Catalogue no. 11-622-MIE — No. 002
ISSN: 1705-6896
ISBN: 0-662-34075-2

Research Paper

The Canadian Economy in Transition

The growth and development of new economy industries

by Desmond Beckstead and Guy Gellatly

Micro-economic Analysis Division
18th Floor, R.H. Coats Building, Ottawa, K1A 0T6

Telephone: 1 800 263-1136

Statistics Canada　Statistique Canada

Canada

How to obtain more information

For information on the wide range of data available from Statistics Canada, you can contact us by calling one of our toll-free numbers. You can also contact us by e-mail or by visiting our Web site.

National inquiries line	**1 800 263-1136**
National telecommunications device for the hearing impaired	**1 800 363-7629**
Depository Services Program inquiries	**1 800 700-1033**
Fax line for Depository Services Program	**1 800 889-9734**
E-mail inquiries	**infostats@statcan.ca**
Web site	**www.statcan.ca**

Ordering and subscription information

This product is available in electronic format on the Statistics Canada Internet site, for free, as Catalogue no. 11-622-MIE. To obtain single issues, visit our Web site at **www.statcan.ca**, and select Products and Services.

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner and in the official language of their choice. To this end, the Agency has developed standards of service which its employees observe in serving its clients. To obtain a copy of these service standards, please contact Statistics Canada toll free at 1 800 263-1136.

The Canadian Economy in Transition Research Paper Series

The Canadian Economy in Transition is a series of new analytical reports that investigate the dynamics of industrial change in the Canadian economy. This new series brings together a coherent set of research reports that provide users with a wide variety of empirical perspectives on the economy's changing industrial structure. These perspectives include the dynamics of productivity, profitability, employment, output, investment, occupational structure and industrial geography. Readers are encouraged to contact the authors with comments, criticisms and suggestions.

The primary distribution medium for the papers is the Internet. These papers can be downloaded from the Internet at www.statcan.ca for free. Papers in the series are distributed to Statistics Canada Regional Offices and provincial statistical focal points.

All papers in *The Canadian Economy in Transition* Series go through institutional and peer review to ensure that they conform to Statistics Canada's mandate as a government statistical agency and adhere to generally accepted standards of good professional practice.

The papers in the series often include results derived from multivariate analysis or other statistical techniques. It should be recognized that the results of these analyses are subject to uncertainty in the reported estimates.

The level of uncertainty will depend on several factors: the nature of the functional form used in the multivariate analysis; the type of econometric technique employed; the appropriateness of the statistical assumptions embedded in the model or technique; the comprehensiveness of the variables included in the analysis; and the accuracy of the data that are utilized. The peer group review process is meant to ensure that the papers in the series have followed accepted standards to minimize problems in each of these areas.

Statistics Canada
Micro-economic Analysis Division

The growth and development of new economy industries

Desmond Beckstead and Guy Gellatly

Published by authority of the Minister responsible for Statistics Canada

May 2003

Catalogue no.11-622-MIE no. 002
Frequency: Occasional

ISSN 1705-6896
ISBN 0-662-34075-2

Ottawa

La version française de cette publication est aussi disponible (nº 11-622-MIF nº 002 au catalogue).

The authors' names are listed alphabetically.

This paper represents the views of the authors and does not necessarily reflect the opinions of Statistics Canada.

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

Acknowledgements

We are especially grateful to Jean-Philippe Daigle of the Micro-economic Analysis Division at Statistics Canada for his exemplary work in preparing the data resources for this study, and in assisting with many of the tabulations reported herein. Mr. Daigle’s programming and database skills were critical to this and other projects being conducted by our research group which examine different aspects of industrial change. We would also like to thank Tarek Harchaoui, Faouzi Tarkhani, Wulong Gu and Sëan Burrows from the Micro-economic Analysis Division at Statistics Canada for their assistance in developing the investment and multifactor productivity estimates reported in this study.

We also wish to thank John Baldwin of the Micro-economic Analysis Division for his many helpful comments and suggestions on our research design. Finally, we wish to acknowledge the members of the National Accounts Advisory Committee for their comments on an earlier draft of this paper.

Table of Contents

Preface

This study explores the industrial dimensions of the New Economy. It examines the growth and development of industries that provide the technological and scientific foundations for the New Economy—a collection of information and communications technology (ICT) industries, both in services and in manufacturing, along with a larger group of science-based industries, which includes most elements of the technology sector, along with many other goods and service industries that make proportionately large investments in research and development (R&D) and human capital. Focusing on the 1980s and 1990s, our comparative profile examines whether the production and performance characteristics of ICT and science industries differ from more traditional elements of the business sector.

A range of production characteristics and performance measures are examined. We explore differences in labour markets by examining the knowledge-intensity of the (industry) workforce, the growth in labour quality, and patterns of remuneration. Our analysis of capital structure includes investment-to-GDP and investment-to-labour ratios, based, first, on all capital investments, and second, on a subset of high-technology assets (computers, software and communications equipment). Patterns of R&D expenditure are also evaluated.

Our exploration of industry performance is based on patterns of labour and multifactor productivity. Differences in corporate profitability are examined, focusing on margins and rates of return. We also investigate Canada's trade in ICT and science-based commodities.

Executive Summary

1. Which industries make up the New Economy?

This paper explores the growth and development of Canada's ICT and science-based industries. These industries play an important role in shaping the emerging industrial structure of the New Economy—ICT industries develop, deliver and support advanced information and communications technologies, products and services at the heart of the technology revolution, while science industries make large investments in R&D and scientific workers, both key sources of industrial innovation.

Our empirical analysis is grounded in a series of research issues that are designed to explore the evolving industrial structure of the New Economy. First, we want to know whether ICT (or technology) industries exhibit different production and performance characteristics than more traditional industries (and if so, how different). Second, we are interested in evaluating whether a singular focus on the technology sector yields an adequate account of the New Economy landscape, or whether there are other clusters of R&D-intensive industries which also warrant attention on the basis of their labour, capital and output characteristics.

Last, we want to learn which industrial clusters within the ICT and science economies serve as the main engines of growth. Are certain elements of the ICT and science landscape more dynamic than others, or are New Economy industries relatively homogenous in terms of their production and performance characteristics? Much of the focus on the technology revolution has centered on two core ICT services, computer services and telecommunications. Are these industries always at the vanguard of industrial change?

Following the definitional framework proposed by the OECD (2000a), 19 separate (4-digit) industries are classified to the ICT sector, 10 in manufacturing and 9 in services. These ICT industries are grouped into three subsectors: (1) core ICT services (i.e., computer services and telecommunications carriers), (2) other ICT services (e.g., cable television and ICT wholesaling) and (3) ICT manufacturing (e.g., electronic products).

A recent Canadian study of business strategies in science environments (Baldwin and Johnson, 1999) classified 51 (4-digit) industries as science-based. This list of science industries includes both technology and non-technology industries, as defined by the OECD's ICT classification. For this study, science industries are also grouped into three subsectors: (1) ICT-based science industries, (2) non-ICT science-based goods industries (e.g., aircraft industries, chemical industries and pharmaceuticals), and (3) non-ICT science-based services (e.g., architecture, engineering and technical services).

These ICT and science industries account for a small, but growing, share of overall business activity. In 2001, firms operating in ICT industries accounted for 5.5% of business sector employment and 5.7% of business revenue. R&D-intensive science industries operating outside the technology sector make up an additional 5.2% of employment and 6.9% of revenue.

We should stress that our perspective on the New Economy's industrial structure is *production-orientated*, and not *use-orientated*. Our focus herein rests with profiling industries that develop, deliver and support investments in technology (ICT industries), or industries that make large investments in R&D-based innovation and scientific personnel (science industries). The take-up of new technologies has reshaped production routines in ICT and science environments, *and* in many other sectors of the economy. Accordingly, we are also interested in how differences in technological intensity across industries, ICT, science or otherwise, are correlated with different aspects of production and performance. While a profile of technology use would shed additional light on the structure of the New Economy, we reserve this for subsequent research.

2. What do we want to learn about New Economy industries?

This study compares the production and performance characteristics of ICT and science-based industries with more traditional elements of the business sector. Its core objective is to evaluate whether ICT and science-based industries—industries that provide the technological and scientific foundations for the New Economy—exhibit different input structures and performance characteristics than more traditional goods and services industries.

This dual focus on input structure and performance is important. Many of the policies designed to promote industrial competitiveness center on improving labour and capital inputs, for example, by encouraging investments in skill development and training, or by reducing the costs of acquiring advanced technology or instituting R&D programs. An analysis of how input requirements in ICT and science industries compare with more traditional sectors may aid in the development of policies designed to foster growth in more innovative and technology-based environments.

An analysis of industrial performance is important because it helps us to understand the extent to which the industrial transitions at work within the New Economy have a positive impact on our competitive prospects. Many exponents of the New Economy have linked its emergence to a new era of higher productivity and corporate profitability. We are interested in learning whether these gains are more apparent in technology and science industries—industries at the heart of the innovation systems that drive the technology revolution.

… How do we evaluate differences in input structure?

Differences in input structure are evaluated here using a range of production indicators: the knowledge intensity of the workforce; long-run growth trends in labour quality; absolute and relative wages; and expenditures on capital and new technologies, evaluated in relation to value added (our proxy for investment intensity) and in relation to labour inputs (our proxy for capital intensity).

… How do we evaluate differences in performance?

Our analysis of performance centers on a small set of key indictors: labour productivity, multifactor productivity and profitability. Three profitability measures are reported—margins, returns on equity and returns on capital employed. We also examine one other structural characteristic of ICT and science industries, their trade orientation. Export-to-output ratios are reported, along with trade balances in ICT goods and science-based goods.

… What can an analysis of inputs and performance tell us?

The research design described above allows us to ask some basic questions about the industrial structure of the New Economy. First, we want to learn if the technology sector has a fundamentally different long-run profile than other less visible industries. Which elements of the production process have received more emphasis in ICT industries? Which facets of their performance record set them apart from other sectors of the economy?

This spotlight on ICT brings two additional research questions into view. First, does a singular focus on the ICT sector, home to firms that develop and support many of the innovative technologies that fuel the technology revolution, capture the most dynamic elements of production and performance in the New Economy, or does it risk omitting an interesting group of industries that resembles the ICT sector in many crucial respects? We address this issue by also focusing on a larger grouping of R&D and skill-based science industries that includes many non-ICT industries. Finally, we also ask whether the engines of growth in the New Economy emanate from narrow clusters of industries within ICT and science-based environments. Much of the analytical interest has been on core ICT services, such as computer services and telecommunications carriers. Are these industries continually at the forefront of industrial change, or are ICT and science-based manufacturing industries also major sources of dynamism in the New Economy?

3. The ICT sector as the vanguard of the New Economy

Our results support a view of the ICT sector that is highly dynamic. For many of the production and performance statistics evaluated herein, the ICT average exceeds that for other R&D and skill-based science industries, and, often by a considerable margin, for industries that fall outside the ICT/science group.

The rapid growth of the technology sector is a central characteristic of the New Economy. From 1987 to 1997, real GDP in the ICT sector increased by 96%, compared to 28% for non-ICT, non-science industries. Firms in the ICT sector employed 44% more workers in 1997 than in 1981. By comparison, employment outside of ICT and science industries increased by 24%.

Dynamism in ICT industries extends well beyond output and employment growth. Knowledge workers comprise a large, and growing, share of the ICT workforce. In 1981, one in four workers in the ICT sector was knowledge-based; by 1996, nearly one-half of the ICT workforce was made up of knowledge workers. This while the percentage of knowledge workers outside ICT and science industries actually declined, from 17% in 1981 to 12% in 1996.

Firms in ICT industries also channel a much larger share of their output into New Economy technologies, such as computers, software and communications equipment. Over the 1981 to 1997 period, the investments in these technologies made by ICT industries averaged 13% of their total GDP. For industries outside the technology sector, this average did not exceed 3%. ICT industries also maintained higher stocks of technology investments relative to the size of their workforce. In 1997, the ratio of technology expenditures to hours worked stood at 5.5. For non-ICT, science-based goods industries (i.e., a collection of heavy manufacturing industries including industrial chemicals, pharmaceuticals, and aircraft manufacturing) this ratio stood at 1.6. For industries operating outside the ICT and science sectors (the vast majority of business sector industries), technology expenditures to hours worked stood at 0.7.

New Economy technologies have been linked to improved productivity performance. Firms in ICT industries produce many of these technologies, and are also heavy consumers of these technologies. Long-run labour productivity gains in the ICT sector (averaging 3.7% per annum from 1987-1997) significantly outpaced those in non-technology and non-science environments (1.4%). After accounting for differences in capital intensity, long-run multifactor productivity (MFP) growth in ICT industries (calculated from 1981-1997) averaged 1.8% per year; industries outside of ICT and science averaged only 0.4% annual MFP growth.

4. Substantial economic dynamism outside of ICT, especially in science environments

ICT industries are highly dynamic. But a singular focus on the technology sector will overlook other industries that play an important role in the transition towards knowledge-based production. Our complementary focus on non-ICT, R&D-intensive science industries corroborates this view.

Employment and GDP growth have also been substantial in R&D-intensive industries outside the technology sector, particularly in services. Real GDP in science-based services increased by 61% over the 1987-1997 period, almost double the amount of growth in non-ICT, non-science based services (34%). Long-run employment growth in science-based services also outpaced job creation in more traditional services industries.

Knowledge workers are just as important in science industries as in the technology sector. In 1996, 71% of the workforce in science-based services was classified as knowledge-based, compared to 53% in core ICT services (computer services and telecommunications).

Science-based services also enjoyed larger long-run improvements in labour quality, exceeding those in ICT industries. Wage rates in science industries have also kept pace with those in the ICT sector.

Although ICT industries invest more heavily in technology assets, science industries also maintain high investment-to-GDP and investment-to-worker ratios, much higher than the corresponding averages calculated for more traditional industries. When the full spectrum of investments is considered (and not just new technologies) science industries exhibit investment profiles that, for much of the post-1981 period, equal or surpass those in ICT.

While labour productivity growth in non-ICT science industries has not been as rapid as in the ICT sector, a very different picture of productivity performance emerges after controlling for capital intensity. Long-run MFP growth in non-ICT science industries (38% cumulative over the 1981-1997 period) actually exceeds that in the ICT sector (32%).

Science industries also experienced higher profit margins than ICT during the 1990s. Average profit margins in science industries over the 1988-1998 period was 12.4%, compared to 8.6% for the ICT sector.

Even outside the technology and science sectors, there are large numbers of industries that surpass the ICT average when evaluating different input and performance characteristics. Nearly one-quarter of other industries exhibited growth in hours worked and total employment that surpassed the corresponding growth averages for ICT. Real wage levels were also higher in about one-quarter of non-ICT, non-science industries. A similar pattern was evident when examining performance indicators. Real GDP growth in the ICT sector nearly doubled over the 1987-1997 period. Yet 10% of non-ICT, non-science industries exceeded this average. Rates of labour productivity in 18% of industries operating in non-technology, non-science environments eclipsed the labour productivity average for the technology sector. And 32% percent of these traditional industries enjoyed superior MFP performance. While only 12% of industries outside of ICT and technology environments experienced higher profit margins, sizeable majorities (62% and 58%, respectively) enjoyed higher returns on equity and returns on capital employed than the ICT sector.

There are also groups of industries outside of our ICT and science boundaries that compare favourably with ICT when evaluating a range of input and performance characteristics simultaneously. A small cluster of automotive industries is illustrative—these industries exhibit rates of long-run GDP growth, employment growth and MFP growth that surpass the growth average for industries in the ICT sector.

5. Patterns of growth within ICT and science differ

Our analysis of industrial structure classifies business sector industries into three broad groupings: (1) ICT (or technology) industries, (2) science-based industries, and (3) all other (non-ICT and non-science) industries.

ICT and science environments were found to be very dynamic in many of their production and performance characteristics. But the source of this dynamism depends very much on which aspect of production or performance is being considered.

The industries that make up the ICT and science sectors are heterogeneous in their input and performance characteristics. We evaluated this heterogeneity by focusing on distinct subsectors within these ICT and science environments. And we found that overall trends within ICT and science often obscure highly variable performance patterns emanating from narrow clusters of industries.

Much of the New Economy focus has been directed towards core technology-based services: computer services and telecommunications. These core services lead other elements of the ICT and science economies in GDP growth, employment growth, and investments in new technologies. However, other groups of ICT and science industries excel in other aspects of production and performance. Knowledge workers, as a percentage of the workforce, are more highly represented in science-based services than in core ICT industries. And these R&D-based services have enjoyed higher rates of labour quality growth. Wage levels in ICT manufacturing have been gaining ground on core ICT services during the 1980s and 1990s. And by the late 1990s, the average real wage in science-based goods exceeded that in core ICT services.

Overall levels of capital intensity in science-based goods industries are also comparable to those in core ICT services. The same is true of profit margins, which are higher in science-based goods and core ICT services than in other New Economy sectors.

The most striking findings emerge when evaluating productivity performance at the subsectoral level—as core ICT services industries are overshadowed by ICT and science-based manufacturing. Long-run labour productivity growth, at 6.7% annually, is much higher in ICT manufacturing than in core ICT services (2.4%). Even after controlling for capital intensity, ICT manufacturing industries exhibit much higher annualized MFP performance than core services. Long-run MFP growth is also significantly higher in science-based goods industries (2.6%) than in any of the service subsectors examined herein. Productivity gains in the New Economy are heavily concentrated in manufacturing.

Chapter 1. Introduction

Over the last decade, the idea of a New Economy has gained widespread currency among economists and business analysts. Proponents of the New Economy talk about a fundamental restructuring in the way the economic system operates—restructuring brought about by the integration of information and communication technologies into many business models, and their impact on systems of production, distribution and consumption. New information and communication technologies have had a revolutionary impact on the institutional structure of the modern economy. New technologies have expanded the boundaries of competition. These technologies serve as a catalyst for the new products and processes that fuel systems of innovation and growth. New technologies have also reshaped the rules for consumers. Search costs have been reduced. Delivery mechanisms that provide access to products and services have been enhanced. As a result, consumers can now avail themselves of far greater choice than in times past.

The idea of a New Economy is multidimensional. We not only find ourselves in a New Economy, but also in a knowledge-based economy, a digital economy, an information economy, an internet economy, an innovation economy, a high-tech economy, a real-time economy, and a global-economy. Central to each of these concepts is the notion that the use of advanced technologies, particularly information and communications technology, is related to economic progress. Consequently, the advent of New Economy technologies has left an indelible mark on the policy agenda—as governments shift their priorities from "industrial economies" to "information economies".[1] Technology use and information management have supplanted scale economies as the cornerstone of industrial competition. Hence, "business and consumers must adapt to a more competitive global economy where success depends on the development, acquisition and use of knowledge", an economy where growth is "increasingly driven by information" (Industry Canada, 2001, pp. 2 and 9). Accordingly, policy priorities are fashioned with New Economy objectives, such as technological literacy, in mind. The Federal government's connectivity agenda—with its stated objectives of transforming Canada "into the most connected country in the world", and hence "a location of choice for e-commerce"—is one visible manifestation of a New Economy policy priority (Industry Canada, 2001).

The attention that the technology revolution has garnered in academic and policy circles has fuelled a wave of research exploring both the microeconomic and macroeconomic dimensions of the technology revolution. We review key aspects of this research below.

1.1 A new microeconomy

Microeconomic research on the New Economy has stressed the reorganization of business models around emergent technologies, and examined the impact that advanced technologies have had on firm performance. The organizational impact of technology is readily apparent in traditional service industries, such as banking and financial services, where new ICT technologies have redefined production methods and service delivery mechanisms (e.g., internet-banking), and supported a range of new portfolio products and investment options.[2] In the manufacturing sector, advanced production technologies are reshaping the dynamics of competition, and often set high-performance firms apart from other businesses.[3]

Many of the firm-level technology studies that have been conducted by statistical agencies focus on entire industry populations (e.g., manufacturing industries versus service industries). This complements a burgeoning academic literature that focuses more narrowly on specialized high-technology populations—such as high-technology small firms or new technology-based firms—that exist at the epicenter of technological change.[4] For many, the growth and development of these firms represent central characteristics of the New Economy. The archetypal small technology-based firm

> "(has) a disproportionate number of R&D employees (i.e. scientists and/or engineers), is active in a recent or emergent technology (e.g. biotechnology, microelectronics, information technology)…(has) a large need for funds to finance R&D projects, and often links with universities and/or public laboratories in order to access new knowledge" (Chaillou, 1999, p.52).

A research priority for microeconomic analysts of the New Economy is to learn more about the competitive dynamics at work within these high-technology populations. Technology-based companies are often portrayed as vibrant examples of New Economy entrepreneurship.[5] Accordingly, we need a better understanding of the organizational and institutional frameworks that support the growth and development of technology-based firms. Networks and strategic clusters are widely cited examples of cooperative interfirm arrangements among technology-based startups—companies that network with university or public research labs, or with other technology firms in science parks, and use these networks as vehicles for information sharing and knowledge creation.[6] These partnership strategies overcome firm-specific limitations in core business areas (financing, human resources, marketing and management), and are more likely to take hold among new small firms that are less encumbered by bureaucratic practices and more open to risk-taking strategies (see Chaillou, 1999).[7]

Microeconomic contributions to New Economy research have focused on how the advent of advanced technologies has reshaped the strategies and competencies of firms—both for traditional firms and for technology-based companies whose business model is *defined* around advanced technologies. From this standpoint, evidence of the New Economy is legion, as technology and information management are more critical determinants of a firm's competitive position than ever before. Witness the emergence of new organizational models in firms wherein Chief Information Officers operate alongside traditional CEOs and CFOs.

1.2 A new macroeconomy

The question of whether or not new technologies have given rise to a New Economy is often evaluated in macroeconomic terms. Several studies have examined whether investments in information and communications technologies have fundamentally shifted the economy's productivity performance. In assessing the U.S. economy, many analysts pointed to the "unprecedented length" of the post-1991 expansion, with its low rates of unemployment and inflation, and high rates of productivity growth, as evidence that some fundamental structural change has occurred (see Landefeld and Fraumeni, 2001).[8] Notions that economic systems undergo profound structural changes due to the introduction of new technologies are not new—as these have occurred with previous shifts in technological paradigms. Major innovations such as the spinning jenny, the steam engine and the electric motor all transformed production routines and led to higher rates of output and productivity growth (OECD, 2000b). In the OECD's view, what distinguishes the current ICT revolution from previous industrial paradigms is the pace at which new technology is being assimilated into systems of production.[9]

The existence of a new macroeconomy is, at bottom, an empirical issue. Numerous studies find significant relationships between the stock of technological capital and macroeconomic performance. The OECD Growth Project has examined patterns of trend growth in member countries. While explanations of growth performance are multidimensional, basic differences in ICT-intensity are a major factor in explaining growth differentials across OECD countries. Jorgenson and Stiroh (2000) have found a linkage between U.S. multifactor productivity growth and investments in information technology in the post 1995 period. Working at the industry-level, Stiroh (2001a) has also found a positive correlation between ICT-investment intensities and labour productivity. In Canada, Armstrong et al. (2002) has examined the extent to which changes in output growth are driven by investments in information and communication technologies, such as hardware, software and telecommunications equipment. The authors found that the percentage of output growth attributable to ICT investment has increased markedly over the 1995-2000 period—along with the linkage between ICT investments and productivity performance.

