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Impact of Information and Communication Technologies on Work and Employment In Canada

By

Gordon Betcherman and Kathryn McMullen

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Canadian Policy Research Networks, Inc.
250 Albert Street, Suite 600
Ottawa, Ontario K1P 6M1

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Table of Contents

Page

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1. Introduction

Controversies surrounding the employment implications of the computer revolution have been with us for a long time. In fact, futurists and social scientists were debating the likely impacts of information and communication technology (ICT) even before the technologies themselves really started making inroads into the workplace in the late 1970s. Now, twenty years later, we are still trying to sort out what effects ICT is having on employment levels and the nature of work. Are we on the road to the disturbing scale of technological displacement and deskilling articulated by Rifkin (1994), Braverman (1974), and others? Or is ICT the key to job creation, skilled work, and rising incomes as most national governments and much of the economics profession contends?

These technology debates, reflecting philosophical, ideological, and class positions, have persisted throughout the past two centuries. They become more intense during periods when technological change accelerates or when the fundamental nature of technology – what have been called "enabling" or "general purpose" technologies – shifts significantly as it has since the diffusion of ICT began.[2] Now, in the late 1990s, it is obvious that these technologies have affected what we produce and how we produce it. And it is also obvious that, in the process, they have transformed our workplaces, our work experiences, and the labour market in many important ways.

But what is not so obvious is the precise nature of these effects. To the layperson, this must come as a surprise. It would seem completely realistic to expect that social scientists, armed with the latest models (and yes, the latest technology), would be able to sort out the impacts of technological change and settle for once all of the age-old debates. However, a review of the literature demonstrates that it is not so simple. Data on the diffusion of ICT tend to be partial and, in a sense, measurement issues are only becoming more problematic as the technology becomes increasingly embedded in everything we produce. Even where ICT can be measured, it is difficult to isolate its effects from related developments such as globalization, deregulation, and new management principles.

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[1] This paper was originally prepared for the Canada-United Kingdom Colloquium, "Implications of the Communications Revolution for Canada and the United Kingdom," held at the University of Keele, Staffordshire, United Kingdom, November 24-25, 1997. The authors are with the Work Network, Canadian Policy Research Networks. The analysis synthesized in the paper is based in part on research carried out for CPRN within the Work Network's project on training and employment.

[2] For a discussion of the sequence of "enabling" or "general purpose" technologies through the industrial era, see Lipsey (1996).

Moreover, there is a qualitative, even subjective, dimension to all of this because the impacts of ICT are neither deterministic nor always tangible. And, finally, it certainly has not helped that mainstream economic theories -- and, thus, mainstream analysis -- has too frequently assumed away the important things about technology.

However, while the research community has not come up with all of the answers, there is a growing body of analysis that is trying to come to grips empirically with the diffusion of ICT and its various employment effects. In this paper, we review the Canadian evidence on four related issues:

- *The diffusion of ICT*. Various surveys have tracked the diffusion of computer-based technologies in Canadian workplaces through the 1980s and 1990s. In the next section, we summarize the trends over time, documenting the increased rates of adoption in terms of both breadth and depth.

- *ICT and organizational change*. The adoption of these technologies has led many establishments to rethink existing organizational strategies, structures, and practices. In fact, as we will argue in section 3, it is these joint forces of technological and organizational change, and not the technologies by themselves, that are driving the significant changes in employment and the nature of the work.

- *ICT effects on labour demand*. In section 4, we turn to the key question of the impacts of ICT on employment. Research on the effects on both (1) aggregate employment levels and (2) the composition of employment will be reviewed. As we will see, evidence relating to aggregate employment effects is very partial and inconclusive. However, the compositional effect seems clearer with most of the analysis pointing to the conclusion that the diffusion of ICT is shifting labour demand to more skilled workers.

- *Distributional effects of ICT*. We argue in section 5 that ICT is contributing to making earnings distributions more unequal. The shift in labour demand is one factor. As well, training activities sparked by the technologies have been concentrated on the already skilled. It is no surprise, then, that Canadian workers with a lot of human capital tend to see ICT as an opportunity while those without the skills are more likely to see it as a threat.

In the final section, we turn to human resource policy issues. ICT and the flexible organizations and institutions that accompany it are very much at the centre of a new economic paradigm which is forcing governments to rethink traditional approaches to human resource policy. On a variety of counts, longstanding policy strategies seem increasingly ill-fitted to the emerging realities of the labour market which has implications for both productivity and growth and for distributional issues. Education and training must be a priority but the ways in which these are delivered undoubtedly will have to change considerably. However, policy-makers must also address changes in the nature of the employment contract and the basis of economic security, both of which have been fundamentally altered by the interdependent forces of technological and organizational change.

