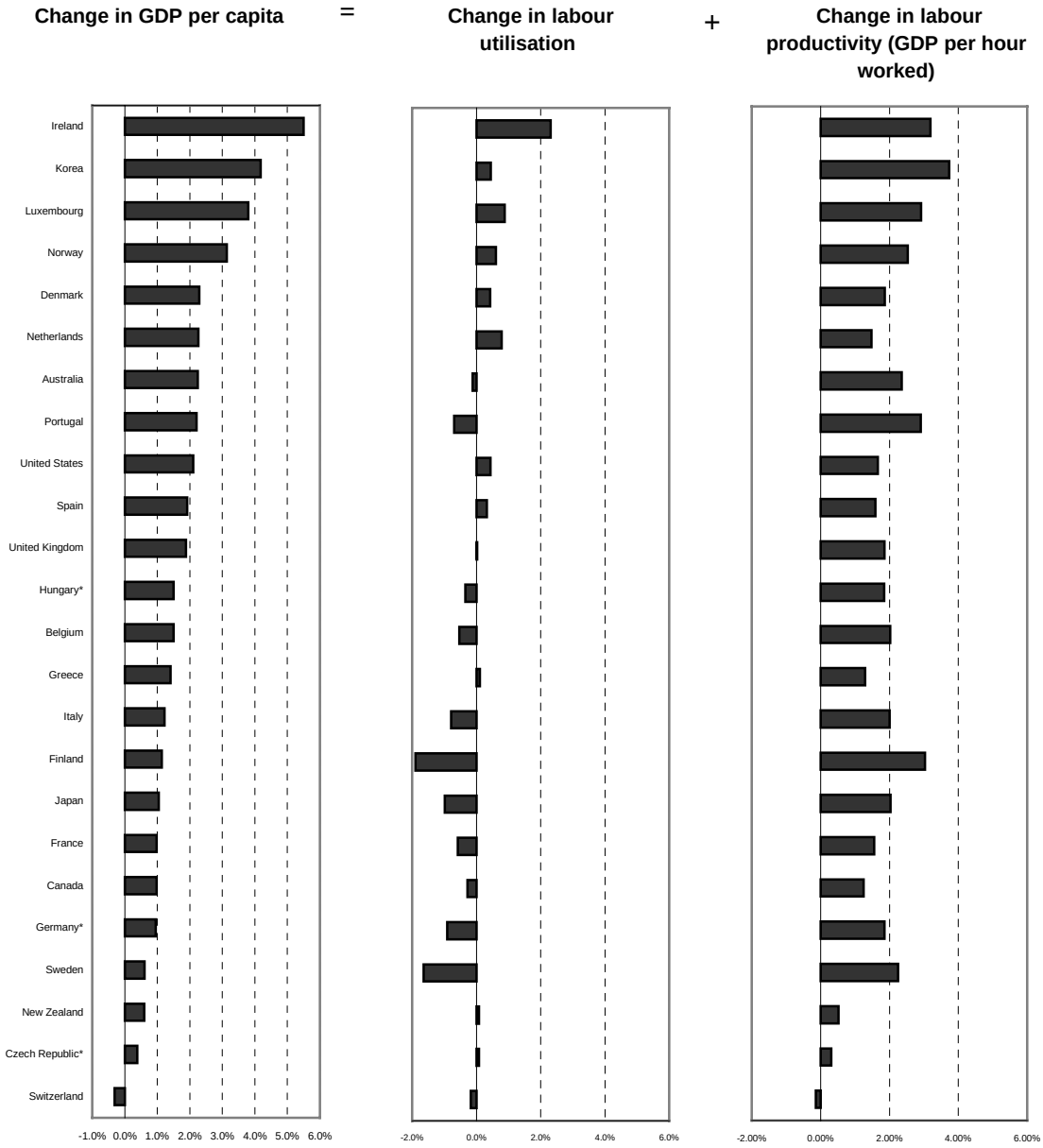
EXECUTIVE SUMMARY

Patterns of economic growth in OECD countries

In the 1990s, levels of GDP per capita diverged across OECD Member countries.	Analysis of growth patterns in the OECD area shows that levels of GDP per capita are no longer converging. In the 1990s, growth was higher in a few high-income countries, such as Australia, the Netherlands, Norway and the United States. In addition, countries such as Ireland and Korea continued to catch up to higher income levels. But growth in Japan and in much of continental Europe, notably its larger economies, was slower than in the 1980s, in some cases owing in part to macroeconomic shocks.
This disparity is largely due to the fact that some countries were able both to increase the number of people working and increase their productivity.	The increasing divergence of labour utilisation rates provides one explanation for the increasing discrepancies in GDP per capita. Greater labour utilisation can make a significant contribution to growth over the short and medium term, as the experience of Australia, Ireland and the United States shows. Countries with higher per capita growth rates maintained or even increased employment over the 1990s, while employment stagnated or fell in those experiencing a slowdown in growth of GDP per capita. Labour productivity continued to converge in the 1990s (see figure), in part as a result of labour shedding in countries with weak employment growth.
