Post Industrial Canada and the New Information Technology

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POST INDUSTRIAL CANADA AND THE NEW INFORMATION TECHNOLOGY

Introduction

In recent years advanced economies have been experiencing two interrelated noteworthy trends. The first is the growing importance of information related activities in the economy, both in terms of output and employment. The second is the development and diffusion, at rapidly falling unit costs, of advanced telecommunications, electronics and related technologies. Concerns have arisen with respect to the impact of these developments on employment, productivity, economic growth and international trade.

The diffusion of the new information technologies has been raising widespread concern regarding its likely impact on overall employment and the occupational structure. Will the application of the new technologies such as microprocessors, result in massive labour displacements, either permanent or temporary? Fears have been expressed, for example, that office automation could result in widespread disemployment of secretarial and clerical staff.

Impacts of the new technology on the international division of labour are also of concern, especially to an open economy such as Canada. In the past, the production of electronics-based goods has tended to rest mainly with the U.S.A., and more recently, Japan. However, microelectronics is increasingly hypothesized to be a "heartland" technology, crucial for any country which wishes to maintain its international competitiveness. Should Canada as a nation be adopting an industrial strategy to ensure the application of these advanced technologies?

In this article, we intend to address the issues raised by these developments by proceeding in the following manner. Part 1, Canada and the Information Economy, will assess the importance of information related activities in the Canadian economy through an analysis of historical and projected employment trends. Part 2, Changes in Information Technology and Employment, will assess available evidence regarding the potential impact of the new information technology on employment. Finally, a concluding part will summarize the findings of the first two parts and will raise other important policy issues related to these developments.

PART 1

CANADA AND THE INFORMATION ECONOMY

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1.1 Introduction

The Information economy is a frequently used concept to describe the process by which the economy is becoming more information intensive. The term denotes that the information input is seen to be the key factor of production in this phase of economic development, in contrast to pre-industrial society which was primarily resource-intensive, and industrial society which is, to a large extent, capital intensive.

Key contributions to the literature on the information economy can be divided into two broad categories, theoretical and empirical. In the former category, Bell(1), and Parker (2) focussed on the qualitative changes in our society due to the new technologies in information production and distribution. Bell compared the revolution in information technology to the industrial revolution and asserted that developed nations are entering a new phase, a "post-industrial" society, where the most important economic activity is the production and distribution of knowledge. Parker emphasized the role of policy in the information sector - to control the development of technology for the achievement of social goals. Both emphasized the problems with the competitive market because of the public-good aspects of information.

On the empirical side, Machlup (3) and Porat (4) attempted to quantify the information sector in order to develop data for the discussion of information technology issues. Machlup pioneered the use of the national accounts as a framework for analysis. Porat provides an exhaustive account of the size of the information sector in the United States in 1967, through an extensive reworking of national accounts and labour force data. His results show that the U.S. is already an information based economy, that 53 percent of employee compensation of the civilian labour force is accounted for by information workers and that an estimated 46 percent of the U.S. Gross National Product is derived from the production, processing and distribution of information goods and services.

He further characterizes the United States as having passed through three distinct stages during the century from 1860 to 1960 based on a disaggregation of the economy into four sectors: agriculture, manufacturing, services and information. In Stage I, which lasted from 1860 to 1906, agriculture was the predominant sector of employment. Stage II, the industrial stage, held reign for the next fifty years, until 1954, at which time the information sector became predominant. It remains the dominant sector in the current period, although Porat foresees its growth rate declining as the private and public bureaucracies become glutted.

Of course the size of the information sector depends crucially on the definition of information adopted. Porat uses a very general and vague definition, namely, "information is defined as the bundle of activities that produce process and distribute symbols as opposed to things" (Porat 1976:2). Adopting this definition leads to extreme heterogeneity in the activities of the information sector and this heterogeneity leads to doubts about the centrality of some of the economic activities which are placed in the information sector. Canadian research addressing the usefulness of the concept of information accounts in described in Part 2, Section 4.

1.2 The OECD Group of Experts

The work of Porat, despite its arbitrariness, on the formulation for the U.S. of a system of national accounts designed to highlight information activities, has raised widespread interest among OECD member countries.

This interest resulted in the formation in 1977 of an OECD Group of Experts with the mandate to define the socio economic dimensions of the growth of information goods and services and the role of electronics, telecommunications and related technologies for advanced economies, and to assess the feasibility of constructing in each member country national accounts à la Porat which would permit international comparisons. The output of the Group of Experts work is to be a comprehensive report which will measure the growth of information activities in member countries, in an internationally comparable manner in terms of information employment, employee compensation, and contribution of information activities to GNP (using value added measures). It will also analyse selected economic and social policy implications induced by these developments such as productivity changes, economic growth, employment consequences, and changes in the international division of labour.

The Department of Communications as Canadian representative to the Group of Experts has made a twofold contribution to the OECD's activities in this area. First, in co-operation with Statistics Canada, the Department has measured the growth of the information economy in Canada through an analysis of the historical importance of information occupations. The value-added concept was not used in this activity because the Canadian national accounts are not sufficiently disaggregated to allow the disentanglement of information from non-information activities. Secondly, as previously mentioned, Canada launched a

study designed to test the usefulness of Porat's concepts in the context of Canadian manufacturing. In the remainder of Part 1 we will present statistical evidence concerning the growth of the Canadian information labour force.

1.3 The Canadian Information Labour Force

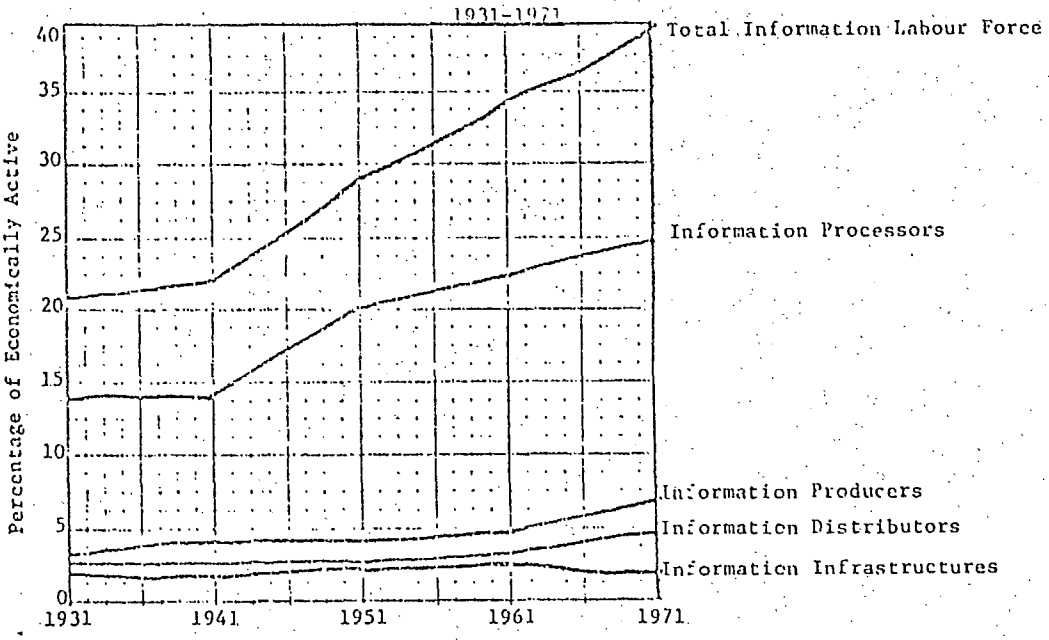
The data presented below show that Canada has been experiencing the same persistent growth phenomenon for informational occupations as reported by other advanced countries. In fact, Canada ranks second only to the U.S.A. throughout the post-war period in terms of the information share of occupations, when measurements are made in an internationally comparable (Note 1) manner.

