CHAPTER 1

INTRODUCTION AND SUMMARY

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Abstract

This chapter summarises the main findings of this report. It shows that ICT is having far-reaching impacts on economic performance and the success of individual firms, in particular when it is combined with investment in skills, organisational change, innovation and new firm creation. These impacts can be observed in firm-level studies for many OECD countries, but have only translated into stronger economic performance at the economy-wide or industry level in a few OECD countries. The limited impact of ICT at the aggregate level in many OECD countries is not necessarily due to lack of investment in ICT, but more to lack of complementary changes and investment that enable the full exploitation of ICT. The chapter also identifies some issues that will require further work, in developing better methods and data, and in further empirical analysis.

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1.1. Introduction

Information and communications technology (ICT) has proven to be the key technology of the past decade. The widespread diffusion of the Internet, of mobile telephony and of broadband networks all demonstrate how pervasive this technology has become. But how precisely does ICT affect economic growth and the efficiency of firms? And what are the conditions under which ICT can become a technology that is effective in enhancing economic performance?

Despite the downturn of the economy over the past few years and the passing of the Internet bubble, these questions remain important to policy makers. This is because ICT has become a fact of economic life in all OECD economies. Almost all firms now use computers and most of them have an Internet connection. Moreover, a large share of these firms use computer networks for economic purposes, such as the buying, selling and outsourcing of goods and services. But despite the widespread diffusion of ICT in OECD economies, questions remain about the impact of the technology on economic performance. Thus far, only few OECD countries have clearly seen an upsurge in productivity growth in those sectors of the economy that have invested most in the technology, notably services sectors such as wholesale trade, financial services and business services. In many OECD countries, these impacts have yet to materialise. Improving the understanding of the ways in which ICT affects economic performance and the factors that influence the potential impacts of ICT thus remains important.

This study aims to contribute to a better understanding of these issues. It brings together 12 studies that all provide a different perspective on the impacts of ICT on economic growth. Nine of these studies (Chapter 3 and Chapters 6 to 13) are based on firm-level data and were carried out by researchers in individual OECD countries. Most of these focus on a single OECD country, but some also include a comparative perspective. These firm-level studies provide a wealth of detail and precision about the impacts of ICT. Three other chapters (Chapters 2, 4 and 5) provide a cross-country perspective for all OECD countries and are based on work carried out by OECD staff, using available OECD data. The variety of approaches that is used in the book is important as each perspective – be it from a specific country or using a specific method – adds new evidence to our overall understanding of ICT. This introductory chapter provides a brief summary of the 12 chapters included in this book. It also highlights some of the remaining questions that could be the subject of further empirical analysis.

1.2. The diffusion of ICT – why does it differ across firms and OECD countries?

The first issue addressed in the book, notably in Chapters 2 and 3, concerns the diffusion of ICT across OECD countries. The economic impact of ICT is closely linked to the extent to which different ICT technologies have diffused across OECD economies. This is partly because ICT is a network technology; the more people and firms that use the network, the more benefits it generates. Chapter 2 uses a range of official statistics to show that the diffusion of ICT currently differs considerably between OECD countries. In practice, different indicators of ICT diffusion all tend to point to the same countries as having the highest rate of uptake of ICT. These include the United States, Canada, New Zealand, Australia, the Nordic countries and the Netherlands. From this perspective, it is likely that the largest economic impacts of ICT should also be found in these countries.

The question that follows is why the diffusion of ICT differs so much across countries? All OECD countries have been faced with a rapid decline in ICT prices and with growing opportunities for efficiency-enhancing investment in ICT. A number of reasons can be noted. Chapter 2, by Dirk Pilat and Andrew Devlin, provides a cross-country analysis of diffusion patterns. The empirical evidence presented in this chapter points to several factors affecting the diffusion of ICT. The first of these concerns the direct costs of ICT, e.g. the costs of ICT equipment, telecommunications or the
installation of an e-commerce system. The available data point to persistent differences in the costs of ICT across OECD countries, despite heavy international trade in ICT and the liberalisation of the telecommunications industry. A second important factor affecting diffusion patterns is the ability of a firm to absorb new technology, such as ICT. This includes the availability of know-how and qualified personnel, the scope for organisational change and the capability of a firm to innovate. Factors related to competition and the regulatory environment also play an important role, since excessive regulation may make it difficult for firms to seize the opportunities offered by ICT.