2. Diffusion of ICT

In order to understand the nature and timing of the changes being brought about by ICT, it is important to have an historical perspective on the patterns that have characterized the diffusion of these technologies.

The innovation diffusion literature has documented a consistent pattern that characterizes the spread of most technological changes. The classic s-shaped curve tells us that, when first introduced, new, and especially, radical innovations tend to first spread slowly. Then, as the technology evolves, as new skills develop, as information about the technology spreads, and as the cost of the innovation declines, the rate of adoption accelerates, until it reaches a saturation point. This pattern provides a very good description of what can be observed in the case of ICT from the development of the transistor in 1948, through the appearance of the micro-chip and personal computers in the mid-70s, to the global networking we see today.

These trends can be documented in Canada using a number of surveys which draw a consistent and fairly detailed picture of the patterns characterizing the diffusion of ICT through time. Further, data are available to allow us to document both the *extensive* spread of ICT in terms of the percentage of firms that have introduced ICT and on the *intensive* spread of ICT within companies.

One of these surveys, the Working with Technology Survey (WWTS), has tracked the adoption of ICT since the early 1980s.[3] Table 1 summarizes those trends. In the period 1980-85, the majority of firms reported having introduced ICT. However, the technology was still early in its life-cycle and only a small percentage of employees (16 per cent) were actually working with the technology. Diffusion across firms continued in the 1980s and into the 1990s, till, by the mid-90s, most firms had introduced some ICT, suggesting that a saturation point was being approached in terms of the extensive spread of the technology.

[3] This survey has been conducted three times and, in the process, has followed the experiences of a sample of establishments with information technology and organizational change over the 1980-1994 period. The latest results are reported in McMullen (1997).

Table 1: ICT Adoption Indicators, Working with Technology Survey

	1985	1991	1994
Percentage of respondents introducing ICT	75.5	88.0	82.3
Percentage of employees working with ICT	16.1	37.0	43.1
ICT expenditures as a percentage of sales	0.55	0.62	0.69

Source: McMullen (1996).

The real focus of attention then shifted to a deepening of the technology within firms. By 1991, the percentage of employees working with ICT had more than doubled from its 1985 level, reaching 37 per cent; by 1994, that percentage was 43 per cent. Throughout the period, expenditures on ICT as a proportion of establishment sales increased. At the same time, costs per unit of computing power have fallen exponentially, so that simple measures of spending significantly underestimate the actual volume of computing power being put in place. Other evidence is consistent with these findings and suggests that today, about one-half of Canadian workers use ICT in the workplace (Betcherman, McMullen, and Davidman 1998, forthcoming; Lowe 1996).

The survey data also shed light on trends in the nature of the technologies that have been adopted. Consistent with what we know about technology trends, ICT adoption in the early 1980s consisted primarily of single pieces of equipment, often in the form of word-processors or single PCs, creating "islands" of automation. In the second half of the 1980s, the emphasis shifted to data and communications networks. This process of integration is becoming even more apparent today as the scale of networking continues to expand well beyond the office or the shop-floor to global networking through the internet. Thus, we have seen the nature of technological change shift over the past two decades from its first superficial contact with firms as they introduced single PCs to its current transformative stage as ICT penetrates more deeply into firms, driving changes in organizational and skills structures.

Other survey work has focussed on the spread of advanced manufacturing technologies through time. Statistics Canada studies report that 48 per cent of manufacturing establishments used at least one advanced manufacturing technology in 1989 (Baldwin, Diverty, and Johnson 1995; Baldwin, Diverty, and Sabourin 1995). Overall, labour-enhancing technologies -- i.e, technologies that led to more employment -- showed higher adoption rates than labour-saving technologies in the 1980s, but the adoption of integrated systems of technology was not widespread.

Significant change occurred, however, in the early 1990s in manufacturing. Use of labour-enhancing manufacturing ICT continued to increase significantly. So, too, did the percentage of firms using integrated systems that incorporated a number of technologies simultaneously. Overall, the percentage of firms using integrated systems rose from 23 per cent in 1989 to 38 per cent in 1993. Again, the evidence suggests that, in terms of the extensive diffusion of manufacturing ICT, a saturation point was being approached; by 1993, the shipment-weighted percentage of firms using at least one of the advanced manufacturing technologies had reached 92 per cent.

The diffusion of ICT has been very uneven across the economy. The clear leader has been the dynamic services sector (transportation, communications, and utilities; wholesale trade; finance, insurance and real estate; and business services). In 1994, for example, the mean percentage of employees working with ICT in establishments in the dynamic services sector, at 65 per cent, was significantly higher than for any other sector (McMullen 1997). The traditional services sector (retail trade; accommodation, food, and beverages; amusement and recreation; and personal services) and the goods sector (primarily manufacturing) ranked well below the dynamic services with a mean percentage of about 40 per cent of employees working with ICT.