Information occupations in Canada grew from 29 percent of the labour force in 1951 to 40 percent in 1971. Comparable figures for the U.S.A. are 30 percent and 41 percent respectively. Thus it can be seen that the rate of growth of the information labour force was roughly the same for Canada and the United States in this period. A closer look at the components of the information labour force as depicted in figure 1 reveals that the greatest increase has taken place in the sub-category information processors, consisting of administrators, managers, supervisors, and clerical and related workers. By 1971, this group alone accounted for 25 percent of the Canadian labour force.

Figure 1

Components[2] of the Canadian Information Labour Force (see Note 2)

1931-1971



Source: Statistics Canada, Census data 1931-1971.

The industrial location of information workers in 1971 is presented in Table 1. The figures show that information workers form the smallest proportion of the economically active in the primary industries, where they represent only 9.7 percent of the work force. In construction and manufacturing the proportion rises to 33.5 percent and in the service sector, information workers represent 46.2 percent of the labour force.

Table 1

Information Occupations as Percentage of Employment by Industry, Canada, 1971

	%		%
PRIMARY INDUSTRIES	9.7	SERVICE SECTOR	46.2
Agriculture	1.7	Transportation, Communications and Utilities	48.4
Forestry	18.3		
Fishing and Trapping	3.1	Wholesale and retail trade	45.7
Mining	33.9	Finance, insurance, real estate	90.9
SECONDARY INDUSTRIES	33.5	Community, business, personal services	50.3
Manufacturing	36.2	Public administration and defence	53.0
Construction	25.0	TOTAL INDUSTRIES	39.9

Source: Statistics Canada, 1971 Census

We can also examine the distribution of particular information occupations by means of Table 2. Information producers, processors and infrastructure occupations tend to have similar industrial distributions, with close to three-quarters of each group being concentrated in the service sector, about one quarter in construction and manufacturing, and the residual in the primary industries. Information distributors, on the other hand, work almost entirely in the service sector of the economy.

Table 2

Distribution of Information Occupations by Industrial Sector, Canada, 1971

	Primary	Construction and Manufacturing	Services	Total
	%	%	%	%
Information producers	4	25	71	100
Information processors	2	23	75	100
Information distributors	-	4	96	100
Information infrastructure	1	30	69	100

Source: Statistics Canada, 1971 Census

What the figures in the two preceding tables suggest is that the growth of the information labour force is inextricably tied to the growth of the service sector. We will examine implications of this observation later in this section.

With growing female participation rates in the labour force, it is of interest to identify the contribution which information sector occupation have made to this phenomenon. Table 3 below presents comparative data for 1971.

TABLE 3

Male/Female Participation Rates (Percentages) by Occupation

Occupational Group	Male/Female Ratio	Total No. of employees
Information producers		
Scientific professional, consultative	83:17	454,335
Information gatherers	81:19	95,735
Market search and co-ordination	86:14	100,270
Information processors		
Administrative and managerial	82:18	252,415
Process control and supervisory	85:15	807,190
Clerical and related	25:75	1,108,750
Information distributors		
Educators	40:60	334,790
Communication workers	64:36	69,510
Information infrastructure		
Information machine workers	55:45	110,765
Postal and telecommunications	64:36	95,790
Total Information Occupations	58:42	3,439,550
Total Non-Information Occupations	70:30	5,187,375
Total Labour Force	66:34	8,626,925

Source: Statistics Canada, 1971 Census

From this table, it is clear that females are disproportionately represented in information occupations. Whereas women represent 34 percent of the economically active, over-all, they represent 42 percent of the information labour force. What is of concern to note is that the female workers tend to be

clustered in occupations which are most susceptible to replacement by new information technology. For example, they represent 75 percent of the clerical and related category which alone accounted for over 1 million workers or 13 percent of the labour force in 1971.

This profile of the Canadian information labour force is useful for highlighting broad policy issues. In summary, we note that our data show that there has been a persistent growth over time in the proportion of the labour force who are information workers. Secondly, the sub-group incorporating routine information handling occupations has also been growing substantially, to the point where clerical workers alone represented 13 percent of the labour force in 1971. Moreover, female workers tend to be concentrated in this routine information occupation sub-group.

As S. Peitchinis (5) has noted, the rapidly expanding Canadian labour force, with an average annual growth rate of 3.6 percent over the period 1961-1974, has been largely absorbed by the service sector, which grew at 5.8 percent per year to absorb the excess labour. By contrast, employment in industry grew at 3.4 percent per year, and employment in agriculture declined at a rate of 2.0 percent per year. What is doubtful is whether these trends can be expected to continue in the future, with the service sector employment continuing to expand at a rate sufficient to absorb the labour force growth, especially in view of the suggestion that the new technology will reduce the labour absorptive capacity of this sector. A review of recent forecasts and their underlying assumptions is useful to gain a perspective on this question.

1.4 Forecasts

In the October 78 issue of Executive, John Kettle presented a forecast of the Canadian economy to 1991 in a very informative article entitled "Canada as a post industrial society".(6) This forecast is particularly interesting because it does not result from some arcane model but was obtained from a relatively simple extrapolation of underlying trends in the economy over the

last 15 years. The reader is referred to the original article for more details on the methodology used to perform the forecast.

Despite the simple methodology of the model the forecast produced by Kettle is rather interesting. It shows that if the major underlying trends of the past 15 years were to continue over the next 15 years, total output expressed in 1977 dollars will grow from $138 million in 1976 to $338 million in 1991. In other words, output is expected to increase at a higher rate than during the 1961-1976 period despite a further increase in the proportion of the service sector in total output over the period from 62% in 1976 to 68% in 1991. During the same period the service sector share of employment is expected to increase from 66% in 1976 to 75% in 1991.

