971	112.8	106.9	150.4
1972	126.2	119.2	161.7
1973	136.4	133.7	171.5
1974	128.4	137.9	173.7

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

FURNITURE AND FIXTURES INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	103.2	100.4	107.5
1963	107.9	104.6	116.3
1964	114.4	109.7	127.2
1965	122.3	113.9	140.8
1966	133.6	116.7	158.7
1967	134.0	119.6	163.3
1968	131.3	119.6	165.5
1969	135.0	121.0	174.4
1970	129.0	114.9	169.6
1971	130.9	118.9	179.8
1972	143.9	125.6	208.5
1973	151.5	126.8	221.4
1974	159.4	130.8	216.2

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

PAPER AND ALLIED INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	101.4	103.1	103.9
1963	102.2	107.2	108.9
1964	107.0	112.0	119.8
1965	110.4	117.8	126.7
1966	116.2	127.8	135.7
1967	117.7	131.9	135.5
1968	116.4	132.2	142.4
1969	120.5	136.1	155.4
1970	119.8	138.1	156.2
1970**	119.2**	136.7**	155.1**
1971	118.4	133.3	156.0
1972	119.9	133.0	171.5
1973	122.4	135.0	184.5
1974	131.1	142.0	209.9

* Real Value of Shipments based on 1971 prices.

** Standard Industrial Classification Changed.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

PRIMARY METAL INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	102.1	101.4	105.2
1963	103.9	107.1	112.0
1964	111.6	111.5	124.7
1965	119.8	118.5	133.8
1966	125.9	127.8	140.8
1967	124.6	128.8	137.6
1968	123.8	131.9	150.0
1969	119.9	134.9	150.5
1970	126.9	136.5	153.4
1971	124.1	137.2	178.0
1972	123.9	136.1	166.1
1973	128.9	131.0	176.9
1974	135.7	136.3	182.8

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

NON METALLIC MINERAL PRODUCTS INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	105.9	102.1	117.0
1963	106.2	106.6	119.0
1964	112.0	111.8	133.8
1965	120.4	112.4	148.2
1966	124.5	118.1	156.9
1967	117.9	119.6	145.6
1968	118.9	120.2	156.6
1969	119.9	119.4	160.4
1970	114.6	117.3	154.5
1970**	113.4**	115.9**	152.8**
1971	119.7	114.8	176.8
1972	123.2	120.7	190.6
1973	130.6	125.2	209.8
1974	134.9	127.2	217.9

* Real Value of Shipments based on 1971 prices.

** Standard Industrial Classification Changed.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

PETROLEUM AND COAL PRODUCTS INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	96.5	101.9	107.9
1963	93.7	94.1	117.3
1964	92.3	90.9	122.5
1965	87.8	87.0	127.1
1966	87.8	99.4	133.0
1967	88.0	101.8	137.2
1968	88.5	101.5	145.0
1969	84.8	104.9	145.5
1970	86.0	103.9	148.7
1971	84.4	103.9	154.4
1972	84.7	102.3	173.6
1973	87.8	107.4	191.1
1974	100.2	111.9	236.4

* Real Value of Shipments based on 1971 prices.

INDUSTRY INDEXES OF EMPLOYMENT AND REAL OUTPUT 1961-1974

(1961 = 100)

CHEMICAL AND CHEMICAL PRODUCTS INDUSTRIES

YEAR	PRODUCTION WORKERS	NON-PRODUCTION WORKERS	REAL OUTPUT*
1961	100	100	100
1962	99.7	102.0	109.0
1963	102.6	104.2	117.5
1964	105.9	107.0	129.6
1965	110.6	113.4	142.3
1966	117.1	114.3	157.5
1967	119.8	117.8	160.9
1968	122.6	120.6	171.5
1969	125.4	122.2	186.4
1970	126.5	123.1	189.9
1971	121.9	122.4	199.6
1972	118.6	117.3	209.9
1973	124.5	119.6	236.8
1974	129.1	122.8	239.5

* Real Value of Shipments based on 1971 prices.

APPENDIX D

20. QUESTIONNAIRE

PROJECT: EFFECT OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS OF ORGANIZATIONS

Opinions differ on the subject under examination: some have held that technological advances have an upward effect on required levels of education and skills; whereas others have argued that highly mechanized and automated processes afford little opportunity to employees to use their education and skills.

Undoubtedly, one can find cases that will provide support for both arguments. Our task is to determine the overall effect: what kinds of adjustments in manpower take place? What changes in education, skills and other work-knowledge are brought about? Do employees in various occupations possess sufficient general and technical education to respond effectively to the requirements of technological changes? In which occupations they do, and in which do they not? These are some of the questions to which we shall seek answers.

Preliminary discussions with managers suggest that organizations generally do not as a matter of policy evaluate the manpower effects of technological changes. Should your organization be an exception, and should there exist a report detailing the actual effects, such as the relocation of personnel, additions to personnel, further education and training, retraining etc., I would appreciate receiving a copy. Furthermore, should you be aware of any studies relevant to this project, I would be interested in learning of them.

INSTRUCTIONS: 1. Technological change is defined for the purposes of this study as:

"Change which involves the use of new or more efficient information handling systems, the use of new and substitute products and services, new uses of computer-control in transactions as well as the mechanization of services previously provided mainly be personnel."

2. If your organization has instituted or is in the process of instituting a number of technological changes (as defined), then either:
   a) relate your answers to the one with the most important implications for educational and skill requirements at all employment levels; or
   b) complete one questionnaire for each of the major technological changes which you feel should be included in this study. (A spare copy of the questionnaire is enclosed.)

3. Please indicate whether specific reference can be made in the report to your organization. If you prefer, reference can be limited to your industry, i.e. one commercial bank, a trust company, a firm in the steel industry, an electronics firm.

   ____ Specific Reference ____ No Reference

QUESTIONS:

1. How many technological changes has your organization introduced within the past five years?

   1 2 3 4 5 None

2. (a) Please describe briefly the main technological change introduced within the past five years.

   (b) Please explain briefly the nature of considerations that entered into the decision to introduce the technological change (i.e. scarcity of qualified manpower, rising costs of operation, quest for greater efficiency, conventional equipment and methods no longer adequate, change in materials inputs, new technology thought to be cost-saving, etc.).

3. Please explain briefly the fundamental difference between the new technology and the technology it replaced.

4. (a) Was the implementation of any technological change delayed by lack of qualified personnel?

_______ YES _______ NO

4. (b) If answer is YES, please indicate the kinds of personnel scarcities to which the delay was attributed.

	Occupation	Educational and Skill Qualifications	Number Required
1.	. . . .	. . . .	. . . . . .
2.	. . . .	. . . .	. . . . . .
3.	. . . .	. . . .	. . . . . .
4.	. . . .	. . . .	. . . . . .
5.	. . . .	. . . .	. . . . . .

4. (c) What was the approximate duration of the delay?

_______ Weeks _______ Months

4. (d) Which occupations (employment positions) posed the greatest difficulty to fill?

1. . . . .
2. . . . .
3. . . . .

4. (e) How was the problem of personnel scarcity resolved?

____ Upgrading existing personnel

____ Retraining

____ Professional development

____ Changes in equipment

____ Hired new employees

____ Internal transfers of personnel

____ Other (please specify)

4 (f) Please indicate which, in your opinion, were the main causes of the difficulty.

____ 1. Inadequate supply at prevailing salaries

____ 2. Salaries demanded too high

____ 3. Inadequate supply at any price

____ 4. Inadequately qualified manpower

____ 5. Other (please specify).

5. How does the new technology differ from the old in terms of "doing the job"?

5. (a) From the Manager's perspective

(b) From the Worker's perspective

6. (a) How many employees (all categories) were employed directly or indirectly in the old process before the change?

Number __________

(b) In what major occupational groups were the employees classified?

	Occupational Classification	Number	Fundamental* Knowledge	Specific* Technical Knowledge	Displaced**
A.	....	......	....	....	....
B.	....	......	....	....	....
C.	....	......	....	....	....
D.	....	......	....	....	....
E.	....	......	....	....	....
F.	....	......	....	....	....

*6. (c) Of those occupational groups which were affected by the technological change in terms of their job functions please indicate the direction of the change in skill or knowledge requirements as follows:

+1 job position incumbents now require a higher level of fundamental knowledge (e.g. math, science, language) or a higher level of specific technical knowledge

0 job position incumbents now require no additional fundamental knowledge or specific technical knowledge

-1 job position incumbents now require less fundamental knowledge or less specialized technical knowledge

(Please mark the appropriate column)

**6. (d) Please indicate in the last column how many employees in an occupational category were displaced by the change.

7. (a) How many of the employees had to be upgraded (retrained)?

....

7. (b) Was the bulk of this upgrading (retraining) done:

In-house (on-the-job) ....
Yes No

External to the company (courses etc.)

....
Yes No

7. (c) Periods of retraining:

_____ One Week _____ Two Weeks _____ Three Weeks

_____ Four Weeks _____ Five Weeks _____ Six Weeks

_____ MORE than Six Weeks

7. (d) Could not be retrained because of:

_____ Inadequate fundamental education

Number ....

_____ Too old

Number ....

_____ Too old and Inadequate Education

Number ....

_____ Other (please explain)

Number ....

8. In relation to those who were DISPLACED or could not be retrained for the new technology, were they

_____ (a) transferred to other positions without retraining
Number ....

_____ (b) retrained for other positions
Number ....

_____ (c) released from employment.
Number ....

9. Did the technological change create any new employment positions at the managerial, professional, technical or any other level?

_____ YES _____ NO

10. If answer is YES, please indicate (a) their occupational classifications (employment categories), (b) the educational qualifications required, and (c) the specific technical qualifications required:

Number		Occupation (employment category)	Education Required	Technical Knowledge
......	1.	....	....	....
......	2.	....	....	....
......	3.	....	....	....
......	4.	....	....	....
......	5.	....	....	....
......	6.	....	....	....

11. Do you anticipate any significant technological changes in your industry within the next 5-10 years?

_______ YES   _____ NO

12. If YES, please indicate:

(a) the nature of anticipated changes

(b) the anticipated effects on educational and skill requirements.

Identification:

Organization (optional): ....

Department: ....

Unit: ....

Name (optional): ....

Position (optional): ....

Date of Completion: ....

ALL INFORMATION RECEIVED WILL BE CONSIDERED CONFIDENTIAL

21. EFFECTS OF TECHNOLOGICAL CHANGES ON EMPLOYMENT AND EDUCATIONAL AND SKILL REQUIREMENTS *

AN

ANNOTATED BIBLIOGRAPHY

Stephen G. Peitchinis
Professor of Economics
The University of Calgary.

January 1978
Calgary, Canada.

* Research for this study was supported by a Grant from the Department of Industry, Trade and Commerce, under the Technological Innovation Studies Program of the Technology Branch.

ABBREVIATIONS OF SOURCES

Acad. Manag, Proc. - Academy of Management, Proceedings.

Am. Econ. R. Pap. and Proc. - American Economic Review - Papers & Proceedings.

Amer. J. Econ. Soc. - American Journal of Economics and Sociology.

Brit. J. Indus. Relat. - British Journal of Industrial Relations.

Brooking Pap. Econ. Act. - Brookings Papers on Economic Activity.

Bus. Q. - Business Quarterly.

Calif. Manage. Rev. - California Management Review.

Can. Bus. - Canadian Business.

Develop. Econ. - Development Economics.

Econ. J. - Economic Journal.

Eng. Econ. - Engineering Economist.

Fin. Post - Financial Post.

Harvard Bus. Rev. - Harvard Business Review.

Ind. Relat. - Industrial Relations.

Int. Lab. Rev. - International Labour Review.

ITCC Rev. - International Technical Co-operation Centre Review.

J. Manag. Stud. - Journal of Management Studies.

Labour Gaz. - Labour Gazette.

Manchester Sch. Econ. Soc. Stud. - Manchester School of Economic and Social Studies.

Mon. Lab. Rev. - Monthly Labor Review.

Prob. Econ. - Problems of Economics.

Pub. Adm. R. - Public Administration Review.

Quart. J. Econ. - Quarterly Journal of Economics.

R. Econ. - Review Economique.

Rev. Econ. Statis. - Review of Economics and Statistics.

Rel. Ind. - Relations Industrielles.

R. Polit. Soc. - Review of Political Sociology.

Rivista Int. Sci. Econ. Com. - Rivista Internazionale di Science Economiche e Commerciali.

Soc. Sci. Q. - Social Science Quarterly.

Soc. Econ. Plan. Sci. - Socio-Economic Planning Science.

So. Econ. J. - Southern Economic Journal.

Voprosy Ekon - Voprosy Ekonomiki.

Western Econ. J. - Western Economic Journal.

World Devel. - World Development.

THE EFFECTS OF TECHNOLOGICAL CHANGES ON EDUCATIONAL AND SKILL REQUIREMENTS.

BIBLIOGRAPHY.

It is relevant to note briefly that bibliographical searches have undergone significant technological changes. About one-half of this bibliography was obtained through bibliographical tape services.

At the outset we had planned to use the services of a few students to compile an annotated bibliography. But, we were informed that the University of Calgary Library had access to the bibliographic tape services of the System Development Corporation, Santa Monica, California, the Lockheed Information Systems, Palo Alta, California, the CAN/OLE tape Services of the National Science Library and National Research Council, and the QL Systems Limited, Kingston, Ontario. Within a period of five days these bibliographic service establishments scanned an estimated 3,000,000 reports and books in the general area of the subject under examination, and provided references to about 400 sources which appeared relevant to the study. We were provided with computer printouts which contained information on author(s), title, sponsoring agency (for reports), publisher, year of publication, number of pages, price, where the publication can be obtained, descriptions, identifiers, and a summary of findings.

The cost of the service was equal to the cost of employing one student for a period of one week.

What are the implications of this for employment, education and skills? Superficially, the impression is conveyed that the introduction of such electronic services has created unemployment-- the students that would have been employed were not employed. But, upon closer examination it becomes evident that considerable employment must have been created. In addition to those employed on the technical and operational side of the information systems, highly qualified persons had to be employed in the preparation of bibliographical notes, summaries of findings and conclusions reached in reported studies. Furthermore, since thousands of titles are added every month to the catalogues, it means that continuous employment is being provided.

The time will come, of course, in the not too distant future, when publishers will produce the tapes and bibliographical notes as part of their production and editorial functions. At that time the demand for bibliographical readers will decrease. But, for the present, and the immediate future, services of this nature will continue to expand, and so will the demand for appropriately qualified personnel.