A second stream of macroeconomic research has asked whether new-technology industries—industries that play a leading role in the production and distribution of technological innovations—have different output and input characteristics than other sectors of the economy. Research on the growth and development of new-technology industries goes to the heart of national, provincial and local efforts to promote industrial competitiveness. During the 1980s, proponents of industrial policies drew distinctions between growing and declining industries. By the mid 1990s, the focus of industrial policies had shifted to the size and performance of high-technology industries.[10] These exercises raise important debates over the scope of the industrial transition at work within domestic economies—debates that center on where the boundaries for the Old Economy end and those for the New Economy begin.[11]

Endnotes

[1] Diane Cohen (in Basset, 1993) gives a useful account of these changing priorities in discussing what she terms as the shift from industrial to information economies.

[2] Using data from a recent survey of service industries, Baldwin et. al. (1998) and Gellatly and Peters (1999) developed profiles of innovative firms in financial services industries.

[3] Using a panel of Canadian manufacturing establishments, Baldwin and Sabourin (2001) examined how the adoption of new production technologies is related to the stochastic growth process within plant populations. They found that gains in relative productivity, and growth in market share, are far more prevalent in firms that make investments in new technologies. This complements earlier evidence from firm-level surveys that found that investments in R&D and technology are strongly correlated with performance.

[4] Small firms have traditionally played a central role in notions of "a new economy". In the late 1980s, Birch and others argued that the emergent role of small firms in job creation was a feature of the modern (U.S.) economy that differentiated it from times past (see Case, 1989). In the "new economy", workers do not have to rely on large firms as the major source of new employment. The net contribution (gains less losses) of small firms on the Canadian economy was recently examined by Picot and Dupuy (1996).

[5] Voyer and Ryan (1994) provide an illuminating case-study review of technology-based firms in the Canadian marketplace, focusing on firms at different stages in their lifecycle (startups, growing firms and mature firms).

[6] A useful example of how emergent technologies can reshape the organizational dynamics of the marketplace is found in the model of the "virtual enterprise", outlined by Lefebrve, Lefebvre and Mohnen (2001, p. 88). Closely tied to the notion of a global marketplace, the virtual enterprise is

> "a temporary consortium of independent member companies which come together to quickly exploit fast-changing worldwide product manufacturing opportunities. Virtual enterprises assemble themselves based on cost effectiveness and product uniqueness without regard for organization, size, geographic location, computing environment, technologies deployed or processes implemented. Virtual enterprise companies share costs, skills, and core competencies which collectively enable them to access global markets with world class solutions that could not be provided individually".

Virtual firms exploit new information technologies to structure their operations along a "virtual value chain", each representing a different stage of the production process.

[7] The emergence of new technologies has spawned a related literature that focuses on strategies for success in the New Economy. For an example, see Kelly (1999).

[8] This array of positive indicators has led to much theorizing on the macroeconomic foundations of the New Economy. Stiroh (1999) identifies three schools of thought in his survey of the New Economy literature. The first, the long-run growth school, argues that New Economy forces—market liberalization, deregulation and IT investments—have enabled the U.S. to enjoy more robust (non-inflationary) rates of output growth. Fueled by the productivity-enhancing impacts of ICT technology, new information-based economies should be able to grow more rapidly than their industrial predecessors. The second school, which focuses on the dynamics of the business cycle, contends that the short-run tradeoffs between inflation and unemployment, long the basis for macro-stabilization policies, has been supplanted by a new era of low-inflation and high-employment. This may reflect a decline in the natural rate of unemployment, owing to the productivity-enhancing effects of ICT and an increase in global price competition. The final group, the sources-of-growth school, also focuses on improvements in long-run trend growth. However, they question whether traditional ICT capital-deepening is a sensible explanation for this growth, instead focusing on the unique networking and externality effects of ICT capital. Technology spillovers across firms (and industries) can lead to "virtuous circles of positive feedback", laying the foundations for rapid expansion.

[9] Morck and Yeung (2001) argue that the accumulation of technological progress that is embedded in everyday goods and services is what differentiates the present economy from earlier economic transitions. In their view "(i)t is this central role of knowledge in competition that distinguishes our modern economy as a "knowledge-based economy" (p. 54). Thurow (1999) notes that the rapid pace of technological change has implications for entrepreneurship: "(i)n this third industrial revolution … no one knows where future profits will be made" (p. 5).

[10] Research at the OECD (1997) has contributed to the competitiveness debate by developing score-sheet indicators that facilitate the ranking of member countries by the size of their domestic high-tech economies.

[11] A lack of consensus over its scope has become a persistent feature of the New Economy debate. Landefeld and Fraumeni (2001, p. 24) report that "estimates of the importance of the new economy vary widely, and a cottage industry seems to have sprung up in estimating the size of the high-tech economy and its impact on growth, productivity, and other aspects of economic activity—including exports, investment and retail sales. The wide variations in such estimates stem from the absence of common definitions for the new economy or its subcomponents." Stiroh (1999, p. 82) notes that "there is not yet a consensus about what the new economy really means or how it should be defined and evaluated." The OECD (2000b, p. 3) makes the same point, acknowledging that "the 'New Economy' remains an elusive concept which means different things to different people".

Chapter 2. Research Strategy

From a microeconomic perspective, the New Economy is unquestionably a very real phenomenon, and not simply an analytic or academic construct. For many businesses, technology and information management strategies represent, to a greater extent than ever before, core competencies that need to be mastered if the firm is to remain competitive. From the corporate manager's standpoint, debates over the existence of a New Economy are likely to be seen as moot, as harnessing and exploiting new technologies are an integral part of day-to-day business.

As noted earlier, previous macroeconomic studies have searched for a New Economy in two ways: (1) by quantifying relationships between technology investments and economy-wide output or productivity growth, and (2) by examining performance differentials across industries that differ in how intensively they invest in new technologies. Jorgenson, Stiroh and Armstrong et al. provide new evidence that investments in technology are correlated with improved productivity and output performance. Stiroh shows that the adoption of new technologies engenders productivity differences at the industry level.

In our view, there is still much work to be done in order to obtain a better sense of how the technological revolution is reshaping the industrial landscape. Accordingly, the goal of this paper is to learn more about the industrial dimensions of the New Economy—by profiling certain clusters of industries that, in varying degrees, have been linked to its growth and development, that is, to the transition from "industrial to information" economies. We have selected industries as our primary unit of analysis because many in the research and policy community view the emergence of vibrant New Economy industries as the key determinant of our current, and future, competitiveness. National, provincial and municipal governments have all developed policies to foster the growth of emergent technology and knowledge-intensive sectors.

2.1 Which Industries make up the New Economy?

To develop a comparative profile, we first have to decide *which* industries should be classified as part of the New Economy. One approach is to rely on the emerging industrial standard for technology statistics developed recently by the OECD. Their definition of the ICT sector represents "the combination of manufacturing and service industries, which electronically capture, transmit and display information" (Statistics Canada, 2001, p.12).[12] For many analysts, ICT industries represent the technological backbone of the New Economy. These industries develop, deliver and support products and services that embody the technological revolution, and fuel the industrial-to-information transition.

While ICT industries represent a clear analytical starting point, they are not the only industry grouping that could be used to study the industrial dimensions of the New Economy. To offer an alternative perspective, we also focus on a broader set of goods and services industries that have been classified as science-based. These industries place more stress on two production inputs that best exemplify the transition towards knowledge-based production—R&D and skilled labour. Investments in R&D have been used by the OECD (1997) to classify industries into high, medium and low technology groupings. Investments in skilled labour, such as professional and technical workers, represent an additional basis for quantifying an industry's knowledge base. Developed by Lee and Has (1996), this classification technique was refined by Baldwin and Johnson (1999) to identify industries that place relatively more stress on the importance of scientific knowledge.[13]

It is important to stress that ICT and science-based industries are not mutually exclusive. The vast majority of ICT industries are located in the science sector because ICT industries also place a strong emphasis on R&D and human capital. Shifting the focus from ICT to science effectively extends our view of the New Economy landscape. While ICT bellwether industries such as computer services and telecommunications fall squarely within the science camp, industries such as aircraft and aircraft parts, industrial chemicals and pharmaceuticals are also classified as science-based, along with technical business services, such as architecture and engineering.

Our comparative ICT/science focus parallels earlier research on systems of industrial innovation. In their study of U.K. manufacturing, Robson, Townsend and Pavitt (1988) recognize that there is a spectrum of innovation intensities across the industrial landscape, allowing industries to be grouped along a production-to-use continuum. Van Ark (2001), in his analysis of technology and growth, distinguishes between ICT producers and ICT users (industries that together make up the ICT economy). Our ICT/science duality is a variant on this theme. There is a base group of technology-producing industries—ICT industries—that are inexorably tied to the notion of a New Economy. And there are industries that fall outside the boundaries of the technology sector, but that place a strong emphasis at the frontier with respect to the use of scientific knowledge. There is a continuum of industries that are amongst the innovation and technology leaders, and a singular focus on ICT producers gives only a partial account of the industrial transition at the heart of the New Economy.

For comparative purposes, we divide the industrial landscape into three main categories: ICT industries, science industries and "other" industries—the final group a vast agglomeration of business sector industries that are neither classified as ICT nor science-based. Each of our three industrial aggregates—ICT, science and other—is, in turn, made up of a diverse cross-section of individual industries. For example, ICT industries include *inter alia* industries that focus on the manufacture of electronic products, the supply of telecommunications services, and computer wholesaling. The science sector includes "heavy" manufacturing industries, such as chemicals and pharmaceuticals, ICT or technology industries, along with other professional services, such as engineering and architecture. The "other" group, is effectively our residual category, and includes the vast majority of commercial industries, both in the goods and services sector.

Because these broad industry classes obscure a great deal of heterogeneity, we have decided to subdivide each category into a small number of sub units. We describe these below.

- Within the ICT sector, three sub-units are evaluated: (1) core ICT services (2) other ICT services, and (3) ICT manufacturing. Core ICT services are limited to two high-technology bellwethers, computer services and telecommunications. Our other ICT services subsector captures the remainder of OECD's ICT service definition, and includes cable providers, ICT wholesaling, and ICT rental and leasing. Last, to control for basic differences in production activity, we group ICT manufacturing separately.

- Our second New Economy aggregate, the science sector, includes the vast majority of ICT industries. It also includes a diverse collection of R&D and skilled-based industries that fall outside the boundaries of the technology sector. Accordingly, we decided to produce data for these non-ICT industries separately, which allows us to evaluate the extent to which the growth and development of the science economy is driven by industries that are not part of the technology sector. Once again to control for basic differences in production activity, we further deconstruct our non-ICT grouping into two parts: science-based goods and science-based services.

- Our residual category, other industries, captures a large percentage of total economic activity. We divide this category into two basic units: other goods industries, and other service industries.

Our final analysis categories are presented in Table 1. Summary statistics on employment, revenue and business establishments as of 2001 are reported in Table 2.

The New Economy sectors that we are studying are not large in absolute size. The ICT sector accounts for about 5.5% of employment in the business sector. The non-ICT science sector has another 5.3% of total employment. Core ICT services is the largest ICT subsector with 3% of total employment. In the non-ICT science sector, the goods subsector also accounts for 3% of employment.

The basic idea behind our analysis categories is to better identify key elements of dynamism within the New Economy. Does a singular focus on ICT—or, as is more often the case, on core technology industries such as computer services and telecommunications—tell us all we need to know about the engines of industrial growth? Or are these core ICT services overshadowed by developments in science-based goods industries, or in science-based services? We outline the structure of our analysis below.

Table 1. ICT and Science Subsectors

Sector	Subsector	SICE code	Description
ICT	Core ICT Services	4821	Telecommunication Carriers Industry
		4839	Other Telecommunication Industries
		7721	Computer services
		7722	Computer Equipment Maintenance and Repair
	Other ICT Services	4814	Cable Television Industry
		5743	Electronic Machinery, Equipment and Supplies, Wholesale
		5744	Computer and Related Machinery, Equipment and Packaged Software, Wholesale
		5791	Office and Store Machinery, Equipment and Supplies, Wholesale
		9913	Office Furniture and Machinery Rental and Leasing
	ICT Manufacturing	3341	Record Player, Radio and Television Receiver Industry
		3351	Telecommunication Equipment Industry
		3352	Electronic Parts and Components Industry
		3359	Other Communication and Electronic Equipment Industry
		3361	Electronic Computing and Peripheral Equipment Industry
		3362	Electronic Office, Store and Business Machine Industry
		3369	Other Office, Store and Business Machine Industry
		3381	Communications and Energy Wire and Cable Industry
		3911	Indicating, Recording and Controlling Instruments Industry
		3912	Other Instruments and Related Products Industry
Science	ICT Science		Above SICEs except for 5743, 5744, 5791, 7722 and 9913
	Non-ICT Science-based Goods	0231	Agricultural Management and Consulting Services
		0239	Other Services Incidental to Agriculture n.e.c.
		3111	Agricultural Implement Industry
		3121	Commercial Refrigeration and Air Conditioning Equipment Industry
		3191	Compressor, Pump and Industrial Fan Industry
		3192	Construction and Mining Machinery and Materials Handling Equipment Industry
		3193	Sawmill and Woodworking Machinery Industry
		3194	Turbine and Mechanical Power Transmission Equipment Industry
		3199	Other Machinery and Equipment Industries, n.e.c.
		3211	Aircraft and Aircraft Parts Industry
		3371	Electrical Transformer Industry
		3372	Electrical Switchgear and Protective Equipment Industry
		3379	Other Electrical and Industrial Equipment Industries
		3611	Refined Petroleum Products Industry (except lubricating oil and grease)
		3612	Lubricating Oil and Grease Industry
		3699	Other Petroleum and Coal Products Industries
		3711	Industrial Inorganic Chemical Industries n.e.c.
		3712	Industrial Organic Chemical Industries n.e.c.
		3721	Chemical Fertilizer and Fertilizer Materials Industry
		3722	Mixed Fertilizer Industry
		3729	Other Agricultural Chemical Industries
		3731	Plastic and Synthetic Resin Industry
		3741	Pharmaceutical and Medicine Industry
		3791	Printing Ink Industry
		3792	Adhesives Industry
		3799	Other Chemical Products Industries n.e.c.
		3913	Clock and Watch Industry
		3914	Ophthalmic Goods Industry
		4911	Electric Power Systems Industry
	Non-ICT Science-based Services	4611	Natural Gas Pipeline Transport Industry
		4612	Crude Oil Pipeline Transport Industry
		4619	Other Pipeline Transport Industries
		7751	Offices of Architects
		7752	Offices of Engineers
		7759	Other Scientific and Technical Services
		9611	Motion Picture and Video Production
		9619	Other Motion Picture, Audio and Video Services

Table 2. Share of Business Sector (%)			
	Establishments	Employment	Revenue
ICT Sector	4.0	5.5	5.7
ICT Manufacturing	0.2	1.2	1.5
Core ICT Services	2.8	3.0	2.3
Other ICT Services	1.0	1.3	1.9
Science-based Industries	6.9	9.6	10.9
ICT-based Science	3.1	4.3	3.9
Non-ICT Science-based Goods	0.7	3.0	5.3
Non-ICT Science-based Services	3.1	2.3	1.6
Other Industries	92.1	89.2	87.4
Goods	27.5	26.6	27.9
Services	64.6	62.5	59.4
Business Sector Total	100	100	100

Source: Statistics Canada Business Register, December 2001.

2.2 What do we want to learn about New Economy industries?

Our objective is to better understand the growth and development of New Economy industries—industries that, in varying degrees, place a premium on innovation, advanced technology, or worker skills. Our central research questions are as follows:

- *How are ICT and science-based industries—industries that provide the technological and scientific foundations for the New Economy—different from industries that are less associated with technological innovation and scientific knowledge?*

- *Which elements of the ICT or science economy constitute the primary "engines of growth"? Are highly visible, high-technology industries, such as computer services and telecommunications, always among the science and technology leaders?*

We explore these questions in two parts. First, we concentrate on differences in input structure, focusing on the characteristics of labour and investment. Second, we evaluate a range of performance outcomes, from productivity to profitability. Both levels of analysis are important. Emergent science and technology industries are seen as drivers of innovation, technological change and economic growth. An analysis of their input, or production, characteristics (changes in labour and capital requirements) may help to strengthen policies designed to improve our competitiveness—as many such policies hinge on improving production inputs, notably the quality of labour. Large investments in skills and learning are often posited to be requisites for success in the New Economy. And the supply of skilled, high-quality workers to emergent industries is sometimes said to be in short supply.[14] Herein we evaluate whether patterns of labour quality growth are more apparent in New Economy industries than elsewhere. Using wage data, we can also evaluate whether the returns to knowledge, earnings premiums that favour knowledge workers, are also more apparent in New Economy industries.

Labour, of course, is only one aspect of the production process. Capital investments—particularly investments in technology assets or soft intangible assets such as R&D—are another major source of industrial competitiveness. Differences in investment intensity provide analysts with one means of assessing an industry's growth or competitive prospects. Accordingly, we evaluate whether ICT and science industries have been placing more emphasis on investment than other sectors of the economy.

We then turn to a direct examination of performance characteristics—focusing on indicators that, for most business analysts and policy makers, are important barometers of industrial competitiveness. We ask which of our New Economy industries are vanguard industries—when evaluated in terms of their productivity and profitability performance.

Our focus on a range of analysis variables enables us to construct a reasonably comprehensive profile of industrial change in different sectors. In addition, it allows us to examine basic relationships between inputs and outputs. For instance, labour productivity differences do not control for underlying differences in labour quality or capital intensity. Are industries that have enjoyed faster labour productivity growth also those that have experienced labour quality gains, or growing concentrations of knowledge workers? Or do differences in labour productivity look to be more closely related to patterns of capital investment? Are sectors that produce important technological products also those that invest more heavily in these products? Are more productive industries also more profitable?

In many cases, we evaluate production and performance characteristics by emphasizing both growth and level differences. Much of the interest in the New Economy centers on growth, as superior growth performance tells us much about patterns of economic dynamism. For certain variables, our primary metric is growth—as we want to ascertain (e.g.) whether gains in labour and multifactor productivity are more accelerated in the ICT sector. But a singular focus on growth only tells part of the story, as, in many cases, growth rates mask significant level differences. New industries that experience rapid growth over a given period may do so because they start relatively small at the beginning of the period; despite growing rapidly, they may still account for only a small share of economic activity at the end of the period. For this reason, we highlight, where possible, both growth and level differences, often to place patterns of growth in context.

Our starting point for analyzing New Economy industries is 1981. Our guiding principles when developing the empirical profile are to report data for as many years as possible, and to provide an analysis of New Economy industries that is as current as possible. Our analysis is based on National Accounting data sources—which place limits on data availability. Constraints on data availability depend on the analysis variable in question. For instance, estimates of labour quality growth are available for the full 1981-2000 period, while real GDP and labour productivity ratios (based on the most recent System of National Accounts pricing methodology) are available only for 1988-1997. Profit data are available only from 1988 to 1998. Data on wages and employment are extracted from the final input-output tables, and are available up until 1997. Knowledge-intensity is based on occupational data from the Census of Population that is available only for census years.

Table 3. A List of Analysis Variables and Data Sources

Variable	Data Source
Constant Dollar GDP (1987-1997)	Input/Output Tables
Growth in Labour Quality (1981-2000) Current Dollar Investment (1981-1997) Labour Productivity (1987-1997) Average Real Wages (1981-1997) Multifactor Productivity (1981-1997) Employment (1981-1997)	Productivity Program
Profit Margin (1988-1998) Return on Equity (1988-1998) Return on Capital Employed (1988-1998)	Industrial Profit Data
Research and Development (1983-1997)	Research and Development Survey
Exports (1981-1997) Trade Balance (1981-1987)	Trade Data

The most notable analytical limitation that we face is that our data sources do not capture the sudden acceleration in science and technology markets in 1999-2000, followed by the shakeout in 2000-2001. This will be the subject of another paper. Effectively, then, our vantagepoint on the New Economy is "pre-bubble". A summary of analysis variables and data sources is presented in Table 3.

2.3 How straightforward is it to obtain estimates for New Economy industries?

There is one measurement issue that represents a critical aspect of our research design. And rather than relegate this to a technical appendix, we wish to stress this issue here. As noted above, our industrial profile is based on data resources that are used to support the System of National Accounts (SNA). Many of these data sources use a system of industrial classification that is less detailed than the 4-digit SIC 1980 codes that are used to define ICT and science industries (described in Table 1). This is important because it affects how precisely we can measure these New Economy industries.

To construct data estimates for ICT industries, it is often necessary to extract data for an individual ICT industry from its corresponding SNA industry, and then combine ICT data to produce an aggregate estimate (e.g., corresponding to "core ICT industries", or "all ICT industries"). In many cases, the relationship between 4-digit ICT industries (what we are trying to measure) and SNA industries (what we are working with) is "one-to-one", that is, they are identically defined and identically measured. In other cases, the relationship between a 4-digit ICT industry and its corresponding SNA industry is "many-to-one". This is often the case for service industries, because SNA service industries are less detailed than SNA goods industries. In such cases, the SNA industry contains a mixture of (4-digit) ICT industries and (4-digit) non-ICT industries. Accordingly, to obtain an estimate for ICT, we have to extract this ICT component from the host SNA industry and combine it with data for other ICT industries. (We discuss this in terms of ICT industries, but the same principle holds when measuring science industries).

The extent to which these ICT extractions are required depends upon the variable being measured. Like all systems of industrial classification, SNA industries are hierarchical. Some statistics are available at less detailed levels. For instance, data on GDP and employment are available for very detailed SNA industries. In these cases, only a minimal amount of ICT extractions are required in order to produce our ICT estimates. Other analysis variables, like multifactor productivity, generally require more "ICT splitting" because the inputs that are needed to construct MFP estimates are available with less industry detail. In these cases, more data on ICT has to be "split out" in order to generate an estimate.

The mechanics of extracting these ICT components from (larger) SNA industries involves allocating a fixed percentage of the host SNA industry to ICT, based on information from secondary data sources. The variable used to derive this fixed percentage depends on the analysis variable under study. Consider ICT employment. In order to obtain an estimate for total ICT employment (or, at the subsectoral level, for other ICT services) we need to obtain information on employment in ICT wholesaling industries, which is not readily available from SNA data. To produce this estimate, we obtained, from another data source, the percentage of total employment in the wholesaling sector accounted for by the three ICT wholesaling industries, and then applied this ratio to SNA data in order to extract an ICT wholesaling estimate. This was combined with ICT employment information from other ICT industries, many of which are available directly from SNA data, to obtain the final estimate of ICT employment.