Productivity (MFP) gains are largely the result of technological developments coupled with smarter ways of working.	In some cases (*e.g.* Australia, Denmark, Ireland, Finland, Norway, the United States), labour productivity growth rates are linked to significant technological progress, as estimated by the growth of multi-factor productivity (MFP), which reflects the overall efficiency with which labour and capital are used. It is also affected by managerial practices, organisational change and, more generally, improved ways of producing goods and services. In many countries, MFP is a more important driver of labour productivity than greater availability of capital per worker. In the second half of the 1990s, MFP accelerated in Australia, Finland and Ireland, but also, and, in contrast to the early 1990s, in the United States. Recent data for the United States show an acceleration in MFP growth, with rates doubling from about 0.6% over the period 1991-95 to 1.25% over 1996-99.

The role of labour utilisation and labour productivity in growth

Total economy, 1990-98



Source: Based on *Economic Outlook 66*, and Scarpetta *et al.* (2000).

Technology and innovation are key drivers of increased growth performance.	An empirical analysis of growth patterns shows that no individual factor can be singled out as the main source of differences in growth performance. Several indicators, such as the pick-up in MFP growth in some countries, the growing importance of technological progress embodied in investment goods such as ICT, and the importance of skills, point to technology and innovation as important factors in recent growth performance.

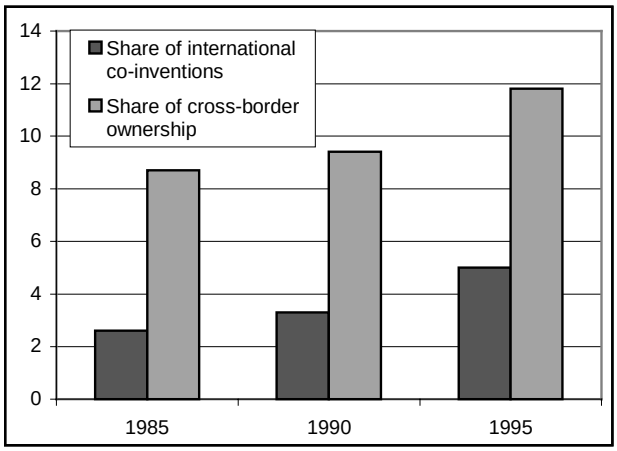
The changing role of innovation in growth performance