A forecast of the Canadian economy for the period 1977-1987 produced by the Ontario Economic Council (7) using the University of Toronto TRACE model provides similar results. This model forecasts the share of output arising in the service sector to rise from 61% in 1975 to 64% in 1987. Employment in this sector is expected to rise from an estimated 67% of total employment in 1975 to 74.9% in 1987.

In both these studies, the employment and output forecasts are based on the continuation of past trends. The OECD forecast, for example, explicitly depends on the assumptions that technical change is equally factor augmenting, and that the technical change will continue to account for the same percentage of the growth in output over the forecast period as it did over the last two decades. Kettle notes that his output and employment forecasts could be altered by a significant change in service sector productivity or by declines in good-sector productivity. This is precisely the question we wish to address: are we at a threshold of a major technological revolution which will

drastically affect productivity, particularly the productivity of services? If this is indeed the case, what will be the impact on employment and on output? The next part will address these questions in more detail.

1. The OECD Scheme for classifying occupations as informational is more restrictive than Porat's.

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2 The OECD has adopted a variant of Porat's conceptual scheme for classifying information workers. In this classification, the major categories are:

INFORMATION PRODUCERS: scientific and technical workers, information gatherers
market search and co-ordination specialists
consultative services

INFORMATION PROCESSORS: administrative and managerial, process control and supervisory, clerical and related

INFORMATION DISTRIBUTORS: educators
communication workers

INFORMATION INFRASTRUCTURE: information machine workers
postal and telecommunications

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Part II

The Employment Effect of Changes in Information Technology

by

Michel Andrieu

2.1 Introduction

Concern about the employment effect of the new information technology has been a dominant factor in recent discussions. In this section we shall attempt to assess the extent to which this concern is warranted, and to review the available evidence which can be brought to bear on this issue.

Two major opinions have been expressed with respect to the employment effect of the new technology. First, it has been predicted by some that this new technology, particularly the application of microprocessors to an increasing range of activities, could not only result in the replacement of blue collar workers by automated machines but could also threaten the livelihood of a large number of white collar workers such as secretaries, clerks and bank tellers.

It is also expected by many that the new information technology will cause considerable change in the occupational composition of employment. For instance, while the demand for occupational groups needed for the new technology, such as computer programmers, may continue to grow, the skills of other occupational groups could become obsolete. These shifts in the demand for various types of labour can be expected to create serious disruptions in labour markets and could cause major social and political problems.

Although rather gloomy forecasts have been made about the impact of the new information technology on employment, very little factual evidence has been advanced to substantiate this bleak outlook. Pessimists point to the virtually endless capability of the new technology, as well as to the ordeal of some occupational groups, such as watchmakers and typesetters, as evidence that the revolution is already under way. They stress further that the service sector which has traditionally been the refuge of displaced workers is now the major target of this new technology and that consequently the ability of the economy to absorb displaced white collar workers will be particularly limited.

Sceptics feel that these fears are greatly exaggerated. They contend that although the new information technology is bound to cause some disruptions which are an inevitable consequence of technological change, these disruptions are not likely to occur on the scale envisaged by the pessimists. They point to the poor track record of technological forecasts in the past and how gloomy forecasts have repeatedly been contradicted by events. For sceptics, this failure of past forecasts has resulted from a gross under-estimation of the ability of the economy to adjust to changes as well as from a disregard of the socio-economic barriers to the introduction of new technology. They remark, for instance, that although electronic funds transfer and electronic mail have been discussed for more than 10 years

they have still to be implemented. Moreover, it is not at all clear to sceptics that the job creation capability of the new technology will not be strong enough to enable society to absorb the displaced workers. Finally, they point out that the new technology could contribute to improving the quality of life to the extent that it will raise the standard of living of Canadians and liberate a large number of workers from boring and repetitive jobs.

In what follows, we shall first examine under what conditions the new information technology can be expected to lead to technological unemployment and assess whether these conditions are likely to be fulfilled in practice. We shall then consider the potential effect of this new technology on factor input mix. For this purpose, preliminary results of a study currently in progress in the Department of Communications will be reviewed. Finally, the empirical evidence regarding the impact of the computer on the demand for labour will be examined and its relevance to the present discussion will be assessed.

2.2 Technical Change and Technological Unemployment

Conceptually, the impact of the introduction of new technology on aggregate employment depends critically on the technical characteristics of the production process and on the nature of the innovations being introduced.

The most important technical characteristic to be considered in this respect is the substitutability between factor-inputs, i.e. the ease with which one factor can be substituted for another in production. One extreme case is the "Leontief" technology, a situation in which no scope exists for substitution. Factor inputs must be used in fixed proportions. If this condition prevails and if the factors are not available in the proportions prescribed by the only technical process known, part of the most abundant factor is redundant and must remain idle, irrespective of relative factor prices. When the technology is "neo-classical" on the other hand, and substitutions in production are possible (there is more than one known way of producing a given output), factor prices will tend to adjust in such a way that the optimal capital-labour ratio will be equal to the ratio of the existing stock of labour and capital, in the absence of institutional constraints.

Also important is the nature of the technical change being introduced. A technology is said to be "labour-saving" if less labour per unit of capital is required after the introduction of the technology than before. Hence a labour-saving technology

tends to increase the capital-labour ratio in production. Similarly, a "capital-saving" technology tends to increase the labour intensity of production while a "neutral" technical change leaves the capital-labour ratio unchanged.

In a fully employed economy with Leontief technology, labour-saving technical change will tend to create unemployment in the short run since less labour is required after the change to operate the existing stock of capital. Similarly, a capital-saving technology would cause part of the capital stock to remain idle in the short run. On the other hand, a neutral technical change would not affect in balance the over-all use of factor inputs.

If factor input substitution in production is possible, the impact of technical change will be significantly different. Assuming that relative factor prices are allowed to vary freely, a labour-saving technology will induce a change in the relative factor prices which will tend to restore full employment of the factors.

Consequently, technical change must be labour-saving for technological unemployment to occur. Moreover, factor substitution in production must be restricted either because the production technology is Leontief, or relative factor prices are prevented from adjusting by institutional constraints. However, even if these conditions prevail, full employment can still be

restored in the long run through capital accumulation. That is, even if fewer workers are required per "machine" after the introduction of technical change, increased employment can be achieved by merely increasing the number of machines available for production. Both the construction and the use of these additional machines will contribute to increased employment.