Chapter 3, by Heinz Hollenstein, examines the question of ICT diffusion with firm-level evidence for Switzerland. He shows that the decision of a firm to adopt ICT depends on the balance of costs (in the broadest possible sense) and benefits that may be associated with the technology. His analysis primarily seeks to explain inter-firm differences of adoption, emphasising the heterogeneity among firms with respect to the potential profitability of technology adoption. But he also takes account of spill-over effects; the more firms that already use a technology, the more sensible adoption becomes.

The chapter points to a range of important determinants of ICT adoption. These include the anticipated benefits of adoption, notably improved customer-orientation and advantages related to costs. The costs of adoption are important too, notably the direct costs of investment, but also the restrictions posed by finance and deficiencies in knowledge. A third range of factors have to do with the absorptive capacity of a firm and include its human capital base and innovative activity. Other factors influencing adoption are information spill-overs and learning effects, competition and, finally, the size of a firm. A more extended version of the analysis shows that the introduction of new workplace organisation (in particular, team-working, decentralised decision-making and flattening hierarchies of a firm) is also an important factor facilitating ICT adoption. The empirical analysis also shows that the adoption of ICT and that of new workplace organisation are interrelated.

1.3. The economic impacts of ICT – an aggregate perspective

Chapters 4 and 5 of the book move on to the second key question concerning ICT, namely its economic impact. In most analysis of economic growth, three effects of ICT on productivity and growth are distinguished. First, as a capital good, investment in ICT contributes to overall capital deepening and therefore helps raise labour productivity. Second, rapid technological progress in the production of ICT goods and services may contribute to more rapid multifactor productivity (MFP) growth in the ICT-producing sector. And third, greater use of ICT may help firms increase their overall efficiency, and thus raise MFP. Greater use of ICT may also contribute to network effects, such as lower transaction costs and more rapid innovation, which will improve the overall efficiency of the economy, i.e. MFP. These effects can be measured and examined at different levels of aggregation, i.e. at the macro-economic level, the sectoral or industry level, and the firm level.

The role of ICT capital

The first measure of ICT impacts highlighted above considers ICT investment. Chapter 4, by Nadim Ahmad, Paul Schreyer and Anita Wölfl, shows that capital deepening through investment in ICT establishes the infrastructure for the use of ICT (the ICT networks) and provides productive equipment and software to businesses. ICT investment in OECD countries rose from less than 15% of total non-residential investment in the early 1980s, to between 15% and 30% in 2001. Since investment mechanically adds to the capital available to workers it contributes to labour productivity growth. Estimates show that it typically accounted for between 0.3 and 0.8 percentage points of growth in GDP and labour productivity over the 1995-2001 period. The United States, Australia, the Netherlands and Canada received the largest boost; Japan and United Kingdom a more modest one,
and Germany, France and Italy a much smaller one. Investment in software accounted for up to a third of the overall contribution of ICT investment.

Chapter 4 also highlights that measuring the impacts of ICT investment is not yet straightforward. This is partly because measures of ICT investment are not always available and when they are, they are not necessarily comparable across countries. Data on software investment are particularly problematic and have been the subject of an OECD/Eurostat Taskforce that has produced a range of recommendations to improve measurement. A second important issue concerns the adjustment of volume measures of ICT investment for rapid quality change. So-called hedonic deflators may help to deal with this issue, but these have only been developed in some countries and for some key product categories. To address problems of international comparability, empirical studies often use US hedonic deflators to represent price changes in other countries. This is only a second-best solution as countries should ideally develop deflators that properly account for quality change of ICT products in their own national context. An OECD Handbook on Quality Adjustment of Price Indexes for ICT Products is due for publication in 2004, and may be followed by further steps to implement its findings in national statistical practices.