The relationship between science, technology and economic performance appears to have changed in the 1990s…	The relationship between technological progress, innovation and growth appears to have changed in the 1990s. The ways in which organisations interact in an economy have been affected, with networking, co-operation and the fluid flow of knowledge within and across national borders gaining in importance. Some countries in the OECD area have thus far been better able to respond and benefit from the change than others. The United States is of particular interest because it has made sizeable gains in MFP although it is already one of the most productive and technologically sophisticated countries.
…and innovation is now more critical to the success of firms and ultimately the growth of economies.	In this changing environment, innovation has become more market-driven, more rapid and intense, more closely linked to scientific progress, more widely spread throughout the economy. Services sector R&D, for example, rose from less than 5% of total business enterprise R&D for the OECD area as a whole in 1980 to more than 15% in 1995. In countries that measure services R&D well, such as Canada, it now amounts to about 30% of total business enterprise R&D.
ICT has played an important role in facilitating innovation.	In many cases, ICT, particularly since the recent emergence of the Internet, the World Wide Web, the browser and electronic commerce, has facilitated these changes by significantly reducing the costs of outsourcing and co-operation with entities outside the firm. It has helped break down the natural monopoly character of services such as telecommunications, it is a key technology for speeding up the innovation process and reducing cycle times, it has fostered greater networking in the economy, it makes possible faster diffusion of codified knowledge and ideas and it has played an important role in making science more efficient and linking it more closely to business.
In this changing environment, new ways to reduce costs in the search for new ideas are evolving. *Networking and openness are of growing importance for innovation….*	Because the costs and risks of innovation have increased, firms have become more specialised, shifting from an inward to a more outward orientation. The role played by research in firms' commercial strategies has also changed. As the range of technologies required for innovation has expanded and technologies have become more complex, companies can no longer cover all relevant disciplines. Many key developments draw on a wide range of scientific and commercial knowledge, so that the need for co-operation among participants in different fields of expertise has become greater in order to reduce uncertainty, share costs and knowledge and bring innovative products and services to the market.
…for technological advances and the setting of standards…	Empirical studies suggest that collaboration is an important factor in the discovery, application and diffusion of technologies and may sometimes be motivated by a desire to develop *de facto* technological standards in the formative periods of new

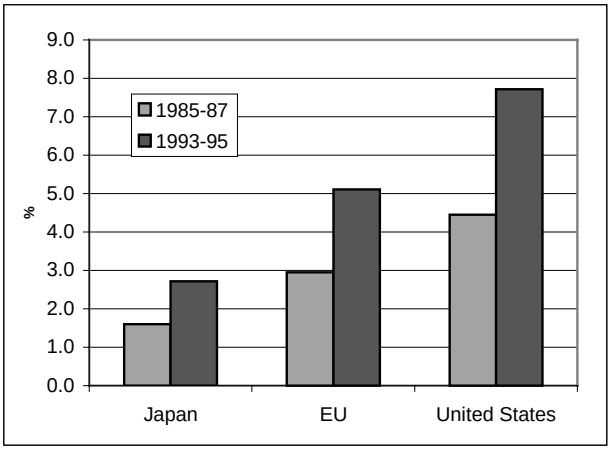
	technologies. A notable example is the development of the GSM standard, which has facilitated extremely rapid growth in the use of mobile phones in Europe. Many co-operative agreements are linked to firms' difficulties in using and implementing ICT, and particularly to the need for compatibility and interoperability, for instance in banking and airlines. Available data show that the number of alliances has grown rapidly, particularly in areas such as information technology and biotechnology. The number of new intraregional ICT alliances, for example, rose threefold between the early 1980s and the mid-1990s. In 1998, strategic alliances were the source of a quarter of the earnings of the top 1 000 firms in the United States, double the share in the early 1990s.
…as trends in patenting reveal.	Patenting also indicates the tendency of countries to seek sources of innovation and knowledge wherever they exist, and cross-border ownership of patents – where the applicant (owner) resides in a different country than the inventor – has increased considerably in the 1990s (see figure). The internationalisation of patenting has not been equally rapid in all countries: the available evidence shows that US patents have a larger, and more rapidly growing, proportion of foreign co-inventors than those of Europe or Japan.
Because human capital is a key factor in the innovation process, openness to ideas from abroad and efforts to attract or use skilled human resources abroad are increasing…	Countries such as Australia and the United States have benefited substantially from the immigration of highly skilled personnel. There are indications that the United States was able to sustain rapid growth in the ICT sector, particularly in the software segment where human capital is the key input, by tapping into international sources of skilled workers. Immigration may therefore be one of the factors that have enabled the US boom to continue, as it filled some of the most urgent skill needs (see figure).
…as are industry-university links.	There is growing evidence that innovation in areas such as ICT or biotechnology draws increasingly and more directly on scientific progress. In the United States, the Bayh-Dole Act (1980), which extended patent protection to publicly funded research, helped to strengthen the role of science in the innovation process and was an early step in facilitating industry-university collaboration. Since then, further policy reform in this area has facilitated innovative performance. A recent analysis of US patent citations found, for example, that more than 70% of citations in biotechnology were to papers originating solely at public science institutions, while a study of scientific publications in the United Kingdom showed that the proportion of articles authored by industry scientists with an academic co-author rose from 20% in 1981 to 40% in 1991.