The evidence on diffusion patterns by firm size is less conclusive. Early studies of the adoption of ICT found that large establishments were much more likely to introduce computer-based technologies than small establishments. However, many of the most intensive users of the technology now are in high-growth industries, especially dynamic services, where there is a significant number of smaller establishments. In addition, with changes in the nature of the technology itself and falling real costs, barriers that at one time impeded adoption have become less important.

In reviewing the evidence on the diffusion of ICT through time, the picture that emerges is one in which the technologies at first spread thinly across the Canadian economy in the 1980s as new adopters were added to existing users. By the mid-1990s, only a very small proportion of businesses had not introduced any ICT. At the same time, existing users continued to invest, deepening the penetration of these technologies within their operations. As a result, the percentage of employees working with ICT has been increasing steadily. As we will see in the next section, this pattern of diffusion has had important implications for the nature and timing of technology-related impacts on organizational structures, on work, and on workers.

3. ICT and Organizational Change

Increasingly, researchers in Canada and elsewhere are taking a broad view of technological innovation, recognizing that it is not the "hard" technologies themselves but rather the interplay between these and organizational changes that determine the economic and employment outcomes.[4]

[4] See, for example, the OECD (1996a) for an international perspective. Like many ideas, this broad conceptualization of "technological change" has diffused slowly and, while it has now become fairly conventional wisdom in academic and policy circles, this was not the case

When we talk about "organizational change," we are referring to changes in the strategies, structures, and practices of organizations. This can involve a number of elements including:

- the basis of *competitive strategy* (i.e., the role of innovation, costs, people, etc.);
- the *structural characteristics* of the organization including hierarchy, functional lines, and organizational boundaries;
- the *work process* including the use of different production inputs, the flow of work, job design, work allocation, and the use of suppliers and subcontractors;
- *human resource management practices*, which can cover hiring and firing, compensation, information sharing, the locus of decision-making, training, and scheduling; and
- *industrial relations practices*, involving the strategies and institutional structures affecting the labour-management relationship.

Information and communication technologies have both necessitated and facilitated organizational changes in these areas. This link is predicated on the fact that the strategies, structures, and practices of organizations are not developed and sustained in isolation. They need to fit both with the organization's environment (e.g., markets and the nature of competition, policy framework, etc.) and with its internal characteristics (e.g., culture, workforce, and technology). When there is a fundamental shift, such as the shifts attendant to something as basic as a new "enabling" or "general purpose" technology, organizations must change as well if they are to be sustainable. The automation of manufacturing, for example, was ultimately accompanied at least in North America by a number of organizational changes which led to a staff-and-line structure, the assembly line, codified human resource management practices, and job control unionism.

While these organizational features – and the stability they engendered – "fit" well in the era of mass production technology, they have been shown to be less appropriate for an ICT-driven technological paradigm. In this environment, flexibility (including cost flexibility) has replaced stability as the underlying organizational imperative. Firms in most industries, and increasingly public sector establishments as well, are experimenting with organizational innovations that are intended to enhance flexibility. Table 2 illustrates the range of changes organizations in Canada have been introducing. These data come from the Workplace and Employee Survey, a recent survey of over 700 establishments in a number of industries. They report on the percentage of the sample that implemented different organizational changes over the 1993-96 period.[5] The table shows the diversity of the innovations -- some are internally oriented, while others are more focused on altering the boundaries of the firm and its relationship to outside agents; some are aimed at reorganizing

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even in the 1980s.

[5] These figures are drawn from Betcherman and Leckie (1998). The Workplace and Employee Survey collected data from both employers and employees on a range of variables, including technological and organizational change. The data presented here have been weighted to make the results representative of the the population of Canadian firms. The survey was carried out by Statistics Canada with the sponsorship of Human Resources Development Canada.

structure, others are directed at reorganizing the work process, while still others are designed to give the firm more flexibility in terms of how it uses labour.

Table 2: Incidence of Organizational Changes, 1993-96, Workplace and Employee Survey

Organizational Change	Incidence Rate (% of establishments reporting change)
Reengineering	32.0
Functional flexibility	26.4
Downsizing	24.9
Flexible work hours	23.2
Functional integration	22.5
Outsourcing	16.5
Greater use of part-time workers	13.7
Interfirm collaboration	12.9
Greater use of overtime	12.7
Greater use of temporary workers	12.6
Delayering	7.6
Decentralization	5.9
Centralization	4.5

Source: Betcherman and Leckie (1998).

As the data reported in Table 2 suggest, organizational changes are not universal; not all workplaces have become "flexible" organizations. The empirical evidence suggests that about one in four firms has. This is roughly true for Canada, as it is for the other advanced industrialized countries (OECD/Government of Canada, 1997). The diffusion of these organizational innovations is not uniform. Incidence tends to be higher among larger enterprises, especially those operating in globally competitive and high value-added markets.