2.3 The Longer Term Impact of the New Information Technology on Employment

It was pointed out above that for technological unemployment to occur innovations must be strongly labour-saving and factor input substitution in production must be restricted for technical or institutional reasons. We shall attempt to assess here whether these conditions are likely to hold in the case of the new information technology.

There has been a long and heated debate over the years in the economic literature on the issue of whether technological progress was dominated by labour-displacing inventions. Until the 1940s the prevailing view among economists was indeed that technical change had a labour-saving bias. Although the debate on this question is far from over, an increasing proportion of writers since the 1950s have come to the conclusion (supported by a number of empirical studies) that there is no reason to expect *a priori* that, on balance, technological change will be non-neutral. Indeed, it would be fair to say that today the burden of proof has been shifted to those who argue that technological change is necessarily labour saving. It has been argued by some that the observed steady decline of the capital-output ratio in the U.S. over the last 40 years could be an indication that technological change has been on balance capital-saving during that period.[3]

The belief in an inherent labour-saving bias in technical change arises to a large extent from a tendency to view

technical progress as consisting solely of inventions in the narrow sense of the word rather than changes in the production technology. Indeed, when one takes technical change in its narrow sense it is easy to find examples of labour saving inventions (steam engine, radio, telephone, airplane), but it is hard to come up with cases of capital-saving improvements. However, if we think in terms of the production process instead of inventions, instances of capital-saving innovations are easy to come by. For example, any innovation which reduces the floor space required in production or lengthens the physical life of plant contributes to saving fixed capital. As well, any innovation which tends to reduce the stock of goods-in-process which must be carried for a given output (speeding up of machinery, faster handling of materials, reduction in delivery time, fuel saving) contributes to reducing the required working capital.[21]

Therefore, it is not at all obvious why the new information technology should <u>necessarily</u> be, on balance, strongly labour-saving when one focuses on the production process rather than on the spectacular inventions which too often have monopolized attention in this discussion.

Clearly, the new technology can be strongly capital-saving. The miniaturization inherent in digital microprocessors and optic fibre technology will certainly contribute to reducing "floor space". Moreover, one can expect that the increased durability of the new equipment will increase the physical life of plant.

There are also reasons to believe that the new information technology will contribute to reducing working capital. It is indeed relatively easy to find examples of applications of microprocessors which result in a speeding up of machinery, and faster handling of materials through automation. The potential for fuel saving is also obvious. Electronic mail and electronic funds transfer could reduce the fuel required to transport regular mail. Teleconferencing could diminish the need to travel and to commute to work. Moreover, the application of microprocessors to engines will improve the fuel consumption of aircraft, cars, trucks and ships. As a final example, one can also expect that the use of microprocessors in heating systems will save fuel in office buildings and homes.

In summary, there does not appear to be any compelling reason to presume that the new information technology will necessarily have a strong labour-saving bias. This is an empirical question and the evidence available so far is, at best, scanty.

Moreover, it is clear that the additional necessary condition of limited substitutability in production, which is required for technological unemployment to occur, is hardly tenable in the longer run. First of all, there are more than one known production process in the production of most goods. Indeed, extensive cross-section and time-series empirical analyses in many countries do support the substitutability contention.[2]

Furthermore, even if fixed proportions prevail in some industries, changes in the aggregate capital-labour ratio can still be achieved through substitution in consumption if different capital-labour ratios prevail in the various industries. Finally, technological change often involves the discovery of new production processes. This by itself should increase the ease of factor substitution over time.

In conclusion, it would seem that we can reject with some degree of confidence the proposition that the new information technology will inevitably lead to permanent and massive unemployment, in the long run, both on the ground that it does not necessarily have a strong labour-saving bias and that ~~equalizing~~ adjustments in the production process will take place through factor substitution and capital accumulation over time.

It is interesting to note that essentially the same argument was made by many economists when concerns were expressed about the introduction and diffusion of computers in the last two decades. For instance the U.S. National Commission on Technology Automation and Economic Progress concluded in 1966 that although technological change plays a major role in determining the particular workers who will be displaced, the rate of economic growth, rather than technological change per se, is the principal determinant of the general level of employment.[45] Similarly, Taviss points out that "clearly, the introduction of computers into factory or office does displace some workers; but it also generates new jobs

and, by stimulating growth, it helps to maintain a high level of employment in the society".[54] As well, Stoneman's main conclusion in his 1975 study on the impact of computers on the demand for labour in the U.K. is that the effect has been quite small and is not likely ever to be large in the future.[55] We shall review this study in more detail below.

2.4 The Impact of the New Technology in the Short and Medium Term

In light of the above discussion it would appear that the possibility of massive unemployment in the long run is a rather remote possibility. However, this conclusion may be of little comfort to most since in the long run we are all dead, as Lord Keynes has so rightly pointed out. Even if adjustment mechanisms exist in the economy which will tend to restore full employment over time, the speed of adjustment may be so slow that serious dislocations may very well occur over the short and medium term. This will be the case, for instance, if strongly labour-saving applications of the new technology are introduced very rapidly and if adjustment through factor input substitution in production and capital accummulation are sluggish.

Many factors can be expected to influence on the one hand, the rate of diffusion of innovations in the economy, and on the other, the speed of adjustment to technical change. In what follows we shall review some of the factors which could be of significance. Moreover, we shall also consider other developments in the economy which are not directly related to the introduction of the new information technology, but which can be expected to affect the employment situation over the next two decades.

There are reasons to believe that technical change may not always occur as rapidly as anticipated by technologists.

First of all, even when the merits of an innovation are well proven, the diffusion of the new knowledge may be slow and it may take some time before business firms will judge their existing plant to be sufficiently depreciated to justify the substitution of the new technology for the old.

Moreover, business firms may face serious difficulties when introducing technical change, even when they are convinced that it is desirable to do so. Institutional barriers such as economic and social regulations may reduce their freedom of action and stifle change. In this respect, the growing concern about the burden of regulatory constraints in both the U.S. and Canada is noteworthy. Another obstacle to change may be the resistance of workers to changing their working habits and their hostility to new technologies which may be perceived as threatening jobs. In this regard, the benefits to be achieved from the new information technologies appear to be particularly dependent on the good will of workers and unions, as has been dramatically illustrated in recent years by the failure of the Post Office yet to successfully introduce technological change into its operations.

The speed of adjustment to the introduction of the new technology will depend on how fast factor input substitution can take place over time and on the rate of accumulation of capital. Factor input substitution can be expected to be rather limited in the short term since such substitution in general will involve

modifications in the production process which can be costly and time consuming. Moreover, relative factor prices may not adjust freely because of institutional barriers (e.g. minimum wage legislation, unions) and distortions in factor input markets (payroll tax, tax incentives). Finally, the response of workers to the new labour demand conditions may be slow if considerable re-training is required to perform the new tasks resulting from the introduction of the new technology.