Global trends in the internationalisation of technology

Share of patents with cross-border ownership or based on international co-inventions, 1985-95



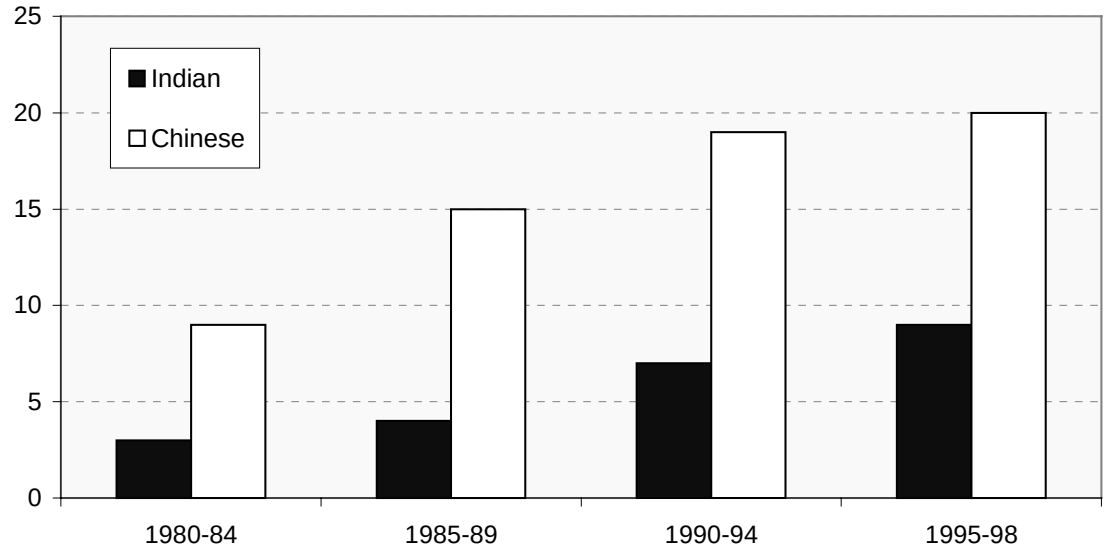
Share of patents with a foreign co-inventor, by major OECD region



Source: OECD. Data are based on patent applications to the European Patent Office, by date of priority.