Of most relevance to us are the high correlations consistently found between flexible organizational

systems and the adoption of ICT. This is illustrated by the Workplace and Employee Survey data that show high rates of association between the most common organizational changes, on the one hand, and, on the other, ICT adoption and product or process innovation (Table 3).

Table 3: Incidence of Selected Organizational Changes by Establishment Technology and Innovation Adoption Characteristics, Workplace and Employee Survey

	Downsizing	Reengineering	Functional integration	Flex. Hours	Functional flexibility
	% of establishments				
Product/service innovation in past 3 years					
Yes	21.9	49.0	34.5	22.0	32.4
No	26.1	25.5	18.0	23.7	22.7
Implemented computer technology in past 3 years					
Yes	24.5	43.0	29.6	22.9	31.9
No	25.3	23.5	17.1	23.4	20.4
Implemented other major technology in past 3 years					
Yes	22.8	39.6	28.1	15.6	38.5
No	25.3	30.9	21.7	24.3	23.5

Source: Betcherman and Leckie (1998).

For the purposes of understanding the employment and work implications of ICT, there are three points to be made about the interrelationship between ICT innovation and organizational change:

- The adoption of flexible organizational strategies and practices may be the key to unlocking the "productivity paradox" and eventually generating the income and employment promises of information technology. Economists in many countries have been puzzled by the productivity slowdown that has persisted over the past two decades despite the tremendous investments in ICT. In Canada, for example, the annual increase in real output per hour in the business sector was only 1.3 per cent between 1990 and 1995, compared to 3.4 per cent

in the 1960s and 2.0 per cent in the 1970s. Moreover, this performance has been even worse in the service sector (0.5 per cent annual growth in the 1990s) despite the fact that this sector has received the bulk of the ICT investment.[6]

There are various explanations put forward to explain this paradox including measurement problems. However, there are also hypotheses that have gained currency which argue that the benefits of ICT will arrive only after we have developed an appropriate institutional framework. One key element of this framework is organizational systems that can exploit the productivity potential of the new technologies. This hypothesis receives support from research showing that firms that have adopted complementary technological and organizational practices have more favourable performance outcomes than firms that have not (Baldwin, Diverty, and Johnson, 1995; Betcherman *et al.*, 1994). This means two things: first, we can expect these complementary innovation strategies to continue to diffuse and, second, if they do, we can expect more dramatic employment impacts of ICT.

- One implication of the importance of the organizational side of innovation is that the impacts of ICT are not deterministic. Studies in North America and Europe have shown that the application of a specific information technology in disparate organizational environments can have very different implications for employment, its composition, and the nature of work[7] Thus, in a sense, the frequent debates both popularly and in the academic literature about whether ICT will inevitably lead to higher or lower unemployment or upskilling or deskilling are based on a misunderstanding of the choice involved in what technologies are adopted and how they are applied. Having said this, however, we must recognize the role that "path dependency" plays in shaping all of this. This refers to the constraints on future technology choices that are created by past choices. And, as we will see in the next section, the paths being followed are now mainly in the direction of upskilling job structures.

- Finally, the employment impacts of ICT increase almost exponentially as these technologies penetrate deeply within firms and drive fundamental changes in organizational structures and strategies. In its early stages, a new technology tends to be confined to discrete and existing functions within the organization; in this way, the nature of the work process remains essentially unchanged and the employment impacts are consequently circumscribed. However, as the technologies progressively affect a larger share of the organization's activities, rigidities in the existing structures and practices become apparent and more fundamental organizational changes are pursued. It is at this stage that the nature of work and the number and type of jobs begin to change dramatically. A good example has been the application of ICT in office situations in Canada. The WWTS data have shown that initially, clerical and secretarial occupations were positively affected by the introduction of technologies. In the 1980s, these workers received an important share of the training

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[6] For more detail on the productivity paradox and its potential explanations in Canada, see Sharpe (1997).

[7] See, for example, Shaiken (1984), Zuboff (1988), and a number of contributions in Adler (1992).

opportunities arising from the introduction of personal computers and there was little evidence of the anticipated displacement of these employees. Through the 1990s, however, as the penetration of these technologies deepened, the work process has been reorganized with managerial and professional workers increasingly using the technologies directly (McMullen 1997). In this decade, clerical employment in Canada has decreased by 250,000, a decline of about 11 per cent.

4. ICT Effects on Labour Demand

ICT impacts on labour demand in a variety of ways. First, it can change the total demand for labour, either displacing workers or creating a need for more workers; often, it does both. Second, it can change the nature of demand for workers and thus the occupational structure, by creating whole new sets of tasks to be performed and eliminating others. Third, it can change the nature of individual tasks performed by a worker in a given occupation, causing a change in skill requirements. Each of these has been the subject of considerable debate in the context of ICT since at least the 1960s.