Bibliographical Information Systems

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEARS OF COVERAGE AND REFERENCES.
1	Civil, Environmental, Geological, Mining, Petroleum and Fuel, Mechanical, Nuclear, Aerospace, Electrical, Electronics, Chemical & Industrial Engineering, Metals, Bioengineering.	COMPENDEX Engineering Index, Inc., New York.	1970 to April 1976 456,000 Refs. 6,000 added per month.
2	Biochemistry, Organic Chemistry, Macromolecular Chemistry, Applied Chemistry and Chemical Engineering, Physical and Analytical Chemistry.	CHEMICAL ABSTR. CONDENSATES	1972 to April 1976 2,420,000 Refs. 3,750 added bi-weekly.
3	Electrical Engineering, Electronics, Physics, Computer Science, Control.	INSPEC The Institute of Electrical Engineers, London, England.	1970 to April 1976 783,238 Refs. 12,500 added monthly.
4	All areas of Education.	ERIC U.S. Office of Education.	1966 to April 1976 232,000 Refs. 3,000 added monthly.
5	Exceptional Child Abstracts (Council for Exceptional Children). Supplement to ERIC. (Approx, 1/4 of these abstracts are contained in ERIC) Comprehensive resource for information about education of Handicapped and Gifted Children.	CEC U.S. Office of Education.	1966 to April 1976 21,250 Refs. 2,500 added monthly.

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEARS OF COVERAGE AND REFERENCES.
6	Abstracts of Instructional and Research Materials. Supplement to ERIC. Vocational Education.	AIM/ARM Centre for Vocational & Tech. Education, Ohio State Univ., Columbus, Ohio.	1966 to April 1976 25,000 Refs. 2,000 added quarterly.
7	Finance, Management, Economics, Statistics, Business Law, Marketing, Banking, Insurance Taxation, Public Relations, Personnel, Pollution Engineering, Medical Economics, Drug Topics.	INFORM ABI, Inc., Portland, Oregon.	1971 to April 1976 38,000 Refs. 900 added per month.
8	General Agriculture, Rural Sociology, Agricultural Economics, Consumer Protection, Human Nutrition, Home Economics, Animal Science, Plant Science, Forestry, Veterinary Medicine, Horticultural Engineering.	CAIN National Agricultural Library, U.S.	1972 to April 1976 715,000 Refs. 12,000 added per month.
9	Cross-Disciplinary Coverage: Aeronautics, Agriculture, Social Sciences, Biological & Medical Sciences, Chemistry, Materials, Electronics & Electrical Engineering, Communications, Nuclear Science, Propulsion, Fuels.	NTIS National Technical Info. Service, U.S.	1964 to 1976 328,000 Refs. 2,300 added monthly. 630 added bi-weekly.
10	Psychology and other Behavioral Sciences.	PSYCHOLOGICAL ABSTRACTS American Psychological Assoc.	1967 to 1976 230,000 Refs. 2,000 added monthly.

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEARS OF COVERAGE AND REFERENCES.
11	Anthropology, Archaeology, Business, Finance, Communication, Criminology, Oceanography, Geography, History, Law, Linguistics, Information and Library Science, Statistics, Philosophy, Marketing, Political Science, Sociology.	SOCIAL SCI Institute for Scientific Info., U.S.	1972 to 1976 367,500 Refs. 7,500 added monthly.
12	F & S INDEXES: Domestic & International company produce & Industry information. CMA/EMA: Digests of all literature significant to Chem. & Elect. Product Marketing. DOMESTIC & INTERNATIONAL STATS: Predicasts and Worldcast; Statistics, Abstracts, Composites, Basebook, etc. EIS PLANTS: Current Information on 90% of total firms in U.S. Industry. MARKET ABST. WEEKLY: CIN: Chemical Industry Notes. Extracts of Articles Published by key Trade and Industry Periodicals.	PREDICASTS Predicasts, Inc., U.S.	1972 to 1976 984,700 Refs. 1974 to date.
13	Mechanical Engineering and Engineering Management.	ISMEC The Institute of Electric & Electronic Engineering, Inc., U.S.	1973 to date 42,600 Refs. 1,400 added monthly.
14	Largest collection in the world of Indexed U.S. Chemical and Chemically related Patents, augmented by Foreign Equivalents.	CLAIMS/CHEM	January 1950 to April 1976.

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEARS OF COVERAGE AND REFERENCES.
15	All U.S. General, Electrical and Mechanical Patents.	CLAIMS/GEM	November 1975 to date. 60,700 Refs. 4,200 added monthly.
16	Life Sciences, Contains Biological Abstracts and Bio. Research Index.	BIOSIS PREVIEWS Biosciences.	1972 to date. 1,030,000 Refs. 20,000 added monthly.
17	File of Foundations active in fields of Education, Health, Welfare, Sciences, International Activities and Religion.	FDN. DIRECT. The Foundation Centre.	2,500 Refs.
18	File of Grants Awarded in fields of Education, Health, Welfare, Sciences, International Activities, Humanities, Religion. Not included are Grants to individuals or under $5,000.	FDN GRANTS INDEX The Foundation Centre.	January 1973 to 1976. 27,000 Refs. 200 added bi-weekly.
19	Biology, Fisheries, Geology, Meteorology, Oceanography, Desalination, Pollution, Costal Resources. Diving, Off-Shore, Deep Sea. Governmental, Legal.	OCEANIC ABSTRACTS Louisville, Ky.	1964 to 1976. 88,400 Refs. 300 added bi-monthly.
20	Meteorological & Geoastrophysical Abstracts. Meteorology, Astrophysics, Physical Oceanography, Hydrosphere, Hydrology, Environmental Sciences, Glaciology.	METEOR. ABSTR. American Meteorological Society, Boston.	1972 to 1976. 27,000 Refs. 600 added monthly.

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEARS OF COVERAGE AND REFERENCES.
21	Acoustics, Aeronautics, Agriculture, Astrophysics, Behavioral Sciences, Biochemistry, Biology, Biophysics, Botany, Chemistry, Electronics, Engineering, Environmental Sciences. Geology, Mathematics, Physics, Zoology, etc.	SCISEARCH Institute for Scientific Info., Philadelphia, P.A.	January 1974 to 1976. 962,000 Refs. 42,000 added monthly.
22	Comprehensive Dissertations Abstracts. Interdisciplinary listing of Doctoral Dissertations in all fields. Essentially all U.S. since 1861, plus Canadian.	COMP. DISSERT. Xerox Univ. Microfilms.	1861 to date. Updated Monthly. 530,000 Refs. 3,300 added monthly.
23	Metals Abstracts. Technical Journals in Metalurgy, Conference Papers, Technical Reports and Books.	METADEX The American Society for Metals, Ohio.	1966 to 1976. 260,000 Refs. 2,000 added monthly.
24	Aerial Geology, Economic Geology, Environmental Geology, General, Geochemistry, Hydrogeology, Mineralogy, Oceanography, Soils, Paleobotany, Structural Geology.	GEO-REF American Geological Institute, Washington, D.C.	1967 to April 1976. 263,000 Refs. 3,000 added per month.
25	Covers the monographic literature of all books cataloguedby the Library of Congress. Non-print records to be added at some future date.	LIBCON Information Dynamics Corp. Reading, Mass.	1965 to April 1976. 837,000 Refs. 7,000 added per week.
26	Research in progress in all areas of Science, on-going and recently completed work in Life and Physical Sciences for Basic and Applied Research Projects.	SSIE Smithsonian Institute, Washington, D.C.	April 1974 to April 1976. 199,000 Refs. 9,000 added per month.

NO.	SUBJECT AREA(S)	DATA BASE ON-LINE AND SUPPLIER.	YEAR OF COVERAGE AND REFERENCES.
27	Major News Publications in the Petroleum and Energy Fields.	P/E NEWS American Petroleum Institute, New York.	January 1975 to April 1976. 32,000 Refs. 500 added weekly.
28	Pollution Control and Pollution Research, Technical and Non-Technical Documents. Air, Water, Marine, Land, Thermal and Noise Pollution, Patents, Pesticides, Sewage and Waste Treatment, Contracts, Legal Developments.	POLLUTION Pollution Abstracts Inc. Louisville, Ky.	January 1970 to April 1976. 41,000 Refs. 1,000added bi-monthly.
29	Content of Working Papers of the U.S. Congress. Hearings Committee Prints, Reports, Documents, Special Publications, Legislative-Related questions and reports from Scientific-Technical Studies.	CIS Congressional Info. Service, Inc. Washington, D.C.	1970 to April 1976. 66,000 Refs. 12,000 added per month.
30	Petroleum Geology, Exploration, Well Drilling, Logging, Completion & Servicing, Oil and Gas Products, Pollution, Alternate Fuels and Energy Sources, Petroleum Transportation and Storage. Oil and Gas Exploration, Development and Production.	TULSA Information Services Dept., Univ. of Tulsa.	January 1965 to April 1976. 165,000 Refs. 3,900 added per quarter.
31	Chemical Industry Notes. Extracts of Articles Published by key Trade and Industry Periodicals.	CIN Chemical Abstracts Service, Div. of American Soc. Ohio State Univ. Columbus, Ohio.	December 1974 to date. Updated - weekly.
32	American Statistics Index. Statistical Information output of the entire U.S. Federal Government: Executive Agencies, Congress and other statistics-producing programs.	ASI Congressional Info. Service Inc. Washington, D.C.	1973 to April 1976 28,000 Refs. 800 added per month.

- A -

Afanas, E.V.G., The Scientific and Technical Revolution: Management, Education, Moskva, Politizdat, 1972, 431 pp.

American Foundation on Automation and Employment, Proceedings of an International Conference on Automation, Full Employment and a Balanced Economy, Rome 1967.
Papers Relevant to this Study:
1. "Full Employment and Technological Change: A Contemporary Analysis," by V.E. Jirikowic
2. "Technological Change and Occupational Structure," by Sir Denis Barnes
3. "Technological Change and its Implications for Education," by Sven Moberg
4. "Technological Change and Job Change by William Haber
5. "The Effects of Technological Changes on Traditional Systems of Wage Payment," by Philip H. Weber.

Auman, F.A., "Retraining; How Much of an Answer to Technological Unemployment," Personnel Journal, vol. 41, no. 10, Nov. 1962, pp. 505-507.

- B -

Backman, Jules, (ed.) Labor, Technology and Productivity in the Seventies, New York, N.Y. Univ. Press, 1974.
Headings: Anticipating and Planning Technology; The Pace of Technology; The Innovative Organization; Responsibility for the Impact of Technology; Technology Assessment; Difficulty of Prediction; The Need for Technology Monitoring. Which way technology will go "will depend very largely on the business executive and his ability and willingness to manage technology," Managing technology is a central management task - it does not belong to R. and D.

Barkin, S. (ed.) Technical Change and Manpower Planning: Coordination at Enterprise Level. Industrial Relations Aspects of Manpower Policy, OECD, Paris, 1967.
The 29 case studies in this report seek to define the policies and practices followed by firms in programing technological change and manpower adjustments. The inquiries were conducted and reports prepared with the cooperation of the participating countries which included Austria, Canada, France, The Federal Republic of Germany, Norway, Sweden, The United Kingdom, and the United States. The cases were selected to represent a wide variety of types of changes, industries, and firms. Representative case studies are (1) "Integrating Two Foundries" (Austria), (2) "Introduction of Electronic Data Processing in a Canadian Insurance Company" (3) "Concentration in a Nationalized Industry" (France), (4) "Data Processing and Manpower Savings in Public Administration" (Federal Republic of Germany), (5) "Rationalisation of the Norwegian Customs Service" (6) "Administrative Reorganisation of the Swedish State Railways," (7) "Modernisation and Shift Work in a Cotton Mill" (United Kingdom), and (8) "Halving the Work Force in a United States Petroleum Refinery."

Baranenkova, T., "Technical Progress and the Movement of Personnel in Industry," Prob. Econ., Sept. 1970, 13(5), pp. 23-43.

Baron, C.G., "Computers and Employment in Developing Countries," Int. Lab. Rev., May - June, 1976, 113(3), pp. 329-44.

Beach, E.F., "Technological unemployment: a failure in theorizing," Rel. Ind., 31, no. 1:122-32, 1976.

________, "Under-Unemployment; Technologically Naive Argument," Rel. Ind., 29, No. 2:403-5, 1974.

Baer, W., "Technology, Employment and Development: Empirical Findings," World Devel., Feb. 1976, 4(2), pp. 121-30.

Bauer, L.L., "The Effect of Technology on the Farm Labor Market," Amer. Journal of Agriculture Economics, Aug. 1969, 51(3).

Bela, Gold (ed.) Research, Technological Change and Economic Analysis, Heath, 1977.

An evaluation of the economic effects of major technological innovations. Effects of innovations, past and prospective, in plants, firms, and industries under actual economic conditions. Amongst contents: Production functions, Productivity and technological change; the sources of technological innovations; economic effects of technological changes; and diffusion of technology in industry.

Bell, R.M., Changing Technology and Manpower Requirements in the Engineering Industry. A report on a study by The Science Policy Research Unit, University of Sussex, Brighton, Sussex University Press, 1972, 101 pp.

Benn, Anthony Wedgewood, "We and Them: The People versus the Machines Royal Inst. of Great Britain Proc., 43, Aug. 1970, pp. 170-89.

Bennett, G., "Unemployment, Automation, and Labor-Management Relations Personnel Administration, vol. 27, Sept. 1964, pp. 22-23.

Bhalla, A.S., "Technology and Employment: Some Conclusions Int. Lab. Rev., March - April, 1976, 113(2), pp. 189-203.

Blair, Larry M., Mechanisms for Aiding Worker Adjustment to Technological Change: Volume 1: Conceptual Issues and Evidence, Utah Univ., Salt Lake City. Human Resources Inst.

The report reviews current literature dealing with past/present/future mechanisms to assist workers' adjustment to technological change. A basic concern of the study is what level of governmental policy, if any, is needed in this area. Part 1 is a discussion of the conceptual impact of technological change on the labor

(cont'd)

market. The four chapters of Part 1 are directed to the effect of technological change on employment as related to production function, input prices, demand shifts, and skill sector requirements; worker adjustment to technological change through private/public adjustment mechanisms; other relationships between workers and technological change; and adjustment mechanisms and social well-being. Part 2, a review of current literature from 1965 through 1973, is anticipated to be representative of total work in the area. Chapter 1 of Part 2 summarizes findings on worker displacement, analyzes policy recommendations in the literature, and indicates needed research. Chapter 2 focuses on which types of workers are affected by technological change (skill, age, sex, ethnic groups, occupation, and industry). Chapter 3 reviews the private/public adjustment mechanisms and which workers benefit most and least from these adjustment mechanisms. An extensive bibliography accompanies Part 2.

Blaug, Mark: Preston, Maurice; and Ziderman, Adrian, The Utilization of Educated Manpower in Industry, Toronto, University of Toronto Press, 1967.

Blum, A.A., "Technology and Unemployment: A Comparative Study," Rel. Ind., 25:485-509, 1970.

Boulier, S.J., "The Effects of Technological Change," Public Relations Qtrly V21 N2 summer 1976, pp. 16-17.

Public relations skills are impacted in two fundamental ways by technological change. The first is in a greater requirement for in-house technological knowledge. The second is needed skill in applying the new technologies to the methods and tools of public relations itself and the day by day use of those procedures. Many large organizations are moving toward internal communications systems that are a combination of visual, voice and computer technologies. The requirement for effective human communications within these systems will be a challenge to which the PR communicator will need to address himself.