The role of the ICT-producing sector

Chapter 5, by Dirk Pilat and Anita Wölfl, moves on to the sectoral impacts of ICT. This is because the second possible economic impact of ICT is linked to having a sector producing ICT goods and services. Having such a sector can be important for growth, since ICT-production has been characterised by rapid technological progress and very strong demand. Chapter 5 shows that in Finland, Ireland and Korea, close to 1 percentage point of aggregate labour productivity growth over the 1995-2001 period was due to the strong productivity performance of the ICT manufacturing sector. In the United States, Japan and Sweden, the ICT-producing sector also contributed significantly to productivity growth. ICT-producing services sector (telecommunications and computer services) typically play a smaller role in aggregate productivity growth, although it has also been characterised by rapid progress. Partly, this is linked to the liberalisation of telecommunications markets and the high speed of technological change in this market. The contribution of this sector to overall productivity growth therefore increased in several countries over the 1990s. Some of the growth in ICT-producing services is also linked to the emergence of the computer services industry, which has been a key factor in the diffusion of ICT networks in OECD countries.

The role of ICT use

A third way of examining the impacts of ICT use is to analyse the performance of those sectors of the economy that are intensive users of ICT. This is the focus of Chapter 5. Most of these sectors are located in the services sector, e.g. industries such as finance, business services and distribution. Chapter 5 finds that the contribution of ICT-using services to aggregate productivity growth rose slightly over the 1990s in Finland, the Netherlands, Norway and Sweden, and more substantially in Australia, Canada, Ireland, Mexico, the United Kingdom and United States. The strong increase in the United States is primarily due to more rapid productivity growth in wholesale and retail trade, and in financial services (securities). The strong increase in productivity growth in Australia, and the contribution made by ICT, is confirmed by Chapter 6, by Paul Gretton, Jyothi Gali and Dean Parham.

In some countries, notably the United States and Australia, there is also evidence that sectors that have invested most in ICT, such as wholesale and retail trade, have experienced an increase in the overall efficiency of using labour and capital, or multi-factor productivity (MFP) growth. This could be because these sectors have received productivity gains from ICT use over and above the labour productivity gains they received from investment in ICT, for instance because of network effects.
Chapter 5 also suggests that some of the impacts of ICT might simply not be picked up in official statistics, since measures of output in the services sector are quite weak. OECD is currently working with statistical offices to develop better output measures for certain services sectors, notably finance and insurance. However, more attention will also be required for other services, notably non-market services such as education and health.

1.4 Impacts of ICT at the firm level

Chapters 6 to 13 go beyond industry aggregates and focus on the firm-level impacts of ICT. Studies with firm-level data often find the strongest evidence for economic impacts of ICT. Firm-level data also point to factors influencing the impacts of ICT that can not be observed at the aggregate level. For example, the role of ICT in helping firms gain market share can only be examined with firm-level data, as can the role of organisational change. Moreover, firm-level analysis may help in distinguishing the impact of ICT from that of other, often firm-specific, sources of growth.

Over the past years, much progress has been made in developing statistics on the use of various ICT technologies in the economy (see Chapter 2). In addition, many countries have developed databases that provide detailed and comprehensive data on the performance of individual firms. Combining these two sources of information helps establish a link between firm performance and their use of ICT. Moreover, providing that these databases cover a large proportion of the economy, they can also link the performance of individual firms to that of the economy as a whole.

Chapter 6, by Paul Gretton, Jyothi Gali and Dean Parham, carries out an analysis of firm-level data for Australia. Australia was already highlighted above as one OECD country where ICT already appears to have had considerable impacts. The chapter finds through aggregate growth accounting and the aggregation of firm-level results that ICTs and related effects raised Australia’s annual MFP growth by around two-tenths of a percentage point. This contribution is significant, although it is a relatively small part of Australia’s 1990s rate of MFP growth of 1.8% a year. The association between ICT use and productivity growth at the industry level was clearest in finance & insurance. Importantly, however, the firm-level econometric analysis, which controls for other influences, found positive links between ICT use and productivity growth in all industry sectors that were examined. The analysis for Australia also found that the productivity effects of ICT taper off over time; the ultimate productivity effect from adoption of (a type of) ICT is thus a step up in levels, rather than a permanent increase in the rate of growth.