In all cases, the split parameters used for this analysis are time invariant. (Accordingly, in the above example, the percentage of ICT employment in wholesaling industries is assumed to be constant from year-to-year). While seemingly straightforward, the mechanics of extracting ICT estimates from SNA aggregates based on fixed shares, or split parameters, is, in practice, fairly complex. This operational complexity arises for two reasons. First, different analysis variables, such as employment, investment, or GDP, all require different split parameters, based, in many cases, on different data sources. Second, SNA data for our set of analysis variables is not available at a common level of industrial detail. This requires us to obtain and apply a range of split parameters (corresponding to different levels within the SNA industrial classification) in order to generate an accurate set of ICT estimates.

We raise these points here because they have an important bearing on our empirical analysis. The more data that needs to be split, the less precise the resulting ICT estimate becomes. (One reason for this, in addition to the time-invariance property outlined above, is that splitting tacitly assumes that the characteristics of the nested ICT component are identical to the larger SNA aggregate. In our example, this amounts to assuming that the economic characteristics of ICT wholesaling are no different than other wholesaling industries, which may or may not be the case). As such, estimates for other ICT services, which includes a large ICT wholesaling component, are apt to be less precise than estimates for ICT manufacturing, which is measured with more detail in the SNA industry structure. An overview of data quality is presented in Table 4.

Table 4. Data Precision, by Analysis Variable

Variable	Source Detail
Constant Dollar GDP	223 Business Sector Industries
Growth in Labour Quality	147 Business Sector Industries
Current Dollar Investment	123 Business Sector Industries
Labour Productivity	223 Business Sector Industries
Average Real Wages	223 Business Sector Industries
Multifactor Productivity	123 Business Sector Industries
Employment	223 Business Sector Industries
Profit Margin	4-digit SICE (726 Business Sector Industries)
Return on Equity	4-digit SICE (726 Business Sector Industries)
Return on Capital Employed	4-digit SICE (726 Business Sector Industries)
Research and Development	4-digit SICE (726 Business Sector Industries)
Exports	4-digit SICE (726 Business Sector Industries)
Trade Balance	4-digit SICE (726 Business Sector Industries)

Our empirical analysis is organized as follows. We start by focusing on two standard dimensions—GDP and employment growth. Comparatively high rates of GDP and employment growth have fuelled much of the interest in New Economy industries, most notably in ICT.

In the next section, we take a more intensive look at input structures in different New Economy industries. We begin by focusing on the characteristics of labour, examining differences in knowledge-intensity, labour quality growth and remuneration. We then examine patterns of investment.

Next, we shift our focus from input requirements to performance characteristics. In this section, we analyze patterns of labour and multifactor productivity growth in New Economy industries, followed by an evaluation of profitability. We then focus on the trade position of ICT and science-based industries.

Throughout the analysis, we compare input and performance trends in ICT and science industries to those in a residual category of *other* industries. This residual category accounts for the vast majority of economic activity in the Canadian business sector. A final section explores sources of industrial dynamism within this group of other industries via a series of input and performance comparisons with the ICT sector.

Endnotes

[12] In manufacturing, ICT industries

> "(m)ust be intended to fulfill the function of information processing and communication including transmission and display" and "(m)ust use electronic processing to detect, measure and/or record physical phenomena or to control a physical process" (OECD, 2000a, p. 7).

In services, ICT industries

> "must be intended to enable the function of information processing and communications by electronic means" (OECD, 2000a, p.7).

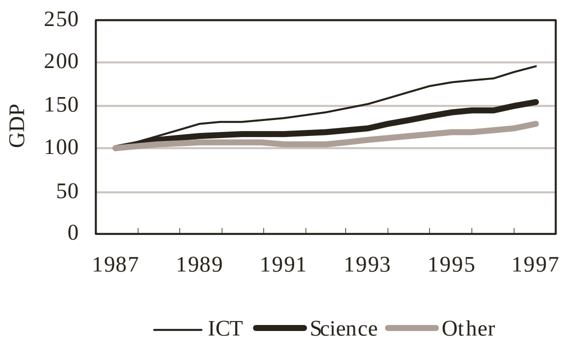
[13] To identify science industries, three R&D variables were used—the industry R&D-to-sales ratio, the share of R&D personnel to total industry employment, and the share of professional R&D personnel to total industry employment—along with three measures of human capital—the shares, respectively, of post-secondary workers, knowledge workers, and scientists and engineers, all expressed in relation to total industry employment. Science-industries are those that fall into the top one-third of industries for two of the three R&D measures and two of the three human capital ratios.

[14] See Baldwin and Peters (2001) and Sabourin (2001).

Chapter 3. GDP and Employment Growth in the New Economy

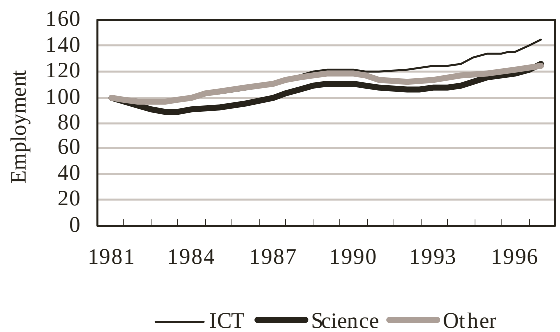
For many analysts, the ongoing transition from industrial-to-information economies is synonymous with the rapid development of ICT industries. ICT industries are home to firms at the vanguard of the technology revolution—firms that develop and market advanced technologies, or that provide services that support advanced technologies. From 1987 to 1997, the real GDP of ICT industries nearly doubled (Figure 1). This GDP growth was fuelled by gains in core ICT services, computer services and telecommunications industries (which witnessed a 120% increase in real GDP over this ten-year period) (Table 5.2). These rates of growth are considerably larger than the cumulative rate of growth in other industries of only 28% over the same period.

Figure 1. Growth in Real GDP (1987=100), by Sector



Output is not the only metric that can be used to judge the growth prospects of an industry. To many, it is the employment prospects of an industry that also make it a candidate of choice. But this metric may give quite different results than that of GDP—especially if the leading growth industries are also those that are increasing their labour productivity the most. Industries with high labour productivity growth may show rapid growth in output but less rapid growth in employment.

Figure 2. Growth in Total Employment (1981=100), by Sector



Employment in the ICT sector has also grown more rapidly over the last two decades than employment in other sectors (Figure 2). Once again, this growth was fueled by core ICT services. During the 1981-1997 period, core services expanded their employment ranks by a cumulative total of 85% or by 3.9% annually (Tables 6.1 and 6.2). As was the case with GDP, this was also above the cumulative growth of employment in other industries (24%) over the same period. But the gap between the ICT sector and other industries was much larger for GDP growth than for employment growth.

Table 5.1. Real GDP (1992 $, Billions), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1987	**19.2**	4.7	11.0	3.4	**59.2**	16.7	34.5	8.8	**420.7**	160.1	259.8
1988	**22.1**	5.5	12.8	3.7	**65.2**	19.3	36.9	9.5	**442.3**	168.2	273.3
1989	**24.5**	6.0	14.5	3.9	**68.5**	21.5	37.6	9.6	**454.1**	172.0	281.3
1990	**25.3**	5.9	15.6	3.8	**69.7**	22.4	37.5	10.0	**451.5**	169.5	281.5
1991	**26.2**	5.9	16.4	3.9	**69.6**	23.3	36.2	10.2	**440.7**	161.6	279.0
1992	**27.3**	6.3	17.0	4.0	**70.3**	24.3	35.7	10.3	**444.4**	159.7	284.7
1993	**29.0**	6.4	18.5	4.0	**73.8**	25.8	37.2	10.8	**458.6**	166.5	292.0
1994	**31.7**	7.4	20.0	4.2	**78.7**	28.2	39.1	11.4	**484.0**	175.5	308.3
1995	**34.1**	8.4	21.5	4.2	**84.2**	30.6	41.6	12.0	**497.8**	179.2	318.6
1996	**35.1**	8.1	22.7	4.3	**85.7**	31.5	42.2	12.2	**508.8**	182.0	327.1
1997	**37.6**	8.8	24.3	4.6	**91.5**	33.6	44.0	14.0	**536.3**	190.3	346.5
Annual Growth Rate (%)	**7.0**	6.3	8.2	3.0	**4.4**	7.3	2.5	4.8	**2.5**	1.7	2.9

Table 5.2. Growth in Real GDP (1987=100), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1987	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1988	**115.3**	117.0	116.1	109.2	**110.1**	115.8	107.1	108.0	**105.1**	105.1	105.2
1989	**127.6**	125.8	131.9	115.4	**115.6**	128.8	109.1	109.8	**107.9**	107.4	108.3
1990	**131.9**	124.2	141.5	112.0	**117.7**	134.4	108.7	113.9	**107.3**	105.9	108.4
1991	**136.6**	123.6	149.1	115.4	**117.6**	139.6	105.0	116.2	**104.8**	101.0	107.4
1992	**142.4**	132.5	154.6	117.4	**118.6**	145.8	103.6	116.8	**105.6**	99.8	109.6
1993	**151.0**	135.5	168.1	118.0	**124.5**	155.0	107.9	122.4	**109.0**	104.0	112.4
1994	**165.0**	156.0	181.6	124.5	**132.9**	169.5	113.5	129.4	**115.0**	109.7	118.7
1995	**177.7**	177.6	195.5	122.7	**142.1**	183.7	120.6	136.8	**118.3**	112.0	122.7
1996	**183.0**	170.3	206.2	126.9	**144.7**	188.8	122.3	139.0	**120.9**	113.7	125.9
1997	**195.9**	184.8	220.2	134.3	**154.5**	201.7	127.6	159.5	**127.5**	118.9	133.4

Table 6.1. Total Employment (Thousands), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**327.2**	104.7	134.2	88.3	**723.6**	245.7	341.1	136.9	**8,124.0**	3,224.6	4,899.5
1982	**322.5**	100.2	134.3	88.1	**678.7**	241.5	308.7	128.5	**7,803.1**	2,985.4	4,817.7
1983	**317.2**	97.3	132.0	88.0	**642.2**	237.0	286.6	118.5	**7,853.1**	2,943.3	4,909.8
1984	**329.1**	105.1	134.3	89.7	**651.5**	246.6	282.8	122.0	**8,088.8**	2,996.7	5,092.1
1985	**337.2**	106.7	139.1	91.4	**663.6**	252.9	288.0	122.7	**8,408.8**	3,067.6	5,341.2
1986	**343.1**	105.9	145.5	91.7	**682.2**	258.2	299.9	124.1	**8,699.9**	3,146.2	5,553.7
1987	**358.9**	111.2	152.4	95.3	**718.0**	270.3	307.1	140.6	**8,986.8**	3,249.4	5,737.3
1988	**382.1**	117.9	166.2	98.0	**763.9**	290.7	325.4	147.8	**9,316.3**	3,362.7	5,953.6
1989	**395.2**	117.9	173.9	103.3	**794.3**	298.3	339.3	156.8	**9,543.1**	3,435.6	6,107.5
1990	**395.8**	113.0	177.3	105.5	**795.4**	296.4	333.5	165.5	**9,547.5**	3,337.4	6,210.1
1991	**389.2**	106.1	180.1	103.1	**781.0**	292.4	316.9	171.8	**9,259.7**	3,099.0	6,160.8
1992	**395.5**	105.8	188.8	100.9	**766.6**	300.0	307.3	159.3	**9,143.3**	3,010.4	6,132.8
1993	**406.3**	99.0	206.9	100.4	**778.1**	311.0	305.8	161.3	**9,236.0**	2,987.0	6,249.0
1994	**413.0**	99.6	210.4	102.9	**784.0**	315.2	299.8	169.0	**9,459.1**	3,041.1	6,418.0
1995	**438.3**	104.9	225.9	107.6	**833.1**	335.2	315.2	182.7	**9,618.4**	3,079.2	6,539.2
1996	**443.0**	103.0	229.9	110.1	**857.4**	336.6	321.1	199.7	**9,801.7**	3,106.6	6,695.1
1997	**470.3**	106.1	247.9	116.3	**906.9**	357.0	327.3	222.7	**10,092.1**	3,198.4	6,893.7
Annual Growth Rate (%)	**2.3**	0.1	3.9	1.7	**1.4**	2.4	-0.3	3.1	**1.4**	-0.1	2.2

Table 6.2. Total Employment (1981=100), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**98.6**	95.7	100.1	99.8	**93.8**	98.3	90.5	93.9	**96.1**	92.6	98.3
1983	**96.9**	92.9	98.3	99.6	**88.8**	96.5	84.0	86.6	**96.7**	91.3	100.2
1984	**100.6**	100.3	100.1	101.6	**90.0**	100.4	82.9	89.1	**99.6**	92.9	103.9
1985	**103.0**	101.8	103.7	103.5	**91.7**	103.0	84.4	89.6	**103.5**	95.1	109.0
1986	**104.9**	101.1	108.4	103.9	**94.3**	105.1	87.9	90.7	**107.1**	97.6	113.4
1987	**109.7**	106.2	113.6	108.0	**99.2**	110.0	90.1	102.7	**110.6**	100.8	117.1
1988	**116.8**	112.6	123.9	111.0	**105.6**	118.3	95.4	108.0	**114.7**	104.3	121.5
1989	**120.8**	112.6	129.6	117.1	**109.8**	121.4	99.5	114.5	**117.5**	106.5	124.7
1990	**121.0**	107.9	132.1	119.5	**109.9**	120.7	97.8	120.9	**117.5**	103.5	126.8
1991	**119.0**	101.3	134.2	116.8	**107.9**	119.0	92.9	125.5	**114.0**	96.1	125.7
1992	**120.9**	101.1	140.7	114.3	**105.9**	122.1	90.1	116.4	**112.6**	93.4	125.2
1993	**124.2**	94.6	154.2	113.8	**107.5**	126.6	89.6	117.9	**113.7**	92.6	127.5
1994	**126.2**	95.1	156.8	116.6	**108.4**	128.3	87.9	123.5	**116.4**	94.3	131.0
1995	**134.0**	100.1	168.3	121.9	**115.1**	136.5	92.4	133.5	**118.4**	95.5	133.5
1996	**135.4**	98.4	171.3	124.7	**118.5**	137.0	94.1	145.9	**120.7**	96.3	136.7
1997	**143.7**	101.3	184.8	131.7	**125.3**	145.3	95.9	162.7	**124.2**	99.2	140.7

Growth in ICT GDP is not limited to core services. ICT manufacturing industries also enjoyed high rates of GDP growth. From 1987 to 1997, real GDP in these industries increased by 85%. However, employment growth occurred primarily in ICT services. ICT manufacturers have not had any employment growth over this period.

When viewed jointly through the lens of GDP and employment growth, one could make the case that the transition to the New Economy has centered on the expansion of *core ICT services*. Computer services and telecommunications have grown rapidly and they account for a high percentage of economic activity within the ICT sector; in 1997, core services accounted for about two-thirds of ICT GDP and one-half of ICT employment. By contrast, ICT manufactures accounted for about one-quarter of total ICT GDP and 23% of ICT employment. While their GDP growth was rapid, their employment remained relatively flat over the period.

Are there other engines of GDP and employment growth beyond the boundaries of ICT? Yes. High rates of GDP and employment growth are also apparent in science-based services, services that place relatively high emphasis on R&D and skilled workers, but that are not part of the technology sector. These include *inter alia* architects and engineers, and scientific and technical services. Real GDP increased by 60% in science-based services from 1987 to 1997, compared to 33% for other service industries. Employment in science-based services, over the 1981-1997 period, increased 3.1% annually, outpacing growth in other services (2.2%).

We begin our profile by examining production characteristics—different aspects of employment and capital investment. Throughout our analysis, we ask which industry groups—e.g., core ICT services, science-based goods—are the source of industrial dynamism in the New Economy.

Chapter 4. Labour and Investment in New Economy Industries

4.1 Labour skills

Our analysis of labour inputs is based on several factors. These include: changes in the knowledge intensity of the workforce associated with shifts in occupational structure; compositional shifts within industries that affect patterns of labour quality; and trends in remuneration. We address each topic in turn below.

4.1.1 Knowledge workers

High rates of employment growth for skilled workers are central to the idea of a New Economy—as these reflect an upgrading in labour market opportunities along the industry-to-information continuum. In this section, we focus on whether employment growth in the ICT sector has coincided with the development of a more specialized, high-wage workforce in these industries.[15]

We examine this by first focusing on the stock of knowledge workers in New Economy industries. For this purpose, we use an occupation-based classification structure developed by Beckstead and Vinodrai (2003) to rank industries on the basis of the knowledge intensity of their workforce. Knowledge intensity is defined as the percentage of an industry's workforce accounted for by knowledge workers—workers employed in select management, professional and technical occupations. A list of knowledge-based occupations is presented in Table 7.

In Table 8, we report the share of knowledge-based workers in each of our industrial categories. Because these percentages are derived from occupational data collected from the Census of Population, estimates are only available for four census years (1981, 1986, 1991, and 1996).

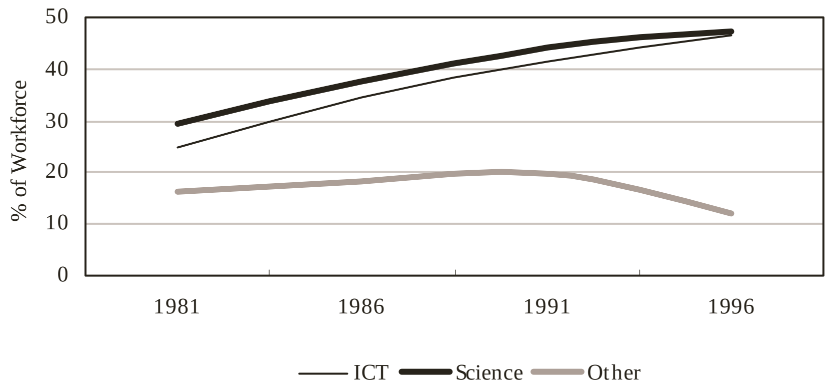
Knowledge workers constitute a larger percentage of the workforce in ICT and science industries than they do in other industries. In addition, their ranks in these industries have expanded more rapidly. By 1996, nearly one half of workers in ICT and science industries are classified as knowledge-based, up from 25% and 29% of ICT and science-based workers in 1981. Among other industries—our residual category of industries that fall outside the boundaries of ICT and science—only 12% of workers are classified as knowledge-based in 1996, down from 17% in 1981 (Figure 3).

Table 7. Knowledge-based Occupations

Occupations (Based on the 1991 Standard Occupational Classification)		
Management	A01	Legislators and Senior Management
	A11	Administrative Services Managers
	A12	Managers in Engineering, Architecture, Science and Information Systems
	A13	Sales, Marketing and Advertising Managers
	A30	Managers in Financial and Business Services
	A31	Managers in Communication (except broadcasting)
	A32	Managers in Health, Education, Social and Community Services
	A33	Managers in Public Administration
	A34	Managers in Art, Culture, Recreation and Sport
	A38	Managers in Primary Production (except agriculture)
	A39	Managers in Manufacturing and Utilities
Business Professionals	B01	Auditors, Accountants and Investment Professionals
	B02	Human Resources and Business Service Professionals
Science and Engineering Professionals		
	C01	Physical Science Professionals
	C02	Life Science Professionals
	C03	Civil, Mechanical, Electrical and Chemical Engineers
	C04	Other Engineers
	C05	Architects, Urban Planners and Land Surveyors
	C06	Mathematicians, Systems Analysts and Computer Programmers
Science–Technical Occupations		
	C11	Technical Occupations in Physical Sciences
	C12	Technical Occupations in Life Sciences
	C13	Technical Occupations in Civil, Mechanical and Industrial Engineering
	C14	Technical Occupations in Electronics and Electrical Engineering
	C15	Technical Occupations in Architecture, Drafting, Surveying and Mapping
	C16	Other Technical Inspectors and Regulatory Officers
	C17	Transportation Officers and Controllers
Health Professionals	D01	Physicians, Dentists and Veterinarians
	D02	Optometrists, Chiropractors and Other Health Diagnosing and Treating Professionals
	D03	Pharmacists, Dietitians and Nutritionists
	D04	Therapy and Assessment Professionals
Other Health Occupations	D11	Nurse Supervisors and Registered Nurses
	D21	Medical Technologists and Technicians (except dental health)
Education, Law and Social Science-related		
	E01	Judges, Lawyers and Quebec Notaries
	E03	Policy and Program Officers, Researchers and Consultants
	E11	University Professors and Assistants
	E12	College and Other Vocational Instructors
	E13	Secondary and Elementary School Teachers and Counselors
Arts and Culture Professionals	F01	Librarians, Archivists, Conservators and Curators
	F02	Writing, Translating and Public Relations Professionals
	F03	Creative and Performing Artists

Within the ICT sector, the shift towards knowledge-based occupations is most apparent in core ICT services—the fastest growing segment. Over the 1981-1996 period, computer services and telecommunications more than doubled their stock of knowledge workers, from 26% in 1981 to 53% of employees in 1996. Gains in ICT manufacturing industries were comparably rapid. By 1996, 45% of workers in ICT manufacturing industries are knowledge-based. This compares with 30% of workers in science-based goods industries, and just 11% of workers in other goods industries.

Figure 3. Percentage of Employed Labour Force in Knowledge-based Occupations, by Sector (Results Presented for Census Years)



Within the science sector, the largest concentration of knowledge workers are found in science-based services, which include professional services such as architecture, engineering and scientific and technical services. In 1981, 56% of workers in science-based services were classified as knowledge-based; their share increased to 71% by 1996. This stands in sharp contrast to service industries that fall outside these ICT/science designations, where only about one in eight workers is classified as knowledge-based (Table 8).

4.1.2 Compositional change

The growth in skilled workers is one measure of skill change at the industry level. An alternate measure of changes to occupational composition comes from an index used by the productivity program (Gu et al., 2003). This index is the difference between the weighted sum of the growth of hours worked for different groups of workers (where the weights are the relative wage share of each strata) and the growth in the sum of hours worked of all strata. Sometimes referred to as a measure of labour quality, it is positive if the hours worked by more highly-paid workers are growing more quickly than those for lower-paid workers. As such, the index captures compositional change towards groups of workers that are more highly paid.

This index tracks the compositional changes in an industry's education, age of worker, and employment characteristics (self employed versus paid workers). Estimates of the growth of 'labour quality', based on this index, are reported in Table 9.