Bowers, Raymond V., Impact of Technological Change on Executive and Professional Careers in Military and Civilian Organizations. Final Report, Air Force Office of Scientific Research, Arlington, Va., 1968.

The purpose was to continue the analysis of data obtained by mailed questionnaires from 3970 middle management executives

(cont'd)

market. The four chapters of Part 1 are directed to the effect of technological change on employment as related to production function, input prices, demand shifts, and skill sector requirements; worker adjustment to technological change through private/public adjustment mechanisms; other relationships between workers and technological change; and adjustment mechanisms and social well-being. Part 2, a review of current literature from 1965 through 1973, is anticipated to be representative of total work in the area. Chapter 1 of Part 2 summarizes findings on worker displacement, analyzes policy recommendations in the literature, and indicates needed research. Chapter 2 focuses on which types of workers are affected by technological change (skill, age, sex, ethnic groups, occupation, and industry). Chapter 3 reviews the private/public adjustment mechanisms and which workers benefit most and least from these adjustment mechanisms. An extensive bibliography accompanies Part 2.

Blaug, Mark: Preston, Maurice; and Ziderman, Adrian, The Utilization of Educated Manpower in Industry, Toronto, University of Toronto Press, 1967.

Blum, A.A., "Technology and Unemployment: A Comparative Study," Rel. Ind., 25:485-509, 1970.

Boulier, S.J., "The Effects of Technological Change," Public Relations Qtrly V21 N2 summer 1976, pp. 16-17.

Public relations skills are impacted in two fundamental ways by technological change. The first is in a greater requirement for in-house technological knowledge. The second is needed skill in applying the new technologies to the methods and tools of public relations itself and the day by day use of those procedures. Many large organizations are moving toward internal communications systems that are a combination of visual, voice and computer technologies. The requirement for effective human communications within these systems will be a challenge to which the PR communicator will need to address himself.

Bowers, Raymond V., Impact of Technological Change on Executive and Professional Careers in Military and Civilian Organizations. Final Report, Air Force Office of Scientific Research, Arlington, Va., 1968.

The purpose was to continue the analysis of data obtained by mailed questionnaires from 3970 middle management executives

(cont'd)

Brunelle, Eugene A., "New Learning, New Libraries, New Librarians," Journal of Academic Librarianship, 1. 5. 20-24, Nov. 1975
Technological change in academic libraries requires a redefinition of the professional librarian's functions and qualifications.

Brunheld, G., Burton, R.H., "A Theory of 'Technical Unemployment' - One Aspect of Structural Unemployment," Amer. J. Econ. & Soc., 26(3), July 1967, pp. 265-277.

Buechner, William Robert, Technological Change and the Occupational Distribution of the American Labor Force, 1950-1960. (Ph.D. Thesis, Harvard University, 1972).

Bumas, L.O., "The Effects of an Advance in Technology on Employment in an Industry: A Theoretical Model," Eng. Econ., summer, 1969, 14(4), pp. 215-220.

Burack, Elmer H., Strategies for Manpower Planning and Programming, General Learning Corporation, Morriston, New Jersey, 1972.
The book is concerned with optimum manpower utilization in the private and public sectors and examines a variety of types of organizations. Contents include: management and manpower in an era of change; a model of the overall manpower planning and implementation process; case material on technological change and the company; the framework of manpower planning and programming; uses of computer-based manpower information systems (the role of the computer, the data base and systems boundaries, the job market and matching systems, and system design); integrating planning and change; and emergent issues in change management (staff-support personnel, managerial obsolescence, delivery system for the disadvantaged, and two case studies related to technological change and environmental pressures). With emphasis placed on application and development of workable planning approaches, the book offers a broad framework in which such functions as personnel, wage and salary administration and industrial relations are viewed.

Burack, E.H.; Cossell, F.H., "Technological Change and Manpower Developments in Advanced Production Systems," Acad. Manag. Proc. 10(3), Sept. 1967, pp. 293-308.

Burack, E.H., and McNichols, T.J., Human Resource Planning: Technology, Policy, Change, Kent State University, Comparative Administration Research Institute Series, no. 6, 1973.

Burack, E.H.: Sorensen, P.F., "Manpower Development and Technological Change; Some Considerations for Revised Strategies," J. Manag. Stud. 8(3), Oct. 1971, pp. 304-314.

- C -

Cain, Glen G., (ed.) Labor Market Analysis of Engineers and Technical Workers, John Hopkins University Press, 1973.

Campbell, Ian, "Training for Technological Change," Canadian Labour vol. 8, no. 11, Nov. 1963, pp. 14-15.

Canada Dept. of Labour, Technological Changes and Skilled Manpower: Electronic Data Processing Occupations in a Large Insurance Company, Ottawa, Queen's Printer, 1961, 41 pp. (Research Program on the Training of Skilled Manpower, No. 98).

Canada Dept. of Labour, Technological Changes and Skilled Manpower: The Household Appliance Industry, Ottawa, Queen's Printer, 1958, 27 pp., (Research Program on the Training of Skilled Manpower No. 3).

Carlson, Robert A., Liberal Adult Education Adapts to the Technological Society: Case Study of West Germany's Adult Education Centers (Volkshochschulen), 1976

The trend in the German Adult Education Centers is clearly away from learning "as" experience and toward learning "from" experience. The latter is lauded as substantial and structured knowledge measurable as to the quality of standard achieved by the learner.

Carter, Anne P., Structural Change in the American Economy, Harvard Studies in Technology and Society. Harvard University Press, Cambridge, Mass., 1970.

Carter, C.F., and B.R. Williams, Industry and Technical Change: Factors Governing the Speed of Application of Science, Oxford University Press, London, 1957.

________, "The Characteristics of Technically Progressive Firms," Journal of Industrial Economics, March 1959.

Clague, Ewan and Greenberg, L., "Technological Change and Employment," Monthly Labor Review, vol. 85, no. 7, (July 1962), pp. 742-746.

Cohen, Phillip, "New Technologies and Changing Manpower Requirements in Canadian Railroads," Labor Law Journal, vol. 14, no. 8, August 1963, pp. 685-693.

Collins, Randall, "Where are Educational Requirements for Employment Highest?", Sociology of Education; 47; 4; 419-442 F 1974.

The author examines varying levels and types of

(cont'd)

educational requirements for employment. The results show that educational requirements are highest in large, nationally-oriented, internally bureaucratic, service oriented organizations with a high rate of technological change.

Conference Board, The, Changes in Occupational Characteristics: Planning Ahead for the 1980's, Report No. 691, New York 1976.

Critchlow, Robert V.; and Others, Computer Manpower Outlook. Bulletin No. 1826, Bureau of Labor Statistics, Washington, D.C., 1974.

The objectives of this study are: (1) to provide information on the current employment and education and training characteristics of computer occupations, (2) to explore the impact of advancing computer technology on computer manpower and education, and (3) to project computer occupational requirements and their implications for training. Some of the major findings of the study are: (1) employment in computer occupations is expected to grow more slowly over the 1970-80 period than during the past decade, and the distribution of workers among computer jobs is expected to change; (2) hardware prices have decreased and are expected to continue to fall over the next decade; and (3) increasing sophistication and complexity of computer personnel functions will require workers with more and better training than in the past.

Crossman, E.R.F.W., Automation, Skill and Manpower Predictions, Seminar on Manpower Policy and Program, U.S. Department of Labor, Manpower Administration, Washington D.C., 1966, 39 pp.

Crossman, Edward R.F.W., and Others, Evaluation of Changes in Skill-Profile and Job-Content due to Technological Change, Methodology and Pilot Results from the Banking, Steel and Aerospace Industries, California University, Berkeley, 1966.

The major objective was to test the hypothesis that the highest levels of mechanization and automation generally require lower levels of skills than earlier production systems. A secondary objective was to develop an instrument capable of giving unbiased projections of the manpower impact of specific advances in production technology. Dependent variables were man-hour requirements per unit product and required skill level rated on a previously developed scale. Data from actual observations of processes, from company job analysis instruments, and employee, cost, and production records were collected independently from two firms in each industry for which an old and a new process were compared--banking, steel annealing, steel galvanizing,

(cont'd)

and aerospace metal machining. All pairs of processes showed the expected reduction in man-hour requirement per unit, and in all cases installation of the new process was justified in terms of higher productivity. Mean skill levels were increased to a statistically significant extent in all cases except metal machining where they were reduced significantly. However, the changes were small in absolute terms. Manpower demand increases resulting from using the new processes were not big enough to affect the labour force. Therefore, other sectors of the economy will have to furnish needed employment. The appendix, approximately 200 pages, contains procedures for creating the instruments used in the study, raw data, data analysis, and job descriptions within the five cases.

Crossman, Edward R.F.W., and Stephen Laner, The Impact of Technological Change on Manpower and Skill Demand: Case-Study and Policy Implications, Office of Manpower Research, Manpower Administration, U.S. Department of Labor, Washington D.C., 1969.

To prove or disprove the hypothesis that automation and technological change impose increased skill demands on manufacturing and service industries, case studies were made of a bank and a steel and air products company, and of two oil companies, airlines, and electric power companies. The basic conceptual tool used to measure skill demands was the skill profile, a study of the distribution of total man-hours required to produce a unit product (or service) along a scale of the least to the most highly skilled labor. The study found that there was little or no net overall tendency for the mean skill level of the workforce to increase with technological change. Small changes in mean skill were largely offset by larger overall productivity increases, and thus, decreases in absolute demand measured in man-hours per unit of production for specific skill brackets were more prevalent than increases. Declines in absolute labor demand were greatest for semi-skilled workers and the next greatest declines were for laborers. Skilled workers were the least affected. A bibliography, charts, and tables used to develop the skill profiles are appended.

- D -

Dalton, G.W., and Thomson, P.H., "Accelerating Obsolescence of Older Engineers," Harvard Bus. Rev., Sept.-Oct. 1971, 49(5), pp. 57-67.

Davis, L.E., "Human Welfare and Productivity; Implications of Technology," ITCC Rev., 3(1), Jan. 1974: pp. 30-46.

Dick, William G., The Impact of Technological Change in the Meatpacking Industry, Automation Program Report, Number 1, Bureau of Employment Security (Department of Labor), Washington, D.C., 1966.

Twenty automation manpower services demonstration projects were started to provide experience with job market problems caused by changing technology and mass layoffs. The first of the series, established in local public employment service offices, dealt with the layoff of 675 workers. The efforts of the project were primarily directed to the re-employment of the workers. Besides displaced workers' unwillingness to face reality, the most important single factor influencing re-employment was inadequate education.

Diebold, J., Beyond Automation; Managerial Problems of an Exploding Technology, New York, Praeger, 70 xii - 220 pp.

________, Man and the Computer; Technology as an agent of Social Change New York, F.A. Praeger, 69, xi-157 pp. Contents: the profound impact of science and technology; educational technology and business responsibility; international disparities; the training of managers; the long-term questions.

DeGreene, Kenyon B., Technological Change and Manpower Resources: A Systems Perspective. Univ. of South Calif., Los Angeles. 1974.

This report synthesizes theories and findings from behavioral and social science and the field of management, as well as from economics and technology, within the framework of systems science. In sequence, the report discusses: the sociotechnical system environment in which the interaction between new technology and manpower resources takes place; the measurement of technological change; how technological change affects manpower; the prediction of skill and manpower requirements; and electronics-based computer-communications technology.

Doeringer, Peter B., and Piore, Michael J., Internal Labor Markets, Technological Change, and Labor Force Adjustment, Harvard University, Cambridge, Mass., 1966.

The study suggests that U.S. Federal manpower programs should be directed toward the following objectives: to provide general training outside the plant in basic mathematical and verbal skills (programs of this kind will capture economies of scale in formal training and enhance the occupational flexibility of the labour force); to subsidize in-plant training programs where there is a likelihood that adjustment costs will be translated into price increases; to subsidize experimental training, screening, and recruitment programs as an incentive to developing new in-plant adjustment techniques; to develop procedures for increasing the flow of information among plants about the various adjustment techniques currently being utilized and their relative costs.

Dymond, W.R., Manpower Implications of Technological Change, Ottawa: Dept. of Labour, 1962, 24 pp. Memeographed.

________, Technological Changes and Their Impact on Employment and Occupations, Ottawa: Dept, of Labour, 1961, 35 pp. Mimeographed.

________, The Impact of Technological Change on Manpower Development, Ottawa: Dept. of Labour, 1964, 21 pp. Mimeographed.

- E -

Economic Council of Canada, A Declaration on Manpower Adjustment to Technological and Other Change, Ottawa: Queen's Printer, 1967, 14 pp.

_______, Fifth Annual Review: The Challenge of Growth and Change, Sept. 1968.

Ells, R.W., "Is Automation Causing Our High Unemployment?", Personnel, vol. 40, no. 4 (July, 1963), pp. 8-17.

- F -

Fechter, Alan, Forecasting the Impact of Technological Change on Manpower Utilization and Displacement: An Analytic Summary, Urban Institute, Washinton, D.C., 1975.

Obstacles to producing forecasts of the impact of technological change and skill utilization are briefly discussed, and existing models for forecasting manpower requirements are described and analyzed. A survey of current literature reveals a concentration of models for producing long-range national forecasts, but few models for generating short-range forecasts disaggregated to the regional, state, and local level. Since there is not much evidence on the accuracy of predictions, attention is focused on the reasonableness of the model structure. Models are also evaluated on the basis of their potential value in policy-formation. It is assumed that this value depends on the value of supply adjustments in the labor market, but a review of the literature on supply reveals that evidence on adjustment is mixed. The conclusion is drawn that existing manpower forecasting models should be modified, so that they are more reasonable representations of labor markets.

Fine, S.A., The Nature of Automated Jobs and Their Educational and Training Requirements, Human Resources Research Inc., McLean Va., 1965.

Fink, C. Dennis, A Forecast of Events and Conditions That Might Affect Job and Training Requirements for Medical Librarians. Technical Report 73-30, Human Resources Research Organization, Alexandria, Va., Dec. 1973.

The Delphi method was used to obtain estimates from 15 experts in medical education and biomedical communications of events and conditions which might occur in the next 20 years in biocommunications, health care services, and medical education that would effect the job and training requirements for future medical librarians.

Franke, W.H., and Sobel, I., The Shortage of Skilled and Technical Workers; An Inquiry into Selected Occupations in Short Supply, Heath-Lexington Books 1970.

Francis, John P., "Manpower Implications of Technological Change in Canada," Labor Law Journal, vol. 14, no. 8, 1966, p. 661.

- G -

Gintis, H., "Education, Technology, and the Characteristics of Worker Productivity," Am. Econ. R. Pap. and Proc 61:266-79, May 1971

Gorman, Liam, and Mullan, C., "Human Aspects of the Management of Technological Change: A Case Study," Journal of Management Studies; 10, 1; 48-61 Feb. 1973.