Chapters 7 to 9 also find clear impacts of ICT on economic performance. Chapter 7, by Thomas Hempell, George van Leeuwen and Henry van der Wiel finds that ICT capital deepening raised labour productivity in services firms in both Germany and the Netherlands. Chapter 8, by John Baldwin, David Sabourin and David Smith finds strong evidence for Canada that the use of ICTs is associated with superior performance. In particular, greater use of advanced information and communication technologies is associated with higher labour productivity growth during the nineties. Chapter 9, by Spyros Arvanitis, finds that labour productivity in Swiss firms is closely correlated with ICT use. Moreover, the use of Internet was found to be less important for firm performance in the manufacturing than in the service sector, presumably because many manufacturing workers do not perform a desk job and are not equipped with a PC and an Internet connection.

Chapter 10, by Mika Maliranta and Petri Rouvinen, finds strong evidence for productivity-enhancing impacts of ICT in Finland. It finds that after controlling for industry and time effects as well as specific characteristics of the firm and workers using ICT, the additional productivity of ICT-equipped labour ranges from 8% to 18%, which corresponds to a 5 to 6 % elasticity of ICT capital. This effect is much higher in younger firms and in the ICT-producing sector, notably ICT-producing
services. Overall, the higher productivity induced by ICT seems to be somewhat greater in services than in manufacturing. Manufacturing firms benefit in particular from ICT-induced efficiency in internal communication, which is typically linked to the use of local area networks (LANs), whereas service firms benefit from efficiency gains in external (Internet) communication.

Chapter 11, by Tony Clayton, Chiara Criscuolo, Peter Goodridge and Kathryn Waldron, examines the economic impacts in the United Kingdom of on specific application of ICT, namely electronic commerce. They find a positive effect on firm productivity associated with use of computer networks for trading. However, there is an important difference between e-buying and e-selling, with e-buying having positive impacts on output growth and e-selling typically having negative impacts. This is likely due to pricing effects, since at least part of the gain from investment in electronic procurement by firms comes from the ability to use the price transparency offered by e-procurement to secure more competitive deals. Part of this comes from efficiency gains, but part is likely to be at the expense of suppliers. The study for the UK also presents some evidence on pricing effects. Overall, it seems that the effects of reduced search costs, price transparency and rapid supplier reaction associated with electronic marketing and sale of goods are likely to have a negative impact on prices. However, there is a great deal of variation across industries depending on market conditions.

Chapter 12, by Carlo Milana and Alessandro Zeli, examines the impact of ICT on MFP growth in Italy from 1996 to 1999. The study breaks MFP growth down in a part attributable to technological change and a part to efficiency improvements. The study finds that MFP growth is positively affected by the increased intensity of ICT use. These impacts are not only found in high-technology sectors or sectors that are intensive users of ICT, but also in the construction sector and other community and social services, sectors that are not particularly intensive users of ICT. Despite the positive impacts of ICT, the overall performance of Italy over this period was characterised by negative MFP growth, which the study attributes to the limited scale of investment in ICT and the costs of adjustment to the new technology.

Chapter 13, by B.K. Atrostic, Peter Boegh-Nielsen, Kazuyuki Motohashi and Sang Nguyen, examines the impact of computer networks in three OECD countries, Denmark, Japan and the United States. For the United States, the estimates show that labour productivity in US manufacturing plants with networks is about 5% higher than in plants without networks if the productivity measure is based on gross output. Estimates based on a value-added measure show that labour productivity is about 11% higher in plants with networks. It also finds that a plant that would move from “less likely to having a computer network” to “more likely to having a computer network” would increase its labour productivity by 6.3%. This effect persists when controlling for a range of firm conditions.

For Japan, Chapter 13 finds that use of both intra-firm and inter-firm networks is positively correlated with MFP levels at the firm level. Positive and statistically significant coefficients are found for several types of networks, including open networks (the Internet), CAD/CAM technologies and electronic data interchange (EDI). In Denmark, firms with networks achieved higher growth of value added, particularly after network introduction. In Japan, firms with network use achieved a less sharp drop in labour productivity growth after network introduction as compared to non-users.