The rate of capital accummulation will also play a major role in the adjustment process. In general, the higher the rate of capital accummulation the faster unemployment can be absorbed, since an increase in the capital-labour ratio will tend to increase the demand for labour in the economy. However, in the short and medium term capital accummulation will be greatly affected by business cycle fluctuations. As a result of those fluctuations, the rates of growth of GNP and of capital accummulation can remain below their potential levels for considerable periods of time. This may be the situation that most advanced industrial countries are now experiencing. Consequently, there is a distinct danger in this respect that the rapid introduction of the new information technology could have adverse effects on employment in the short and medium term, in light of the depressed present state of our economy.

Because of the dependence of the Canadian economy on foreign trade (25-30% of GNP), productivity can be expected to be a major determinant of employment in the short and medium term. In this respect, policy makers are faced with a real dilemma. If, on the one hand, they discourage the rapid introduction of the new technology for fear of technological unemployment, they may induce a deterioration in the competitiveness of the Canadian economy and this could result in a loss of jobs. If, on the other hand, policy makers stimulate innovation too much, they face the danger of serious dislocation in the short run if the new technology is strongly labour-saving, since the adjusting mechanisms are likely to be sluggish over that period. However, it is clear that the new technology could have a significant beneficial effects on employment if it contributes to stimulating of Canadian exports of processed goods and services.

Developments other than the introduction of the new information technology will affect the employment situation in Canada over the next two decades. In particular, further increases in the price of energy and changes in consumption patterns can be expected to play a major role.

An increasing proportion of GNP has been devoted over time to the production of services. This is because of the high income elasticity of the demand for such services and the low productivity of the service sector. Indeed, concern has been expressed that the over-all rate of productivity gain will decline

over time as the relative size of this labour-intensive sector increases in the economy. This concern is in sharp contrast with the fear that the new information technology is "too productive". In balance ~~Indeed~~, the apparent bias of consumption toward labour-intensive activities may very well offset in the medium term any labour-saving bias of the new information technology.

If man is truly a social animal, he will continue to give high value to labour intensive services and to devote, individually or collectively, an increasing proportion of his income to such services, as he becomes more affluent. A world in which man will talk only to machines is hard to visualize. Another contributing factor here is the anticipated aging of the population over the next two decades. This will certainly induce an increase in social spending on health, an activity which is likely to remain labour-intensive despite the introduction of new technologies.

The impact of future increases in the price of energy will depend critically on the relationship of this input with other factor inputs in production . Although the issue is far from settled, recent empirical studies suggest that energy tends to be a close complement to capital in production, but a substitute for labour.[6] If these results are confirmed by further studies, this would imply that expected increases in the price of energy could also help to offsetting any labour-saving bias which may arise from the introduction of the new information technology.

However, both the direction and the strength of this effect need to be analyzed further before any conclusion can be drawn with any degree of confidence. In particular, increases in the price of energy are likely to speed up the introduction of the new information technology and energy may have different technical relationships with different types of labour and of capital.

2.5 The Information Economy and Factor Input Substitution

Knowledge of factor input substitution is important not only for assessing the over-all effect of technical change on aggregate labour requirements, but also for determining the differential impact that such changes may have on various categories of labour. This is particularly true if the innovation results in significant reductions in the prices of some types of capital goods such as computers and microprocessors. Firms will usually react to such changes by substituting the cheaper capital good (e.g. computers) for other factors. The effect on the use of the other factors will depend on the ease with which such factors can be substituted for one another.

It appears useful, in the analysis of the impact of the new information technology on various categories of labour, to make a clear distinction between information capital (e.g. computers) and non-information capital on the one hand, and between information labour and non-information labour on the other. This is appropriate since the new technology is likely to have a differential effect on these different factors.

In this section we shall examine some preliminary empirical evidence from a recent study conducted by the Department of Communications on the role of information activities in Canadian manufacturing over the 1948-73 period.[7] This study which will be completed by the end of March 1979, will be part of

Canada's contribution to an OECD report devoted to the impact of information activities on the economy.

The work of Porat in re-grouping the U.S. national accounts to highlight information activities, raised widespread interest among OECD member countries. This interest resulted in the formation in 1977 of a Group of Experts with a mandate to analyse the economic and social impact of information-related activities, and to assess the feasibility of constructing in each member country national accounts, à la Porat, which would permit international comparisons..

The position taken by the Canadian delegate, which was shared by many other participants in the Working Group, was that a clearer understanding of the potential usefulness of launching such a massive statistical exercise was required before proceeding any further. In particular, it was felt that Porat's definition of information was too vague and arbitrary. Hence, it was not clear what economic issues could be usefully addressed with the accounts once the data had been produced.

In response to this concern it was decided that, in addition to the compilation of already existing data on information activities by Statistics Canada, the Department of Communications would launch a study designed to assess the role of information related activities in Canadian manufacturing. It was hoped that the study would not only provide an empirical test

of the value of Porat's concepts but would also give some rough estimates of the substitutability among information workers, information capital and non-information inputs, following a definition similar to Porat's. This second objective of the study appeared particularly important since such estimates of substitutability would be extremely valuable in assessing the likely effect of changes in the price of information capital on employment.

Because of severe data limitations it was decided that a two-stage approach would be adopted in the study. The first stage involved using three factor inputs: information labour, non-information labour, and capital. In the second stage of the study, capital would also be disaggregated into information capital and non-information capital. Only the first stage of the study has been completed so far and will be discussed here.

The approach used to assess the usefulness of the distinction between information and non-information workers requires the use of fairly sophisticated econometric techniques. It involves, in particular, the estimation of a production function for Canadian manufacturing and the application of certain statistical tests of "separability" of the factor inputs. The hypothesis to be tested is that the production process is better explained statistically by separating information and non-information labour, than by treating labour as a single aggregate as is often done in production function estimations.

Although the results obtained in this study are still preliminary, they suggest that there is a significant increase in explanatory power (from a statistical point of view) when a distinction is made between information and non-information labour. Moreover, there are indications that further improvements are likely to be obtained when the distinction between information and non-information capital is implemented.

The preliminary results of the study are also noteworthy with respect to factor substitutability. Although information labour and non-information labour are close substitutes in production, information labour is a complement to machinery and equipment, whereas non-information labour is a substitute. Confidence in these results is strengthened by the fact that they are consistent throughout the entire 25 year period. Moreover, their remarkable agreement with the results of a study of U.S. manufacturing in which a distinction is made between production and non-production workers is also interesting.[8] The similarity of results between the two studies seems to point to an important structural characteristic in manufacturing which is not captured when labour is treated as an aggregate.