Describes the switchover from an outdated cargo warehouse using shelves and forklifts technology to a new semi-automatic facility with electronically controlled freight storage and retrieval, and an associated computerized documentation system. Illustrates the management of the personnel aspects in introducing technological change.

Grandjean, B.D., "Division of Labor, Technology, and Education: Cross-National Evidence," Soc. Sci. Q., 55:297-309.

- H -

Haber, William, and Others, The Impact of Technological Change: The American Experience, Studies in Employment and Unemployment, Upjohn Institute for Employment Research, Washington, D.C. 1963.

Technological change is a complex term involving many more factors than "changes in machinery or automation". Six changes which affect jobs and influence skills in our industrial systems that could logically be called technological change have been identified: (1) scientific management, or time and motion studies, (2) mergers and consolidations, (3) changes in the locations of plants, (4) shifts in product demand, (5) changes in machinery and technology, and (6) automation. A review of the literature does not reveal a neat group of hypotheses that can be clearly delineated. However, four major problem areas have received repeated attention: the factors affecting re-employment of displaced workers; the process of finding a job; mobility of displaced workers; and the economic and non-economic consequences of job displacement.

Hall, N.A., "Impact of Technology on Organization and Individuals," Bus. Q., 31:58-62, winter, 1966 .

Hall, Robert E., "The Market for Professional and Technical Workers," Brooking Pap. Econ. Act., 1971, 0(1), pp. 213-18.

Hamilton, Phyllis D. and Kincaid, Harry V., Impacts of Technological Changes in Warehousing, Phase I, Stanford Research Institute, Menlo Park, California, 1965.

The objectives of this study were (1) to determine the availability, nature, and reliability of data on the rapid change in the warehousing function in industry and (2) to provide a basis for decisions concerning the desirability and feasibility of conducting subsequent studies. Three major sources of information on California, Oregon, Washington, Hawaii, and Alaska were investigated--general literature, interviews with knowledgeable persons, and field studies of warehouses. It was concluded that mechanization of warehousing in the five-state region would proceed at a gradual pace, but historically this pace had not resulted in significant disemployment of the warehouse labor force. It was recommended that (1) the full-scale nation-wide Phase II Study not be done at this time, (2) a study be conducted which would identify rapidly changing warehousing, make a definitive inventory of current warehousing technology, and develop methods of

(cont'd)

relating technological change to its effects on labor, (3) an exploratory study of the apparent trend to centralization of warehousing functions be considered, and (4) a reconnaissance study of the warehouse aspects of the wholesale and multiple outlet retail food industry be considered.

Harbison, Fred H., "Manpower and Innovation: Several Pointers for Management: Increasing Competition in the Labour Market is Becoming a Contest for Brains, Not Hands," Personnel, vol. 36, no. 6, Nov./Dec. 1959, pp. 3-15.

Hastings, T., "The Characteristics of Early Adapters of New Technology: An Australian Study," Econ. Rev., June 1976, 52(138), pp. 239-50.

Hay, E.N., "Training Technology; Men and Management Series," Canadian Personnel and Industrial Relations Journal, vol. 17, no. 1, 1970.

Hayes, A.J., and Ruttenberg, S.H., "Labor's Aims in Adjusting to the New Technology," Monthly Labor Review, vol. 82, no. 2, February 1959, pp. 160-165.

Helfgott, Roy B., "Easing the Impact of Technological Change on Employees: A conspectus of United States Experience," International Labour Review, vol. 91, no. 6, June 1965, pp. 503-520.

Henry, N., "Bureaucracy, Technology, and Knowledge Management," Pub. Adm. R., 35:572-8, Nov. 1975.

Herman, A.S., "Manpower Implications of Computer Control," Mon. Lab. Rev., October 1970, 93(10), pp. 3-8.

Hershkowitz, M., and Sussman, Z., "Growth, Induced Changes in Final Demand, Educational Requirements, and Wage Differentials," Rev. Econ. Statis., May 1971, 53(2), pp. 169-75.

Hiestand, Dale L., High Level Manpower and Technological Change in the Steel Industry: Implications for Corporate Manpower Planning, Praeger Publishers, New York, N.Y., 1974.

The purpose of this study was to examine the role that high level manpower plays in the establishment of new technologies at the plant and industry level. The steel industry was selected as an appropriate industry to approach these questions due to: its considerable technological changes; its straight-forward, easier-to-understand technology; its lesser degree of

(cont'd)

influence by governmental policy. The first stage of research involved extensive interviews with executives of five major steel companies and executives of six engineering and equipment companies. The study revealed that steel companies do not decide whether or not to undertake an investment program on the basis of manpower factors. "Technological change per se is almost never a central preoccupation of steel executives." Steel executives engage in continuous learning, with the learning pace accelerating as major technological changes and investments are imminent. The study showed that engineering firms were more concerned with manpower issues and the technological/managerial capacity of their high level manpower. In summary, top-level steel managers are needed to provide leadership, skill, incentives, and general climate that evoke and advance technological proposals; most manpower planning is a response to fairly predictable developments.

Hodges, W.L., and Kelly, M.A. (eds.), Technological Change and Human Development: An International Conference, N.Y. State School of Ind. Relations 1970.
Statement by Sir Denis Barnes (pp. 128-129):
"...some particular technological innovations which are most clearly apparent to individuals at work......electronic computers, developments in instrumentation and automatic control, the numerical control of machine tools, advances in communication technology, improvements in machinery, the mechanization of material handling, new developments in metal processing, technological advances in agriculture and in transportation of all types, progress in power production, and the continuous development of new products and materials.

The most significant technological advances have taken place in the chemical, oil and steel industries, transport, commerce and communications."

Holtmann, A.G., "On-the-Job Training, Obsolescence, Options, and Retraining," Southern Econ. J., Jan. 1972, 38(3), pp. 414-17.

Hoos, Ida R., "Retraining by Private Industry," Ch. 3 of Retraining the Work Force, Univ. of Calif, Press, Berkeley, 1967.
Several San Francisco Bay area companies were examined for specific programs for displaced employees. Armour and Co., sought to guide displaced employees to classes or courses of action outside its own sphere of operation. Lockheed has provided unusually well for upgrading and retraining, mainly because of industry
(cont'd)

fluctuations and rapid technological change. American Can Co., offered Journeymen a combination of on-the-job training and junior college courses. The Western Die Casting Co., focused on improved quality control. By means of a Tracer Lathe Operators' program, Kaiser Aerospace Corp., partly succeeded in reducing turnover. Findings show that (1) industry develops few training programs except during labor shortages, (2) displacees may not be needed, or else low skills make salvage impossible, (3) programs often fail to meet anticipated skill changes because of poor communication within the organization, and (4) values of training emerge despite labor conditions.

Hoos, Ida R., "Technological Change in the Government Enterprise, Retraining in the Federal Service," Ch. 2, of Retraining the Work Force, Univ. of Calif. Press, Berkeley, 1967.
To counteract bureaucratic stagnation, encourage self-development, and use workers effectively, since 1957 the Civil Service Commission has emphasized continuing education. Case studies of the Instrument Technician Training program at Alameda Naval Air Station and McClellan Air Force Base and The Internal Revenue Service Automated Data Processing Retraining program indicate that success depends on early identification of obsolete skills and anticipation of future requirements, coupled with screening procedures and carefully designed training courses. Occupations remaining in demand after new methods and machines have eliminated routine office and production jobs will call for a high degree of literacy and verbal skill. By including personnel specialists in every phase of planning, even in the study group analyzing or proposing applications of automation, appropriate job specifications can be designed and training programs for career development initiated. Federal Agencies have a dual responsibility toward automation in the future--to assure human capability to increase the effectiveness of automation and to minimize adverse impact upon employees.

Hunter, L.C.; Reid, G.L.; Boddy, D., Labour Problems of Technological Change, London, Allen and Unwin, 1970, 3-363 pp.

Hutchinson, G.D., "Transferring People Helps Move Technology From Lab to Factory," Fin. Post., 68:14, March 9, 1974.

Hybels, Judith, and Others, Technological Advance in an Expanding Economy: Its Impact on a Cross-Section of the Labor Force, Michigan University, Survey Research Center, Ann Arbor, 1969.
The monograph is a report on a nation-wide survey

(cont'd)

dealing with the impact of changes in machine technology on a cross-section of the U.S. labor force. Three aspects of technological change are of particular concern in this study: (1) the economic impact of machine change on the work force in terms of income change, promotions, steadiness of employment and unemployment; (2) the relevance of machine change for job satisfaction and job content; and (3) the relation of machine change to education and training.

- I -

Industrial Relations Research Association, Comparative Canadian-U.S. Industrial Relations, Proceedings of Spring 1963 Meeting, Montreal, Quebec.
Session I - Manpower Implications of Technological Change.

International Labour Organization, Effects of Technological Changes on Conditions of Work and Employment in Postal and Telecommunications Services, ILO, Geneva, 1977.

International Labour Organization, Textile Committee. Effects of Technological Developments on Wages, on Conditions and on Level of Employment in the Textile Industry, Geneva, 1958, 167 pp.

International Labour Organization, Training for Progress, CIRF Publications, Geneva, Switzerland, 1968
Any new product or system demands that both user and producer adapt. The impact of technological change on people and training is illustrated by the introduction of color television in France, Germany, and England. Training was necessary at several levels before the mass production of color television sets could begin. The production and engineering staffs at the television stations received a course designed to familiarize them with the new equipment and techniques. A series of dry runs tested the practical application of their training. Some job categories needed redefinition. The technician who repaired and installed the set was also helped to upgrade his skills. New information and techniques were taught after the aptitude and skill levels of those technicians who wanted to branch out into the new field were assessed. The process of adapting to color television thus required systematic training rather than the more usual gradual upgrading of skills.

Irigarne, A.D., "L'action due progres technique sur l'évolution des qualifications," R. Écon., (Paris) 25(3), Mai 1974, pp. 360-394.

Iwauchi, R., "Adaptation to Technological Change," Develop. Econ., 7(4), Dec. 1969, pp. 428-450.

- J -

Jablonski, Ronald Edward, "The Effects of Technological Change on Job Content," (Ph.D. Thesis, Harvard University, 1963).

Jaffe, A.J. and Joseph Froomkin, Technology and Jobs - Automation in Perspective, Frederick A. Praeger Publishers, New York 1968.
Among contents:
"Shifts in Skills and Productivity"
"How Much Education?"
"Some Theories of Technological Change and Employment"
"The Younger and Older Worker"
"The Long-term View"

Jain, H.C., "Technological Change: The Big Labor Challenge," Can. Bus. 43:56-8, 60 Feb. 1970.

Jakubauskas, Edward Benedict, "The Impact of Technological Change on Railroad Employment, 1947-1958," (Ph.D. Thesis, The University of Wisconsin-Madison, 1961).

Jequier, Nicolas (Ed.), Appropriate Technology - Problems and Promises, Development Centre, Organization for Economic Co-operation and Development, Paris, 1976.

- K -

Kamien, M.N., Schwartz, "Some Economic Consequences of Anticipating Technical Advance," Western Econ. J., June 1972, 10(2), pp. 123-38.

Kamrany, N.M., "Technology: Measuring the Socioeconomic Impact of Manufacturing Automation," Soc-econ, plan Sci., 8(5), Sept. 1974, pp. 281-292.

Kantorovich, L.V., "Economic Problems of Scientific-Technical Progress," Prob. Econ., Aug.-Sept.-Oct. 1976, 19 94-5-6 pp. 183-211.

Karp, William, Danger: Automation at Work; Report of the State of Illinois Commission on Automation and Technological Progress, Illinois State Commission on Automation and Technological Progress, Chicago, 1967.

The 74th Illinois General Assembly created the Illinois Commission on Automation and Technological Progress to study and analyze the economic and social effects of automation and other technological changes on industry, commerce, agriculture, education, manpower, and society in Illinois. Commission members visited industrial plants and business and government offices having automated and computerized systems. One-day hearings were held on the meat packing, banking, and insurance industries, and a 2-day hearing was held on the vocational education and manpower training programs. The Commission's investigations revealed that (1) technological change has brought about such events as obsolescence of meatpacking plants, a decline in railroad jobs, and a reduction in coal mining operations, (2) the Manpower Development and Training Act is failing to meet the needs of changing industries, (3) the vocational education system is not keeping up with current needs, (4) industry is not contributing enough to retraining workers displaced by automation, (5) government agencies are not doing enough to conduct research into new occupational fields, and (6) the financing of job programs must be changed so that local authorities can be brought into closer contact with the programs. Based on its findings, the Commission formulated 22 recommendations in the nature of proposals and suggested changes in public policy and programs.

Kaufman, H.G., "Work Environment, Personal Characteristics and Obsolescence of Engineers," (Doctoral thesis, New York University, N.Y., 1970).

The phenomenon of rapid technological change has not only been said to pose a threat to unskilled and skilled workers, but it reportedly results in fears about job security among engineers, who paradoxically are often the initiators of technological change. This problem is usually couched in terms of obsolescence of technical knowledge and skills and it is generally attributed to the information explosion. In a study of 39 firms in various industries, all but four indicated that obsolescence was a problem among their technical staff members, with the problem being major or sizeable in 27 of the organizations (Norgren 1966). From this evidence, it may be observed that both engineers and their managers perceive obsolescence to be a significant problem which is likely to be serious in the not too distant future.

Keller, L.A., "Automation and the True Causes of Unemployment," Personnel Journal, vol. 41, no. 7, July/August 1962, pp. 331-334.

Keppel, F., "New Relationship Between Education and Industry," Pub. Adm. R., 30:353-9, July 1970.

Khromov, P., "Scientific and Technical Progress and Labor Productivity," Problems of Economics, July 1972, 15(3), pp. 46-59.

Kisler, Y., and N. Shchori-Bachrach, "The Process of an Innovation Cycle," American Journal of Agricultural Economics, February 1973, pp. 28-37.

Kleingartner, A., "The Characteristics and Work Adjustment of Engineering Technicians," Calif. Manage. Rev., spring 1969, 11(3), pp. 89-96.

Kordoes, T.,"Experimental Studies of the Impact of Technical Progress on the Employment Structure," Wiadom, Statyst, (11), 1969:8-12.

Kostanian, S. and Zhil'tsov, E., "Problems of Effectiveness in the Training of Specialists," Prob. Econ., January 1976, 18(9), pp. 48-63.

Kraft, Richard H.P., "Technological Change and the Need for Educational Adjustment," (Ph.D. Thesis, 1967), University Microfilms, Ann Arbor, Michigan.

(cont'd)

Case studies were made in 1966 in German industry and technical universities to formulate and test hypotheses about the adjustment of technical higher education to technological change, and to collect information on occupational and educational relationships for future manpower research. Theoretical aspects of manpower forecasting were discussed, including conversion of occupational structures into structures required by educational qualifications. The views of industrial officers, employers, and academic staff members were obtained, and the earnings of 8,806 engineers and technicians were investigated. Findings showed neither a shortage of engineers or technicians in the electrical industry nor underutilization of highly educated manpower, but data suggest future shortages unless the system of technical education better reflects the wishes of industry. Contrary to the weight of opinion in industry, most academic staff members felt that higher technical education should stress a broad intellectual foundation. The rate of monetary return was higher at the technician than the diploma level. More flexible educational requirements, better differentiation of engineer and technician functions, and extensive, long-range research were recommended.