First, with respect to net changes in aggregate labour demand, there is little consensus in the literature. Some observers take the view that the net effect of ICT is to reduce total labour demand as increasingly sophisticated information technologies eliminate the need for workers. Currently this perspective is most popularly associated with Rifkin (1994), though this has been a prominent view of technology impacts for a long time. In its present version, this argument pivots on the contention there is no new economic sector to absorb displaced workers as there was when first manufacturing, then services, absorbed workers who were displaced during previous technological revolutions. It is also partly based on the argument that globalization is magnifying the effects of ICT since multinational corporations essentially operate in a borderless environment, forcing workers to compete worldwide for jobs.

The counter argument is that technological forecasting is inherently a “mugs game,” since its goal is to predict the appearance of technologies, and by extension, industries and economic activities, that do not yet exist. Those in the optimistic camp generally point to history and the emergence of economic activities that had not been imagined before new technologies appeared. A generation ago, who would have forecast the job opportunities associated with the information highway of internet sites, web-masters, mutimedia producers, and chip manufacturers?

As for direct evidence on the net employment effects of ICT, there is very little. Economic theory tells us that the productivity gains stemming from technological change will result in increased product demand and so, to job growth. In reality, the net employment effects of technological change are very difficult to measure, for a number of reasons. First, it is hard to isolate the impacts of technology from the variety of other factors that affect firm competitiveness and growth. Second, it is hard to measure technological change; this is especially the case for ICT which has simultaneously encompassed large gains in quality and decreases in real costs. Third, it is also hard to know what to compare an ICT world to -- that requires that we have a good idea of what would have happened to net employment had ICT not been developed and widely applied.

At a micro level, the productivity gains that are assumed to accompany ICT should translate into employment gains as companies that use the technology gain a competitive edge over less-skilled users of the technology and over non-users. And, indeed, the evidence from the three waves of the Working with Technology Survey points to a pattern in which more intensive users of ICT experience stronger sales and employment growth than non-users (McMullen, Leckie, and Caron 1993; McMullen 1997). However, while internally consistent, results such as these cannot tell us whether high rates of sales and employment growth come from ICT use or whether the causal relationship runs in the other direction. More detailed analysis found that the strongest influence on employment growth was sales growth itself – businesses that are successful in expanding their sales tend to hire more people. In turn, sales growth was affected by a number of factors, including technological intensity; at the same time, successful businesses will have more capital to invest in technology.

In their study of ICT in the manufacturing sector, Baldwin, Diverty, and Johnson (1995) analyzed the linkages between technological change and firm performance using a broader group of indicators, including growth in market share, labour productivity, and employment share. They find that users of manufacturing ICT gained market share at the expense of non-users. But, users of labour-enhancing technologies in particular, showed significantly larger productivity gains than non-users. The net effect was that the change in employment share, while positive, was lower than the change in market share because of the productivity gains.

What are the effects of these technologies on the overall industrial structure? Recent analysis based on input-output data concludes that structural change in the Canadian economy since the 1970s has been shifting output and employment toward industries that are knowledge- and technology-intensive (Gera and Massé 1996). Other research has found that the fastest growth rates since the mid-1970s have occurred in the information services industries which are part of the dynamic services sector where, as we have seen, ICT has penetrated most deeply.

These industry growth patterns are paralleled by trends in the occupational composition of employment. The share of employment in information-intensive occupations has grown substantially, rising from 45 per cent of employment in 1971 to reach almost 60 per cent in the mid-1990s (Betcherman, McMullen, and Davidman 1998, forthcoming). As well, the nature of information work has been shifting from the lower-skilled "data" occupations to the higher-skilled "knowledge" workers.[8] Overall, this ratio dropped from just over 5 data workers for each knowledge worker in 1971 to about 2 in the 1990s. Thus, even as the share of information workers is increasing, so too is the employment share of highly skilled occupations within that group.

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[8] Following a methodology developed by Osberg, Wolff, and Baumol (1989), occupations can be divided into four groups – services, goods, data, and knowledge. "Data" workers (for example, clerical workers, sales workers, and bookkeepers) deal with the production of data and are generally considered to be lower skilled. "Knowledge" workers (for example, scientists, engineers, managers, and writers) are concerned with the development and interpretation of information and are generally considered to be higher skilled.

At the firm level, there is mounting evidence that the intensification of ICT use is driving a process of occupational upgrading. The WWTS asked responding companies what types of jobs had been created and eliminated when ICT was introduced. The results, summarized in Table 4, indicate that the positions created around ICT have been very different from those that have been eliminated. Professional positions accounted for over half (56 per cent) of all the jobs created, whereas intermediate and unskilled positions accounted for only 16 per cent. In sharp contrast, intermediate-level positions represented close to 60 per cent of the job-types that were eliminated; less than 10 per cent were professional or managerial jobs.