Start-ups are more flexible and unencumbered than large established firms and are essential to the "creative destruction" that occurs in periods of technological change.	Start-up firms are important sources of new ideas and innovation and may have an advantage over larger established firms in emerging areas where demand patterns are unclear, risks are large, and the technology has yet to be worked out. Microsoft is a notable example of a firm that began life as a start-up. In the United States, large firms – Cisco is one example – "go shopping" in Silicon Valley and buy up or buy shares in small innovative projects. In 1999, Microsoft acquired shares in 44 firms (for USD 13 billion) and Intel in 35 (for USD 5 billion).
However, they need the support of financial systems, including venture capital, which are capable of evaluating and monitoring high-risk innovative firms.	Start-ups require financial backing and often management help as well. At present, the United States has by far the most developed venture capital market. Internet-related investment represented over half of all US venture capital investment in 1999. In terms of level of investment in venture capital, Europe – where traditional banks play a major role – lags the United States. In Japan, venture capitalists, largely subsidiaries of banks, tend to invest small stakes in many firms, in order to diversify risk. In FY1998, the average size of a deal was USD 0.5 million in Japan, as compared to USD 4.7 million in the United States and USD 1.1 million in Europe. Where venture capitalists in the United States are often involved in the management of start-ups, this is frequently not the case in Europe or Japan. The share of venture capital investment in the early stages of the development of a project also remains relatively low in Europe and Japan.

Share of Silicon Valley start-ups by ethnic origin (%)



Source: Saxenian (1999).

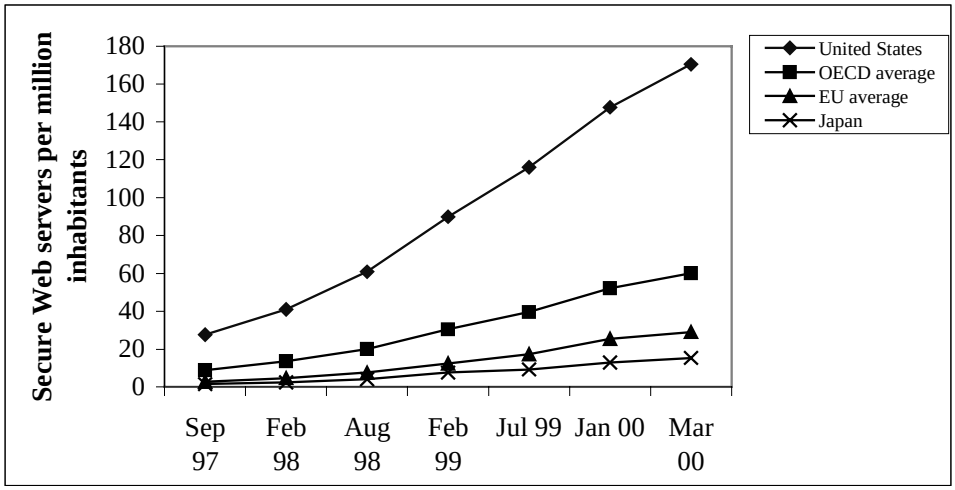
In short, a broad set of factors creates the foundation that supports innovation-intensive economic growth.	Innovation and information technology are closely related in recent growth performance. Some recent changes in the innovation process and related impacts on innovation could not have occurred without ICT. Conversely, some of the impact of information technology might not have been felt in the absence of changes in the innovation system and the economy more broadly. Policies to encourage innovation and foster growth performance therefore need to address both areas.

The role of information and communications technology in growth performance

The rapid diffusion of ICT, so far most conspicuously in services, best exemplifies the shift in the relationship of innovation, science, technology and the economy.	Investment in ICT is making an important contribution to growth and labour productivity growth across the OECD. The 1990s witnessed rapid accumulation of ICT equipment. In the G7 countries (and most likely in other OECD countries as well) ICT investment progressed at two-digit figures over the past two decades and accounted for 10-20% of total non-residential investment in the business sector. However, while computers seem to be everywhere, use of ICT is actually concentrated in the services sector and a few manufacturing sectors. In constant (chained 1996) prices, US investment in information processing equipment and software as a share of total equipment and software increased from 29% in 1987 to 52% in 1999. The diffusion of ICT accelerated after 1995 as a new wave of ICT, based on applications such as the World Wide Web and the browser, spread rapidly throughout the economy. At relatively low cost, these technologies link the existing capital stock of computers and communications systems in an open