Kruger, A.A., "Human Adjustment to Technological Change: An Economists' View," Relat. Industr., 26(2), April, 1971, pp. 265-307.

Kubota, Gordon H., "Technological Change and Labor Skill Substitutability: An Econometric Study," (Ph.D. Thesis, Claremont Graduate School, 1975).

While a variety of measures for aggregating the labor skill mix into a single factor of production have been proposed in various studies, there has been little concern for the influence of technological change on the aggregation of the skill mix itself. Further, the theoretical limitations of treating labor as a single factor have not been fully developed. The use of a single index of labor makes sense only if there is one kind of labor or if all existing varieties of labor have infinite substitutability. With imperfect substitutability between skill categories, aggregate measures of labor should consider the degree to which labor categories substitute for one another. Realistically, such substitutability between skill categories is influenced by technological change.

(cont'd)

The principal conclusion drawn is that labor skill substitutability is influenced by technical change. However, the degree and direction to which an evolving technology effects skill substitutability are dependent upon how technical change enters the labor aggregating function itself.

- L -

Labour Gaz., 67:684 Nov. 1967, "CNR Agreement Faces Up to Technological Change."

Labour Gaz., 67:174-5, March 1967, "Human Adjustment to Industrial Conversion," (Domtar Plan).

Labour Gaz., 67:296 May 1967, "New Agreement Deals With Displacement by Automation."

Lancaster, T., "Redundancy, Unemployment and Manpower Policy: A Comment," Econ. J., June 1976, 86(342), pp. 335-38.

Layton, C., Harlow, C.; De Haghton, C., Ten Innovations: An International Study on Technological Development and the Use of Qualified Scientists and Engineers in Ten Industries, London: George Allan and Unwin, 1972.

Layard, R., et. al., Qualified Manpower and Economic Performance: An Inter-Plant Study in the Electrical Engineering Industry, The Penguin Press, London, 1971.

Leider, Richard J., "Mid-Career Renewal," Training & Development Jrnl., May 1976, pp. 16-20.

Not everyone initially makes the correct career choice. Acceptance of this fact has created the new business phenomenon of the mid-career change. During this transition period, many individuals are more carefully examining their needs and goals as they relate to present careers. This has been made possible because of the industrial and societal factors of mass-production, a higher standard-of-living and greater career expectations, technology and job obsolescence and the human behavioral sciences. All of this stresses the need for life/career planning that causes an employee to carefully examine goals, values and life styles, skills and the related work environment. Once such decisions are made, he cannot fear change - but accept it as a fulfilling challenge.

Levesque, J.R., "Manpower Planning in Canada - Trends and Prospects," Canadian Business Review, V3 N2 Spring 1976, pp. 30-33.

Until recently the importance of manpower planning in Canada was not recognized. However, such factors as changes in the labor market, the impact of technological

(cont'd)

change, more government involvement in the private sector, and the pressure to hire minorities has changed all this. Manpower is a great productive resource and, as such, should be carefully planned for and utilized. Manpower planning systems must forecast future requirement, determine the resources in the organization, anticipate future problems, and conduct recruiting and training programs. To achieve efficient manpower planning systems, top-management must see that human-resources are put first, that the program is an integral part of corporate-planning, and that there is more cooperation between corporate and government manpower planners.

Linstone, H.A., and Sahal, D. (eds.), Technological Substitution: Forecasting Techniques and Applications, New York, American Elsevier, 1976

Lofthouse, S., and Wood, M., "Thoughts on Education, Technology, and the Characteristics of Worker Productivity," Rivista Int. Sci. Econ. Com., Feb. 1974, 21(2), pp. 123-36.

Long, Clarence D., "Manpower Implications of Technological Change: A Symposium," Labor Law Journal, vol. 14, no. 8, Aug. 1963, pp. 655-676.

- M -

Maceachern, Gordon Albert, "Regional Projections of Technological Change in American Agriculture to 1980," (Ph.D. Thesis, Purdue University, 1964).

MacKay, D.I., "Redundancy and Re-Engagement: A Study of Car Workers," Manchester Sch. Econ. Soc. Stud., Sept. 1972, 40(3), pp. 295-312.

Mangum, Garth L., Adjustment to Technological Change: Summary and Policy Implications, Office of National Research and Development Assessment, Washington, D.C.

A supplement to the report on adjustment to technological change, the document reviews policies of recent years related to adjustment to technological change and the added implications of the Blair and Fechter studies ("Mechanisms for Aiding Worker Adjustment to Technological Change" by Larry M. Blair and "Forecasting the Impact of Technological Change on Manpower Utilization and Displacement: An Analytic Summary" by Alan Fechter). The author concludes that, despite concern generated by the unemployment issue at the beginning of the 1960's, little was done through public policy to aid worker adjustment to technological change. Displacement, rather than neglect, was viewed as the economic and social malady; whether the displacement had technological or other roots was incidental. However, considerable progress was made on behalf of displaced and unplaced individuals during the Manpower Decade, 1960-70. Reviews of post-1965 literature on worker adjustment to technological change by Balir and Fechter further support the fact that technological change is just one of the factors determining future manpower requirements. Fechter feels that, given the general mobility and adaptability of the United States labor force, improvement of forecast methodology is not a high priority need. Nine recommendations related to the issue conclude the report.

Mansfield, Edwin, Industrial Research and Technological Innovation, W.W. Norton & Co., Inc., New York 1968.

________, The Economics of Technological Change, W.W. Norton and Co., Inc., N.Y., 1968.
-presents an overview and interpretation of the economics of technological change
Chapters IV and V - Innovation and the Diffusion of New Techniques - Automation, Labor Displacement and Adjustment Problems
Chapter V. Automation Etc., headings are:

1. Technological Unemployment
2. Automation
3. Technological Change, Aggregate Demand, and Structural Unemployment
4. Changes in Skill Requirements
5. Labor Displacement
6. Private Adjustment Policies
7. Two Experiments: Armour and Kaiser
8. Public Manpower and Training Policies
10. Union Policies Toward New Techniques
12. Make-Work Rules Featherbedding
13. Conflict and Accommodation
14. Hours of Work

Mansfield, Edwin, et. al., The Production and Application of New Industrial Technology, W.W. Norton & Co., Inc., New York 1977.

Marcson, S., "The Utilization of Scientific and Engineering Manpower in Industry," Calif. Manage. Rev. summer 1970, 12(4), pp. 33-42.

Marlow, H. Leroy,"An Age of Technological Development," NUEA Spectator, 40, 24, 29-32 Jun. 1976.

Science and technology have exerted a major influence on higher education/continuing education from 1960-75, as evidenced by more part-time students, increased awareness of continuing education opportunities, personal concern for obsolescence and lack of information, and the resulting management changes to cope with changing situations.

McCarthy, R.C., "Automation and Unemployment; A Second Look," Management Review, vol. 51, no. 5, May 1962, pp. 34-43.

McCormick, Robert W., "1960-1975 A Period of Accelerated Change: An Overview of the Period," NUEA Spectator, 40, 24, 23-4 Jun. 1976.

Several perceptions of higher continuing education/ university extension in 1960 are reflected in the writings of Malcolm Knowles, Renee and William Petersen and A.A. Liveright. Social idealism, technological development, and increased occupational obsolescence were areas of change from 1960-75.

Meisser, M., Technology and the Worker; Technical Demands and Social Processes in Industry, San Francisco, Chandler Publishing Co., Chicago, Science Research Associates, 69, xiii - 264 pp.

Mesthene, E.G., Harvard University Program on Technology and Society; Fifth Annual Report, Harvard University Program on Technology and Society, Cambridge, Mass., 1969.

The fifth annual report of Harvard University's Program on Technology and Society describes current research in the Program's major areas of concentration--namely the effects of technological change on the life of the individual in society, social and individual values, the political organization of society, and the structure and processes of social institutions. In the past year interest has shifted towards the first area, the study of the position of the individual in a technological society, with new investigations of work and leisure patterns, and the relationship between psychological character and the changing technical requirements of occupations. Other studies investigate the strain put upon traditional social values by new advances, in particular new biomedical techniques which allow redefinition of traditional concepts such as life, death and human dignity. The anatomy of the categorical negative response to innovation is explored. The appendices contain details about publications, research personnel, teaching activities and the Program's organization.

Mesthene, E.G., How Technology Will Shape the Future. Harvard University Program on Technology and Society; Reprint Number 5, Cambridge, Mass., 1968.

The development and adoption of new technologies make for changes in social organization and values by creating new possibilities for human action and thus altering the mix of options available to men. Because it alters the conditions of choice, new technology has a high probability of changing individual and social values: adopting new means to better accomplish old ends very often results in the substitution of new ends for old ones. There is only a "soft" determinism in the technology-society relationship, hence different societies can react differently to the same new possibilities. Our own age is characterized by a deliberate fostering of technological change and by the growing social role of knowledge. A fundamental implication of a world of flux (a "Heraclitean world") is the greater theoretical utility of concepts of process over those of structure, in sociological and cultural analysis. This shift in philosophical emphasis will alter conventional thinking regarding personal identity and social stability in the future. Education, and the interdependence between industry, government and the university will predominate.

________, Technological Change: Its Impact on Man and Society, Cambridge, Mass., Harvard University Press, 1970.

Miller, Stanley, "The United Mine Workers: A Study on How Trade Union Policy Relates to Technological Change," (Ph.D. Thesis, The University of Wisconsin, Madison, 1957)

Mincer, Jacob, "On-the-Job Training: Costs, Returns and Some Implications," Journal of Political Economy, October 1962.

Moore, L.F., (ed.), Manpower Planning for Canadians, Institute of Industrial Relations, University of British Columbia, Vancouver 1975.

Moore, Omar Khayyam, On Responsive Environments, Learning Research and Development Center, Pittsburg University, Pa., 1967.

Educational Technology is of great importance now because the enormous increase in the rate of technological change which took place during the 1940's has altered our society from a performance to a learning society. In a performance society, learning is a prelude to the practice of a fixed set of skills. However, in a learning society the required

(cont'd)

skills change too rapidly for this to be possible. Learning must continue into adulthood, and making this possible requires a thoroughgoing reform of educational institutions. These must now inculcate fundamental concepts and abstract symbolic skills rather than technical virtuosity. Through the use of computers as teaching machines, technology can be turned back on itself to solve the problems it poses. This usage is now beginning to be realized through the intervention of "Big Business" and government. One example of this usage is the development of the Edison Responsive Environment Machine or "talking typewriter." Heretofore, the behavioral sciences have not contributed to educational technology, but this machine is based on a sociological conceptualization of the learner and his environment. This has led to startling results. It also has offered a possible solution to the problem of matching hardware and software availabilities by using the learner as a source of material for his own education.

Moore, Wilbert E., (ed.), Technology and Social Change, New York Times Book Series, New York 1972.

Moskovis, L. Michael, "Education for the Office of the Future," Business Education Forum, 31, 2, 3-4, 7, Nov. 1976.

A discussion of how office productivity, technological innovation, and changing work patterns of women may have an impact on business education.

Moss, Leonard Wallace, "The Master Plumber in Detroit: A Study of Role Adjustment and Structural Adaptation in a Handicraft Occupation undergoing Technological Change," Ph.D. Dissertation, The University of Michigan, 1955.

Mueller, Eva, and Others, Technological Advance in an Expanding Economy: Its Impact on a Cross-Section of the Labor Force. Survey Research Center, Michigan University, Ann Arbor, 1969.

In 1967 the Survey Research Center at the University of Michigan conducted a nationwide survey to determine the impact of changes in machine technology on a cross-section of the labor force. Although many studies have been made about automation, this study was larger in scope than most research and made use of cross-sectional analysis to show the frequency of changes in

(cont'd)

machine technology and in what occupational and educational groups they occurred. Over a 5-year period about 10 percent of the labor force underwent one or more changes in machine technology which altered their work significantly, and technological advance changed about 2 or 3 percent of all jobs a year, about 1.5 to 2 million jobs. Individual chapters in this report contain detailed information on: (1) Machinery Use by the Work Force, (2) Change in Machine Technology, (3) Change-over Process to New Equipment, (4) Economic Consequences of Machine Technology, (5) Impact of Changes on Perceived Job Characteristics and Job Satisfaction, (6) Analyses of Cases who made a Poor Adjustment to Technological Change, and (7) Role of Education in Relation to Technological Change.

- N -

Newhouse, Joseph P., "Technological Change in Banking," in Employment Impact of Technological Change, Appendix II, U.S. Commission on Technology, Automation and Economic Progress, Washington, D.C., 1966.

New York State, Department of Labor, Manpower Impacts of Industrial Technology, Publication B-172, 1969.

The effects of technological change on the manpower and training needs of New York State industry were studied in a survey of 281 Industrial situations. The study was designed to help answer questions about the effects of factory and related technological change in displacing workers, in creating recruitment and training needs, and in altering the skills required of persons working on or in connection with industrial equipment during the period from 1962 to 1966. Of the situations studied, 15 involved the installation or modification of automatic production lines; 39 the addition of instrumentation to equipment; 105 metalworking and related equipment; 35 mechanical material handling and moving equipment; 20 packaging and related equipment; 29 assembly and related equipment; and 47 other equipment. Some jobs were eliminated in 259 of the 281 cases studied, with 4,542 workers being affected; however, the survey found that while the replacement of one type of machine by another was accompanied by upward skill changes in some cases and by downward changes in others, the number of no-change cases was numerically most important.

Norris, W.K., "Manpower Aspects of Technical Change," International Journal of Social Economics, vol. 3, no. 2, 1976.

- O -

O'Carroll, Lloyd T., "Technology and Manpower in Nonelectrical Machinery," Mon. Lab. Rev., June 1971, 94(6), pp. 56-62.

"Occupations in Aircraft, Missile and Spacecraft Manufacturing" Journal of Aerospace Education, 2, 3, 16-17, Apr. 1975.

Describes the nature of the aerospace industry and the types of occupations available in the industry as well as information on training, advancement opportunities and the employment outlook in the future.

OECD, Manpower Aspects of Automation and Technical Change, Paris, Organization for Economic Co-operation and Development, Manpower and Social Affairs Directorate, Social Affairs Division, 66, 138 pp. (with a Supplement, 66 vi - 439 pp.)

OECD, Manpower Policy and Programs in the United States. Reviews of Manpower and Social Policies, 2. Organization for Economic Co-operation and Development, Paris (France), Feb. 1964, 202 pp.