Table 4: Share of Job-types Created and Eliminated, 1992-94, Working with Technology Survey III

Skill Level	Jobs Created	Job-types Eliminated
	(Per cent)	(Per cent)
Managers	6.5	2.2
Professionals	56.4	6.7
Skilled technical	21.2	26.7
Intermediate	11.3	60.0
Unskilled	4.6	4.4
Total	100.0	100.0

Source: McMullen (1996).

The more detailed occupational data collected by the WWTS indicate that the bulk of the positions created because of ICT were, in fact, occupations directly related to the technology itself -- computer programmers and systems analysts, and managers of information systems and data processing. Thus, the survey evidence suggests that, while ICT does create new opportunities within organizations, these tend to be narrowly concentrated. On the other hand, just over half the job-types eliminated consisted of clerical occupations.

These patterns of job creation and destruction lead to very different occupational profiles in organizations that are major users of ICT and those that are not. Table 5 shows these profiles for "high-ICT" and "low-ICT" WWTS respondents. The high-ICT group had significantly higher shares of managers, professionals, and other office workers and a much lower share of unskilled employees.

Table 5: Occupational Structure, Low- and High-Tech Establishments, 1994, Working with Technology Survey III

	Low Tech[1]	High Tech[1]
	(Per cent)	(Per cent)
Managers	7.3	13.6
Professional/technical	7.9	17.6
First-line supervisory	5.2	7.0
Skilled production	28.2	25.3
Unskilled	36.4	10.5
Sales	7.5	10.1
Other office	6.6	16.1
Total	100.0	100.0

[1] The low-tech group includes establishments at or below the median (35.6 per cent) for percentage of employees working with computer-based technologies in 1994; the high-tech group includes establishments above the mean. The figures refer to establishment mean percentage shares.

Source: McMullen (1996).

Technological change can also affect skill requirements by altering the content of work. Indeed, this issue has been the subject of debate for some time. Both the waxing and waning of the de-skilling argument and the increasing prominence of the view that ICT has an upskilling effect on jobs are a reflection, in part, of changes that have taken place through time in the nature of ICT technology.

The earliest incarnations of ICT -- such as mainframe computers or early numerically controlled machine tools -- dictated a centralization of operations and control because of their size and complexity. That, combined with the dominant management philosophy of the time which focused on the task-simplification potential offered by automation, led to the centralization of programming and control functions and an attendant loss of discretion and control for individual workers. However, as more workers became familiar with the technologies and as the technologies themselves evolved, responsibility for programming and machine control moved out of the centralized locations back to workers (Attewell 1992).

Recent reviews underscore the importance of considering both the innovation process and, as we

have argued, the organizational and managerial context in examining the effects of ICT on skills. Attewell (1992) reviewed a number of studies investigating the nature of skill shifts through time for a range of occupations. The evidence points to increases in complexity, responsibility, and accountability. Workers' roles have been changed as ICT systems have integrated business processes, led to the aggregation of tasks, and increased the amount of lateral dependence in organizations.

The most recent wave of the WWTS addressed this question of job content by asking establishments how the job requirements for their "core" employees had been affected by ICT over the three years covered by the survey.[9] Three dimensions of skill were considered: know-how, problem-solving, and autonomy. The results suggest that, along each of these dimensions, ICT had a modest upskilling effect. This finding holds for each of the five occupational groups considered. Upskilling was most evident in terms of "know-how" -- the technical, specialized knowledge needed to perform a job. Further, it was most pronounced in establishments that ranked high in terms of technological intensity -- a finding which, again, may provide a window on likely future trends.

How this is playing out in the labour market can be seen in the data on trends in ICT use by occupation. Data from the 1994 General Social Survey show that the most extensive use of ICT is found in two clusters of occupations -- knowledge workers (managerial and administrative occupations; life sciences, mathematics and computer occupations; and architects and engineers); and clerical workers. The majority of workers in these two groups reported that their jobs had been "greatly affected" by computerization and most of those indicated both that the skill requirements for their job had increased and that their jobs had become more interesting (Lowe 1996).

[9] "Core" employees were defined as "the largest group of employees...directly involved in making or providing the [establishment's] principal product or service." See McMullen (1997).

Overall, then, the evidence strongly points to a process wherein ICT is increasingly shifting demand to skilled labour. And, even as this process is occurring, the skills required of already highly-skilled workers also are rising.

5. Distributional Effects of ICT

Concerns about income distribution have assumed a high profile in the past couple of decades. As we will see in this section, there are plausible connections between the wide diffusion of ICT during this period and the increases in earnings inequality and polarization that have occurred in some industrialized countries. It is difficult, however, to conclusively determine how much of the changes in income distributions have been due to ICT, largely because technological change is so hard to isolate and measure.