An important implication of these results is with respect to the impact of a change in the capital service price on employment. They suggest that a fall in the relative price of capital services may stimulate the demand for

information labour, and reduce the demand for non-information labour. Such a change in price, which could be caused by technological progress in the capital good industries, will lead to an increase in the proportion of information to non-information labour.

These results appear consistent with experience over the 1948-73 period in which a large increase in the proportion of information labour has been experienced. Clearly, a distinction between information and non-information capital would increase significantly our understanding of the process and enable us to track down more precisely the impact of technological change in information capital (such as computers) on employment.

However, even when the second part of this study is completed, major gaps will remain in our understanding of the impact of the new information technology on employment since the information labour group is itself too aggregate. Indeed, some categories of information workers (e.g. computer programmers) tend to be complementary to information capital. On the other hand, other groups among information workers, such as clerks and secretaries, are likely to be substitutes. However, we can only make conjectures at this time since there are limits to the substitution process. Advances in user-oriented software will increase the accessibility of computer to non-programmer information workers. This may cause a substitution of non-programmer information workers for computer programmers. It is clear that a more detailed analysis of all these

issues will be required before a more definite assessment can be achieved. However, some analogies can be drawn from available empirical evidence pertaining to the introduction of third generation computers. This will be discussed in the next section.

2.6 The Effect of Computers on the Demand for Labour

Although very little empirical evidence exists so far on the impact of microprocessors on employment, some inferences can be drawn from some of the studies which have been made in recent years on the effect of third generation computers on the demand for labour. The discussion will focus here on one of the most recent of such studies published by P. Stoneman in the September 1975 issue of the Economic Journal[9]. In this paper, the author, taking the U.K. as an example, first compares a highly computerized economy with a non-computerized economy in order to assess the longer term impact of the introduction of third generation computers on the demand for labour. In the second part of the study, Stoneman analyzes the changes along the transition path, as the economy approaches full computerization.

The data used in the paper were obtained from two surveys of computers in offices conducted in 1965 and 1972 by the British Ministry of Labour (1965) and the Department of Employment (1972). In the 1965 survey, estimates were made of the entire staff which would have been required to cope with the expansion of business if EDP facilities had not been available to deal with it, and of the positions which were actually discontinued as a result of the introduction of the computer. These figures tend to over-estimate the manpower displaced to the extent that they include

work that would not have been done without a computer. However, this effect was judged to be small and ignored in the analysis. In the 1972 study, managers of those installations that had a computer for more than two years were asked how many additional office workers would have been required to maintain the level of business without the computer.

Information on jobs created by EDP-related activities was also obtained from the Computers-in-Offices Survey. Moreover, data on labour usage in computer construction were obtained from the Census of Production as well as data on labour usage in office machinery construction, to account for the replacement of office machinery by computers.

The results of the analysis suggest that the net labour saving which would have resulted from full computerization in 1970 (as compaired to non-computerization) amounted to only 0.87 percent of the 1970 labour force. This is based on the assumption that about 72 per cent of machines at that time were produced in the U.K.

If these estimates are any indication, the potential impact of third generation computers on employment has been minor to date. Moreover, it is worth pointing out that as late as 1970 only 54 percent of the satiation stock of third generation computers was installed, according to Stoneman's analysis. Consequently, the actual effect was even much smaller than the potential effect.

Stoneman turns his attention in the second part of his paper to the estimation of the actual effect on labour demand. The results of the analysis suggests that up to the mid 1960s the computerization process

was creating more jobs in the U.K. than it was displacing workers, because of the high rate of diffusion. After that date the labour savings tends gradually to dominate, as the diffusion rate tapers off. Stoneman estimates that by 1978 the net labour-saving effects should amount to about 250,000 jobs or about 1 per cent of the labour force. He concludes that the impact of computers on the demand for labour is small and is not even likely to be large.

As the author admits, his analysis is based on a number of heroic simplifying assumptions, particularly with respect to the heterogeneity of computers and their uses. Consequently, we are warned that the results which have been obtained should be considered as order of magnitude only.

Although Stoneman's results are rather encouraging, it is clear that the British experience cannot be transposed to Canada without qualification. First of all, the labour creation resulting from computer construction is likely to be smaller in this country than in the U.K. Moreover, because of the branch-plant nature of the Canadian economy it may very well be that same job creation in computer usage has tended to take place abroad in the headquarters of foreign-owned companies, while the job losses take place in Canada. Finally, Stoneman's analysis only applies to third generation computers and does not address the implementation of microprocessors which can be expecte to have a different effect on labour usage and labour saving. The labour requirement for the construction of microprocessors is critically affected by chip technology. The proportion of bought-in inputs is probably higher for microprocessors, and their source is pretty much restricted today to Silicon Valley. Hence the labour creation component is probably concentrated in the U.S. and may be quite small. But because microprocessors encourage decentralized processing, it may well be that the job creation component of microprocessor applications will take place in Canada instead of abroad, as was likely the case for third generation computers.

2.7 Summary of Major Findings and Conclusion

There are a number of broad conclusions which can be drawn from this second part of the paper. They pertain to the impact of the new information technology on employment in the short and the long run, as well as to the interpretation of the empirical findings which are available to date on this subject.

First of, it appears that we can reject with some degree of confidence the proposition that the new information technology will inevitably lead to permanent and massive unemployment, both on the ground that it does not necessarily have a strong labour-saving bias and that equilibrating adjustments in the production process will take place through factor input substitution and capital accummulation over time.

However, serious dislocation can nevertheless take place in the short and medium term if strongly labour-saving applications of the new technology are introduced very rapidly and if adjustments are sluggish.

Whether this will actually take place will depend on the speed of diffusion of the new technology, the speed of adjustment mechanisms as well as on developments not directly related to the introduction of the new technology, but which may be expected to have a strong impact on employment, such as business cycle fluctuation, changes in consumption patterns or further significant increases in the cost of energy.

The empirical evidence available to date is rather limited but tend to suggest that up to now the introduction of computers has only had a minor effect, if at all on the demand for labour. However, significant changes in the occupational distribution of labour has taken

place and it can be expected that the new information technology will have a different effect on different occupational groups.

Further research is required to determine whether these preliminary results based essentially on the introduction of second and third generation computers can be extended to microprocessors. There are reasons to believe that this may not be the case. Moreover, there is a distinct possibility that the negative impact of computers on employment has been so small up to now that it has not been detected by the rather crude methods which have been used in estimating this effect.

Notes

1. This discussion draw heavily on M. Blaug, "A Survey of the Theory of Process - Innovations", Economica, February 1963, pp. 13-32.