Examiners appointed by the organization for economic co-operation and development (OECD) representing the International Labour Office, Canada, and Sweden, visited the United States in January 1963 to study the country's Manpower Policy, and prepare a list of questions to be addressed to the U.S. Authorities. The Examiners' Report and a background report submitted by the U.S. Authorities were discussed at a 1963 meeting of OECD's Manpower and Social Affairs Committee, when representatives of U.S. Government Agencies replied to questions raised by the Examiners and by Members of the Committee. (1) Economic Growth and the Unemployment Problem, (2) Technological Change and its Implications, (3) Education and Training for Economic Growth, and (4) The Employment Service and Manpower Policy.

OECD, Requirements of Automated Jobs, Organization for Economic Co-operation and Development, Final Report and Supplement, OECD, Paris, 1965.

OECD, Technological Forecasting in Perspective, Organization for Economic Co-operation and Development, Paris, 1967.

Onila, John, "Impact of Technological Change on the Steelworker: A Case Study at Inland Steel Corporation" (Ph.D. Thesis, Purdue University, 1966).

Orlando, J.A., and Others, Research and Education in Management of Large-Scale Technical Programs, Drexel Institute of Technology, Philadelphia, Pa., 1969.

Owen, J.E., "Automation and the American Worker," Rev. Int. Sci. Econ. Com., Oct, 1972, 19(10), pp. 1006-17.

Owen, J.P., and Belzung, L.D., "Epilogue to Job Displacement: A Case Study of Structural Unemployment," So. Econ. J., 33:395-408, Jan. 1967.

- P -

Pack, Howard and Todaro, Michael, "Technological Transfer, Labour Absorption and Economic Development," Oxford Economic Papers, 21, Nov. 1969, pp. 395-403.

Paukert, F., "Technological Change and the Level of Employment in Western Europe," Brit. J. Industr. Relat., 6(2), July, 1968, pp. 139-155.

Peitchinis, Stephen G., Canadian Labour Economics, McGraw-Hill, Toronto, 1970, Chs. 4, 5, 10.

________, Labour-Management Relations in the Railway Industry, Task Force on Labour Relations, Study No. 20, Information Canada, 1971, Chapter IX.

Pennsylvania State Employment Service, The Effects of Automation on Occupations and Workers in Pennsylvania, Harrisburg, Penn. 1965.

Information on the relationship of automation to changing occupational patterns and related worker displacements. Examples of automation and technological change in industry are given. Some of the summary findings are: (1) Technological advancements cause some jobs to disappear and also cause some new jobs to appear, (2) Many workers displaced from disappearing jobs usually do not possess the knowledge, skills, and education needed to perform the new, more highly skilled jobs, (3) Worker displacements are inherent in the process of automation, (4) It appears that worker displacements in smaller numbers or as isolated cases take place much more frequently than generally supposed, and (5) Corrective measures must be rapidly applied to prevent displaced workers from slipping into the unemployed habit. Examples of displacement due to automation are given in areas of (1) mining, (2) manufacturing, (3) transportation, communication, electric, gas and sanitary services, (4) wholesale and retail trade, (5) finance, insurance and real estate, (6) services, and (7) government.

Pepino, Lyle F., "Occupational Technology: An Experiment in Curricular Flexibility," Engineering Education, 65, 8, pp. 831-832, May 1975.

Describes an Occupational Technology Curriculum,

(cont'd)

designed to meet the widely divergent needs of individuals already employed in industry or business who desire to upgrade a present skill or acquire a new one. The curriculum is structured so that half of the credits required for the associate degree are free electives and half are required core courses.

Phillips, W., "Technological Levels and Labour Resistance to Change During Industrialization," R. Polit. Soc., 75 July-Sept., 1967, pp. 39-52.

Piore, Michael J., "On The Job Training and Adjustment to Technological Change," The Journal of Human Resources, Fall 1968.

________, "Technological Change and Structural Adjustment in the Labor Market," (Ph.D. Dissertation 1967, Harvard University).

________, "The Impact of the Labor Market Upon the Design and Selection of Productive Techniques Within the Manufacturing Plant," Quart. J. Econ., 82(4), Nov. 1968, pp. 602-620.

Piron, Robert, "Two Essays on Human Capital and its Relation to Changing Patterns of Employment and Technological Change," (Ph.D. Thesis, Northwestern University, 1966).

Porter, R.C., "Technological Change With Unlimited Supplies of Labour," Manchester Sch. Econ. Soc. Stud., 36(1), March 1968, pp. 69-74.

Prasow, Paul and Massarik, Fred, A Longitudinal Study of Automated and Nonautomated Job Patterns in the Southern California Aerospace Industry, National Technical Information Service, Springfield, Va., 1969.

There is a great imbalance between the effort devoted to technological change and the attention given to the social and economic consequences of this change. Although automation has strong implications for society, the real problem is not the changes themselves; instead, it is our failure to understand and adjust for these changes. Using data gathered from personal interviews with a random sample of employees of six major aerospace firms, this study compares automated and nonautomated factory and office jobs in order to determine the effects of automation. By measuring the worker's ability and willingness to adapt to a

(cont'd)

changing environment, while considering his background and attitudes, the study provides findings of value in establishing public training and retraining programs, as well as in revising vocation education programs to meet changing needs.

Presthus, Robert, Technological Change and Occupational Responses: A Study of Librarians, Final Report, Office of Education, Washington, D.C., 1970.

The library occupation and its capacity to accommodate to several pervasive changes now confronting the field, including preparation for computer-inspired automation. The study is presented in five chapters: (1) Theoretical Framework: Social Change and Organizational Accommodation, (2) Organizational and Authority Structure, (3) Social and Occupational structure, (4) Occupational Values and (5) The Accommodation Potential.

Pullen, Edward W.S.; Imko, Robert G., "Our Changing Industry" Datamation V23 N1 Jan. 1977, pp. 49-53.

The growth of existing markets, the development of new ones and the surge of technical innovations are causing changes in the DP industry which will cause change in the business itself. As conventional DP reaches maturity, information services are leaping ahead with the acceptance of more sophisticated transmissions systems. While the trend is for decreasing hardware prices, the surge in cost increases for such areas as software, maintenance, training and customer service is becoming widespread. Competitive freedom is rising in areas of software and warranty. Productivity improvements in office and business communication abound. Computer architecture is evolving steadily with advances in memory technology, bubble memories and charged coupled devices. As all of these significant advances are achieved, new demands are made on the DP professional. Changes in organization are necessary to meet the challenge.

Pym, Denis, " 'Technical' Change and the Misuse of Professional Manpower: Some Studies and Observations," Occupational Psychology, 41, Jan. 1967, pp. 1-16.

- R -

Relyea, Ruth, "Technological Change: How Fares the Worker?" Manpower; 2; 9; pp. 27-29, Sept. 1970.

Rezler, Julius, Automation and Industrial Labor, New York: Random House, 1969, pp. xvi, 224.

Rosow, Jerome M., (ed.), The Worker and the Job: Coping with Change, The American Assembly Series. Englewood Cliffs, N.J., Prentice-Hall, 1974, pp. x, 208.

Ross, D.P., "Economic Critique of Current Technological Change Displacement Techniques," Rel. Ind., 26:924-42(0) 1971.

- S -

Salyev, R.V., "Technical Progress and its Socio-Economic Consequences, Influence on Labour, Worker, Society," in Voprosy Ekon, Moskva, 1971, pp. 235-243.

Scoville, J.G., "A Theory of Jobs and Training," Industrial Relations, Oct. 1969.

Segal, Martin, "Some Economic Aspects of Adjustment to Technological Change," (Ph.D. Thesis, Harvard University, 1953).

Sen, A.K., "Employment, Institutions and Technology: Some Policy Issues," Int. Lab. Rev., July 1975, 112(1), pp. 45-73.

Sen, Amartya, Employment, Technology and Development, London: Clarendon Press, 1975, pp. xi, 193.

Setzer, Florence Orletta, "Technological Change over the Life of a Product: Changes in Skill Inputs and Production Processes," (Ph.D. Thesis, Yale University, 1974).

This dissertation examines changes in production processes for technological innovations over their lifetimes in order to measure and explain changes in inputs of capital and highly skilled and unskilled labor. Each process on the production lines for two electronic product innovations was examined using cost accounting and interview data. Changes over time in production activities are discussed, stressing the role of engineering. Changes in factor costs and proportions, and changes in output, are measured for every production process. Finally changes in skill levels are discussed.

The histories of the production lines indicate that highly skilled scientists and engineers are required for development of a product and production process before high volume production can occur. Engineering inputs reach a maximum during installation of high-volume production lines. Less highly skilled engineers, and fewer of them, are needed later for cost-reducing improvements and for problem solving associated with production. As they age products move to organizations with progressively lower average skill levels. Great emphasis is

(cont'd)

placed on transfer of information from early to later production organizations. The primary function of highly skilled labor in product innovation thus appears to be acquisition of knowledge. The amount and difficulty of additional information needed declines with engineering experience with the product.

Shirom, Arie, "Industrial Cooperation and Adjustment to Technological Change: A Study of Joint Management-Union Committees," (Ph.D. Thesis, The University of Wisconsin-Madison, 1968).

Smith, Donald N., Technological Change in Michigan's Tool and Die Industry, Industrial Development Division, Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan, 1968.

This study was conducted to answer four questions about the tool and die industry in Michigan. These were: (1) What are the current production techniques? (2) To what extent are these industrialists aware of new technologies? (3) What technical and economic factors affect technological change? and (4) To what extent will new technologies replace existing skills and manufacturing processes? Data were collected from 122 firms over a 3-year period by personal interview utilizing a 24-page questionnaire. Descriptive chapters are: (1) Structure of the Tool and Die Industry, (2) Profile of the Industry in Michigan, (3) Skills, Equipment, and Productivity, (4) Factors affecting Tool-Making Innovations, (5) Electrical Discharge Machining in Tool and Die Manufacture, (6) Features of Numerical Control, (7) Transition to Numerical Tool-Making, (8) Pace of Transition, (9) Challenges for the Industry, and (10) Impact on Labor. Numerical control and electrical discharge machining were found to be the most significant technological advancements.

Somers, Gerald F., et. al., (eds.), Adjusting to Technological Change, (Industrial Relations Research Association Series), Harper & Row, Publishers, New York, 1963.

Speirs, Rosemary E.J., "Technological Change and the Railway Unions 1945-1972," (Ph.D. Dissertation 1974, University of Toronto).

Steiner, Carl L., Automation and Technological Change in Banking, Bureau of Employment Security (Department of Labor, Washington, D.C., 1966.

The purposes of this study were to determine

(cont'd)

the personnel change directly resulting from the installation of electronic data processing in one of the large commercial banks in Baltimore, to describe the processes and job duties involved, and to indicate how changes have affected employment and what may be expected in the future. The use of the equipment resulted in some shifting and retraining of personnel but no unemployment. Actually more workers were added to care for the increased volume of business. Only 48 jobs were abolished while 58 were created and 40 were increased. Although the outlook is for continued growth in the industry, bankers do not agree on the amount of employment expansion likely to take place. Banks have been able to fill the executive ranks with higher starting salaries, training programs, and rapid promotion but have been forced to use handicapped and part-time workers such as housewives and college students to meet peak seasonal demands. However, most are using electronic data processing now to meet growing shortages of clerical personnel. So far high speed machines are tools for coping with shortages rather than replacing employees. They are being used to make possible a wider range of services at greater speed. Because of the considerable time required to change to automation and get the system working, the impact of electronic data processing on jobs in banking probably will not be apparent for several years. The Appendix contains job titles and codes, organization charts, and job descriptions for new and expanded jobs resulting from installation of electronic processing equipment in one large commercial bank.

Stewart, F., "Technology and Employment in LDCs," <u>World Development</u> vol. 2, #3, March 1971.

Stieber, Jack (ed.), <u>Employment Problems of Automation and Advanced Technology: An International Perspective</u>, New York: St. Martins, 1966, pp. 478.

Stieber, J., and Paukert, L., "Manpower and Technological Change in Czechoslovakia," <u>Ind. Relat</u>., Oct. 1968, 118(2), pp. 17-32.

Stoneman, P., "The Effect of Computers on the Demand for Labour in the United Kingdom," <u>Econ. J</u>., Sept. 1975, 85(339), pp. 590-606.

- T -

Tatarinova, N., "Scientific-Technical Progress and Female Labor," Prob. Econ., July 1974, 17(3), pp. 41-53.

Taviss, I., "Technology and the Individual," Cambridge, Harvard Univ. Program on Technology and Society, 1970, v-62 pp.

Taviss, I., and Gerber, W., Technology and Work. Research Review No. 2, Program on Technology and Society, Harvard University, Cambridge, Massachusetts, 1969.

Recent literature reflecting the impact of technological change on the occupational distribution of the labor force and on work patterns and skills is reviewed. Social and policy implications of technological change which are considered include mechanisms for improving the coordination between labor supply and demand and the problems and prospects of a future leisure society. The effect of technological advancement on the occupational distribution of the labor force is discussed in reference to professional, technical, skilled, unskilled, blue collar and white collar workers. Also 13 abstracts of materials published since 1966 are included. The effects of technological change on work patterns and skills deals primarily with the nature of the worker response to technological change and the question of whether skill levels are raised or lowered as a consequence of automation. Abstracts of 17 books and articles published since 1965 are included. The effects of technology on the problems of social choice in the allocation of resources among productivity, leisure and retailing goals is discussed, accompanied by 16 abstracts of materials published in 1965 or later. The document contains an alphabetically ranged author index to the abstracts.

Townsend, Edward T., "The Human Equation: Automation and Displaced Workers," Challenge, vol. 9, no. 3, Feb. 1961, pp. 16-20.

Turin, Duccio, "Technology: The Dialectics of Change and Its Effects on the Profession," Royal Inst. of British Architects J., 77, Aug. 1970, pp. 370-2.

- U -

U.S. Bureau of Labor Statistics. Department of Labor. America's Industrial and Occupational Manpower Requirements, 1964-75, Washington, D.C.: U.S. Government Printing Office, 1966.

Conducted at the request of the National Commission on Technology, Automation, and Economic Progress. This study projects the manpower requirements of the United States to 1975, under the assumption that the unemployment rate will be 3 percent. The major conclusion of the study, which takes into account every technological change in American industry that can be identified and makes a careful appraisal of its potential effect on employment, is that the overall demand for less-skilled workers will not decrease over this 11-year period, although it will decline somewhat as a percentage of the total. Other findings include--(1) given the projected growth of the labor force, the assumptions made imply that 88.7 million persons will be gainfully employed in 1975, 18.3 million more than in 1964, (2) while farm employment is expected to decline by about one million, all other employment is expected to increase by over 19 million, (3) requirements of goods producing industries will increase by 17 percent and those in the service producing sector by 38 percent, (4) the effect of these trends will be to continue recent changes in the industrial composition of the economy, (5) occupationally, the greatest increase in requirements will be for professional and technical workers, an increase of 54 percent or 4.5 million additional personnel, and (6) the occupational requirement changes could most adversely affect non-white workers, young workers, and women workers.

U.S. Bureau of Labor Statistics, Industrial Retraining Programs for Technological Change: A Study of the Performance of Older Workers.