Starting with the international perspective, it is important to note that earnings distribution trends have by no means been uniform across the major industrialized nations (OECD 1996b).[10] Drawing from the experience of the G-7 countries over the 1980s and 1990s, we find: (1) countries where earnings have become less equally distributed (the United States and the United Kingdom); (2) others where there has been little overall change (Japan, France, and Italy); and (3) distributions that have become more equal (Germany).

Canada, with moderate increases in inequality and polarization, fits somewhere between the first two experiences. The trends between 1981 and 1995 in real annual earnings by labour force decile are shown in Table 6. The only gains were in the top two deciles (with the highest decile having by far the largest gains) while real losses were experienced by everyone else and especially those in the bottom decile.[11] This pattern also describes the experience of male workers except that the magnitudes of the losses at the bottom of the distribution have been much larger. For women, the trend has been quite different, with real earnings growth of similar magnitude in all deciles (except

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[10] Definitional issues need to be taken carefully into account in considering income distribution. The types of income included can vary (i.e., total income or just earnings); the unit of analysis can be the individual or the family; and samples can differ in terms of which individuals are included (i.e., ranging from all to only those with full-time, full-year employment). The OECD analysis pertains to trends in the distribution of earnings of individuals with full-time, full-year employment. It should also be noted that there are a variety of distributional measures, some of which capture "inequality," which is the degree to which members of the population have equal shares of the aggregate income, and others measure "polarization," which is the extent to which the population is concentrated at the top and bottom ends of the distribution. For a discussion of these measurement issues, see the appendix to Beach and Slotsve (1996).

[11] There were different trends within this complete period that are lost when we only examine end points. Picot (1997) highlights the fact that much of the increase in polarization and inequality occurred during the recession of the early 1980s.

the bottom one where growth has been smaller).

Table 6: Percentage Change in Real Annual Earnings, by Decile and by Sex, All Paid Workers, Canada, 1981-95

Decile	Men	Women	All workers
	(% change in real annual earnings, 1981-95)		
1	-31.7	9.8	-11.4
2	-24.5	17.1	- 4.1
3	-21.6	17.5	- 5.0
4	-17.7	13.6	- 5.4
5	-12.3	11.9	- 3.5
6	- 8.5	13.4	- 2.0
7	- 4.7	13.7	- 1.7
8	- 2.2	16.1	- 0.2
9	0.5	17.0	1.0
10	6.2	17.9	5.5
All deciles	- 4.8	15.7	0.1

Source: Picot (1997).

In countries where earnings have become more unequal, a number of possible explanations have been put forward.[12] These tend to focus on either institutional factors or labour demand factors. The former involves the potential role of developments like the weakening of collective bargaining and labour market deregulation (including real declines in minimum wages) in changing income distributions and, particularly, in explaining relative earnings decreases for low-wage workers. It is interesting to note that generally the countries where distributions have become more unequal have experienced institutional changes along these lines while this has not been the case, at least not to the same degree, where earnings distributions have remained stable.

While institutions do seem to matter, then, the research does emphasize the central role of shifts in labour demand in driving the growing inequality where it has occurred. There are three variants of

[12] For comprehensive reviews, see Levy and Murnane (1992) and Gottschalk and Smeeding (1997).

this labour demand story. The first focuses on deindustrialization which, it is argued, involves a shift in the economic structure toward service industries that have less equal wage distributions than declining goods sector industries. The second highlights the role of globalization and trade in increasing the demand in industrialized countries for products and services that require high-skill labour while decreasing demand for output produced by low-skill workers. The third is technological change and its skill "bias" which, as we have seen, is clearly toward high-skill labour.

These three trends are all closely interrelated and thus difficult to disentangle through empirical analysis. This is especially true in Canada (at least relative to the U.S. and some other countries) where data to diagnose why distributional changes have occurred have been scarce until very recently. Nonetheless, analysis carried out with U.S. data coupled with what we have learned about the employment impacts of ICT do suggest that technological change has important distributional implications (especially where labour markets are flexible).

There are three additional points to make about the distributional effects of information technology in Canada.

First, the more moderate inequality trend compared to the U.S. and the U.K. does not mean that technology has not had the same effect on labour demand in Canada. Rather, any differences may well be due to the fact that postsecondary enrolment in Canada has grown dramatically over the past two decades with the result that the increased supply of well-educated workers has held down earnings growth at the upper end of the distribution. The fact that increased returns to education have still been observed in Canada suggests that the demand for highly-skilled labour has outstripped even the strong growth in supply.[13]

Second, the upward skill bias of ICT which we have already documented does not mean that there are no low-skill jobs in the economy. Indeed, there are, especially in consumer and personal service industries. However, the relative share of these jobs is declining and the still ample supply of workers with low levels of education means that competition for those jobs is intensifying with the result that wages are being bid down and employment opportunities for low-skill workers are falling dramatically. As evidence of the latter point, consider a comparison of employment-to-population ratios between 1976 and 1996. The aggregate ratio was very similar between the two years, increasing only slightly from 57.1 to 58.6. For Canadians with postsecondary degrees or certificates, there was virtually no change. However, for those without high school, the employment rate dropped almost 20 points, from 42.1 to 23.3.