Overall, Chapters 6 to 13 show significant impacts of ICT on firm-level performance in all countries considered. In several countries, these impacts are larger than those associated with ICT capital, as there is also evidence for more rapid MFP growth or more rapid innovation.
1.5 Complementary factors – innovation, human capital and organisation

Firm-level studies also show that the use of ICT is only part of a much broader range of changes that help firms to enhance performance. This includes complementary investments, e.g. in appropriate skills, and organisational changes, such as new strategies, new business processes and new organisational structures. ICT use by firms is also often linked to the ability of a company to innovate. Users of ICT often help make their investments more valuable through their own experimentation and innovation, e.g. the introduction of new processes, products and applications.

This is confirmed in many of the firm-level studies in the book. Chapter 6 on Australia finds significant interactions between ICT use and complementary organisational variables in nearly all sectors. The complementary factors for which data were available and which were found to have significant influence were: human capital, a firm’s experience in innovation, its use of advanced business practices and the intensity of organisational restructuring. The data for Australia also showed that the earliest and most intensive users of ICTs and the Internet tended to be large firms with skilled managers and workers. Computer use was also commonly associated with use of advanced business practices, the incorporation of companies and firm reorganisation. Moreover, firms with a greater openness to trade seemed to be more intensive users of the Internet.

Chapter 7, by Thomas Hempell, George van Leeuwen and Henry van der Wiel points to the complementarity of innovation and ICT for both Germany and the Netherlands. They test the hypothesis that firms that introduce new products, new processes or adjust their organisational structure can reap higher benefits from ICT investment than firms that refrain from such complementary efforts. Although limited to two countries, the chapter provides important insights in cross-country patterns and differences. For both countries, the results indicate that ICT is used more productively if it is complemented by a firm’s own efforts to innovate. These spill-over effects are a particular feature of ICT capital, since no complementarities between non-ICT capital and innovation could be found in the study. The results also show that innovating on a more continuous basis seems to pay off more in terms of ICT productivity than innovating occasionally. This effect is found for product innovations (Germany) and non-technical innovations (Netherlands) and, to a much smaller extent, for process innovations. For Germany, Chapter 7 also finds evidence for direct benefits from product and process innovation in services on multi-factor productivity (MFP). Service firms that innovate permanently show higher MFP levels. This positive direct effect of innovation on productivity, however, cannot be found for the Netherlands.

Chapter 8 finds that such characteristics are also important in Canada. The innovation strategy of a firm, its business practices, and its human-resource strategies all influence the extent to which a firm adopts new advanced technologies. Moreover, a management team with a focus on improving the quality of its products by adopting an aggressive human-resource strategy – by continuously improving the skill of its workforce through training and recruitment – is also associated with higher productivity growth. A central theme emerging from the Canadian evidence is that a strategic orientation on high-technology is often the core of a successful firm strategy.

Chapter 8 also finds that firms that combined ICT with other advanced technologies do better than firms that only use one technology. Furthermore, the results emphasise that combinations of technologies that involve more than just ICT are important. For example, adoption of advanced process control technology, by itself, has little effect on the productivity growth of a firm, but when combined with ICT and advanced packaging technologies, the effect is significant. Similar effects are evident when firm performance is measured by market-share growth instead of productivity growth. ICTs are therefore important, but mainly in facilitating the effectiveness of other advanced technologies.
Chapter 9 finds important complementarities for Switzerland. It finds that labour productivity is positively correlated with human capital intensity and also with organisational factors such as teamwork, job rotation and decentralisation of decision making. It also finds some evidence for complementarities between human capital and ICT capital with respect to productivity. However, it does not find evidence of complementarities between organisational capital, human capital and ICT capital, a combination that is found in some other studies.