U.S. Bureau of Labor Statistics. Department of Labor. Occupational Manpower and Training Needs: Information for Vocational Counseling and Planning for Occupational Training, Bulletin No. 1824, Washington, D.C.: U.S. Government Printing Office, revised 1974.

The bulletin presents projections of the 1985 manpower requirements of 240 occupations for which

(cont'd)

considerable training is most often required or desirable, and which will comprise an estimated 70 million workers or two-thirds of the civilian labor force at that time. A brief chapter discusses the use of occupational projections and training data for planning and counseling. Another chapter presents projections of occupational requirements for broadly-defined occupational groups through the mid-1980's based on the Bureau of Labor Statistics' studies of economic growth, technological change, and industrial and occupational trends. A third chapter discusses available occupational training offered by: vocational education, apprenticeship programs, employer training, armed forces training, Federal manpower programs, home study courses, junior and community colleges, and colleges and universities. A final 50-page chapter describes in detail for each of 240 occupations in 14 categories: occupational training requirements, statistics on 1972 employment, projected 1985 requirements, projected rate of growth from 1972 to 1985, projected annual openings for growth and replacement, and most recent data on the number of persons completing training. Four appendixes covering 30 pages deal with methods and assumptions for projections of manpower requirements, detailed occupational projections, detailed training statistics, and State employment security agencies.

U.S. Bureau of Labor Statistics. Department of Labor. Outlook For Technology and Manpower in Printing and Publishing. Final Report, Washington, D.C.: U.S. Government Printing Office, 1973.

The bulletin describes changes in technology in the printing and publishing industry, a major industry employing over 1 million workers. The study focuses on the effect of new technology on productivity, employment, and occupational requirements, and describes methods of adjustment. It includes firsthand information on the impact on production and manpower of electronic computers, phototypesetting equipment, web-offset printing, and other innovations at the nine printing firms which participated in the study.

U.S. Bureau of Labor Statistics. Department of Labor:

1. Technological Change and Manpower Trends in Five Industries, 1975
2. Occupational Projections and Training Data, 1976.

U.S. Bureau of Labor Statistics. Department of Labor. Technological Trends in Major American Industries. Bulletin No. 1474, Washington, D.C.: U.S. Government Printing Office, 1966.

This bulletin appraises some of the major technological changes emerging among American industries, and it projects the impact of these changes over the next 5 to 10 years on patterns of employment, occupations, and issues requiring labor-management adjustment. The bulletin extends and up-dates the report, "Technological Trends in 36 Major American Industries", which was issued in 1964 for the President's Advisory Committee on Labor-Management Policy. Major industries are covered in 40 separate reports in the bulletin, some covering groups of related industries, and the emphasis in each report is on the outlook for technological changes. Statistical data pertaining to productivity, production, employment trends, investment, and research development, all of which provide a quantitive basis for assessing the implications of technological change, are shown in charts and tables and are analyzed in the text. Among the implications were: (1) All industries will be affected, to some degree, by changes in equipment, methods of production, materials, and products, (2) Employment prospects in the industries studied are generally favorable, and (3) Prospective technological changes will continue to reduce the proportion of jobs involving primarily physical and manual ability and to increase the need for jobs requiring ability to work with data and information.

U.S. Bureau of Labor Statistics. Department of Labor. Technology and Manpower in the Textile Industry of the 1970's. Bulletin No. 1578, Washington, D.C.: U.S. Government Printing Office, 1968.

This bulletin describes changes in technology in the textile industry, one of the major industries of the economy, projects their impact on productivity, employment, and occupational requirements, and discusses methods of adjustment. The focus of this study includes the following topics: trends towards modernization, technology in the 1970's, shift to manmades, potential for technological advance, production prospects, imports increase,

(cont'd)

employment and unemployment outlook, women in textile mills, outlook for Negro employment, more patrolling and monitoring, implications for education and training, and adjustments to technological change.

U.S. Congress, House Committee on Education and Labor, Subcommittee on Unemployment and the Impact of Automation. Impact of Automation on Unemployment; Hearings, March 8/April 25, 1961, General Investigation Into Types and Causes of Unemployment, 87 Congress, 1st Session, Washington, Government Printing Office, 1961, 793 pp.

U.S. Manpower Administration. Department of Labor. Work Force Adjustments in Private Industry. Their Implications for Manpower Policy. Manpower Automation Research Monograph No. 7, Washington, D.C.: Manpower Administration, 1968.
The first part of this monograph represents the proceedings of a 1-day conference of manpower analysts on the processes by which private industry meets changing manpower requirements and the implications of these work force adjustments for manpower policy. The second part consists of a summary of two doctoral dissertations prepared under grants from the Manpower Administration entitled, "Internal Labor Markets, Technological Change, and Labor Force Adjustment". The internal labor market is an administrative unit, within which are performed the market functions of pricing, allocating, and often of training labor. It is governed by a set of institutional rules covering recruitment procedures, training, compensation, and the like, over which the employer exercised discretionary control. These internal mechanisms constitute the alternative modes of adjustment to changes in both production techniques and labor market conditions. Implications of the internal market are discussed in relation to federal programs of job training, recruitment and screening, coordination of public and private training programs, and governmental manpower planning and labor force adjustment programs.

U.S. National Commission on Technology, Automation and Economic Progress. Technology and the American Economy. Volume I. Washington, D.C.: U.S. Government Printing Office, 1966.
The Commission was asked to identify, assess, describe, and define aspects of technological change and to recommend specific legislative and administrative steps which should be taken by

(cont'd)

federal, state, and local governments. Their examination covered (1) The Pace of Technological Change, (2) Creating an Environment for Adjustment to a Change--Employment and Income, and (3) Technology and Unmet Human and Community Needs. Recommendations included (1) a program of public service employment in which the government would be an "employer of last resort" for hard core unemployed, (2) an income floor to guarantee economic security of families, (3) compensatory education for persons in disadvantaged environments, (4) the creation of a national computerized job-man matching system, (5) a shift in the administration of employment services from the states to the federal government, (6) the permanent extension of experimental relocation assistance for families stranded in declining areas, and (7) exploration of a system of social accounts to make possible assessment of the relative costs and benefits of alternative policy decisions.

U.S. National Commission on Technology, Automation and Economic Progress. *The Outlook for Technological Change and the American Economy*. Appendix Volume I. Washington D.C.: U.S. Government Printing Office, 1966.

Manpower requirements to 1975 are presented. Part I, on the employment outlook, consists of a 10-year projection of manpower requirements by occupation and by industry; Part II, on the technological outlook, presents (1) a description of the state of computer development and use, and speculation on future developments in the general use of computers; (2) a description of the specialized art of information processing networks; (3) an examination of computer applications to industrial process control, which reveals an exaggeration both of the number of process control installations and of their employment impact; (4) an assessment of computer applications in the fabricating industries; and (5) ways of projecting future productivity.

U.S. National Commission on Technology, Automation and Economic Progress, *The Employment Impact of Technological Change. Technology and the American Economy*, Appendix Volume II. Washington, D.C.: U.S. Government Printing Office, 1966.

Eleven descriptive studies prepared by independent experts and dealing with the employment impact of technological change are

(cont'd)

presented. Part I contains (1) an analysis, at the establishment level, of employment-increasing growth of output and employment-decreasing growth of output per man-hour, (2) case studies of the elapsed time involved in the process of invention, innovation, and diffusion of selected new technologies, and (3) a review of literature. Part II deals with the employment impact of technological developments occurring in agriculture, banking, and steel-making and includes an evaluation and speculations for the future in three papers. Part III treats the impact upon skill requirements in selected automatic installations, examines the same problem by looking at the raw data upon which the 1949 and 1960 editions of the "Dictionary of Occupational Titles" were based, and examines changes occurring in the nature of work. Part IV examines current issues related to shortening the basic workweek and compares the possibilities for growth in income or leisure in an economy where the output of an hour's work doubles in less than a quarter century.

U.S. National Commission on Technology, Automation and Economic Progress. Adjusting to Change. Technology and the American Economy, Appendix Volume III. Washington, D.C.: U.S. Government Printing Office, 1966.

Seven studies dealing with adjustment to technological change which were done by independent experts are presented: "Programs in Aid of the Poor", by Sar A. Levitan assesses the state of social insurance, public assistance, the poverty program and other assistance to the poor and compares them to such current proposals as the negative income tax; "Manpower Adjustments to Automation and Technological Change in Western Europe and the United States" which were designed to aid displaced workers; "Technology and the Negro", by Mahlon Puryear, examines the problems of Negroes due to technological developments; "The Uses of Systems Analysis in Manpower Adjustment", by Evelyn Murphy and Gary Stonebraker, reports a pilot project on the use of the computer to analyze the adjustment process in the labor market; "The Role of the Federal Government in Technological Forecasting", by Donald Schon, surveys the art of manpower projections and the needs of projection users; "The Effects of Wages on the Relative Employment of Unskilled Labor", by Malcolm S. Cohen, examines questions relative to the effects of

(cont'd)

minimum wages on unskilled employment.

U.S. National Commission on Technology, Automation and Economic Progress, Educational Implications of Technological Change, Appendix Volume IV, Washington, D.C.: U.S. Government Printing Office, 1966.

U.S. Office of Manpower Policy, Department of Labor. Manpower Implications of Automation. Papers Presented by the U.S. Department of Labor at the O.E.C.D. North American Regional Conference (Washington, D.C., December 8-10, 1964), Washington, D.C.: Department of Labour, 1965.

Sponsored jointly by the Canadian Department of Labour and the U.S. Department of Labor, the Conference was held to examine the impact of automation on employment and unemployment, the nature of jobs being created and eliminated, and steps to be taken to ease the effect of technological change on workers. The participants were government, management, labor, and university representatives. Amongst the papers these are the following: (1) "Technological Change, Productivity, and Employment in the United States"; (2) "The Pace of Technological Change and the Factors Affecting It"; (3) "Effects of Technological Change on Occupational Employment Patterns in the United States"; (4) "Effects of Technological Change on the Nature of Jobs"; (5) "The Labor Force Adjustment of Workers Affected by Technological Change"; and (6) "Implications for Government-Sponsored Training Programs in the U.S.A.".

U.S. Office of Manpower Policy, Evaluation, and Research. Department of Labor. Technology and Manpower in Design and Drafting 1965-75. Manpower Research Bulletin Number 12. Washington, D.C.: Department of Labor, 1966.

This study of the design and drafting process aimed: (1) to identify the major technological changes in the next 10 years, (2) to determine the extent and rate of diffusion of these changes, and (3) to assess their effects. The major technological changes expected will utilize computer based systems to perform design computations, process design information, and carry out, or assist in carrying out, the steps in design itself. The interaction of the factors of equipment, methods of using the equipment, and the design and drafting process itself will determine the rate and direction of change. The effects of technological changes on the total requirements for draftsmen

(cont'd)

during the period are expected to be moderate. The use of time-shared graphics systems may substantially reduce the demand for draftsmen after 1975, however, the effects of technological changes upon engineers are difficult to isolate, but clerical-type routine activities are being reduced, thus freeing many engineering man hours. Industries active in introducing technological change into design and drafting are expected to continue in the forefront to 1975.

U.S. President's Advisory Committee on Labour - Management Policy, Methods of Adjusting to Automation and Technical Change, Washington: Government Printing Office, 1964, 33 pp.

- W -

Walker, K.F., Automation and Non-Manual Workers, Geneva, International Labour Office, 1967, iv - 113 pp.

Wedderburn, D., "Are White-Collar and Blue-Collar Jobs Converging?" Document P-12-68, Third International Conference on Rationalization, Automation and Technological Change, Metalworkers Industrial Union of the Fed. Republic of Germany, Oberhausen, Germany 1968.

West, Harry Miles, "An Analysis of the Current Manpower Modeling System Approaches in Private Industry with Implications of Technological Change and Future System Design," 280 pp. (D.P.A. Thesis, The George Washington University, 1973).

This study was undertaken to provide an analysis of manpower planning systems in use today. The objectives were (1) to determine what types of manpower systems are being used in industry today, (2) to analyze variables associated with those systems in an attempt to isolate those variables that contribute to an effective manpower planning system, and (3) to develop an integrated micro and macro modeling concept based on the data obtained as a result of the preceding two objectives.

Many of the firms have micro modeling systems that provide data during the corporate planning cycle as well as for the management of personnel resources. However, only 7% of the firms responding used micro modeling techniques to plan for qualitative manpower requirements. If at the micro level, and perhaps more importantly at the macro level, equilibrium is to be achieved between manpower demands and personnel supplies, much more research will be required to improve the state of the art.

Westie, Charles M.W., "Reactions of Railroad Workers to a Major Technological Change" (Ph.D. Dissertation 1953, The Ohio State University).

Wiley, W.W., and Fine, Sidney A., A Systems Approach to New Carriers, The Upjohn Institute, Kalamazoo, Michigan, 1969.

Wolfbein, Seymour L., "Automation and Education," New Leader, April 30, 1962, pp. 6-15.

Wood, Percy, "Change Begets Change," Training and Development Journal 30, 7, pp. 24-6, 55-6, July 1976.

United Air Lines' progress is directly related to its training programs, which are geared to constant change and new technology. Its training objectives include: a clearly formulated corporate training policy, needs assessment, training budgeting, systematic job performance assessment, interdepartmental coordination, up-to-date training, personal recognition, and supervisory training.

- Z -

Zelikoff, Steven Barry, "The Obsolescence of Engineering Personnel Under Conditions of Rapid Technological Change" (Ph.D. Thesis, University of Pennsylvania, 1968).

The study analyzes the obsolescence of engineering personnel employed in all economic sectors. The single most important cause of engineering obsolescence, hypothesized to be advances in technical knowledge, is examined in both a quantitative and qualitative framework. General patterns of engineering obsolescence are presented, and examined in detail in order to uncover the more promising solutions to the problem of the erosion of technical knowledge. The importance of technological obsolescence in the November 1967 Radio Corporation of America - Association of Scientific and Professional Engineering Personnel labor dispute is detailed. Finally, the current roles of the individual engineer, the engineering employer, the engineering college, the professional society and various governmental agencies in their attempts to stem the tide of engineering obsolescence are examined, and recommendations are offered for other programs which are deemed worthwhile.