Despite the growth in the proportion of knowledge workers employed in the ICT sector, there is little evidence from this index that the ICT sector exhibited larger gains in labour quality than other sectors of the economy (Figure 4). From 1981 to 2000, labour quality in ICT industries improved by 14%. In comparison, other industries—the vast majority of industries that fall outside of our New Economy classifications—experienced a 15% quality gain over this twenty-year period. Science industries fared slightly better, with an estimated quality gain of 17%.

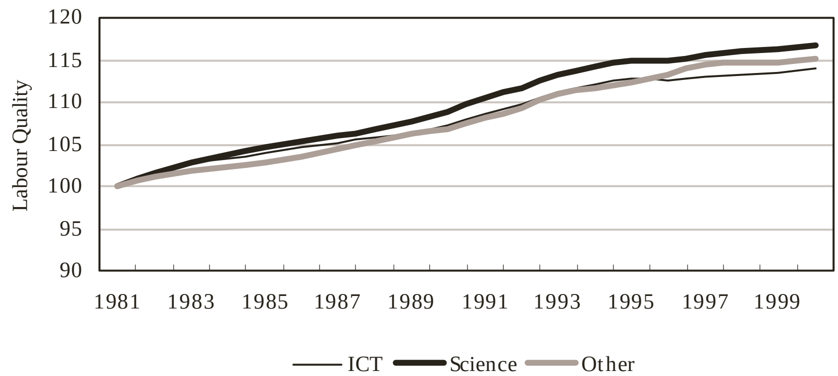
Table 8. Knowledge-based Occupations as a Percentage of the Employed Labour Force, by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**24.8**	28.6	25.8	17.9	**29.3**	27.1	21.0	56.1	**16.5**	7.4	20.7
1986	**34.5**	36.0	37.7	24.6	**37.6**	36.9	22.8	68.7	**18.3**	8.7	22.1
1991	**41.4**	41.4	45.1	31.5	**44.3**	43.6	27.6	68.6	**19.9**	10.8	23.1
1996	**46.4**	44.7	53.1	33.1	**47.2**	50.0	29.6	70.5	**12.1**	10.8	12.8

Table 9. Labour Quality Index (1981=100), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**101.7**	101.1	101.9	101.5	**101.7**	101.8	101.2	103.7	**101.2**	100.6	101.5
1983	**102.8**	101.4	103.3	102.3	**102.8**	103.0	102.2	106.7	**101.9**	101.5	102.2
1984	**103.2**	101.4	103.9	102.5	**103.7**	103.5	102.8	108.0	**102.4**	102.0	102.7
1985	**103.9**	102.0	104.6	102.8	**104.7**	104.2	103.7	110.3	**102.7**	102.5	103.0
1986	**104.6**	102.7	105.2	103.5	**105.4**	104.9	104.3	111.1	**103.6**	103.2	103.9
1987	**105.1**	102.9	105.5	104.3	**106.0**	105.2	105.0	111.5	**104.4**	104.2	104.7
1988	**105.7**	103.8	105.9	105.1	**106.8**	105.6	105.8	112.6	**105.4**	105.4	105.8
1989	**106.3**	104.5	106.4	105.8	**107.6**	106.3	106.6	114.0	**106.2**	106.2	106.6
1990	**107.3**	105.7	107.4	106.8	**108.8**	107.2	107.9	115.6	**106.8**	106.7	107.1
1991	**108.6**	107.9	108.6	108.0	**110.4**	108.6	109.4	117.8	**108.1**	107.6	108.7
1992	**109.8**	109.3	109.9	109.1	**111.7**	109.9	110.8	119.6	**109.3**	108.6	110.0
1993	**111.2**	108.6	111.3	110.3	**113.2**	111.2	112.6	121.3	**111.0**	110.0	111.8
1994	**112.1**	110.4	112.2	110.8	**114.3**	112.2	113.7	122.0	**111.7**	111.1	112.4
1995	**112.7**	111.5	112.6	111.5	**114.8**	112.7	114.7	121.7	**112.4**	112.3	112.8
1996	**112.6**	112.4	112.2	112.0	**114.9**	112.4	115.1	121.9	**113.2**	112.8	113.8
1997	**113.1**	114.3	112.4	112.9	**115.6**	112.7	115.9	122.7	**114.3**	114.0	115.0
1998	**113.3**	114.6	112.5	113.0	**116.0**	112.8	116.1	123.5	**114.6**	114.2	115.4
1999	**113.5**	114.9	112.7	113.2	**116.3**	113.1	116.5	123.9	**114.7**	114.4	115.4
2000	**113.9**	115.5	113.1	113.7	**116.8**	113.5	116.9	124.6	**115.2**	114.8	116.0

Figure 4. Labour Quality Index (1981-2000), by Sector



The primary driver of the 'labour quality' index is educational attainment. This means that the growth in the proportion of knowledge workers employed in ICT industries was more or less evenly spread across workers with different educational attainments. Higher levels of educational attainment were being demanded of all groups of workers.

Two important results emerge when examining quality changes within ICT and science industries. First, core ICT services exhibit lower quality gains (albeit marginally) than either ICT manufactures or other ICT services. Hence rapid employment growth in core ICT services, along with greater concentrations of knowledge workers, is not synonymous with a shift to relatively higher levels of educational attainment. The second noteworthy result centers on the comparatively large quality gains apparent in science-based services. At 25%, labour quality gains in science-based services were significantly higher than in any other subsector—certainly much higher than either science-based goods or ICT industries. However, it should be stressed that much of the labour quality growth in science-based services, post 1980, is a form of "catch up", as labour quality growth in these industries lagged behind other sectors prior to 1981.

4.1.3 Wage rates

Relative wages reflect differences in labour composition across sectors. Workers with higher educational qualifications generally receive higher wages. Ultimately, changes in the composition of the labour force are reflected in changes in relative wage rates.

Average industry annual wage rates for paid workers in ICT industries are significantly higher than for workers in the other industries sector—consistently about one-third higher, on average (Figure 5 and Table 10.1). Moreover, during the 1981-1997 period, the average real wage in ICT industries increased by 13% (Figure 6 and Table 10.2), which was more than twice that in other industries (5%).

It is noteworthy that the average wage in the science sector was generally above that in the ICT sector, and that the increase in the science sector as a whole was just as great as in the ICT sector. This larger group of industries that we have dubbed the science sector not only has about the same proportion of knowledge workers, it also pays equally high wage rates.

Table 10.1. Average Real Wage (1992 $, Thousands), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**40.0**	35.7	47.6	33.6	**42.3**	42.0	43.6	39.6	**30.2**	37.1	25.8
1982	**41.3**	37.3	49.8	32.9	**44.6**	43.9	46.0	42.3	**29.8**	36.9	25.5
1983	**41.5**	39.3	48.2	33.7	**44.8**	43.8	46.2	42.9	**29.3**	36.9	24.9
1984	**42.5**	39.0	50.4	34.9	**45.0**	45.0	46.3	41.8	**29.6**	37.0	25.5
1985	**42.1**	39.7	47.9	36.2	**45.1**	44.1	46.9	42.7	**30.1**	37.5	26.0
1986	**42.4**	39.7	47.2	38.2	**44.4**	43.8	45.7	42.4	**29.6**	36.7	25.7
1987	**42.6**	39.5	46.6	40.2	**43.8**	43.4	45.3	40.8	**30.1**	36.8	26.4
1988	**43.0**	39.6	45.7	42.8	**44.0**	43.1	45.5	42.4	**30.8**	37.6	27.1
1989	**43.7**	39.8	47.3	42.2	**44.2**	44.2	44.8	42.9	**30.8**	37.5	27.1
1990	**43.4**	40.0	47.4	40.8	**45.2**	44.4	46.4	43.9	**30.4**	37.4	26.8
1991	**43.8**	41.1	48.0	39.8	**45.9**	45.3	47.4	43.5	**29.9**	37.5	26.3
1992	**44.3**	43.1	47.3	40.4	**47.1**	45.8	48.8	46.2	**30.3**	38.0	26.6
1993	**44.3**	44.1	46.4	40.4	**47.7**	45.7	49.9	46.9	**30.2**	38.1	26.5
1994	**45.0**	44.7	47.4	40.6	**48.7**	46.6	51.2	47.6	**30.5**	38.7	26.6
1995	**44.4**	43.7	46.6	40.8	**48.2**	45.8	51.1	47.1	**30.4**	38.7	26.6
1996	**44.7**	43.8	47.2	40.7	**47.8**	46.1	50.8	44.8	**30.7**	39.1	26.9
1997	**45.1**	45.1	46.9	41.7	**48.4**	46.4	51.8	46.0	**31.8**	39.8	28.1
Average	**43.3**	40.9	47.4	39.0	**45.8**	44.8	47.5	43.9	**30.3**	37.7	26.4
Annual Growth Rate (%)	**0.8**	1.5	-0.1	1.4	**0.8**	0.6	1.1	1.0	**0.3**	0.5	0.5

Table 10.2. Average Real Wage (1981=100), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**103.2**	104.3	104.6	97.9	**105.3**	104.7	105.4	106.8	**98.7**	99.5	98.8
1983	**103.6**	110.1	101.3	100.4	**105.8**	104.5	106.1	108.4	**97.1**	99.7	96.3
1984	**106.2**	109.3	105.9	103.9	**106.4**	107.2	106.1	105.5	**98.2**	99.8	98.6
1985	**105.2**	111.3	100.6	107.8	**106.6**	105.0	107.5	107.9	**99.7**	101.2	100.5
1986	**105.9**	111.2	99.1	113.6	**105.0**	104.4	104.9	107.0	**98.2**	99.1	99.6
1987	**106.4**	110.6	97.8	119.6	**103.5**	103.5	104.0	103.2	**99.7**	99.2	102.2
1988	**107.4**	110.9	96.1	127.4	**104.1**	102.7	104.4	107.2	**102.1**	101.4	104.9
1989	**109.0**	111.6	99.4	125.5	**104.5**	105.3	102.9	108.3	**102.1**	101.1	105.0
1990	**108.5**	112.1	99.6	121.4	**106.7**	105.9	106.3	110.9	**100.8**	100.8	103.7
1991	**109.5**	115.2	100.8	118.5	**108.4**	108.0	108.8	109.9	**99.3**	101.1	101.7
1992	**110.7**	120.7	99.3	120.2	**111.4**	109.1	111.9	116.7	**100.5**	102.6	103.0
1993	**110.7**	123.5	97.6	120.3	**112.7**	109.0	114.5	118.5	**100.1**	102.7	102.6
1994	**112.4**	125.3	99.6	121.0	**115.0**	111.0	117.5	120.2	**101.0**	104.5	103.1
1995	**111.0**	122.4	98.0	121.5	**113.9**	109.2	117.3	119.0	**100.9**	104.5	103.0
1996	**111.6**	122.8	99.1	121.4	**112.9**	110.0	116.6	113.2	**101.9**	105.4	104.2
1997	**112.7**	126.2	98.6	124.1	**114.4**	110.6	118.7	116.3	**105.4**	107.4	108.8

Figure 5. Average Real Wage (1992 $, Thousands), by Sector

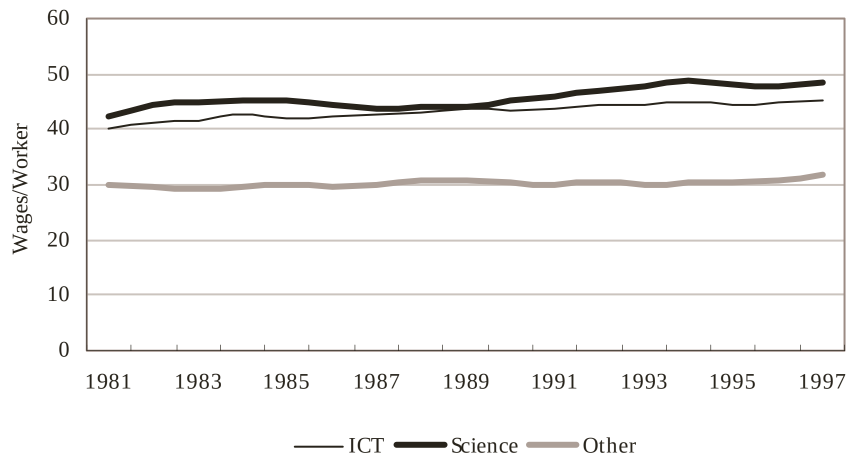
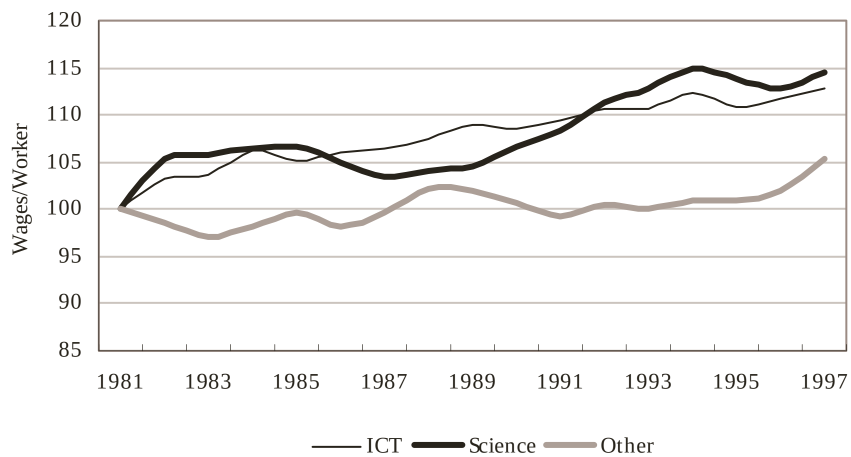


Figure 6. Average Real Wage (1981=100), by Sector

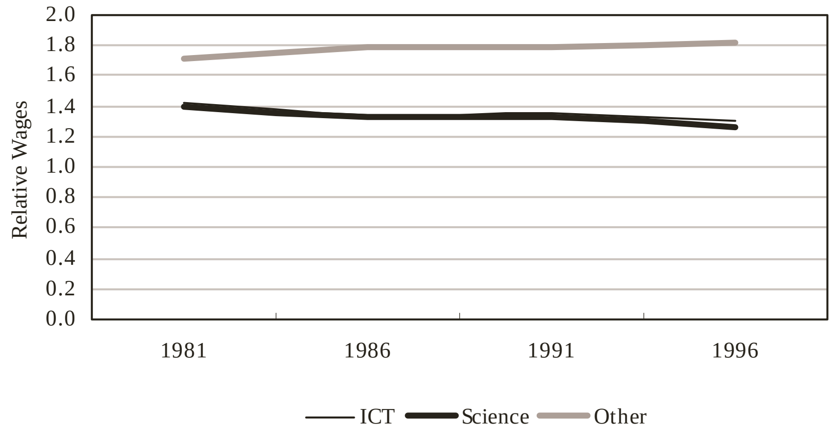


In New Economy industries where are relative wage gains most apparent? ICT manufactures and other ICT services both enjoyed relatively strong wage increases (26% and 24%), while real wages in core ICT services actually decreased slightly from their 1981 level. Wage gains in science-based goods and science-based services were both high during the 1990s, often exceeding the ICT average.

Of course, patterns of wage growth have to be viewed against actual wage levels in these industries (Table 10.1). Core ICT services, despite a decline in the real wage beginning in the mid-1980s, still had the highest average ICT wage at the end of the period. But ICT manufactures and other ICT services have been able to close the gap substantially.

Significant earnings differentials also exist between ICT and science industries. Science-based goods are, on average, much higher paying than ICT manufactures. Average wages in science-based services and core ICT services are very similar throughout the 1990s. And both these New Economy service industries are much better paying than other services.

Figure 7. Ratio of Average Hourly Wages–Knowledge Workers to Non-Knowledge Workers, by Sector



The industry wages reported above pull together earnings data from across an entire distribution of occupations. In light of the similarities in the growth rate of the labour composition index across sectors, but differences in the increase in the percentage of the workforce that were knowledge workers, it is interesting to ask whether the returns to knowledge—the earnings premium enjoyed by knowledge workers—are more apparent in New Economy industries than they are elsewhere, and whether they have changed over time. Simply put, we ask whether knowledge workers are paid more in New Economy industries, relative to their counterparts in less knowledge-intensive occupations. Relative wages for ICT, science and other industries are depicted in Figure 7.

First, it should be noted that the gap in relative wages between knowledge and non-knowledge workers is much more apparent for industries outside of the ICT or science fold. In 1981, the average wage rate for knowledge workers in our residual grouping of other industries was 1.71 times that of non-knowledge workers. In ICT industries, this earnings differential stood at 1.42.

What is more interesting is that while the earnings gap between knowledge and non-knowledge workers has increased slightly in other industries, these relative wages have been declining in ICT and science industries. Hence the returns to knowledge (the wage premium to knowledge workers) are less, and have become increasingly less, in New Economy industries.[16] In the ICT sector, this decline is most apparent in core ICT services, where relative wages decreased from 1.46 in 1981 to 1.18 in 1996 (Table 11).

This trend, along with the similarity in the labour quality indices that weight different educational classes by their relative wage rates, suggests that in the ICT sector, educational requirements were probably increasing more in non-knowledge workers. While the proportion of knowledge workers was increasing, the index that weights different educational groups by their relative wage rates did not—partially because those in lower educational groups (the non-knowledge workers) began to receive relatively higher wage rates in the ICT sector.

Table 11. Ratio of Average Hourly Wages–Knowledge Workers to Non-Knowledge Workers, by Subsector (Results Presented for Census Years)				
	1981	1986	1991	1996
ICT Sector	**1.42**	**1.34**	**1.35**	**1.31**
ICT Manufacturing	1.41	1.43	1.50	1.55
Core ICT Services	1.46	1.26	1.28	1.18
Other ICT Services	1.36	1.36	1.36	1.32
Science-based Industries	**1.39**	**1.33**	**1.33**	**1.27**
ICT-based Science	1.44	1.33	1.34	1.29
Non-ICT Science-based Goods	1.42	1.44	1.38	1.38
Non-ICT Science-based Services	1.40	1.33	1.36	1.28
Other Industries	**1.71**	**1.79**	**1.79**	**1.82**
Goods	1.62	1.72	1.64	1.63
Services	1.81	1.85	1.90	1.95

4.2 Capital

Our analysis of capital inputs is based on different measures of investment and capital intensity. These include investment-to-GDP and investment-to-labour ratios, calculated, first, for all capital assets, and then for a special group of high-technology assets (computers, software, telecommunications equipment). Measures of R&D-intensity are also examined.

4.2.1 Investment intensities

Investments in machinery and equipment are the key to increases in labour productivity. During the late 1990s, the Canadian business sector experienced rapid growth in investment. In this section, we shift our focus from labour to capital inputs and examine which sectors placed more importance on investment, and whether rates of investment have been increasing over time.

We first compare investment intensities across sectors by calculating investment expenditures as a proportion of GDP. A high investment-to-GDP ratio indicates that capital formation takes up a substantial proportion of output. Current dollar investment-to-GDP ratios are reported in Table 12.1.

ICT and science-based industries have a higher ratio of investment to GDP than do other industries. And for both these sectors, there is a cyclicality that follows the business cycle. In both the early 1980s and the 1990s, the amount of investment by these sectors fell relative to GDP (Figure 8).

Science industries have traditionally exhibited the largest, and most volatile, investment-to-GDP ratios. These ratios declined during the early 1980s and 1990s. By the mid-to-late 1990s, investment levels in science industries and ICT industries were very similar, at roughly 20% to 25% of sectoral GDP. Investment ratios in the ICT sector fluctuate between 20% and 30% over the 1981-1997 period. Both our New Economy sectors—ICT and science—exhibit higher investment to GDP rates than other industries, which fall below 20%.

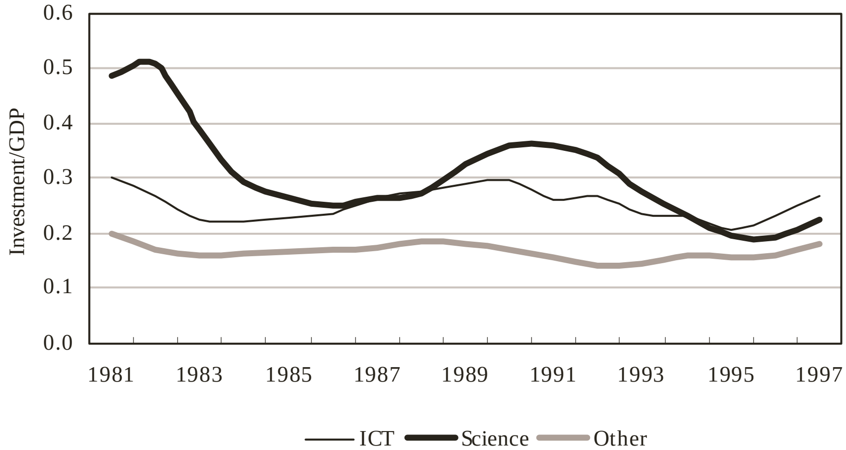
Table 12.1. Investment Intensity (Investment/GDP, Current $, All Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**0.30**	0.12	0.41	0.13	**0.49**	0.33	0.62	0.38	**0.20**	0.24	0.17
1982	**0.27**	0.12	0.36	0.10	**0.51**	0.29	0.72	0.36	**0.17**	0.22	0.13
1983	**0.22**	0.13	0.28	0.12	**0.39**	0.24	0.57	0.13	**0.16**	0.18	0.14
1984	**0.22**	0.13	0.28	0.13	**0.30**	0.24	0.37	0.15	**0.16**	0.18	0.15
1985	**0.23**	0.13	0.30	0.13	**0.27**	0.25	0.31	0.12	**0.17**	0.19	0.15
1986	**0.24**	0.14	0.31	0.14	**0.25**	0.26	0.29	0.10	**0.17**	0.18	0.16
1987	**0.26**	0.13	0.36	0.15	**0.27**	0.29	0.30	0.08	**0.18**	0.17	0.18
1988	**0.28**	0.13	0.39	0.14	**0.27**	0.30	0.30	0.12	**0.19**	0.18	0.19
1989	**0.29**	0.11	0.42	0.15	**0.33**	0.32	0.37	0.19	**0.18**	0.18	0.18
1990	**0.30**	0.12	0.42	0.15	**0.36**	0.33	0.42	0.21	**0.17**	0.17	0.17
1991	**0.26**	0.11	0.35	0.13	**0.36**	0.28	0.44	0.27	**0.16**	0.17	0.14
1992	**0.27**	0.09	0.37	0.15	**0.34**	0.29	0.40	0.26	**0.14**	0.14	0.14
1993	**0.24**	0.10	0.31	0.16	**0.28**	0.25	0.31	0.21	**0.14**	0.16	0.13
1994	**0.23**	0.11	0.30	0.15	**0.23**	0.25	0.23	0.20	**0.16**	0.19	0.14
1995	**0.21**	0.08	0.27	0.17	**0.20**	0.22	0.19	0.17	**0.16**	0.20	0.13
1996	**0.23**	0.12	0.29	0.18	**0.19**	0.25	0.18	0.14	**0.16**	0.19	0.14
1997	**0.27**	0.12	0.34	0.20	**0.23**	0.29	0.20	0.17	**0.18**	0.23	0.15
Average	**0.25**	0.12	0.34	0.15	**0.31**	0.27	0.37	0.19	**0.17**	0.19	0.15
Annual Growth Rate (%)	**-0.7**	-0.2	-1.1	2.5	**-4.7**	-0.8	-6.8	-4.8	**-0.6**	-0.1	-0.7

Table 12.2. Investment Intensity (Investment/GDP, 1981=100, All Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**89.3**	96.1	87.2	78.2	**104.5**	89.1	114.8	96.4	**86.4**	94.2	78.0
1983	**74.5**	104.6	68.7	89.6	**79.9**	73.9	90.6	34.4	**80.3**	77.1	85.4
1984	**74.0**	109.6	68.1	99.9	**60.6**	72.8	59.5	39.7	**82.0**	76.1	90.2
1985	**76.6**	106.9	73.0	97.4	**54.4**	75.4	50.1	32.5	**84.4**	79.0	92.3
1986	**78.9**	114.1	74.1	101.0	**51.6**	78.0	46.3	25.8	**85.1**	76.6	97.2
1987	**87.6**	109.2	86.2	112.6	**54.3**	87.0	48.6	21.3	**87.8**	71.5	108.5
1988	**92.4**	104.3	94.9	103.8	**56.1**	92.4	47.3	31.6	**93.1**	77.7	113.0
1989	**96.9**	94.8	100.8	111.4	**67.2**	97.2	59.6	50.8	**90.7**	75.1	110.6
1990	**98.6**	96.9	100.8	110.8	**73.5**	99.3	67.9	55.5	**85.3**	72.6	103.0
1991	**86.6**	92.3	85.5	98.2	**73.9**	86.8	70.2	71.1	**77.5**	73.7	86.1
1992	**90.0**	77.1	89.4	110.1	**69.6**	89.0	63.6	68.4	**70.9**	61.3	83.9
1993	**79.0**	83.7	74.7	117.2	**56.7**	77.0	50.0	56.5	**72.0**	68.7	79.7
1994	**77.4**	94.7	72.2	113.8	**47.9**	75.9	37.4	54.2	**79.4**	81.1	82.6
1995	**69.2**	68.3	64.7	124.8	**40.3**	67.7	30.1	45.3	**79.2**	83.0	80.1
1996	**77.5**	95.8	69.4	136.8	**39.8**	76.3	28.0	36.4	**79.9**	80.8	83.3
1997	**88.9**	97.5	83.2	147.5	**46.5**	87.6	32.7	45.9	**90.6**	98.0	90.1

Figure 8. Investment Intensity
(Investment/GDP, Current $, All Assets)



Among New Economy industries, core ICT services and science-based goods exhibit comparatively high investment rates for much of this period. However, like most other sectors, these investment ratios have been trending downward. A decline in ICT and science investment ratios was apparent during the early 1990s. Over the entire time period, other sectors saw a modest decline and then recovered by 1997 to almost the same level experienced in 1981. The same was true for ICT as a whole. It is the science-based sector where the cumulative declines are most noticeable—with the ratio of investment to GDP in 1997 standing at less than 50% of its level in 1981 (Table 12.2).