2. For a review of recent empirical evidence on this topic see D.S. Hamernesh and J. Grant, "Econometric Studies of Labour - Labour Substitution and their Implications for Policy, Journal of Human Resources, forthcoming.

3. National Commission on Technology, Automation and Economic Progress, Technology and the American Economy (Washington, D.C.: Government Printing Office, 1966).

4. I. Taviss, The Computer Impact (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970).

5. P. Stoneman, "The Effect of Computers on the Demand for Labour in the United Kingdom", Economic Journal, 85 (September 1975), pp. 590-606.

6. See for instance M.Denny et al., The Demand for Energy in Canadian Manufacturing: Prologue to an Energy Policy", Canadian Journal of Economics, XI, no. 2, May 1978.

7. G. Warskett, The Role of Information Activities in Canadian Manufacturing 1948-73, Report prepared for the federal Department of Communications, December 1978.

8. See D.S. Hamernesh and J. Grant, op. cit., for evidence obtained in recent U.S. studies.

9. P. Stoneman, op. cit.

Part III

Policy Issues

by

Maurice Estabrooks

Post Industrial Canada and the New Information Technology

Part III
Policy Issues

3.1 Introduction

Technology has played a crucial role in man's efforts to improve his standard of living and is likely to continue to do so in the foreseeable future. In the past, technology has been relatively scarce and unmalleable. Man has had to adapt to technology for these reasons. However, one may wonder if we have not now entered an age where technology is no longer scarce, an age where man can intelligently choose how he wants to live and can then develop the technology for designing this society? If this is the case, it means that signigicant changes are in store for the way our society operates, economically socially and politically.

In the previous sections of our paper, we examined the increasing role information and information technology is playing in the Canadian economy and the possible impact on employment. In this section, we wish to consider what choices are open to Canada from social, economic and political perspectives. In particular, we will examine industrial development policy issues, economic and social policy issues as well as international issues in an effort to assess what strategies can be adopted by Canada and examine what policy instruments are at its disposal for making choices and achieving social objectives in the information economy.

In part 1 of this paper we have observed that information related activities play an increasingly important role in the agricultural, manufacturing and services sectors. These sectors are also vulnerable to the introduction of electronic technology which is at the heart of the information process. Because this technology promises higher productivity and higher output for these sectors, it will offer benefits to producers and to the whole economy if this is diffused optimally throughout the economy. A second force which will cause this diffusion or this push is that of international competition. Since Canada has an open economy domestic economic activity is highly sensitive to Canada's comparative advantage. Generally speaking, Canada's economy is best suited to the use of market incentives to promote the innovation and diffusion of this technology.

The governments of several western countries, however, including Japan are pursuing policies which directly or indirectly promote industrial development in and related to the information technology sector. These countries use tax incentives to stimulate investment, diminish risk, promote research and development and attract foreign suppliers to establish within the domestic economy. Some pursue tariff protection and government procurement policies while many make use of education and exchange programs designed to diffuse knowledge and awareness of this new technology. Choice of policies would appear to depend upon the specific developmental strategy of each country.

Canada must also examine its role in the information industry itself. We have observed the strategies of the governments of France, Germany and the United Kingdon in fostering the development of the data processing industry through the manufacturing of mainfname computers. We might also ask ourselves what prospects Canada has in this regard. Canada, as other countries, would appear to have several options. First, Canada can develop a hardware industry, Second, Canada can specialize in particular hardware and software applications for large or small

systems for the domestic and foreign markets. Third, Canada can pursue a strategy which emphasizes the role infrastructure will play in the information economy. [illegible] of these strategies [illegible]. The second and third would appear to be the most desirable for Canada [illegible]. However, Canada must recognize her strengths and build on them in such a way that it takes maximum advantage of natural linkages in the economy. Many of the instruments suggested above such as tax incentives for investment and R&D, education and procurement policy, are important elements of this strategy as well. [illegible]

Recent developments in computers and communications promise to bring to the consuming public and business alike the benefits of immediate access to a large variety of information services such as publishing, library services, news services, stock market quotations to name a few. In the very near future, Canada will witness the development of information networks accessible through cable, telephone and radio. These networks will enable citizens and organizations to access large data bases of public and private information. Information suppliers would be able to sell information at a price to an intermediary who would then market it to the customer. Other types of services will also be available such as banking and postal services and educational and entertainment services. The governments of several European countries are currently pursuing market trials to determine the marketability of such services as these and the results to date are encouraging.

The imminent introduction of new services such as these causes one to reflect on their potential to displace or create employment. It raises questions as to the impact of such an emerging industry on the older industry it replaces. Will the established industries adapt to the new technology or will they be destroyed by it? The market structure of the existing industries could be radically altered if the transition is very great.

This causes one to wonder whether policies can be designed to reduce such disruption while taking full advantage of market forces.

Information technology is a force which, by affecting the production and decision making processes themselves, can transform the whole structure of industry. These effects are speculative at this time but we can identify two relatively important ones. One effect will tend to create or destroy economies of scale and therefore represents an important factor tending to raise or lower barriers to entry as well as to increase or decrease competition. This set of forces could lead to extreme economic concentration or it could diminish it. The second impact could be to centralize or decentralize economic activity at the corporate and industry levels. This would tend to aggravate regional disparities or to diminish them. These are important factors to be considered in developing an industrial strategy for Canada. Canada's relatively small economy, distributed over a very large geographical area, would appear vulnerable to the forces of increased economies of scale and centralization.

3.3 Employment, Productivity and Output

There is an apparent contradiction between the concern expressed by many that, on the one hand, the increasing number of workers in the information sector will cause a decline in productivity and, on the other, concern about the impact on productivity of the information technology. Both could be occuring simultaneously if structural shifts were taking place within the information sector with productivity increases coming from the introduction of information technology and productivity decreases occuring in complementary activities or areas not directly or currently affected by this technology. There is widespread agreement that the introduction of new technology has increased productivity and output both in quality and quantity in banking and business generally. In a time of high inflation, this is particularly important for it acts as a force to diminish the effects of inflation on individuals and businesses. Inflationary and competition forces in the economy will accelerate the introduction of new technology. We might ask ourselves if accelerating this diffusion process is a reasonable goal of government as an instrument for increasing productivity and improving the comparative advantage of Canadian industry. This has already been discussed previously under the industrial development issues. In this section, the specific goal of increased productivity and output is one which is generally accepted as a legitimate responsibility of governement and one which government pursues through fiscal and monetary policy at the macro level and the provision of incentives at the micro level.