TECHNOLOGICAL INNOVATION STUDIES PROGRAM

PROGRAMME DES ÉTUDES SUR LES INNOVATION TECHNIQUES

REPORTS/RAPPORTS

	AUTHOR(S)/AUTEUR(S)	UNIVERSITY/UNIVERSITÉ	REPORT TITLE/TITRE DE L'OUVRAGE
1.	I.A. Litvak C.J. Maule	Department of Economics, Carleton University.	Canadian Entrepreneurship: A Study of Small Newly Established Firms. (October 1971)
2.	Harold Crookell	School of Business Administration, University of Western Ontario.	The Transmission of Technology Across National Boundaries. (February 1973)
3.	R.M. Knight	School of Business Administration, University of Western Ontario.	A Study of Venture Capital Financing in Canada. (June 1973)
4.	Blair Little R.G. Cooper R.A. More	School of Business Administration, University of Western Ontario.	The Assessment of Markets for the Development of New Industrial Products in Canada. (December 1971)
5.	K.R. MacCrimmon W.T. Stanbury J. Bassler	Faculty of Commerce and Business Administration, University of British Columbia.	Risk Attitudes of U.S. and Canadian Top Managers. (September 1973)
6.	James C.T. Mao	Faculty of Commerce and Business Administration, University of British Columbia.	Computer Assisted Cash Management in a Technology-Oriented Firm. (March 1973)
7.	J.W.C. Tomlinson	Faculty of Commerce and Business Administration, University of British Columbia.	Foreign Trade and Investment Decisions of Canadian Companies. (March 1973)

8.	Gérard Garnier	Faculty of Management, University of Sherbrooke.	Characteristics and Problems of Small and Medium Exporting Firms in the Quebec Manufacturing Sector with Special Emphasis on Those Using Advanced Production Techniques. (August 1974)
9.	I.A. Litvak C.J. Maule	Deprtment of Economics, Carleton University.	A Study of Successful Technical Entrepreneurs in Canada. (September 1972)
10.	M.R. Hecht J.P. Siegel	Faculty of Management Studies, University of Toronto.	A study of Manufacturing Firms in Canada: With Special Emphasis on Small and Medium Sized Firms. (December 1973)
11.	Blair Little	School of Business Administration, University of Western Ontario.	The Development of New Industrial Products in Canada. A Summary Report of Preliminary Results, Phase 1. (April 1972)
12.	A.R. Wood J.R.M. Gordon R.P. Gillin	School of Business Administration, University of Western Ontario.	Comparative Managerial Problems Early Versus Later Adoption of Innovative Manufacturing Technologies: Six Case Studies. (February 1973)
13.	S. Globerman	Faculty of Administrative Studies, York University.	Technological Diffusion in Canadian Manufacturing Industries. (April 1974)
14.	M. James Dunn Boyd M. Harnden P. Michael Maher	Faculty of Business Administration and Commerce, University of Alberta.	An Investigation Into the Climate for Technological Innovation in Canada. (May 1974)
15.	I.A. Litvak C.J. Maule	Department of Economics, Carleton University.	Climate for Entrepreneurs: A Comparative Study. (January 1974)

16.	J. Robidoux Gérard Garnier	Faculté d'administration, Université de Sherbrooke.	Factors of Success and Weakness Affecting Small and Medium-Sized Manufacturing Businesses in Quebec, Particularly those Business Using Advanced Production Techniques. (December 1973) Facteurs de Succès et Faiblesses des Petites et Moyennes Entreprises Manufacturières au Québec, Spécialement des Entreprises Utilisant des Techniques de Production Avancées. (décembre 1973)
17.	I. Vertinsky K. Hartley	Faculty of Commerce and Business Administration, University of British Columbia.	Project Selection in Monolithic Organizations. (August 1974)
18.	Jean Robidoux	Faculté d'administration, Université de Sherbrooke.	Analytical Study of Significant Traits Observed Among a Particular Group of Inventors in Quebec. (August 1974) Étude Analytique de Traits Significatifs Observés Chez un Groupe Particulier d'Inventeurs au Québec. (août 1974)
19.	Blair Little	School of Business Administration, University of Western Ontario.	Risks in New Product development. (June 1972)
20.	Blair Little R.G. Cooper	School of Business Administration, University of Western Ontario.	Marketing Research Expenditures: A Descriptive Model. (November 1973)
21.	Blair Little	School of Business Administration, University of Western Ontario.	Wrecking Ground for Innovation. (February 1973)

22.	J.W.C. Tomlinson	Faculty of Commerce and Business Administration, University of British Columbia.	Foreign Trade and Investment Decisions of European Companies. (June 1974)
23.	Blair Little	School of Business Administration, University of Western Ontario.	The Role of Government in Assisting New Product Development. (March 1974)
24.	R.G. Cooper	Faculty of Management, McGill University.	Why New Industrial Products Fail. (January 1975)
25.	M.E. Charles D. MacKay	The C.E.R.C.L. Foundation 200 College Street, Toronto, Ontario M5S 1A4	Case Studies of Industrial Innovation in Canada. (February 1975)
26.	M.R. Hecht	Faculty of Management Studies, University of Toronto.	A Study of Manufacturing Firms in Canada: With Emphasis on Education of Senior Officers, Types of Organization and Success. (March 1975)
27.	I.A. Litvak C.J. Maule	Department of Economics, Carleton University.	Policies and Programmes for the Promotion of Technological Entrepreneurship in the U.S. and U.K.: Perspectives for Canada. (May 1975)
28.	R.R. Britney E.F.P. Newson	School of Business Administration, University of Western Ontario.	The Canadian Production/ Operations Management Environment: An Audit. (April 1975)
29.	R.F. Morrison P.J. Halpern	Faculty of Management Studies, University of Toronto.	Innovation in Forest Harvesting by Forest Products Industries. (May 1975)
30.	J.C.T. Mao	Faculty of Commerce and Business Administration, University of British Columbia.	Venture Capital Financing for Technologically-Oriented Firms. (December 1974)

31.	J.W.C. Tomlinson C.S. Willie	Faculty of Commerce and Business Administration, University of British Columbia.	Guide to the Pacific Rim Trade and Economic Data Base. (September 1975)
32.	D.A. Ondrack	Faculty of Management Studies, University of Toronto.	Foreign Ownership and Technological Innovation in Canada: A Study of the Industrial Machinery Sector of Industry. (July 1975)
33.	James C.T. Mao	Faculty of Commerce and Business Administration, University of British Columbia.	Lease Financing for Technology Oriented Firms. (July 1975)
34.	John A. Watson	Faculty of Business Administration and Commerce, University of Alberta.	A Study of Some Variables Relating to Technological Innovation in Canada. (June 1975)
35.	Gary A. Sheehan Donald H. Thain Ian Spencer	School of Business Administration, University of Western Ontario.	The Relationships of Long Range Strategic Planning to Firm Size and to Firm Growth (Ph.D. Thesis). (August 1975)
36.	John P. Killing	School of Business Administration, University of Western Ontario	Manufacturing Under Licence in Canada (Ph.D. Thesis). (February 1975)
37.	Peter R. Richardson	School of Business Administration, University of Western Ontario.	The Acquisition of New Process Technology by Firms in the Canadian Mineral Industries (Ph.D Thesis). (April 1975)
38.	Steve Globerman	Faculty of Administrative Studies, York University.	Sources of R & D Funding and Industrial Growth in Canada. (August 1975)
39.	R.G. Cooper	Faculty of Mangement, McGill University.	Winning the New Product Game. (June 1976)

40.	Peter Hanel	Department of Economics, University of Sherbrooke.	The Relationship Existing Between the R & D Activity of Canadian Manufacturing Industries and Their Performance in the International Market. (August 1976)
41.	Albert R. Wood Richard J. Elgie	School of Business Administration, University of Western Ontario.	Early Adoption of Manufacturing Innovation. (1976)
42.	Robert G. Cooper	Faculty of Management, McGill University.	Project Newprod: What Makes a New Product a Winner? (July 1980) An Empirical Study. Available at $10.00/copy Send all orders payable to: Quebec Industrial Innovation Centre. P.O. Box 6079 Station A Montreal, Quebec H3C 3A7
43.	James T. Goode	Department of Commerce and Business Administration, University of British Columbia.	Japan's Postwar Experience With Technology Transfer. (December 1975)
44.	Robert Knoop Alexander Sanders	Department of Management, Concordia University.	Furniture Industry: Attitudes Towards Exporting. (May 1978)
45.	Stephen G. Peitchinis	Department of Economics, University of Calgary.	The Effect of Technological Changes on Educational and Skill Requirements of Industry. (September 1978)
46.	Christian Marfels	Department of Economics, Dalhousie University	Structural Aspects of Small Business in the Canadian Economy. (May 1978)

47.	R.W. Wright	Faculty of Commerce and Business Administration, University of British Columbia.	Study of Canadian Joint Ventures in: Japan. (1977)
	J.W.C. Tomlinson M. Thompson		Mexico. (1977)
	J.W.C. Tomlinson S.M. Hills		Venezuela and Columbia. (1978)
	J.W.C. Tomlinson		Brazil. (1979)
48.	Joseph Chicha Pierre-André Julien	Département d'administration et d'economique, Université du Québec.	Les Stratégies de PME et Leur Adaptation au Changement. (Avril 1978) Strategy of SMBs and Their Adaptation to Change. (April 1979)
49.	Ilan Vertinsky S.L. Schwartz	Faculty of Commerce and Business Administration, University of British Columbia.	Assessment of R & D Project Evaluation and Selection Procedures. (December 1977)
50.	K.C. Dhawan L. Kryzanowski	Faculty of Commerce and Administration, Concordia University, Montreal, Quebec.	Export Consortia: A Canadian Study. (November 1978) Available at $15.00/copy Send all orders payable to: Dekemco Ltd. Box 87 Postal Station H, Montreal, Quebec H3G 2K5
51.	I.A. Litvak C.J. Maule	York University Carleton University	Direct Investment in the United States by Small and Medium Sized Canadian Firms. (November 1978)

52.	R.M. Knight J.C. Lemon	School of Business Administration, University of Western Ontario.	A Study of Small and Medium Sized Canadian Technology Based Companies. (September 1978)
53.	M.J.C. Martin J.H. Scheilbelhut R. Clements	School of Business Administration, Dalhousie University.	Transfer of Technology from Government Laboratories to Industry. (November 1978)
54.	J. Robidoux	Faculty of Administration, University of Sherbrooke.	Study of the Snowmobile Industry in Canada and the Role that Technological Innovation has Played in Its Economic Performance. (English summary only). Facteurs de Croissance de l'Industrie Canadienne de la Montoneige (1959-1978). (November 1978)
55.	R.A. More	School of Business Administration, University of Western Ontario.	Development of New Industrial Products: Sensitivity of Risk to Incentives. (January 1979)
56.	Rein Peterson	Faculty of Administrative Studies, York University.	A Study of the Problems Brought to the Attention of the Business Student Consulting Teams Sponsored by the Ontario Government's Small Business Assistance Programme. (February 1979)
57.	Robert G. Cooper	Faculty of Management, McGill University.	Project Newprod: What Makes a New Product a Winner? (July 1980) An Emprical Study. Available at $10.00/copy. Send all orders payable to: Quebec Industrial Innovation Centre P.O. Box 6079 Station A Montreal, Quebec H3C 3A7

58.	George F. Farris	Faculty of Administrative Studies, York University.	Comments on the Course: Management of Creativity and Innovation. (February 1979)
59.	J. Graham Smith	Faculty of Management, McGill University.	The Renewable Energy Business Sector in Canada: Economic Prospects and Federal Government Initiatives. (May 1979)
60.	J.W.C. Tomlinson	Faculty of Commerce & Business Administration, University of British Columbia.	Cross Impact Simulation of the Joint Venture Process in Mexico. (December 1978)
61.	Robert H. Grasley	Faculty of Administrative Studies, York University.	The Status of Innovation in the Strategies of Larger Canadian Corporations. (March 1979)
	Jerry D. Dermer	Faculty of Management Studies, University of Toronto.	
62.	Z.M. Kubinski	Department of Economics, University of Calgary.	The Small Firm in the Albertan Oil and Gas Industry. (February 1979)
63.	Don S. Scott R.M. Blair	Faculty of Engineering, University of Waterloo.	The Technical Entrepreneur. Inventions, Innovations & Business. (1979) Available at $18.95/copy Send all orders payable to: The MacMillan Company of Canada Limited 70 Bond Street Toronto, Ontario M5B 1X3
64.	Harvey F. Kolodny	Faculty of Management Studies, University of Toronto.	Sociotechnical Study of Productivity and Social Organization in Mechanical Harvesting Operations in the Canadian Woodlands. (May 1979)

65.	Richard T. Barth	Faculty of Commerce and Business Administration, University of British Columbia.	A Directory of Research on Research. (May 1979)
66.	W. Ed. McMullan	Faculty of Management, University of Calgary.	Development of a Course on Innovation and Entrepreneurship. (September 1979)
67.	Stephen G. Peitchinis	Department of Economics, University of Calgary.	Technological Changes and the Demand for Skilled Manpower in Canada. (January 1980)
68.	Stephen G. Peitchinis Assistance of: Elizabeth MacDonald	Department of Economics, University of Calgary	The Attitude of Trade Unions Towards Technological Changes. (April 1980)
69.	Stephen G. Peitchinis	Department of Economics, University of Calgary.	Technological Changes in Banking and their Effects on Employment. (January 1977)
70.	Thomas E. Clarke Gordon Laurie R. Peterson W.A. Pieczonka	T.I.M.E. P.O. Box 6291, Station "J", Ottawa, Ontario. K2A 1T4	Proceedings of the T.I.M.E. for Canada Workshop. (September 29 & 30, 1979)
71.	Dr. K. Palda Dr. B. Pazderka	School of Business, Queen's University.	Background to a Target: Approaches to a Valid Internat-tional Comparison of Canada's R & D Expenditures with Particular Reference to Pharmaceuticals. (April 1980)
72.	V.H. Kirpalani N.B. Macintosh	Concordia University. Queen's University.	Small Firm International Effectiveness: An Exploratory Survey. (June 1980)
73.	Dr. S.K. Bhattacharyya Assistance of: P.H. Hallett Dr. R. Bhattacharyya		An Assessment of Market Potential for Intermediate Capacity Transit System in North America. (July 1980)

74.	D.A. Ondrack	Faculty of Management Studies, University of Toronto.	Innovation and Performance of Small and Medium Firms: A Re-analysis of Data on a Sample of Nineteen Small and Medium Firms in the Machinery Industry. (May 1980)
75.	T. Abdel-Malek	College of Commerce, Department of Management and Marketing, University of Saskatchewan.	Canadian Direct Investment in Western Europe. (August 1980)
76.	Stephen G. Peitchinis	Department of Economics, University of Calgary.	Technological Changes and the Sectoral Distribution of Employment. (February 1980)
77.	J.E. Crozier	Canadian Insitute of Metalworking McMaster University Hamilton, Ontario	A Survey to Identify the Attitudes and Awareness of Numerical Control Users to CAD/CAM Technology and the Technological and Economic Strengths and Weaknesses of Machine Tool Part Programming. (November 1980)
78.	Stephen G. Peitchinis	Professor Economics University of Calgary	The Introduction of Computer-Aided Design/Computer-Aided Manufacturing CAD/CAM Systems and Their Employment Implications (September 1980)
79.	G.K. Hewitt	Department of Economics Concordia University	R&D in Selected Canadian Industries: The Effects of Government Grants and Foreign Ownership (January 1981)

Veuillez faire parvenir votre demande à PEIT:
Please forward your request for TISP reports to:

Program Manager,
Technological Innovation Studies Program,
Technology Branch,
Department of Industry, Trade and Commerce,
235 Queen Street,
Ottawa, Ontario CANADA
K1A OH5

Revised April 1981