Investment in the above exercise is a composite good—it takes into account expenditure on all assets. Recently, attention has been focused on a core set of critical technology investments in such assets as computers, software and telecommunications equipment—investments that are seen to be enabling companies to take advantage of the information revolution.

Restricting our focus to these high-technology assets yields a different perspective on patterns of investment intensity (Figure 9). ICT industries now have higher investment-to-GDP ratios than science industries, and much higher ratios than industries that fall outside of our ICT/science classification. This occurs because technological investments account for a much larger share of the investment expenditure in ICT industries than in other sectors of the economy. The ICT sector is not only an important producer of ICT products. It is also an intensive user of these products.

Figure 9. Investment Intensity
(Investment/GDP, Current $,
Critical Assets)

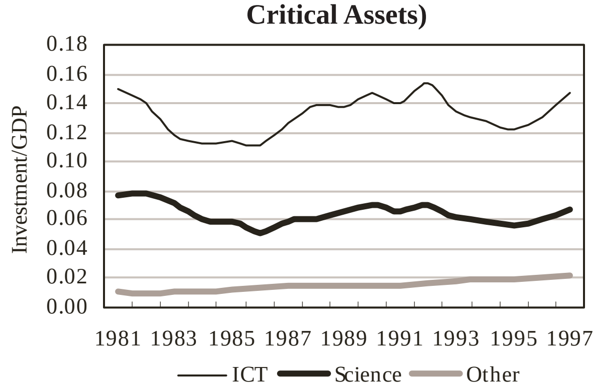


Table 13.1. Investment Intensity (Investment/GDP, Current $, Critical Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**0.149**	0.010	0.232	0.035	**0.077**	0.166	0.039	0.004	**0.010**	0.004	0.016
1982	**0.140**	0.017	0.209	0.031	**0.078**	0.155	0.047	0.003	**0.009**	0.005	0.012
1983	**0.119**	0.022	0.171	0.041	**0.071**	0.131	0.049	0.004	**0.011**	0.005	0.015
1984	**0.112**	0.023	0.165	0.043	**0.061**	0.124	0.034	0.004	**0.011**	0.005	0.017
1985	**0.114**	0.022	0.174	0.038	**0.059**	0.126	0.031	0.005	**0.013**	0.005	0.019
1986	**0.111**	0.025	0.166	0.039	**0.051**	0.123	0.019	0.005	**0.013**	0.007	0.018
1987	**0.127**	0.027	0.195	0.042	**0.058**	0.140	0.020	0.005	**0.015**	0.007	0.021
1988	**0.138**	0.026	0.219	0.041	**0.061**	0.154	0.018	0.005	**0.015**	0.007	0.021
1989	**0.138**	0.023	0.219	0.042	**0.065**	0.154	0.023	0.006	**0.015**	0.007	0.021
1990	**0.147**	0.026	0.229	0.038	**0.070**	0.164	0.025	0.006	**0.015**	0.007	0.020
1991	**0.140**	0.030	0.210	0.035	**0.066**	0.156	0.025	0.005	**0.015**	0.008	0.020
1992	**0.154**	0.029	0.229	0.041	**0.070**	0.170	0.020	0.007	**0.016**	0.008	0.021
1993	**0.134**	0.034	0.193	0.047	**0.061**	0.147	0.018	0.010	**0.018**	0.009	0.023
1994	**0.128**	0.030	0.185	0.046	**0.059**	0.140	0.020	0.012	**0.019**	0.008	0.025
1995	**0.122**	0.022	0.175	0.062	**0.056**	0.134	0.021	0.009	**0.019**	0.009	0.026
1996	**0.131**	0.033	0.182	0.060	**0.060**	0.143	0.020	0.010	**0.021**	0.009	0.029
1997	**0.147**	0.032	0.213	0.063	**0.067**	0.162	0.022	0.011	**0.022**	0.010	0.030
Average	**0.132**	0.025	0.198	0.044	**0.064**	0.146	0.026	0.007	**0.015**	0.007	0.021
Annual Growth Rate (%)	**-0.1**	7.5	-0.5	3.8	**-0.9**	-0.2	-3.5	5.6	**4.8**	4.9	4.1

Table 13.2. Investment Intensity (Investment/GDP, 1981=100, Critical Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**93.8**	170.2	90.0	89.5	**101.8**	93.1	121.3	68.0	**86.2**	112.6	77.8
1983	**79.4**	214.5	73.8	118.7	**92.2**	79.0	127.0	83.8	**101.6**	107.9	97.5
1984	**75.3**	226.8	71.3	123.7	**79.3**	74.5	87.7	92.6	**110.4**	113.4	107.6
1985	**76.4**	219.6	74.9	110.3	**77.1**	75.8	79.5	104.3	**124.8**	120.2	122.3
1986	**74.6**	249.0	71.5	112.5	**66.8**	74.4	49.8	107.9	**128.4**	146.9	115.9
1987	**84.7**	270.7	84.0	121.3	**75.9**	84.6	52.0	112.6	**141.8**	146.1	131.9
1988	**92.5**	261.4	94.5	117.6	**79.2**	92.9	46.9	118.5	**145.0**	152.6	133.5
1989	**92.3**	228.3	94.4	120.8	**84.8**	92.8	58.8	136.9	**144.6**	151.4	132.4
1990	**98.2**	255.7	98.5	109.3	**90.3**	98.9	64.3	138.2	**141.9**	164.0	125.0
1991	**93.8**	297.9	90.5	100.5	**85.8**	94.0	64.6	116.8	**147.5**	178.3	125.0
1992	**103.3**	291.3	98.8	117.0	**91.2**	102.5	51.9	166.2	**157.1**	176.1	135.1
1993	**90.0**	332.8	83.1	136.7	**79.8**	88.4	46.2	215.4	**170.4**	191.6	147.0
1994	**85.8**	296.4	79.8	132.4	**77.0**	84.2	50.8	258.5	**180.7**	183.4	161.3
1995	**81.6**	213.1	75.4	178.2	**73.1**	80.5	53.2	200.8	**182.8**	189.4	163.8
1996	**87.5**	322.5	78.3	174.1	**77.7**	86.1	51.1	223.0	**201.3**	195.1	183.6
1997	**98.7**	320.0	91.7	181.2	**87.1**	97.4	56.7	238.0	**213.1**	215.0	188.8

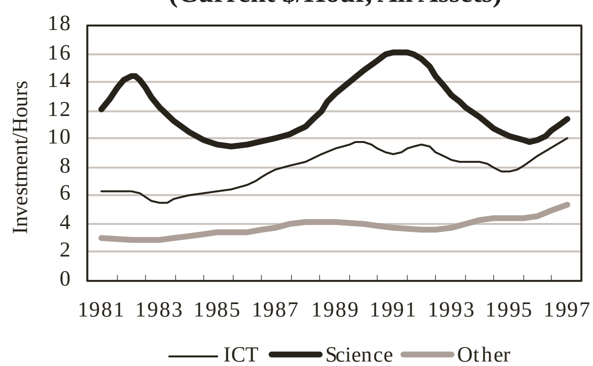
Core ICT services—computer services and telecommunications—account for much of this difference. As a percentage of GDP, core ICT services allocate a far greater share of their investment expenditures to computers, software and communications equipment than ICT goods producers. On average, technology investments in core ICT services stand at 20% of GDP. For ICT manufacturing, science-based goods and science-based services, technology investments account for less than 3% of GDP (Table 13.1).

4.2.2 Capital-to-labour ratios

Investment-to-GDP ratios effectively compare the size of a production input to its outputs. But for many purposes, we want to know whether workers are being given more capital with which they can work. And this is given by the ratio of investment expenditures to labour inputs. This provides us with a better sense of how production requirements—the mix of labour and capital—are changing in different sectors of the economy. Current dollar investment-to-labour ratios are reported in Table 14.1.

Does moving to investment-to-labour ratios change our view of investment patterns in the science and technology sector? Yes and no. Investment-to-labour ratios in the science sector follow the same cyclical pattern apparent in their investment-to-GDP profile. While science industries exhibit the highest levels of spending per hour worked, there is little evidence that the science sector is becoming more capital intensive, as its investment-to-labour ratio in 1997 stands slightly below its 1981 level. Investment-to-labour ratios in the ICT sector and in the larger group of other industries trend upward slightly over the 1981-1997 period. By 1997, the investment-to-labour ratio for the ICT sector had nearly reached the science average. Both ICT and science industries remain significantly more capital intensive than other industries (Figure 10).

Figure 10. Investment to Labour (Current $/Hour, All Assets)



In terms of capital intensity, science-based goods industries and core ICT services lead the way. In 1997, investment-to-labour ratios in science-based goods were three times as high as for ICT manufacturing. Core ICT services—computer services and telecommunications industries—exhibit higher investment per hour ratios than other service industry groupings: science-based services, other ICT services, and other services.

Restricting investment expenditures to technology assets (computers, software and communications equipment), as before, shifts the focus from science to ICT industries (Figure 11). The core ICT services sector again stands out—these industries maintain much higher investment-to-labour ratios than other sectors. That said, investments in technology assets have grown rapidly in all sectors (Table 15.1).

Table 14.1. Investment to Labour (Current $/Hour, All Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**6.3**	2.0	13.3	1.3	**12.1**	8.3	16.9	6.7	**3.1**	4.1	2.3
1982	**6.4**	2.2	13.3	1.1	**14.5**	8.4	21.8	8.3	**2.9**	4.1	2.0
1983	**5.6**	2.4	11.0	1.4	**12.2**	7.2	20.1	3.1	**2.9**	3.8	2.3
1984	**6.1**	2.9	11.7	1.6	**10.4**	7.8	15.6	3.6	**3.1**	4.0	2.6
1985	**6.3**	3.0	12.1	1.8	**9.7**	8.1	13.9	3.0	**3.4**	4.3	2.8
1986	**6.7**	3.2	12.5	2.1	**9.6**	8.6	13.4	2.6	**3.4**	4.0	3.1
1987	**7.8**	3.4	14.7	2.5	**10.1**	10.0	13.9	2.2	**3.7**	3.9	3.6
1988	**8.4**	3.3	15.9	2.5	**10.8**	10.6	14.5	3.2	**4.1**	4.4	4.0
1989	**9.3**	3.4	17.4	2.8	**13.2**	11.9	18.2	5.3	**4.2**	4.4	4.1
1990	**9.7**	3.5	18.1	2.8	**14.9**	12.6	21.4	5.8	**4.0**	4.3	3.9
1991	**9.0**	3.3	16.3	2.6	**16.1**	11.7	24.7	7.8	**3.7**	4.3	3.4
1992	**9.6**	2.8	17.3	2.9	**15.6**	12.2	22.7	8.2	**3.5**	3.8	3.4
1993	**8.5**	3.4	13.8	3.3	**13.1**	10.6	18.9	6.9	**3.7**	4.4	3.2
1994	**8.4**	4.0	13.1	3.3	**11.5**	10.5	15.4	6.6	**4.2**	5.6	3.4
1995	**7.7**	2.9	12.0	3.8	**10.1**	9.6	13.4	5.7	**4.4**	6.1	3.4
1996	**8.8**	4.1	13.1	4.1	**9.9**	11.0	12.3	4.3	**4.5**	6.2	3.6
1997	**10.0**	4.7	14.8	4.4	**11.5**	12.4	14.5	5.6	**5.3**	7.5	4.2
Annual Growth Rate (%)	**2.9**	5.3	0.7	8.0	**-0.3**	2.6	-0.9	-1.2	**3.6**	3.9	3.8

Table 14.2. Investment to Labour (1981=100, All Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**100.5**	106.2	99.6	81.8	**120.0**	101.2	129.1	123.0	**93.4**	101.6	84.9
1983	**87.7**	116.5	82.7	105.9	**101.3**	87.4	118.8	46.2	**94.9**	91.9	101.1
1984	**95.7**	143.8	87.7	128.5	**86.1**	94.5	92.4	52.7	**103.0**	98.7	111.5
1985	**99.6**	146.0	90.6	138.7	**80.2**	97.7	82.5	45.2	**110.4**	106.0	119.8
1986	**106.1**	154.2	93.4	162.6	**79.2**	103.1	79.3	39.1	**111.7**	97.2	132.9
1987	**123.2**	163.9	110.1	193.9	**83.7**	120.3	82.3	32.0	**121.5**	95.5	156.1
1988	**132.6**	160.9	119.3	196.9	**89.8**	128.0	86.1	47.0	**135.2**	107.6	172.3
1989	**147.2**	163.7	130.8	217.0	**109.6**	144.0	107.5	77.9	**137.2**	107.4	176.8
1990	**153.6**	169.5	135.7	215.6	**123.3**	152.4	126.9	86.6	**132.0**	106.1	167.6
1991	**142.0**	163.4	122.1	199.3	**133.3**	140.6	146.5	115.0	**122.7**	106.4	148.1
1992	**151.1**	137.8	129.6	230.1	**129.4**	147.1	134.5	121.3	**115.3**	92.0	147.5
1993	**134.4**	164.0	103.4	254.4	**108.5**	127.9	111.8	101.7	**119.8**	107.9	141.3
1994	**133.1**	193.0	98.6	256.6	**95.4**	126.6	91.0	98.2	**137.4**	136.9	149.4
1995	**121.8**	143.1	89.8	292.9	**84.1**	115.4	79.2	84.1	**143.2**	149.9	149.0
1996	**138.3**	200.0	98.5	320.9	**81.8**	132.5	72.7	63.3	**147.4**	150.9	157.0
1997	**157.3**	229.3	111.0	343.1	**95.1**	150.2	86.0	82.5	**174.9**	183.0	182.8

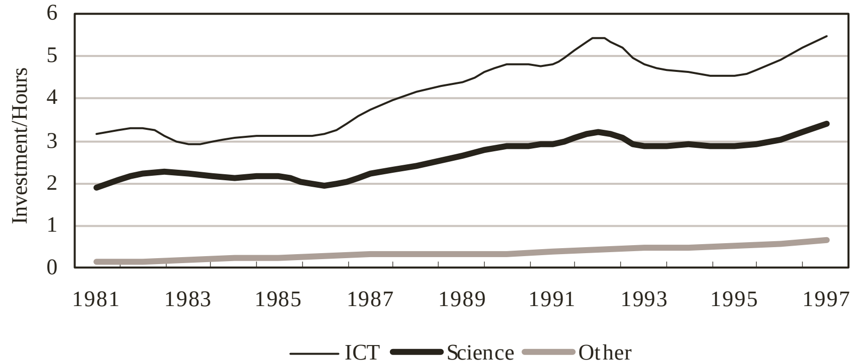
Table 15.1. Investment to Labour (Current $/Hour, Critical Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**3.14**	0.17	7.50	0.33	**1.90**	4.20	1.05	0.08	**0.16**	0.08	0.22
1982	**3.32**	0.32	7.70	0.31	**2.23**	4.44	1.43	0.07	**0.15**	0.09	0.18
1983	**2.94**	0.41	6.66	0.47	**2.23**	3.93	1.75	0.09	**0.19**	0.10	0.25
1984	**3.06**	0.51	6.89	0.53	**2.14**	4.07	1.43	0.10	**0.22**	0.11	0.29
1985	**3.12**	0.52	6.97	0.52	**2.16**	4.13	1.37	0.12	**0.26**	0.13	0.35
1986	**3.15**	0.58	6.76	0.60	**1.95**	4.13	0.90	0.13	**0.27**	0.15	0.34
1987	**3.74**	0.70	8.05	0.69	**2.23**	4.92	0.92	0.14	**0.31**	0.15	0.41
1988	**4.17**	0.70	8.92	0.74	**2.41**	5.41	0.89	0.14	**0.33**	0.16	0.44
1989	**4.41**	0.68	9.18	0.78	**2.63**	5.78	1.11	0.17	**0.35**	0.17	0.46
1990	**4.81**	0.77	9.95	0.71	**2.88**	6.38	1.26	0.17	**0.35**	0.19	0.45
1991	**4.83**	0.91	9.70	0.68	**2.94**	6.40	1.41	0.15	**0.37**	0.20	0.47
1992	**5.45**	0.90	10.75	0.81	**3.23**	7.12	1.15	0.24	**0.40**	0.21	0.52
1993	**4.82**	1.13	8.62	0.98	**2.90**	6.17	1.08	0.31	**0.45**	0.23	0.57
1994	**4.64**	1.04	8.17	0.99	**2.91**	5.90	1.30	0.38	**0.50**	0.24	0.64
1995	**4.52**	0.77	7.85	1.39	**2.91**	5.77	1.47	0.30	**0.52**	0.27	0.66
1996	**4.91**	1.16	8.33	1.36	**3.04**	6.28	1.39	0.31	**0.59**	0.28	0.75
1997	**5.49**	1.30	9.17	1.40	**3.39**	7.01	1.56	0.34	**0.65**	0.31	0.83
Annual Growth Rate (%)	**3.6**	13.4	1.3	9.4	**3.7**	3.3	2.5	9.5	**9.2**	9.1	8.8

Table 15.2. Investment to Labour (1981=100, Critical Assets), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**105.7**	188.0	102.7	93.6	**117.0**	105.8	136.4	86.8	**93.2**	121.4	84.7
1983	**93.5**	238.9	88.8	140.2	**117.0**	93.5	166.5	112.8	**120.1**	128.6	115.4
1984	**97.3**	297.6	91.8	159.0	**112.6**	96.8	136.2	123.0	**138.7**	147.0	133.0
1985	**99.3**	299.9	92.9	157.2	**113.7**	98.2	130.9	145.0	**163.3**	161.3	158.6
1986	**100.3**	336.3	90.1	181.1	**102.6**	98.3	85.4	163.2	**168.5**	186.3	158.5
1987	**119.1**	406.3	107.3	208.8	**117.0**	117.0	88.0	169.1	**196.1**	195.3	189.8
1988	**132.7**	403.2	118.9	223.1	**126.8**	128.7	85.4	176.6	**210.5**	211.4	203.6
1989	**140.2**	394.3	122.4	235.5	**138.2**	137.4	106.0	210.1	**218.6**	216.5	211.6
1990	**153.0**	447.4	132.6	212.5	**151.4**	151.8	120.0	215.7	**219.6**	239.7	205.2
1991	**153.7**	527.3	129.2	204.0	**154.7**	152.2	134.8	188.9	**233.4**	257.5	215.0
1992	**173.4**	520.9	143.3	244.5	**169.6**	169.5	109.7	294.9	**255.5**	264.1	237.6
1993	**153.2**	652.3	114.9	296.6	**152.6**	146.8	103.2	387.9	**283.3**	300.8	260.7
1994	**147.4**	604.1	109.0	298.6	**153.2**	140.5	123.7	468.4	**312.8**	309.5	291.9
1995	**143.6**	446.7	104.6	418.1	**152.7**	137.2	140.1	372.4	**330.5**	342.2	304.7
1996	**156.2**	673.0	111.0	408.2	**159.7**	149.5	132.7	388.0	**371.6**	364.6	345.9
1997	**174.7**	752.4	122.3	421.5	**178.4**	166.8	149.2	428.0	**411.3**	402.1	382.8

Figure 11. Investment to Labour
(Current $/Hour, Critical Assets)



4.2.3 R&D-to-Labour Ratios

In the previous section, we have focused on two categories of investment, a composite good and a subset of technology assets, and two measures of investment intensity, an investment-to-GDP ratio and an investment-to-labour ratio. We focused on technology assets because these investments are posited to be critical determinants of growth. There is one other category of investment that is often described as critical to innovation in the New Economy—research and development (R&D). R&D expenditure per hour worked is reported in Table 16.1.