Chapter 10 finds some evidence of complementarities for Finland, notably for human capital and organisational factors. Organisational factors appear important in Finland since the productivity effects of ICT in the manufacturing sector seem to be much larger in younger than in older firms. Some other studies have shown that the productivity of capital (primarily non-ICT) tends to be higher in older plants, which is possibly due to learning effects. While learning effects undoubtedly also exist with ICT, the finding for Finland is consistent with a view that it may be even more important to be able to make complementary organisational adjustments. Such changes are arguably more easily implemented in younger firms and even more so in new firms. The study for Finland also points to a role for experimentation and selection. While most of the increase in ICT use is driven by growth within firms, restructuring (the growth of some firms and decline of others) also plays an important role. This is notably the case among young firms, where some succeed and grow, and many others fail.

Overall, the evidence of firm-level studies suggests that ICT is associated with complementary changes and investments, notably in skills, organisational changes and innovation. Moreover, investment in ICT may be linked to other technological changes, as shown in the case of Canada. Finally, some of the benefits of ICT seem linked to the entry and growth of new firms and the decline of less successful firms.

1.6 Reconciling evidence from different levels of analysis

Examining the role of ICT at the aggregate, sectoral and firm level raises some difficult questions (see also Chapter 6). The firm-level evidence presented in Chapters 6 to 13 suggests that ICT use is beneficial – though under certain conditions – to firm performance in all countries for which micro-level studies have been conducted. However, the aggregate and sectoral evidence in Chapters 4 and 5 is much less conclusive about the benefits of ICT use. It shows that investment in ICT capital has contributed to growth in most OECD countries, and that the ICT-producing sector has contributed to productivity growth in some OECD countries. There is, however, little evidence that ICT-using industries have experienced more rapid productivity growth, the United States and Australia being the major exceptions. There are several reasons why the aggregate and sectoral evidence may differ from firm-specific evidence.

First, aggregation across firms and industries, as well as the effects of other economic changes, may disguise some of the impacts of ICT in sectoral and aggregate analysis that are more evident from firm level analysis. This may also be because the impacts of ICT depend on other factors and policy changes, which may differ across industries. The size of the aggregate effects over time depends on the rate of development of ICT, their diffusion, lags, complementary changes, adjustment costs and the productivity-enhancing potential of ICT in different industries (Gretton et al., 2002 and Chapter 6).

Second, the firm-level benefits of ICT may be larger in the United States (and possible also in Australia) than in other OECD countries, and thus show up more clearly in aggregate and sectoral evidence. Given the more extensive diffusion of ICT in the United States, and its early start, this interpretation should not be surprising. This is particularly the case if it takes time before the benefits from ICT become apparent, e.g. because of the high costs of adjustment to the new technology. Moreover, the conditions under which ICT is beneficial to firm performance, such as sufficient scope for organisational change, might be more firmly established in the United States than in some other OECD countries.

Measurement may play a role as well. The impacts of ICT may be insufficiently picked up in macroeconomic and sectoral data outside the United States, due to differences in the measurement of output. For example, the United States is one of the few countries that have changed the measurement of banking output to reflect the convenience of automated teller machines. Since services sectors are the main users of ICT, inadequate measurement of service output might be a considerable problem. Improvements in measurement may make some of the benefits of ICT more clearly visible.

Fourth, countries outside the United States may not yet have benefited from spillover effects that could create a wedge between the impacts observed for individual firms and those at the macroeconomic level. The discussion above has already suggested that the impacts of ICT may be larger than the direct returns flowing to firms using ICT. For example, ICT may lower transaction costs, that can improve the functioning of markets (by improving the matching process), and make new markets possible. Another effect that can create a gap between firm-level returns and aggregate returns is ICT’s impact on knowledge creation and innovation. ICT enables more data and information to be processed at a higher speed and can thus increase the productivity of the process of knowledge creation. A greater use of ICT may thus gradually improve the functioning of the economy. Such spillover effects may already have shown up in the aggregate statistics in the United States, but not yet in other countries.