We have seen that, contrary to the views of many, permanently high levels of unemployment are unlikely to result from

the transitions toward informatisation occuring in the economy but that serious temporary dislocations are nevertheless possible depending upon the rate of introduction of new technology. We have also suggested the use of policy instruments to accelerate the diffusion process in order to achieve such goals as higher productivity and output as well as to remain competitive with our trading partners. Should this strategy succeed, it could result in serious dislocations in employment, however, and unless other policy instruments were used to minimize these adverse effects, any gains made from increased productivity could be lost. What instruments are available to ensure that the transitions in labour markets occur smoothly? Among the most important instruments are education and incentive schemes devised for labour and industry. Retraining programs could be provided from public funds. Incentives to relocate could be devised and educational programs could be developed to help overcome the adverse psychological effects of job and career change. There is an enormous latitude for using tax incentives aimed at business and industry for providing on-the-job retraining programs for those whose jobs are in jeopardy. Finally, it will probably be the responsibility of government to ensure that displaced workers are reallocated to the services sector of the economy and that jobs are created to absorb these. There is a potential that the services sector, particularly the personal health and social segments will absorb much of the dislocation.

~~[illegible] ... there is essential for high growth, high investment and high levels of employment. Consequently major developments in technology such as the micro-electronic revolution should be seen as offering enormous new constructive possibilities in the advanced countries. But it will only be possible for labour to see them in this way if the OECD countries are wholeheartedly committed to full employment policies, imaginative retraining and lifelong learning experience, education policies and social welfare policies which minimize the hardships and insecurity of labour displacement.~~

Stephen Peitchinis [1] in a report to the Department of Industry, Trade and Commerce makes several policy recommendations based on a survey he conducted on the effects of technical change on educational and skill requirements in Canadian industry. He makes the following conclusions:

> "...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)....consideration should be given to the question of government participation...in retraining programmes....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.....it is recommended that governments continue to place education high on the social policy priorities list.....An investigation should be undertaken to determine the reasons for the decision to opt out of fundamental research (in Canada)..... It is recommended, therefore, that 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."

3.4 Social and Cultural Issues

There are those who view the interaction of technology and society as one eventually leading to cultural disaster while others take a utopian view emphasizing those aspects of technology which liberate man from undesirable labour and provide him with the freedom and the means to choose and design a society which harnesses his most creative energy. The former emphasize the de-humanization of man caused by a world increasingly dominated by machines. They point also to the increasing vulnerability of society to strikes, sabotage, invasion of privacy, information overload, alienation and stress and suggest as evidence the increasing number of individuals who are voluntarily "opting out" of society.

The optimists emphasize the positive impact of technology on society such as higher productivity, output and wealth, increased leisure and the pursuit of more creative endeavors. They believe in man's ability to control and shape his social system.

A less extreme interpretation of these two views can be described by the belief in a technology-driven future and a policy-driven future. A technology-driven future reflects the more pessimistic view that man is dominated by technology and must submit to it. The policy-driven future reflects the more optimistic view that man's future will be decided by himself on the basis of informed choice. In the latter view, our democratic system of government has an important role to play in determining the kind of future we want and how we will use technology to achieve it. The information economy would appear to have an important role to

play in this democratic process. As well, there may be an important role for private and public policy making organizations as well as for individuals in formulating problems, educating the public, gathering information and implementing decisions which make our social system truly democratic.

The emergence of the information economy and information industries raises many other social and cultural questions. In a society which is information intensive, access to this information becomes an important political question for this could be a force to create as well as to diminish social inequality in the same way that employment and opportunity creates wealth and income equality. Will access to information be regarded as the right of every individual? Will such access be priced, and, if so, according to what rules? Will the quality and accuracy of information be important enough to limit its utility? Will privacy and security aspects cause concern to society? Can the rights to information property be protected so that those producing and supplying information can gain remuneration for their efforts? How effective will copyright laws be? None of these questions can yet be answered. However, they pose ultimate questions relating to the control and regulation of information in the economy. Although free market forces would appear to be performing the regulatory functions satisfactorily currently, there is little doubt that Canada, like other nations, will soon have to develop an information policy which addresses these problems.

3.5 International Policy Issues

Canada's economy is an open economy dependent on the export of some 25-30 percent of its gross national product. Canada's competitive advantage would deteriorate rapidly if other trading nations were to achieve too great a lead in the development and application of new information technology. The results for Canada would be a deterioration in its standard of living. Other industrialized nations in the west and Japan are pursuing policies designed to maintain and enchance their competitive position. Should Canada do the same?

Canada would appear to have little choice but to pursue those policies which can maintain its competitive position in international markets. This is particularly true in the resource-based industries where Canada already possesses a degree of comparative advantage. At the same time, Canada should reflect on those sectors of industry in which a comparative advantage could be developed by adopting new technology and providing incentives to domestic and foreign suppliers to establish within Canada. This is especially true of manufacturing industries. If new technology reduces the economies of scale in certain manufacturing industries, for example, this could provide Canadian industry with an unusual opportunity to improve its competative position in international markets. In other industries, such as main frame computers and television sets, there would appear little opportunity to improve Canada's prospects for international trade.

The emerging importance of international data networks is a major concern to industry, governments and individuals in many countries. Besides carrying confidential and private information concerning individuals, these networks carry data which are

becoming of increasingly economic importance. The domestic economy benefits through the production, processing, distribution and consumption of information. When data processing services are imported, they displace the employment of domestic resources such as labour. Importing such services is therefore equivalent to importing unemployment. On the other hand, where the foreign suppliers offer a specialized and more economical service to the domestic industry, this benefits the domestic economy. The danger to the Canadian economy is that having such a large proportion of branch plants of foreign firms, these may, as a matter of policy and not of economics, have their processing done outside Canada, thereby depriving the Canadian economy of these benefits. This has already caused concern to governments especially those in Europe where regulations are being considered to control this flow.

4. Conclusions

The Canadian economy is gradually being transformed into an information economy on which a greater proportion of the labour force and, indeed, of all economic activity will depend to an increasing degree. Although research efforts to measure the extent of impact are by no means complete, there are signs that the concerns of many that the trends [redacted] may generate high levels of permanent unemployment are not justified. However, temporary employment dislocations may occur depending upon the nature of information technology, its rate of diffusion and on the strength of adjustment mechanisms. Public policy instruments are available to minimize any adverse effects, however.

We have also concluded that Canada will have no alternative but to adopt appropriate measures designed to harness this technology if Canada wishes to maintain high living standards and to maintain and improve its standards of international competitiveness.

The longer term consequences of the "information revolution" and the "microprocessor revolution" could mean unusually great opportunities for business and individuals to improve Canada's standards of living but they also pose a serious challenge to domestic industry and governments to create an environment in which employment transitions are achieved with a minimum of adverse affects. The question of the extent of government involvement in the transition period will be the subject of intense debate.

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