ICT and science industries as a whole have very similar R&D-to-labour ratios (Figure 12). R&D-intensity is one aspect of the production process where ICT manufactures, and not core ICT services, emerge as New Economy leaders; R&D ratios in ICT manufacturing industries eclipse those in other sectors by a significant margin. Not surprisingly (given the method by which classification occurs), science-based goods and science-based services also exhibit relatively high R&D-to-labour ratios.

Figure 12. Ratio of Research and Development
to Labour (Current $/Hour)

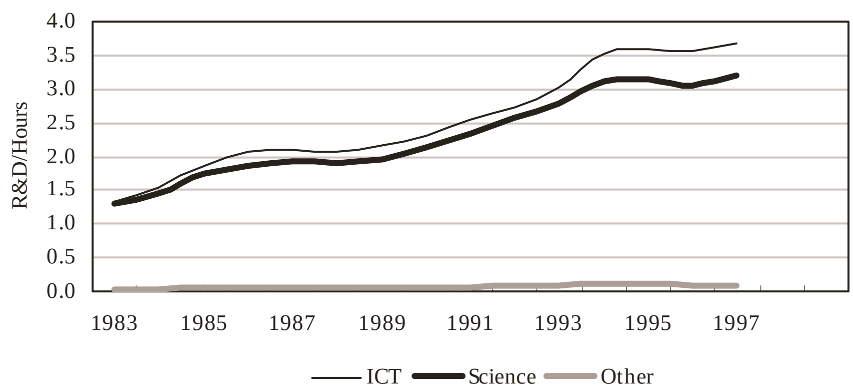


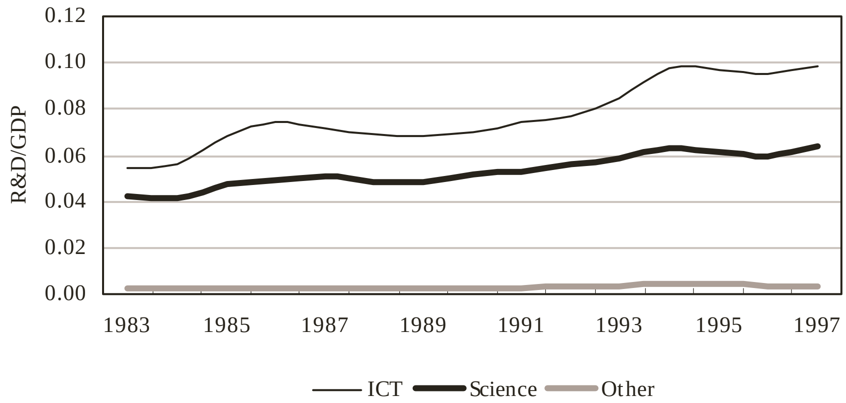
Table 16.1. Ratio of Research and Development to Labour (Current $/Hour)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1983	**1.34**	3.64	0.50	0.06	**1.31**	1.82	1.21	0.59	**0.04**	0.09	0.01
1984	**1.54**	4.00	0.62	0.08	**1.45**	2.06	1.25	0.74	**0.04**	0.09	0.01
1985	**1.87**	4.74	0.81	0.20	**1.74**	2.46	1.43	1.03	**0.05**	0.10	0.01
1986	**2.09**	5.23	1.00	0.23	**1.88**	2.72	1.49	1.13	**0.05**	0.10	0.02
1987	**2.11**	5.30	0.97	0.26	**1.92**	2.75	1.60	1.12	**0.06**	0.10	0.03
1988	**2.08**	5.26	0.86	0.25	**1.90**	2.68	1.61	1.09	**0.06**	0.10	0.03
1989	**2.18**	5.85	0.90	0.27	**1.95**	2.83	1.63	1.06	**0.06**	0.10	0.03
1990	**2.30**	6.39	0.95	0.30	**2.14**	3.02	1.88	1.17	**0.07**	0.11	0.04
1991	**2.55**	7.25	1.06	0.39	**2.34**	3.30	2.11	1.21	**0.07**	0.12	0.04
1992	**2.72**	7.47	1.21	0.53	**2.58**	3.46	2.33	1.48	**0.09**	0.14	0.06
1993	**3.03**	8.72	1.37	0.75	**2.79**	3.75	2.47	1.63	**0.10**	0.16	0.06
1994	**3.53**	10.12	1.66	1.02	**3.10**	4.32	2.53	1.90	**0.11**	0.20	0.07
1995	**3.57**	10.27	1.58	1.18	**3.14**	4.32	2.66	1.88	**0.11**	0.20	0.07
1996	**3.56**	10.95	1.42	1.19	**3.04**	4.32	2.61	1.63	**0.10**	0.18	0.06
1997	**3.66**	12.04	1.29	1.27	**3.21**	4.43	3.08	1.48	**0.10**	0.18	0.06
Annual Growth Rate (%)	**7.4**	8.9	7.0	24.8	**6.6**	6.6	6.9	6.9	**6.9**	5.2	15.6

Table 16.2. Ratio of Research and Development to Labour (1983=100)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1983	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1984	**114.7**	109.9	123.9	143.6	**110.3**	113.1	103.2	126.8	**107.4**	108.0	112.2
1985	**139.8**	130.2	162.3	347.0	**132.6**	135.5	118.5	174.9	**119.5**	114.8	171.2
1986	**155.7**	143.9	198.5	402.2	**143.3**	149.8	123.7	192.2	**132.9**	116.0	280.2
1987	**157.3**	145.7	193.2	457.1	**146.6**	151.2	132.6	190.9	**140.6**	117.1	333.0
1988	**154.9**	144.7	170.5	442.8	**144.7**	147.2	132.9	186.0	**150.3**	119.4	393.7
1989	**162.2**	160.8	179.6	478.5	**148.9**	155.9	134.9	180.1	**156.2**	120.3	440.7
1990	**171.3**	175.8	189.8	523.6	**162.9**	165.9	155.5	198.7	**164.8**	126.5	483.8
1991	**190.3**	199.4	210.8	684.8	**178.0**	181.5	174.4	205.7	**182.8**	140.5	556.6
1992	**202.8**	205.3	241.8	929.8	**196.4**	190.2	192.7	252.7	**222.1**	160.9	749.1
1993	**225.6**	239.7	273.0	1317.1	**212.6**	206.2	204.7	277.1	**246.9**	182.4	819.6
1994	**263.1**	278.3	331.5	1793.8	**236.1**	237.5	209.5	323.9	**284.5**	224.8	859.0
1995	**266.5**	282.4	314.3	2062.5	**239.5**	237.9	220.4	319.5	**282.3**	225.4	845.2
1996	**265.3**	301.1	282.3	2080.1	**231.8**	237.7	215.8	277.5	**251.4**	206.0	725.1
1997	**272.8**	331.1	256.4	2233.4	**244.8**	243.7	255.2	252.7	**254.3**	203.9	761.9

Figure 13. Ratio of Research and Development to GDP (Current $)



R&D-to-labour ratios have increased in all sectors during the last two decades. The largest absolute increases have occurred in the ICT manufacturing sector—going from 3.6 in 1983 to 12.0 in 1997. This sector does not have the highest rate of increase—but this is probably the result of it starting from a higher level. For industries outside of the ICT and science sectors, expenditure on R&D per hour worked remains low despite healthy growth rates (Table 16.1).

Next, we base R&D expenditures on GDP (Figure 13 and Table 17.1). This yields similar results. Though high rates of growth occurred in other services, the largest expenditure ratios are in ICT and science industries, most notably in ICT manufacturing.

The R&D data yield a different perspective on the structure of investment than one obtains when focusing on critical technology investments, or all investments. While significant investments in technology are occurring in all sectors, investments in R&D remain concentrated largely within the boundaries of ICT and science industries.

Our analysis to this point has focused on exploring input structures in New Economy industries. In the next section, we turn from production to performance—and investigate differences in productivity and profitability. Once again, we start with a basic question. Is there evidence that New Economy industries are leaders in terms of their productivity and profitability performance? If so, in which industries is this most evident?

Table 17.1. Ratio of Research and Development to GDP (Current $)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1983	**0.054**	0.191	0.013	0.005	**0.042**	0.061	0.034	0.024	**0.002**	0.004	0.000
1984	**0.057**	0.179	0.015	0.007	**0.041**	0.062	0.030	0.031	**0.002**	0.004	0.001
1985	**0.069**	0.203	0.020	0.014	**0.048**	0.075	0.032	0.041	**0.002**	0.004	0.001
1986	**0.074**	0.227	0.024	0.015	**0.050**	0.081	0.032	0.041	**0.003**	0.005	0.001
1987	**0.071**	0.207	0.023	0.016	**0.051**	0.079	0.035	0.041	**0.003**	0.004	0.001
1988	**0.069**	0.200	0.021	0.014	**0.048**	0.076	0.033	0.041	**0.003**	0.004	0.001
1989	**0.068**	0.198	0.021	0.015	**0.049**	0.076	0.033	0.038	**0.003**	0.004	0.002
1990	**0.070**	0.214	0.022	0.016	**0.052**	0.078	0.037	0.042	**0.003**	0.004	0.002
1991	**0.074**	0.240	0.023	0.020	**0.052**	0.080	0.037	0.041	**0.003**	0.005	0.002
1992	**0.077**	0.245	0.026	0.026	**0.056**	0.083	0.041	0.046	**0.004**	0.005	0.002
1993	**0.084**	0.261	0.031	0.036	**0.059**	0.089	0.041	0.050	**0.004**	0.006	0.003
1994	**0.098**	0.291	0.038	0.047	**0.063**	0.102	0.038	0.058	**0.004**	0.007	0.003
1995	**0.096**	0.287	0.035	0.052	**0.061**	0.100	0.037	0.056	**0.004**	0.006	0.003
1996	**0.095**	0.308	0.031	0.053	**0.060**	0.098	0.037	0.052	**0.004**	0.006	0.002
1997	**0.098**	0.300	0.030	0.057	**0.063**	0.102	0.043	0.046	**0.003**	0.005	0.002
Annual Growth Rate (%)	**4.4**	3.3	6.2	18.9	**3.0**	3.8	1.7	4.7	**3.2**	1.9	11.2

Table 17.2. Ratio of Research and Development to GDP (1983=100)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1983	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1984	**104.5**	93.3	115.9	131.9	**98.5**	103.0	87.1	128.6	**101.0**	99.2	107.4
1985	**126.6**	106.2	157.6	287.6	**114.1**	123.8	94.4	169.1	**107.9**	101.9	156.2
1986	**136.4**	118.6	189.9	295.1	**118.4**	134.1	94.6	171.1	**119.7**	109.0	242.5
1987	**131.8**	108.1	182.2	313.5	**120.8**	129.4	102.7	171.0	**120.1**	104.4	273.8
1988	**127.1**	104.5	163.3	275.6	**114.7**	125.7	95.8	167.9	**122.3**	102.8	305.4
1989	**125.8**	103.7	166.7	290.0	**115.9**	124.5	98.1	157.9	**122.1**	100.3	326.2
1990	**129.5**	111.9	169.8	317.9	**123.2**	127.9	109.2	171.3	**125.8**	103.2	348.7
1991	**136.7**	125.5	177.7	398.6	**125.3**	132.6	109.6	171.1	**136.5**	116.0	382.8
1992	**142.2**	127.9	200.8	525.4	**133.9**	136.1	119.5	191.6	**161.3**	127.9	504.0
1993	**156.1**	136.2	237.7	717.0	**141.0**	147.0	120.0	207.0	**175.4**	138.5	547.0
1994	**180.3**	152.1	292.3	939.6	**150.5**	168.4	112.8	240.6	**194.2**	158.8	561.8
1995	**178.3**	150.1	272.8	1038.2	**145.5**	165.2	109.8	231.9	**184.5**	148.7	537.6
1996	**174.9**	160.7	239.6	1047.7	**143.1**	161.9	109.0	214.6	**160.9**	131.4	455.3
1997	**181.5**	156.8	231.5	1134.0	**151.6**	168.2	127.2	189.1	**155.6**	130.0	444.5

Endnotes

[15] Picot and Heisz (2000) have characterized the shift towards self-employment as the definitive characteristic of the Canadian labour market. Self-employment continues to play less of a role in ICT and science industries than in other sectors; however, the rates of self-employment in ICT and science industries have increased relative to other industries. By 1997, 10% of the workforce in both the ICT and science sectors was self-employed, compared to 15% of workers in other industries; this contrasts sharply with just 2% and 3% of the ICT and science workforces in 1981, when the self-employment rate in other industries stood at 11%.

[16] These ratios will, of course, mask compositional effects, as the occupational characteristics of knowledge workers will differ from sector to sector.

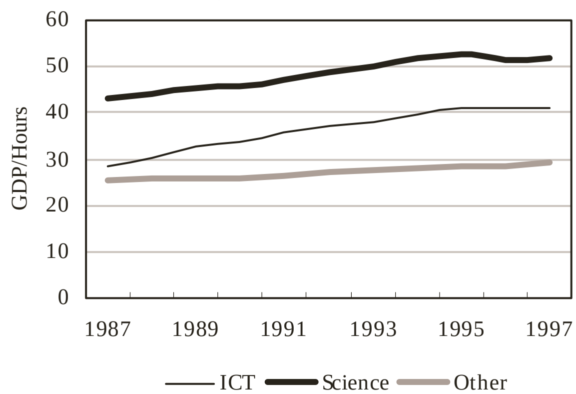
Chapter 5. Performance in New Economy Industries

5.1 Labour productivity

Labour productivity statistics provide a measure of how efficiently labour services are transformed into economic value within different industrial climates. The ratio of real GDP-to-hours worked is one of the most widely used measures of labour productivity. Real GDP-to-hours ratios for the 1987-1997 period are reported in Table 18.1. Interindustry differences in the level of labour productivity reflect differences in capital intensity, technology use, the exploitation of scale economies and organizational efficiency.

In the late 1980s, science industries had significantly higher GDP-per-hour ratios than the ICT sector, partially reflecting their higher capital intensity outlined in the previous section. Beginning in the early 1990s, ICT industries steadily began to close this gap (Figure 14). Science industries increased their labour productivity by 20% from 1987 to 1997, while ICT industries recorded a 44% increase over this ten-year period.

Figure 14. Labour Productivity (GDP/Hour, 1992 $)



Both our New Economy aggregates, ICT and science, recorded higher labour productivity levels, and exhibited faster productivity growth, than the agglomeration of other industries that fall outside these New Economy classifications. A significant labour productivity (GDP per hours worked) gap was apparent in 1987, and this gap widened as the growth of labour productivity in ICT and science industries accelerated over the period (Figure 15).

Figure 15. Labour Productivity (GDP/Hour, 1987=100)

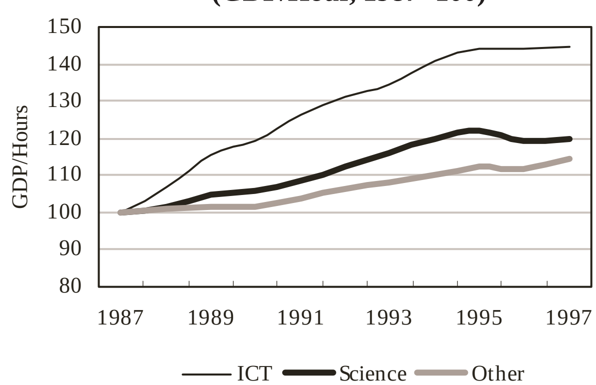


Table 18.1. Labour Productivity (GDP/Hour, 1992 $), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1987	**28.3**	22.7	39.3	18.2	**43.2**	33.2	58.1	31.8	**25.5**	24.7	25.9
1988	**30.3**	24.2	41.7	19.3	**44.0**	35.2	57.5	32.3	**25.8**	24.9	26.3
1989	**32.7**	27.3	44.7	19.3	**45.2**	38.6	58.1	31.0	**25.9**	25.0	26.3
1990	**33.8**	28.0	47.1	18.4	**45.8**	40.5	58.4	30.4	**25.9**	25.6	26.1
1991	**35.9**	29.6	49.5	19.6	**47.0**	43.0	60.1	30.1	**26.4**	26.4	26.4
1992	**37.2**	31.7	49.9	20.5	**48.6**	44.2	60.8	33.3	**27.1**	27.0	27.2
1993	**38.1**	34.3	49.1	20.7	**50.1**	44.9	63.8	34.2	**27.6**	28.1	27.3
1994	**39.9**	38.8	49.9	21.0	**51.8**	47.0	67.2	33.8	**28.2**	28.8	27.8
1995	**40.9**	41.8	51.0	20.0	**52.7**	48.4	68.6	33.5	**28.6**	29.3	28.3
1996	**40.9**	40.7	51.3	19.9	**51.5**	48.5	67.9	30.9	**28.6**	29.2	28.3
1997	**40.9**	43.2	49.9	20.0	**51.7**	48.4	69.3	31.7	**29.2**	29.7	29.0
Annual Growth Rate (%)	**3.7**	6.7	2.4	0.9	**1.8**	3.8	1.8	0.0	**1.4**	1.8	1.1

Table 18.2. Labour Productivity (GDP/Hour, 1987=100), by Subsector

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1987	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1988	**107.0**	107.0	106.0	105.9	**101.8**	106.0	99.1	101.4	**101.0**	100.5	101.3
1989	**115.5**	120.3	113.6	106.2	**104.6**	116.2	100.0	97.3	**101.3**	101.2	101.5
1990	**119.2**	123.6	119.8	101.0	**106.0**	122.0	100.6	95.5	**101.5**	103.3	100.5
1991	**126.6**	130.5	126.1	107.6	**108.8**	129.5	103.6	94.5	**103.6**	106.7	102.0
1992	**131.2**	139.7	127.0	112.9	**112.5**	133.1	104.7	104.5	**106.4**	109.3	104.9
1993	**134.6**	151.1	124.9	113.9	**116.0**	135.2	109.8	107.4	**108.2**	113.7	105.2
1994	**140.8**	171.3	127.0	115.6	**120.0**	141.5	115.8	106.3	**110.4**	116.4	107.2
1995	**144.3**	184.5	129.7	109.8	**122.0**	145.9	118.2	105.1	**112.2**	118.3	109.0
1996	**144.3**	179.5	130.5	109.7	**119.2**	146.2	116.9	96.9	**112.0**	118.0	109.0
1997	**144.4**	190.4	127.1	109.8	**119.7**	145.8	119.3	99.7	**114.6**	120.1	112.0

The most rapid growth rates occurred in ICT manufacturing, with a 90% increase over the 1987-1997 period (Table 18.2). Core ICT services, by comparison, recorded a 27% increase. Faster productivity growth in ICT manufacturing brought their productivity levels more in line with these core ICT services, which prior to the mid 1990s exhibited much higher GDP-per-hour ratios than ICT manufactures.

Within the science sector, much of the labour productivity gains were generated by ICT. Outside the technology sector, science-based goods industries experienced only a 19% gain in labour productivity. Other goods industries, by comparison, realized a 20% gain.

No long-run productivity gains were apparent in science-based services—these industries exhibit the same GDP per hour ratios in 1987 as they did in 1997. Other service industries that operate outside the ICT/science fold experienced a 12% gain in labour productivity.

5.2 Multifactor productivity

One limitation of labour productivity statistics is that they do not control for cross-industry differences in capital endowment. Gains in labour productivity may be due to improvements in efficiency, or they may reflect basic differences in the amount of capital that is used in production. We noted earlier that ICT and science industries exhibit higher investment to labour ratios than other sectors of the economy. Basic differences in investment intensity, and capital accumulation, may account for relatively high rates of labour productivity in these industries.

To obtain productivity growth measures that correct for differences in capital intensity and labour force composition (more as opposed to less skilled workers)—and thus arrive at a measure that is more closely aligned with efficiency gains—we turn to multifactor productivity estimates, a metric that controls for changes in capital and labour. Efficiency gains, in this context, are broadly defined. They are the net effect of a host of underlying influences, including technological and organizational change, differences in plant size, and externalities.

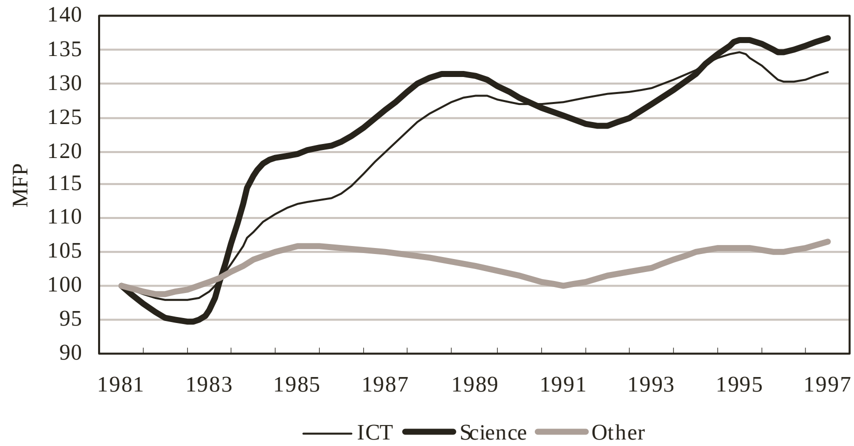
A Fisher-chained index of multifactor productivity is presented in Table 19 (Figure 16). ICT and science-based industries experienced significant MFP gains during the 1980s, coming out of the economic downturn. MFP performance in the large agglomeration of other industries (representing approximately 90% of business sector activity) stagnated during the mid-to-late 1980s—with successive year-to-year declines negating positive growth in the early 1980s. Cumulative productivity growth in this large cross-section of non-ICT, non-science industries was negligible between 1981 and 1991. In comparison, MFP grew by 27% in the ICT sector and 25% in the science sector between 1981 and 1991.

MFP increased steadily in technology industries during the early-to-mid 1990s. MFP in science industries declined during the economic downturn in the early 1990s, and then rebounded sharply after 1992. By 1997, long-run productivity growth in science industries (a cumulative gain of 37% over the 1981-1997 period) actually surpassed long-run growth in the ICT sector (a gain of 32%). Long-run productivity performance in other industries improved by 7%.