	network that significantly increases their utility.
ICT's contribution to output and labour productivity growth is rising…	The contribution of ICT capital to output and labour productivity growth has been significant and rising in relative terms. In Canada, the United Kingdom and the United States, ICT equipment contributed about half of fixed capital's contribution to output growth. The Bank of Korea reports that 40% of recent GDP growth in Korea came from the ICT sector, five times its 1999 share in GDP. In many cases, the measurable contribution of ICT to macroeconomic growth and MFP is still small, although sectoral and firm-level studies indicate a strong positive link between ICT use, productivity and output growth. Recent data for the United States show that about half of the uptick in MFP growth over the period 1996-99 occurs in industries other than ICT.
…along with its contribution to innovation, as increased patenting indicates.	ICT is the technology area with the highest rate of innovation as measured by patents. Of the overall growth in patents granted by the US Patent and Trademark Office over 1992-99, ICT accounted for 31% and rose by almost 20% annually. The high rate of patenting points to the many changes in ICT hardware and software needed to use ICT effectively. More generally, ICT is enabling many changes in the economy and the innovation process that help make other economic sectors more innovative.
Services play a leading role in the adoption of ICT.	The services sector is by far the main purchaser of ICT equipment and its performance has been particularly affected by the take-up of ICT. Services sectors such as finance and business services lead in investment in ICT and many services are now highly innovative. Moreover, services have become more tradable, with the result that they are more exposed to competition and are led to innovate to improve the quality of service offered and therefore remain or become competitive. Efforts to improve measurement of services output by introducing quality adjustments to capture the effects of improved service characteristics, such as easier and more convenient transactions and intermediation, typically result in upward revisions of these sectors' productivity. For instance, a study of the US banking industry shows output growing by over 7% a year between 1977 and 1994, instead of 1.3% according to the traditional measure.

Growth of secure servers



Note: The population data used for February 1999 to March 2000 refer to 1999.
Source: OECD (www.oecd.org/dsti/sti/it/cm) based on Netcraft (www.netcraft.com).

The advent of the Internet and e-commerce has created a potential for further innovation…	The Internet and electronic commerce appear to be able to make a substantial contribution to economic growth, particularly in service industries. Here again, countries differ. The Nordic countries, Canada and the United States lead in terms of Internet host density. In September 1999, the host penetration rate for the United States was three times the average for the OECD area, seven times that of the European Union and just over eight times that of Japan. Between 1999 and March 2000, the United States added an additional 25.1 Internet hosts per 1 000 inhabitants, compared to an additional 5.5 Internet hosts for the United Kingdom, 4.1 for Japan, 3.0 for Germany and 2.7 for France. In short, instead of other countries catching up to the United States, the gap appears to be widening. Moreover, as of March 2000, the United States had six times as many secure servers per capita as the European Union, nine times more than France, eleven times more than Japan and sixteen times more than Italy. Even the Nordic countries, traditionally leaders in communication infrastructure, currently lag behind the OECD average. Here again, the most recent data show that the United States has been expanding its lead (see figure).
…largely thanks to low-cost, open access, which markedly lowers barriers for electronic commerce.	The Internet has also been at the heart of a further deepening of ICT investment, by making possible a sharp increase in the quality and functionality of existing ICT equipment. It creates an environment that substantially lowers the entry barriers for electronic commerce, in part because it adheres to non-proprietary standards based on the existing communications infrastructure. The low cost of connecting to the Internet and its independence from specific equipment or operating systems mitigates the opportunity costs of being locked in to a particular technology and reduces the "switching costs" that accompanied the adoption of earlier forms of e-commerce. In countries like Denmark and Finland that have attempted to measure e-commerce through the Internet, over half of firms with more than