Finally, the state of competition may also play a role in the size of spillover effects. In a large and highly competitive market, such as the United States, firms using ICT may not be the largest beneficiaries of investment in ICT. Consumers may extract a large part of the benefits, in the form of lower prices, better quality, improved convenience, and so on. In other cases, firms that are upstream or downstream in the value chain from the firms using ICT might benefit from greater efficiency in other parts of the value chain. For example, Chapter 11 demonstrates productivity impacts for firms purchasing through computer networks, not for firms selling through networks. In countries with limited competition, firms might be able to extract a greater part of the returns, and spillover effects might thus be more limited. Further cross-country research may help to address these questions, and provide new insights in the extent of ICT-related spillovers.

1.7 Concluding remarks and remaining questions

The range of studies presented in the book shows that the empirical evidence of the economic impacts of ICT is significantly improved from what it was only a few years ago. Many OECD countries now provide estimates of ICT investment that enable calculations of capital services (see Chapter 4). Data on the ICT sector and on the services sector are available for many countries, although important gaps in our knowledge remain (Chapter 5). Moreover, many countries now have regular business surveys of ICT use that provide an overview of diffusion patterns (Chapter 2). These surveys provide a wealth of information for the type of empirical research presented in Chapter 3 and Chapters 6 to 13 of the book.
The evidence also shows that achieving benefits from investment in ICT is not straightforward. It typically requires complementary investments and changes, e.g. in human capital, organisational change and innovation. Moreover, ICT-related changes are part of a process of search and experimentation, where some firms succeed and grow and others fail and disappear. Countries with a business environment that enables this process of creative destruction may be better able to seize benefits from ICT than countries where such changes are more difficult and slow to occur.

The more solid evidence on the economic impacts of ICT and the conditions under which these impacts occur are important for policy, as it helps underpin evidence-based policies. However, further progress in both measurement and economic analysis is feasible and desirable. One important area, already highlighted above, concerns the measures of economic impacts that are available at the aggregate or industry level. This will require more comparable investment data, a greater use of hedonic deflators and improved output measures for services. But a tremendous potential also lies in further work with firm-level data. There are at least two aspects to this.

First, cross-country studies on the impact of ICT at the firm level are still relatively scarce, primarily since comparable data sources are still relatively new. This book contains two studies (Chapters 7 and 13) that engaged in international comparisons. Another example is a recent comparison between the United States and Germany (Haltiwanger et al., 2002), that examined the relationship between labour productivity and measures of the choice of technology. It found that firms in all categories of investment had much stronger productivity growth in the United States than in Germany. Moreover, firms with high ICT investment had stronger productivity growth than firms with low or zero ICT investment. In addition, firms in the United States had much greater variation in their productivity performance than firms in Germany. Understanding the reasons for these differences and the cross-country differences found in Chapters 7 and 13 would benefit from further work, and could lead to helpful insights for policy.

Second, there are several key issues that remain poorly analysed and that offer scope for progress. For example, further work with firm-level data could provide greater insights into firm dynamics, e.g. the role of new firms, the conditions that lead to successful survival and the factors determining firm exit. Moreover, the link between innovation and ICT has only been examined for some OECD countries (see Chapter 7). Understanding this link is of great importance as long-term growth depends on the future pace of innovation. A better understanding of such (and related) phenomena would provide insights into the relative importance of various factors, their interaction, and the scope for policy. Moreover, quantitative analysis of the price and productivity impacts of electronic commerce and e-business processes is still in its early stages, but is a promising area of further work, as suggested by Chapter 11. Finally, while there is growing evidence that ICT can help transform the service sector and make it more innovative and productive, a good understanding of ICT’s impact on the service sector is still lacking, partly because of some thorny measurement problems but also due to lack of cross-country empirical analysis.

Finally, the studies contained in this book point to the importance of close interaction between statistical development and policy analysis. Many of the data used in this book were not yet available 5 or 6 years ago; the bulk were developed in response to demands by policy makers for new and better data on ICT diffusion. The response of statistical offices to this demand has been quick and comprehensive. But this interaction also works the other way; effective use of the large amounts of

data held by statistical offices can provide a wealth of policy-relevant information if the data is made accessible for research. This remains a challenge in several OECD countries.

ICT has emerged over the past decade as a key technology than can transform economic and social activity. However, its full potential remains unknown, requiring continued monitoring of its impacts and the appropriate policies to seize its benefits.
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