Table 19. Value Added Multifactor Productivity for Components of the Business Sector (Fisher Index, 1981=100)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
1981	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0	100.0	**100.0**	100.0	100.0
1982	**98.1**	98.7	98.6	93.6	**95.2**	98.4	92.7	95.5	**98.9**	99.9	97.9
1983	**99.1**	98.5	99.5	98.0	**96.6**	98.8	95.5	93.8	**100.8**	103.6	98.1
1984	**108.1**	124.0	103.2	101.9	**116.2**	108.2	125.6	97.9	**104.0**	109.2	98.9
1985	**112.2**	132.0	105.9	106.8	**119.5**	111.9	129.8	96.8	**106.1**	111.5	100.9
1986	**113.8**	128.5	108.3	111.1	**121.5**	113.0	133.1	96.6	**105.6**	110.5	100.8
1987	**120.0**	145.2	112.5	110.9	**126.2**	119.6	136.4	100.3	**105.1**	110.2	100.2
1988	**125.4**	155.6	116.8	114.5	**130.8**	124.9	140.3	105.2	**104.1**	109.9	98.6
1989	**128.1**	168.3	117.8	111.5	**131.0**	127.9	139.1	102.1	**102.9**	109.4	96.9
1990	**126.9**	166.6	117.9	105.0	**127.9**	127.5	134.3	98.2	**101.6**	110.0	94.2
1991	**127.3**	168.4	117.7	106.7	**125.1**	127.9	128.9	95.9	**100.2**	110.1	92.1
1992	**128.4**	182.1	115.8	108.9	**123.8**	128.6	125.6	95.8	**101.4**	111.2	93.3
1993	**129.4**	190.6	115.6	107.7	**126.8**	129.6	130.7	96.9	**102.6**	114.9	93.0
1994	**132.1**	207.2	115.5	110.7	**131.5**	132.1	138.6	96.1	**105.2**	116.5	96.0
1995	**134.7**	227.1	116.3	105.9	**136.4**	135.5	146.4	95.9	**105.7**	115.8	97.3
1996	**130.2**	209.2	114.0	102.7	**134.8**	130.7	148.1	92.5	**105.1**	115.5	96.5
1997	**131.9**	226.4	113.4	101.0	**136.7**	132.6	151.2	91.5	**106.7**	115.9	98.7
Annual Growth Rate (%)	**1.7**	5.2	0.8	0.1	**2.0**	1.8	2.6	-0.6	**0.4**	0.9	-0.1

Figure 16. Value Added Multifactor Productivity for Components of the Business Sector



It is useful to bring together the evidence from the various sections. The ICT sector experienced higher labour productivity growth over the period, but also experienced significant increases in capital per worker. After controlling for differences in capital intensity, multifactor productivity growth in science environments is on par with gains in the technology sector. Both science and technology environments have much stronger long-run MFP performance than other industries.

Viewed from either a labour productivity or multifactor productivity standpoint, ICT manufacturing industries emerge as the primary engine of growth. ICT manufacturing industries exhibited a much higher MFP growth trajectory than other sectors. Beginning in 1984, MFP in ICT manufacturing accelerated far more rapidly than other New Economy industries. Over the full 1981 to 1997 period, ICT manufacturing enjoyed a 126% increase in MFP—strikingly higher than any of the other industry groupings examined herein. By comparison, core ICT services experienced only a 13% increase in MFP growth during this period, and no significant productivity gains were apparent in other ICT services. It should be noted that the ICT manufacturing sector also had high growth rates in labour productivity and capital intensity. Despite correcting for the latter, its multifactor productivity performance is the highest of all sectors.

Science-based goods industries—R&D-intensive goods industries outside the technology sector—also exhibited comparatively large gains in MFP. Long-run productivity increased by 51% in these industries; science-based services, by contrast, experienced a 9% decline in their MFP over the 1981-1997 period.

Productivity growth is one aspect of economic performance in the New Economy where the focus shifts markedly from technology-based services to manufacturing. Both ICT and science-based manufacturing industries enjoyed much higher rates of productivity growth than core ICT services (computer services and telecommunications).

5.3 Profitability

Productivity statistics create strong impressions of differences in relative performance in different sectors of the economy. We now shift our focus from productivity to the balance sheet, and compare the financial performance of ICT, science and other industries. Strong corporate profits have been identified as a key feature of the New Economy (Lakatos and Benderly, 1999). In this section, we ask whether higher productivity growth in New Economy industries has translated into superior profit performance.

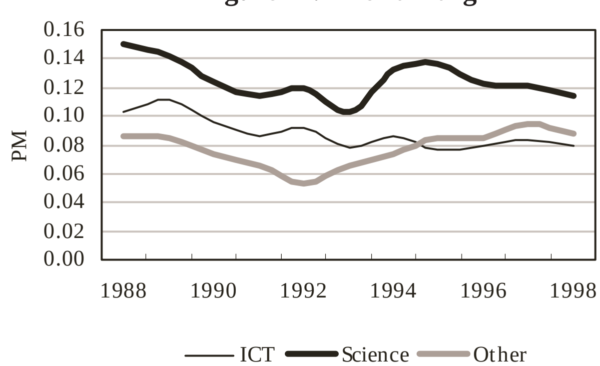
We focus on three standard profit ratios: (1) profit margins, a measure of the operating profits that accrue from the firm's main business activities; (2) return on capital employed, the return to creditors (owners and lenders); and (3) return on equity, the net profits available to owners and investors.[17] Profit data are available for the 1988-1998 period.

5.3.1 Profit margins

The profitability measure derived from profit margins will be affected by differences in capital intensity across industries. Industries that invest substantial sums relative to GDP would be expected to have higher profit margins—or they could not expect to finance this capital. There is therefore reason to expect long-run trends in investment intensity to be reflected in long-run trends in margins—if markets operated relatively well. There is a second reason to expect these ratios to move together, especially in the short run across the business cycle. Investment closely follows cash flow, because cash flow is used to finance investment. We should therefore expect short-run changes in profit margins to be reflected in short-run changes in investment.

Profit margins for ICT and science industries exhibit a downward trend during the late 1980s and early 1990s (Figure 17). ICT margins remain stable during the 1990s. Profit margins for other industries rebound sharply after 1992, and eclipse those in ICT industries by the mid 1990s. Margins in science industries, though higher, show some evidence of decline in recent years. These trends are more or less the same as we found for the investment-to-GDP ratios reported in Chapter 4. The ICT profit margins track the investment ratios quite closely over the period. The overall science margins track investment intensity less perfectly, but the relationship is close enough to suggest that profit margins and investment are closely related in both sectors.

Figure 17. Profit Margin



Basic differences in profit margins are apparent across subsectors. Average profit rates, calculated over the full 1988-1998 period, are reported in Table 20.

Table 20. Average Profitability (1988-1998), by Subsector (%)

	ICT Sector	ICT Manu-facturing	Core ICT Services	Other ICT Services	**Science-based Industries**	ICT-based Science	Non-ICT Science-based Goods	Non-ICT Science-based Services	**Other Industries**	Goods	Services
Profit Margin	**8.6**	5.7	12.1	4.8	**12.4**	9.9	14.5	9.6	**7.9**	5.6	9.4
Minimum	**7.7**	3.3	10.0	3.7	**10.3**	8.7	11.2	7.5	**5.2**	2.8	6.6
Maximum	**11.1**	7.6	16.5	5.8	**15.0**	13.3	16.8	13.2	**9.5**	7.6	11.6
Return on Equity	**6.5**	7.0	6.7	4.0	**6.7**	6.6	7.1	5.2	**7.4**	6.6	7.7
Minimum	**1.0**	1.8	-7.6	-3.0	**1.3**	1.5	-5.8	-6.1	**1.4**	-5.2	2.2
Maximum	**10.7**	12.4	12.5	20.5	**12.3**	10.6	13.2	11.2	**11.6**	12.8	11.2
Return on Capital Employed	**5.2**	6.4	5.2	4.0	**5.5**	5.3	5.8	4.9	**6.1**	5.2	6.5
Minimum	**2.4**	2.7	-0.4	1.7	**3.0**	2.0	3.0	1.9	**2.9**	1.5	3.5
Maximum	**7.6**	9.8	8.4	9.4	**8.1**	7.9	8.3	8.8	**8.2**	8.5	8.5

Within the ICT sector, core services exhibit the highest profit margins, estimated at 12% over the ten-year period. This compares with 6% for ICT manufacturing and 5% for other ICT services. At 15%, science-based goods industries exhibit the highest average margin. This compares to 6% for other goods industries.

5.3.2 Rates of return

Rates of return provide a measure that can be used to evaluate whether a sector earns higher returns on capital invested—either all capital or a subset of capital such as equity. In a world of well-functioning capital markets, rates of return will be equalized by capital movements from one industry to another.

Fewer inter-industry differences are apparent when rates of return are examined—return on equity and return on capital employed (Table 20). For the vast agglomeration of other industries, these ratios exhibit a cyclical pattern—declining through the late 1980s and increasing through the 1990s (Figures 18 and 19). Returns on equity and capital employed are more volatile in ICT and science industries. In some years, the rates of return in New Economy industries are similar to those in other industries. In 1996 and 1997, however, profit rates in ICT and science industries show evidence of a sharp decline—because of a significant reduction in net operating profits. Despite this, average rates of return are very similar between ICT, science and other industries. The long-run return on equity is 6.5% in ICT industries; it is 6.7% in science industries, and 7.4% in other industries. The long-run return on capital employed is 5.2% in the ICT sector, 5.5% in the science sector, and 6.1% in other industries.

Figure 18. Return on Equity

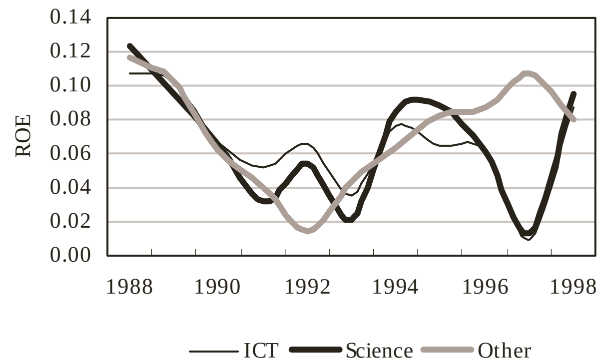
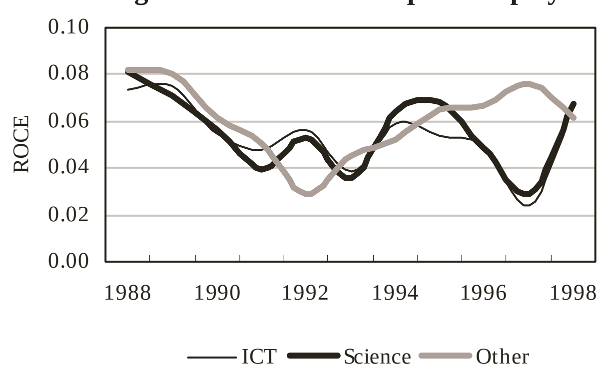


Figure 19. Return on Capital Employed



Endnotes

[17] We selected measures of profitability that provide useful barometers for the regular operating activities of the firm.

Chapter 6. Other Structural Characteristics

Industries differ from one another in a number of ways other than in their input structure, their productivity growth and their profitability. They can have more or less entry of new firms. They may have more or less firm turnover and worker separations. They may be characterized by small or by large firms. They may be primarily exporters or primarily importers.

We examine one of these characteristics here—the nature of the trade balance for the ICT and science-based sector. Historically, an interest in the trade balance of an industry has often been associated with the mercantilist position that 'desirable' industries are those with a positive trade balance and the reverse. International trade theory points out that having more of those industries whose balance is negative would often make a country less well off.

6.1 Trade balance

During the last twenty years, falling world tariffs have led to increased international trade. As part of the international trading community, Canada has been affected by these trends. Successive rounds of tariff reductions under the Kennedy and the Tokyo Round of GATT reductions led to increased Canadian exports. These tariff reductions culminated in the Free Trade Agreement (FTA) between Canada and the United States and then the North American Free Trade Agreement (NAFTA) for Canada, Mexico and the United States in the late 1980s and early 1990s. As a result of these changes, Canada's export-to-gross output ratio for the goods sector, where most of trade occurs, gradually climbed from 24% in 1982 to about 26% by 1990. It then rapidly increased to 38% by 1997 (Table 21.1).

The ICT sector was a substantial beneficiary of this move to freer trade (Figure 20). At the start of the 1980s, it was already heavily involved in trade, with an export-to-output ratio of over 50%. During the 1980s, this ratio languished, falling to 44% by the late 1980s. But the advent of the trade agreement with the United States in the early 1990s saw the export ratio begin to climb and it reached 75% by 1997.

Non-ICT science-based goods industries had lower export ratios at the beginning of the 1980s than the ICT sector. And their export ratios also saw little growth in the 1980s but then leaped upwards in the 1990s. Indeed the rate of growth in the export-to-output ratio was about the same in both sectors over the two decades.

Table 21.1. Ratio of Exports to Output, by Subsector			
	ICT Manu-facturing	Non-ICT Science-based Goods	Goods
1982	0.43	0.22	0.24
1983	0.48	0.21	0.24
1984	0.52	0.22	0.27
1985	0.49	0.23	0.26
1986	0.47	0.24	0.26
1987	0.48	0.23	0.25
1988	0.44	0.24	0.26
1989	0.44	0.23	0.25
1990	0.52	0.25	0.26
1991	0.56	0.26	0.27
1992	0.59	0.26	0.31
1993	0.61	0.29	0.33
1994	0.66	0.32	0.35
1995	0.67	0.35	0.37
1996	0.72	0.36	0.37
1997	0.75	0.38	0.38
Annual Growth Rate (%)	2.57	2.57	3.01

Table 21.2. Ratio of Exports to Output (1982=100), by Subsector			
	ICT Manu-facturing	Non-ICT Science-based Goods	Goods
1982	100.0	100.0	100.0
1983	111.8	94.0	99.0
1984	121.4	102.1	112.0
1985	113.6	103.0	109.5
1986	109.7	107.5	109.5
1987	111.8	105.4	103.8
1988	103.5	109.3	108.4
1989	102.7	104.8	102.3
1990	121.1	113.1	107.0
1991	130.5	117.2	112.8
1992	137.8	118.9	126.9
1993	142.8	132.5	137.0
1994	153.4	144.9	145.3
1995	155.4	158.5	153.6
1996	167.7	165.9	153.5
1997	175.4	172.8	156.1

Figure 20. Ratio of Exports to Output, by Sector

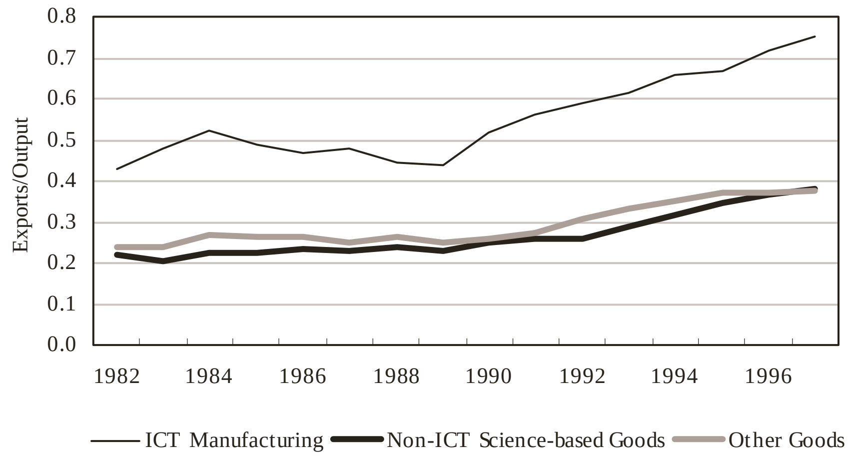
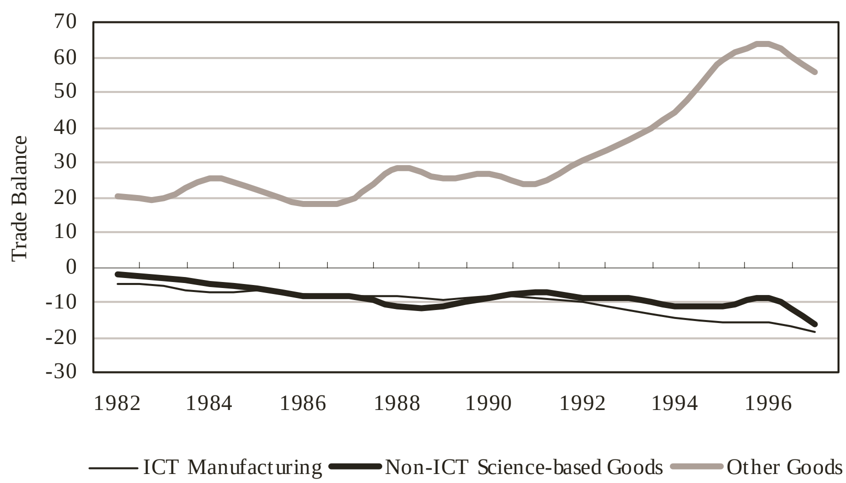


Figure 21. Trade Balance, by Sector (Current $, Billions)



While both the ICT manufacturing sector and science-based goods industries in Canada became more internationally oriented during this period, Canada also increased its imports of goods that are produced in these industries. Indeed, it has tended to import more of these goods than it exports. The trade balance in the goods and services produced by ICT manufacturing and science-based goods is negative (Table 22). And over time, the size of the negative trade balance in both of these areas has grown. While the net trade balance for other goods had reached some $55 billion by 1997, it was -$19 billion for ICT goods and -$16 billion for non-ICT science-based goods. Canada then exports more than it imports in more traditional sectors, and buys more than it sells in the ICT and science sectors (Figure 21).

Table 22. Trade Balance (Current $, Billions), by Subsector			
	ICT Manu-facturing	Non-ICT Science-based Goods	Goods
1982	-4.6	-2.2	20.5
1983	-5.2	-3.3	19.6
1984	-7.0	-4.7	25.6
1985	-6.6	-5.7	22.0
1986	-7.5	-8.6	18.2
1987	-8.1	-8.3	18.9
1988	-8.2	-11.4	28.0
1989	-9.3	-11.2	25.3
1990	-8.5	-8.7	26.3
1991	-8.7	-7.0	23.7
1992	-9.9	-8.6	30.4
1993	-12.2	-9.0	36.0
1994	-14.4	-11.3	44.2
1995	-15.9	-11.3	59.0
1996	-15.7	-8.9	63.7
1997	-18.8	-16.0	55.5
Annual Growth Rate (%)	11.3	14.4	6.8

Chapter 7. ICT and Science: Not the Only Examples of Dynamic Growth

In studies of the New Economy, ICT industries invariably garner the lion's share of attention. These industries are, after all, home to firms that develop, deliver and support the technological products and services—computers, software, and communications equipment—that most view as catalysts for the technology revolution. In this report, we have tried to offer an alternative perspective on the industrial structure of the New Economy by training our lens on other science-based industries—industries that, via their investments in R&D and human capital, also make substantial contributions to patterns of industrial innovation.

Even with this dual ICT/science focus, one is led, almost by design, to a *high-tech* view of the New Economy—one in which highly visible technology or R&D-based industries are the primary agents of industrial change. This impression is, in no small part, aided by our nomenclature. In our comparisons, we relegate industries operating outside the borders of ICT and science to a residual category of "other" industries. At various stages of this report, we refer to these other industries as "non-ICT, non-science based" or as "more traditional" industries. Yet it is important not to lose sight of the fact that these industries account for the vast share of overall business activity—they are home to 92% of establishments, 89% of employees, and 87% of business revenue. And the labour, capital, GDP, productivity and profitability histories presented for this "other industries" category are based on broad cross-sectional averages, tabulated for all non-ICT, non-science industries, while making basic distinctions between goods-producers and service-providers.

In earlier sections, we devoted a considerable amount of our analysis to ICT and science-based subsectors, such as ICT manufacturing industries, core ICT services industries, and science-based services. We did so as a means of highlighting input and performance heterogeneity within the ICT and science-based industrial groups. When considering variation in input or performance histories, our residual group of "other industries" is no different. Averages based on large cross-sections often obscure a great deal of heterogeneity—encompassing potentially large amounts of industry-to-industry variation.

To see this, consider the previous section on multifactor productivity. Taken together, our residual class of other industries exhibit a long-run MFP growth rate of 0.4%, much lower than the ICT and non-ICT science averages of 1.7% and 2.0%, respectively. Yet a mean of 0.4% may result from a highly variable distribution of industry-specific MFP growth rates. And many individual "other industries" may enjoy MFP growth histories that compare favourably with the long-run MFP averages for ICT and science industries.

Table 23. Percentage of *Other* Industries Outperforming the ICT Average, Select Variables	
Variable	% of *Other* Industries (Non-ICT, Non-science) Above the ICT Average
GDP Growth	10.0
Growth in Hours Worked	22.0
Growth in Total Employment	23.6
Wages Rates	24.1
Labour Productivity	17.8
Multifactor Productivity	32.5
Profit Margins	11.5
Return on Equity	61.7
Return on Capital Employed	57.8

See Table 4 for level of industry detail.

We bring this point into clearer focus by calculating how many industries within the "other" category outperform the ICT average for different input and performance characteristics. Table 23 reports, for select variables, the percentage of "other" industries that exceed the corresponding mean for ICT industries.

For each of our input and performance categories, there exist clusters of non-ICT, non-science industries that surpass the ICT average. Net job growth in the ICT sector was very substantial during the 1980s and 1990s. But nearly one-quarter of other industries—industries outside the science and technology sector—exhibited long-run growth rates in hours worked and total employment which surpassed the corresponding growth averages for ICT. Real wages were also higher than the ICT average for about one-quarter of non-ICT, non-science industries.

Similar patterns emerge when examining performance indicators. Real GDP growth in ICT industries—one of the defining characteristics of the technology revolution—nearly doubled over the 1987-1997 period. Yet 10% of non-ICT, non-science industries exceeded this average. Productivity performance in ICT industries was much stronger than in "other industries", when other industries are measured in the aggregate. However, rates of labour productivity growth in 18% of industries operating in non-technology, non-science environments eclipsed the productivity average for the technology sector. And this climbed to 33% of other industries when examining MFP growth. Twelve percent of industries operating in non-technology and non-science environments experienced higher profit margins (12%) than ICT, and sizeable majorities (62% and 58%, respectively) enjoyed higher returns on equity and capital employed.

Which of these "other" industries consistently fare well in relation to the ICT average? Below we report on three groups of industries that surpass the ICT average across a range of input and performance characteristics. Group A is a small collection of industries that outperform the ICT average in five of seven input and performance categories. Group B industries best the ICT average in four categories. Last, Group C industries surpass the ICT average in three analysis categories. These groupings represent collections of *high-*

performance industries; all, in varying degrees, outperform the ICT sector across a significant number of analysis categories. We restate these categories below.[18]

- Growth in real GDP, 1987-1997 (GDP)
- Growth in hours worked, 1981-1997 (HRS)
- Growth in employment, 1981-1997 (EMP)
- Average annual real wages, 1981-1997 (WAGE)
- Growth in labour productivity, 1987-1997 (LP)
- Growth in multifactor productivity, 1981-1997 (MFP)[19]
- Average profit margin, 1988-1998 (PM)

We report on the composition of these three groups in Table 24. Values of one represent categories where the score for the "other" industry exceeds the ICT average. Values of zero represent categories where the estimate for the other industry is less than (or equal to) the corresponding ICT average.