	20 employees used the Internet for ordering in 1999, up from about 15% in 1997, while 40% of firms received orders over the Internet, up from just 7% in 1997.
However, the Internet's most profound economic impact may in fact be its effect on existing industries that are adopting ICT and restructuring to exploit the new technology.	In agriculture, the Internet is providing better information about market prices and has fostered the emergence of new online commodity markets. In construction, it reduces the need for blueprints and allows seamless communications between subcontractors. In manufacturing, it is generating new efficiencies by reducing procurement costs and improving supply chain management. Its role in the services sector is linked to qualitative aspects of products, such as convenience and customisation, thereby reducing costs and delays and increasing reliability.
While technology diffusion and investment in ICT offer the potential for stronger growth, organisational change is indispensable.	ICT seems to offer the greatest benefits when ICT investment is combined with other organisational assets, such as new strategies, new business processes, new organisational structures and better worker skills. In a recent US survey, a quarter of all firms reported that they have made organisational changes to respond to the changes wrought by the Internet. For example, US durable goods manufacturers reduced inventories as a share of sales by more than a quarter between 1989 and 1999. This does not take into account savings associated with not having to finance inventories, warehouse them and discount them to accommodate shifts in demand.

Policies to support growth based on innovation and information and communications technology

To make effective use of the opportunities offered by ICT, countries need to ensure an environment conducive to innovation and receptive to new technologies.	A preliminary examination of the policies that help support innovation and investment in, and diffusion of, ICT suggests that a range of complementary factors and policies matter. Countries' ability to respond to rapid technological change greatly depends on the availability of the right set of skills and well-functioning product and capital markets. Collectively, these factors create an environment conducive to innovation and receptive to new technologies. The most recent evidence on the US economy points to the strong positive impact of ICT on economic growth and performance, probably enabled by the "right" environment.
Competition is a necessity.	Firms invest in innovation and in efficiency-enhancing technology if they can expect sufficient returns and if competition forces them to do so. Competition is also important for driving down the cost of technology. This is crucial for diffusing technologies such as ICT and the Internet throughout the economy. Technological change itself has resulted in the removal of the monopoly character of many parts of the telecommunications market and thus contributed to the introduction of greater competition and regulatory reform. Countries such as Australia, Denmark, the Netherlands and the United States have already undergone a long process of regulatory

	reform aimed at greater competition.
Liberalisation of telecommunications markets and regulatory reform facilitate investment in ICT…	Investment in ICT is making an important contribution to growth and labour productivity growth across the OECD. However, OECD countries differ in their take-up of ICT, partly due to the varying pace of telecommunications market liberalisation. Where it is slow, this has limited investment in the necessary infrastructure and raised costs. Many successful OECD countries moved early to liberalise the telecommunications and information technology industries.
…since the price of telecommunications affects the diffusion of ICT and thus the Internet.	There is evidence that the Internet and electronic commerce can make a substantial contribution to economic growth, particularly in service industries. But the take-up of the Internet differs considerably across OECD countries. The Nordic countries, the United States and Canada are the leading nations in terms of Internet host density. Regulatory frameworks, the pricing of local calls – including the taxes imposed – and a low critical mass of ICT users in some countries are among the important factors that contribute to cross-country differences in the diffusion of the Internet.
The degree to which openness and collaboration are facilitated may help explain differences in innovation patterns and growth performance.	The ability to establish technology alliances between firms, to engage in mergers and acquisitions, and the degree of openness to trade and foreign direct investment all play a significant role in innovation as key developments in new areas draw on a wide range of scientific and commercial knowledge and make co-operation a necessity. However, co-operation in pre-competitive research needs to be balanced with a strong role for competition authorities at later stages. In addition, as OECD countries do not seem to look equally towards international sources of knowledge and technology, this may affect innovation and technological change.
Policies favourable to collaboration between science and industry are important...	Links between science and industry are not equally developed across OECD countries. While reforms are under way, recent OECD work suggests that regulatory frameworks and deficient incentive structures continue to limit co-operation in many countries. Several successful countries, including Denmark, Finland and the United States seem to be characterised by strong links between science and industrial innovation.
…but public support for basic scientific research remains important to increase the stock of fundamental knowledge and to provide highly skilled graduates.	Scientific institutions, including their links to the business sector, are important for technology diffusion and innovation. Science is also of increasing importance if countries want to benefit from the global stock of knowledge. Basic scientific research is the source of many technologies that are transforming society, such as the Internet and the laser, while research on the genome is contributing to advances in health care and biotechnology. Clearly government has an important role to play in the funding of scientific research, but there are likely to be diminishing returns to investment in science and governments will need to consider carefully the