Finally, access to ICT in the workplace is part of a chain of events that appears to be creating virtuous employment circles for some Canadians, primarily those who already have a lot of human capital, while creating more vicious ones for others. Various studies have found that well-educated employees in professional and managerial occupations are most likely to work with information technology. And, working with ICT has been associated with a wage premium as well as increasing

[13] See Riddell (1995) for evidence of increasing returns to education. Admittedly, however, the Canadian evidence has not been as strong as the U.S. results on this point.

skill requirements and access to training (Lowe 1996; McMullen 1996).[14] Thus, it is skilled and well-educated workers who appear to be receiving a disproportionate share of both the short-run and long-run benefits of the technology. This circle of relationships is consistent with scenarios pointing to increased labour market inequality. It is not surprising, then, that well-educated Canadians tend to perceive the increasing importance of ICT and the information highway as opportunites while the less educated are much more likely to interpret these as threats to employment and economic security.[15]

6. Public Policy Issues

For at least a decade, technological change has been central to the debates around employment and human resource policy in Canada. Think tank reports, election platforms, and preambles to legislation routinely stress the fact that Canadians are now in a new economic era defined by information technology, that people are the key to prosperity in this emerging economy, and that human resource strategies are now more important than ever. The conventional (and largely empirically supported) wisdom is that the "rules of the game" have changed -- that our historically high rates of growth and productivity can no longer be guaranteed by rich natural resources but that they will increasingly be dependent on the skills and knowledge embodied in the workforce. The corollary of this is that human capital is now a prerequisite for participation in the information economy. The rhetorical emphasis on human resources, then, has both efficiency and equity underpinnings.

Public opinion polls show that most Canadians recognize these new rules. They rate education as a top priority for governments, postsecondary enrolment levels remain very high, and skills development is widely identified as a key for individuals to navigate in the economy. However, polls also show that there is a great deal of anxiety about the future of work. Canadians are not sure that they will have access to the education and training opportunities they understand are so important. They are concerned about a weakened safety net. And they are concerned about jobs. Unemployment has not dropped below 9 per cent in this business cycle and many Canadians believe that high unemployment will be an inherent feature of the ICT era.

While jobs are seen as the number one priority by the voters, governments of all political stripes have adopted the new orthodoxy that employment creation is not something that is directly "done" by governments. In this view, the most important thing is to get the fundamentals right in terms of macroeconomic policy and then ensure that the micro framework supports the innovation and knowledge creation on which growth and, thus, employment are based. In this paradigm, then, the

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[14] The wage premium associated with computer use was first established in the U.S. by Krueger (1993). Recent unpublished Canadian analysis using Statistics Canada's Workplace and Employee Survey supports this finding.

[15] See Lowe (1996) for evidence in support of this. More recent data on these differences in the perception of ICT have been collected by Ekos Research Associates in a study that has not yet been released.

focus of human resource policy-makers is on the "supply side," primarily on human capital investment and on labour force adjustment.

There have been some interesting initiatives in Canada in these areas in recent years. However, governments at both the federal and provincial levels are uncertain about how to deal with old problems, many of which are getting worse, in new ways. International testing and literacy surveys show that far too many Canadians lack the basic skills that are so necessary in a high technology economy. There are difficult access and funding issues associated with postsecondary education and retraining. Effective programming to improve transitions from welfare or unemployment to work remains elusive. Addressing these education and training concerns has been affected by three complications: (1) public debt levels that have led to major cutbacks; (2) sustained pressures on government to redefine its role vis-à-vis the private sector and move away from big, top-down solutions; and (3) jurisdictional issues between the federal and provincial levels. The first of these is abating as the fiscal situation improves; however, the way forward on the second and third seems less clear.

In the final analysis, human resource strategies will be central to the "social contract" in an economy based on information technologies and the "flexible" organizations and institutions that seem inevitably to accompany them. The cornerstones of economic security in the industrial era – full employment and the welfare state – have been weakened in the current technological and economic transformation and, in the process, the social contract they supported has become more fragile. A new social contract seems likely to depend less on full employment and "passive" income guarantees and more on access to lifelong learning and "active" supports to enhance employability. It is difficult to imagine, however, that a consensus can be built on this foundation alone because of the ways in which information technology is altering labour demand, the nature of the employment contract, and income distributions. Revitalized forms of social insurance and assistance also seem essential.

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