When making these comparisons, it is important to bear in mind that many of these *high-performance* industries are very small when viewed in relation to the ICT sector. Collectively, the four industries that comprise Group A have an employment base that is only 5% the size of ICT sector's. Group B industries together have a workforce that is about 20% the size of the ICT employment base. This said, many of these industries do have long-run input and performance characteristics that compare favourably with the growth profile established by the ICT sector. High rates of GDP and employment growth are two defining characteristics of ICT industries. Eleven of the *high-performance* industries in Groups A and B have long-run GDP growth rates that exceed the ICT average. And nine of these industries also have expanded their labour inputs (employment and hours worked) more rapidly than the ICT sector. Most of these high-performance industries are drawn from the goods-producing sector. Of the 13 industries that outperform the ICT average in four or more categories (Groups A and B), 12 are either manufacturing or primary goods industries. Of the group of 18 industries that best the ICT average in three of seven categories (Group C), 14 are located in manufacturing or primary goods industries.

The exercises in this section are meant to place changes in industrial structure in context. ICT and science-based industries are important sources of industrial growth, and have contributed significantly to the evolution of the New Economy. But just as a singular focus on the ICT sector risks omitting an interesting group of R&D-intensive science industries, relegating the vast majority of business-sector industries to a residual class of other industries may inadvertently create the impression that there are scant examples of industrial dynamism beyond the boundaries of ICT and science. Yet there exist sizeable concentrations of "other" industries that surpass the ICT average—whether in terms of output growth, employment growth, or GDP performance. And some industries (such as those listed in Table 24) consistently fare better than ICT in many input and performance categories.

Table 24. High Performance Industries in the "Other" Sector

	Size Relative to ICT (%)	GDP	HRS	EMP	WAGE	LP	PM	MFP	TOTAL
Group A: Industries that Outperform the ICT Average in Five of Seven Categories									
Motor Vehicle Wiring Assemblies Industry	0.8	1	1	1	0	1	0	1	5
Other Transportation Equipment Industries	0.5	1	1	1	0	1	0	1	5
Particle and Wafer Board Industries	0.9	1	1	1	1	1	0	0	5
Plastic Parts and Access. for Motor Vehicles Industries	2.5	1	1	1	0	1	0	1	5
Group B: Industries that Outperform the ICT Average in Four of Seven Categories									
Gold Mines	1.5	0	1	1	1	0	0	1	4
Lotteries, Bingos, Casinos, etc.	6.0	1	1	1	0	0	1	0	4
Man-made Fibre and Filament Yarn Industry	0.6	0	0	0	1	1	1	1	4
Motor Vehicle Stampings Industry	2.2	1	1	1	0	0	0	1	4
Motor Vehicle Steering and Suspension Parts Industries	1.1	1	1	1	0	0	0	1	4
Other Motor Vehicle Accessories, Parts and Assembly Industries	5.7	1	1	1	0	0	0	1	4
Other Rubber Products Industries	2.4	1	1	1	0	0	0	1	4
Steel Pipe and Tube Industry	1.2	1	0	0	1	1	0	1	4
Vegetable Oil Mills (except Corn Mills)	0.1	1	0	0	1	1	0	1	4
Group C: Industries that Outperform the ICT Average in Three of Seven Categories									
Accounting and Legal Service	27.3	0	1	1	0	0	1	0	3
Aluminium Rolling, Casting and Extruding Industries	1.1	0	0	0	1	1	0	1	3
Crude Petroleum and Natural Gas Industries	7.0	0	0	0	1	1	1	0	3
Educational Service Industries, Private	142.0	1	1	1	0	0	0	0	3
Hydraulic Cement Industry	0.3	0	0	0	1	0	1	1	3
Lime Industry	0.1	0	0	0	1	1	0	1	3
Machine Shop Industry	5.8	1	1	1	0	0	0	0	3
Motor Vehicle Engine and Engine Parts Industry	1.9	0	0	0	1	1	0	1	3
Motor Vehicle Fabric Accessories Industry	1.8	1	0	0	0	1	0	1	3
Motor Vehicle Industry	7.9	1	0	0	1	1	0	0	3
Musical Instrument and Sound Recording Industry	0.9	1	1	1	0	0	0	0	3
Non-ferrous Metal Smelting and Refining Industries	3.7	0	0	0	1	0	1	1	3
Other Metal Mines	2.0	0	0	0	1	0	1	1	3
Other Primary Steel Industries	4.3	0	0	0	1	1	0	1	3
Railway Transport and Related Service Industries	6.9	0	0	0	1	1	0	1	3
Real Estate Operator Industries	31.3	0	1	1	0	0	1	0	3
Tire and Tube Industry	1.1	0	0	0	1	1	0	1	3
Wine Industry	0.3	0	0	0	0	1	1	1	3

Industries within each group are listed alphabetically.
Relative size is the ratio of industry employment to ICT employment, expressed as a percentage (source: Business Register 2001).

The most striking feature of these high performance lists is the cluster of motor vehicle industries. Many analysts view the motor vehicle industry as the backbone of the traditional industrial economy. Automotive industries are to the "Old Economy" what computer services and telecommunications are to the new. Yet eight separate motor vehicle industries (ranging from assembly to parts to accessories) make the grade as high-performance, when their input and performance characteristics are compared directly to the ICT average. Collectively, these eight automotive industries have an employment base that is about one-quarter the size of the ICT sector's.

Five of these high-performance automotive industries best the ICT average in at least four separate categories (Groups A and B). Which categories contribute to this performance record? GDP growth, growth in labour inputs and MFP performance are important aspects of the track record for high-performance automotive industries in Groups A and B.[20] In contrast, labour productivity, wages and profit margins in these automotive industries compare less favourably with the ICT sector.

What the comparisons in this section do not address, however, is the extent to which the input and performance records for different industries are determined by investments in new technologies—specifically, the technologies developed, delivered and supported by firms in the ICT sector. It may well be the case that many of these "other industries" are surpassing the ICT average *because* of ICT capital (and automotive industries may be illustrative of this). New research on business productivity (Armstrong et al., 2002) has begun to emphasize how technological innovations developed in ICT industries are improving business performance in different sectors. A complete analysis of the impact of ICT and science industries requires an evaluation of how the goods and services produced by these industries has affected systems of production throughout the economy. From a *technology-use* perspective, straightforward conceptual distinctions between New Economy industries, such as ICT and science, and more traditional segments of the business sector serve more as analytical constructs than as precise descriptions of the economy's evolving industrial structure.

Endnotes

[18] Only one measure of profitability—profit margins—is examined in this exercise. We have excluded the return on equity and the return on capital employed from our list of analysis categories because the majority of industries in non-ICT and non-science environments have rates of return that exceed the ICT average (see Table 23). Consequently, these two profit rates are less useful barometers of (superior) ICT performance on which to base our comparisons.

[19] Compared to other analysis categories, less data detail is available to support industry-specific estimates of MFP. Of the 31 industries listed in Table 24, 11 have MFP estimates that are specific to the reported industry. In the remaining 20 cases, MFP estimates are calculated for a combination of industries that include the reported industry.

[20] MFP statistics, however, are generated collectively for two groups of industries within the cluster of eight industries that comprises the automotive sector. Limitations on data availability preclude us from examining variations in MFP performance within this group. See note 19.

Chapter 8. Conclusion

This paper has addressed four distinct issues. First, is there something unique about the ICT sector? Second, is there another set of industries, perhaps the group that are more intensive performers of R&D, that possess many of the same characteristics as ICT industries? Third, are ICT industries a homogeneous group, or are there industry subsets within ICT that have quite different characteristics? Fourth, are there dynamic industries outside of the ICT and science-based sectors?

To answer the first two questions, we have divided the business sector into three groups—ICT, science-based, and 'other'. Science-based industries are a group of industries that have been variously referred to as the R&D intensive group, or the knowledge group. They have relatively high R&D-to-GDP ratios and their workforce includes a large proportion of scientists and professionals. Science industries include many in the ICT group, but they also include industries like aerospace, pharmaceuticals, architecture and engineering. ICT industries account for about 5% of employment, non-ICT science-based industries for another 5%, and the 'other' sector for the remaining 90%.

In terms of growth in GDP in the 1990s, the ICT sector led both the science and 'other' sectors and, in this sense, was extremely dynamic. It is also the case that employment growth was relatively higher in the ICT sector than in either the science-based sector or in 'other' industries.

On the employment side, the percentage of knowledge workers in ICT industries is much higher than in the 'other' sector. Moreover, the share of the ICT workforce employed in knowledge-based occupations has increased rapidly during the 1980s and 1990s. In contrast, the increase in labour quality (the compositional shift towards higher paid workers) was no greater in the ICT sector than elsewhere. This indicates that there was no greater shift toward higher paid workers, in particular those whose educational attainments were higher. Of particular interest is the declining wage premium for knowledge workers in the ICT sector. Knowledge workers did not suffer an absolute decline in their wages. Rather, non-knowledge workers saw a higher relative increase—probably because their educational requirements were increasing relatively faster.

In keeping with the higher proportion of knowledge workers in the ICT sector, the average hourly wage rate is higher there than in 'other' industries. The rate of growth of ICT wages was also slightly higher than in these non-ICT, non-science industries.

Investment intensity (measured as a percentage of GDP) was higher in the ICT sector than in the 'other-industry' sector. But this measure of investment intensity has been trending downward over the last two decades. When core computer, telecommunications and software assets are examined, the ICT sector leads the way.

If we consider investment-to-labour ratios, the ICT sector is more capital intensive than 'other industries' but the increase in this ratio over the period has been no higher for the ICT sector than for the 'other' sector. A similar pattern emerges when just critical ICT investment commodities—computers, telecommunications and software—are considered. ICT industries had a relatively high level of investment per worker in these areas at the beginning of the period, but the rate of growth of this ratio was actually higher in the 'other' sector. The one area where ICT capital investment stands out is in terms of R&D per capita spending.

It is clear from these data that the ICT sector differed from the 'other' sector in terms of the level of knowledge workers and the level of capital investment, whether measured in terms of investment per dollar of GDP or investment per worker. But evidence concerning the long-run growth of knowledge workers and investment intensity is mixed. On the labour input side, the rate of growth of knowledge workers is higher for ICT industries, but there is no disproportionate shift to higher-educated or higher-wage workers within the overall employed workforce in the ICT sector. In fact, there is a decline in the knowledge worker wage premium over time in the ICT sector.

The level of labour productivity and labour productivity growth is much higher in the ICT sector than in 'other' industries. The ICT sector also experienced much higher increases in capital services per worker because of the concentration of investment in this sector in high cost, rapidly depreciating ICT commodities. Despite this, multifactor productivity growth is also higher in the ICT sector.

Finally, it should be noted that profitability is not particularly high in technology industries. While it is true that profit margins are higher in the ICT sector, this is just in keeping with higher investment to GDP ratios. More importantly, the rates of return that are earned on total capital or on equity are very similar to those earned by 'other' industries.

The second question examined by this paper is the extent to which focusing on a narrowly defined high-tech sector known as ICT, risks omitting an interesting group of industries that resemble the ICT sector in many respects. For this purpose, we defined a group of related industries that has variously been referred to as high-knowledge or high-tech, and that we refer to as the science-based sector because of their emphasis on R&D and scientific personnel. This is the group that resembles the ICT sector in that they have high R&D intensities.

This sector was found to resemble the ICT sector in a number of other dimensions. First, science-based service industries also had high GDP growth rates. The science-based sector was found to have a similar percentage of workers that are knowledge intensive. It also has high wage rates. It has high investment intensities that have also been trending downward and higher investment to worker ratios. Labour productivity growth rates in the science sector are lower than for the ICT sector. But after controlling for differences in capital intensity, multifactor productivity gains in the science sector actually exceed those in the ICT sector. While rates of return in science industries are quite similar to those in the ICT and 'other' sectors, profit margins in science industries are slightly higher.

The evidence presented herein suggests that there are other industries beyond the ICT sector that could also be included as part of the New or Knowledge Economy. The input structure and performance characteristics of science industries resemble, in many dimensions, those of the ICT sector. What is more, there are industries in more traditional segments of the economy (e.g., motor vehicles) with input and performance profiles that stand up well against the ICT sector. Accordingly, studies that attempt to evaluate the full extent of the changing industrial paradigm might well be prepared to train their lens on a wider array of industries than just highly-visible, technology industries.

The third major question focuses on whether there are substantial industry differences within the ICT and science-based sectors. Is the ICT sector a homogeneous group of industries or is there a core set of industries that lead the group? To answer this question, we first divided the ICT sector into goods and service industries. We then examined what we arbitrarily defined as a core set of ICT service industries—computer services and telecommunications industries.

Core ICT services (computers and telecommunications) have the fastest rate of both GDP and employment growth over the period. Science-based services also had relatively high rates of growth. The shift towards knowledge workers is greatest in core ICT services. But knowledge workers are just as important in science-based services.

The ICT core service sector possessed the highest average wage rates at the beginning of the study period—but experienced relatively low growth rates. By the end of the period, the average wage rate in the ICT manufacturing sector caught up with the ICT service sector.

Productivity growth is much higher in ICT manufacturing than elsewhere—this allowed GDP-per-worker ratios in ICT manufacturing industries to gain ground on core ICT services during the 1990s. ICT manufacturing also has the highest MFP growth over the post 1981 period. It should be noted that this sector also had high growth rates in capital intensity. Despite correcting for this, its multifactor productivity growth is the highest of all sectors.

All this suggests that studies of the ICT sector had best focus separately on the service and the goods sectors. Employment growth in the service subsectors of both ICT and science has been comparatively rapid. But it is the ICT manufacturing sector that has seen its wage rates and its productivity increasing more dramatically over the last two decades.

References

Armstrong, P., T.M. Harchaoui, C. Jackson and F. Tarkhani. 2002. *A Comparison of Canada-US Economic Growth in the Information Age, 1981-2000: The Importance of Investment in Information and Communication Technologies.* Economic Analysis Research Paper Series 11F0027MIE2002001. Analytical Studies Branch. Ottawa: Statistics Canada.

Baldwin, J.R., G. Gellatly, J. Johnson and V. Peters. 1998. *Innovation in Dynamic Service Industries*. Catalogue No. 88-516. Ottawa: Statistics Canada.

Baldwin, J.R. and J. Johnson. 1999. *The Defining Characteristics of Entrants in Science-based Industries.* Catalogue No. 88-517. Analytical Studies Branch. Ottawa: Statistics Canada.

Baldwin, J.R. and V. Peters. 2001. *Training as a Human Resource Strategy*. Analytical Studies Research Paper Series 11F0019MIE2001154. Analytical Studies Branch. Ottawa: Statistics Canada.

Baldwin, J.R. and D. Sabourin. 2001. *Impact of the Adoption of Advanced Information and Communication Technologies on Firm Performance in the Canadian Manufacturing Sector*. Analytical Studies Research Paper Series 11F0019MIE2001174. Analytical Studies Branch. Ottawa: Statistics Canada.

Basset, P. 1993. "Diane Cohen on the new economy" *Perspectives on Labour and Income.* Catalogue No. 75-001. Summer. Ottawa: Statistics Canada.

Beckstead, D. and T. Vinodrai. 2003. *Dimensions of Occupational Changes in Canada's Knowledge Economy, 1971-1996.* The Canadian Economy in Transition Research Paper Series 11-622-MIE2003004. Analytical Studies Branch. Ottawa: Statistics Canada. Forthcoming.

Case, J. 1989. "The Disciples of David Birch" *INC*. January: 39-45.

Chaillou, N. 1999. "Partnering Strategy for Small Technology-Based Firms: An Empirical Analysis — the Case of the US Biotechnology Industry". In *New Technology-Based Firms in the 1990s* (vol. 6). Edited by R. Oakey, W. During and S.-M. Mukhtar. Amsterdam: Pergamon. 52-68.

Gellatly, G. and V. Peters. 1999. *Understanding the Innovation Process: Innovation in Dynamic Service Industries.* Analytical Studies Research Paper Series 11F0019MIE2001127. Analytical Studies Branch. Ottawa: Statistics Canada.

Gu, W., M. Kaci, J.-P. Maynard and M.-A. Sillamaa. 2003. "The Changing Composition of the Canadian Workforce and its Impact on Productivity Growth". In *Productivity Growth in Canada — 2002*. Edited by J.R. Baldwin and T.M. Harchaoui. Catalogue No. 15-204-XPE. Ottawa: Statistics Canada.

Industry Canada. 2001. *Making a Difference. Our Priorities for 2000-1*. Catalogue No. C1-12/2001E-I. Ottawa: Industry Canada.

Jorgenson, D.W. and K.J. Stiroh. 2000. "Raising the Speed Limit: U.S. Economic Growth in the Information Age". *Brookings Papers on Economic Activity*, 1: 125-211.

Kelly, K. 1999. *New Rules for the New Economy: 10 Radical Strategies for a Connected World*. Viking Penguin.

Lakatos, S.C. and J. Benderly. 1999. "S&P Earnings, Corporate Profits and Productivity". *Business Economics*, XXXIV(2), April: 25-28.

Landefeld, S.J. and B.M. Fraumeni. 2001. "Measuring the New Economy" *Survey of Current Business*, March: 23-40.

Lee, F.C. and H. Has. 1996. "A Quantitative Assessment of High-Knowledge Industries Versus Low-Knowledge Industries". In *The Implications of Knowledge-Based Growth for Micro-Economic Policies*. Edited by P. Howitt. Calgary: University of Calgary Press. 39-78.

Lefebvre, L.A., E. Lefebvre and P. Mohnen. 2001. "The Global Information Infrastructure: From the Virtual Enterprise to the Virtual Economy". In *Doing Business in the Knowledge-Based Economy*. Edited by L. Lefebvre, E. Lefebvre and P. Mohnen. Boston: Kluwer Academic Publishers. 81-115.

Morck, R. and B. Yeung. 2001. "The Economic Underpinnings of a Knowledge-Based Economy." In *Doing Business in the Knowledge-Based Economy*. Edited by L. Lefebvre, E. Lefebvre and P. Mohnen. Boston: Kluwer Academic Publishers. 425-467.

OECD. 2000a. *Measuring the ICT Sector.* Paris.

OECD. 2000b. *Is There A New Economy? First Report on the OECD Growth Project.* Paris.

OECD. 1997. *Science, Technology and Industry*. *Scoreboard of Indicators.* Paris.

Picot, G. and R. Dupuy. 1996. *Job Creation by Company Size Class: Concentration and Persistence of Job Gains and Losses in Canadian Companies*. Analytical Studies Research Paper Series 11F0019MIE1996093. Analytical Studies Branch. Ottawa: Statistics Canada.

Picot, G. and A. Heisz. 2000. *The Performance of the 1990s Canadian Labour Market*. Analytical Studies Research Paper Series 11F0019MIE2000148. Analytical Studies Branch. Ottawa: Statistics Canada.

Robson, M., J. Townsend and K. Pavitt. 1988. “Sectoral patterns of production and use of innovations in the UK: 1945-83”. *Research Policy* 7, 1: 1-14.

Sabourin, D. 2001. *Skill Shortages and Advanced Technology Adoption.* Analytical Studies Research Paper Series 11F0019MIE2001175. Analytical Studies Branch. Ottawa: Statistics Canada.

Statistics Canada. 2001. *Beyond the Information Highway: Networked Canada.* Catalogue No. 56-504. Ottawa: Statistics Canada.

Stiroh, K.J. 2001a. “Investing in Information Technology: Productivity Payoff for U.S. Industries” *Current Issues in Economics and Finance*, 7,6: 1-5.

Stiroh, K.J. 2001b. *Are ICT Spillovers Driving the New Economy?* Presented at the Canadian Economic Association Annual Meetings, Montreal, Canada. June 2001.

Stiroh, K.J. 1999. “Is There a New Economy?” *Challenge*. July-August: 82-101.

Thurow, L. 1999. *Building Wealth: The New Rules for Individuals, Companies, and Nations in a Knowledge-Based Economy*. Harper Collins Publishers.

Van Ark, B. 2001. *The Renewal of the Old Economy: An International Comparative Perspective*. Working Paper. University of Groningen and The Conference Board.

Voyer, R. and P. Ryan. 1994. *The New Innovators: How Canadians Are Shaping the Knowledge-Based Economy*. James Lorimer & Company.

Suggestions for Further Reading

Baldwin, J.R. and G. Gellatly. 1998. *Are There High-Tech Industries or Only High-Tech Firms? Evidence from New Technology-Based Firms.* Analytical Studies Research Paper Series 11F0019MIE1998120. Analytical Studies Branch. Ottawa: Statistics Canada.

Bosworth, B.P. and J.E. Triplett. 2001. "What's New About the New Economy? IT, Economic Growth and Productivity". *International Productivity Monitor*, 2: 19-30.

Gera, S., C. Lee-Sing and K. Newton. "The Emerging Global Knowledge-Based Economy: Trends and Forces." In *Doing Business in the Knowledge-Based Economy*. Edited by L. Lefebvre, E. Lefebvre and P. Mohnen. Boston: Kluwer Academic Publishers. 1-48.

Howitt, P. 1996. "On Some Problems in Measuring Knowledge-Based Growth." *In The Implications of Knowledge-Based Growth for Micro-Economic Policies.* Edited by P. Howitt. Calgary: Calgary University Press. 9-29.

Kouparitsas, M.A. 1999. "Is There Evidence of the New Economy in the Data?" Federal Reserve Bank of Chicago Working Paper Series, WP-99-22.

McLean, R.I.G. 1995. *Performance Measures in the New Economy: A report commissioned by The Premier's Council with support from the Canadian Institute of Chartered Accountants*. Ontario: Premier's Council.

Nordhaus, W.D. 2001. *Productivity Growth and the New Economy.* NBER Working Paper No. 8096.

Oliner, S.D. and D.E. Sichel. 2000. "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives*, 14, 4: 3-22.

OECD. 1996. *Employment and Growth in the Knowledge-Based Economy*. OECD. Paris.

Sichel, D.E. 1999. "Computers and Aggregate Economic Growth: An Update" *Business Economics,* XXXIV(2), April: 18-24.

Statistics Denmark, Statistics Finland, Statistics Iceland, Statistics Norway, Statistics Sweden. 2000. *The ICT Sector in the Nordic Countries*. Denmark: Statistics Denmark.

Steindel, C. 1992. “Manufacturing Productivity and High-Tech Investment”. *Federal Reserve Bank of New York Quarterly Review*, Summer: 32-47.

Stiroh, K.J. 1998. “Computers, Productivity and Input Substitution”. *Economic Inquiry* XXXVI(2): 175-191.

Triplett, J.E. 1999. “Economic Statistics, the New Economy, and the Productivity Slowdown”. *Business Economics* XXXIV(2): 13-17.

Zhao, J., D. Drew and T.S. Murray. 2000. “Brain Drain and Brain Gain: The Migration of Knowledge Workers from and to Canada” *Education Quarterly Review*: 6.3: 8-35.