	appropriate amount of public investment.
Furthermore, innovation in emerging areas requires favourable conditions for start-up firms.	Differences in the business environment for start-ups, such as their access to human capital and venture capital, the degree to which they are subject to administrative regulations, and the conditions for entrepreneurship, may affect innovation and economic performance. Many "successful" OECD economies, such as Australia, Denmark, Ireland and the United States, have relatively low administrative barriers for start-ups.
Differences in financial systems and the availability of venture capital also play a role.	Differences in financial systems, particularly the degree to which they are able to finance risky projects, may affect innovation in emerging industries and therefore growth, as new firms have limited access to finance and may be unable to grow or invest in innovation. Countries with well-developed financial markets and active venture capitalists may be better geared towards innovation and the reallocation of capital to such new industries than countries where traditional banking plays a dominant role.
The lack of a sufficient supply of skilled personnel is a key barrier to innovation and needs to be addressed.	Human capital is a key factor in the innovation process and many innovation surveys suggest a lack of skilled personnel as one of the crucial barriers to innovation. While a case can be made for greater international mobility of human resources, countries also need to address education, skills upgrading and human resource management at the domestic level. Initial levels of education are no longer sufficient in an economy in which demands change continuously; lifelong learning is increasingly important. Creativity, working in teams and cognitive skills are needed as economies become more based on innovation and technological change.
Attention needs to be given to ensuring access to new technologies and to providing people with the basic tools and skills for using them.	While innovation and technological change appear very important for strengthening growth performance, they may also have undesirable effects. There are concerns that the rapid spread of information technology may lead to a "digital divide" between those with access to the technology and those without. This may reinforce the skill bias of technological change and increase the gap in opportunities between low-skilled and high-skilled workers. In addition, some OECD countries have concerns that the financial benefits from innovation may accrue to only a small proportion of the population and increase earnings inequalities. It is unclear to what extent these effects are significant, as many are not new and recent US experience suggests a decline in income inequalities and higher employment rates for low-skilled workers. Rapid technological change has often been accompanied by major social changes and policy makers can help best by providing people with tools and skills that enable them to adjust to these changes, such as lifelong learning and well-functioning labour markets.
While countries may differ in their tendency to adapt to the new environment, policy changes	It has been argued that some countries and cultures may be better able than others to adapt to rapid growth and innovation. Cultural attitudes may affect people's willingness to take risks, to start a firm

can help ease the transition….	or to migrate. They may also affect a country's institutional framework. Cultural – and institutional – factors may therefore affect the transferability of policies and policy instruments and reduce the relevance of the US experience to other OECD countries. However, culture is not a static concept and attitudes towards risk and entrepreneurship may, for instance, be affected by changes in taxation, regulations, labour markets and the education system. Issues such as trust and basic confidence in society are also important in this respect and are the topic of ongoing OECD work.
…so that countries reap the benefits of economic growth through innovation which some have already achieved.	It is essential to bear in mind that to use ICT and the Internet as a basis for innovation requires more than simply buying equipment or wiring schools. It is necessary to have the broader framework conditions that support organisational change, labour mobility, product market competition, training for new skills, a willingness to experiment and take risks and an openness to ideas, whatever the source.