THE OECD JOBS STRATEGY

TECHNOLOGY, PRODUCTIVITY AND JOB CREATION:

BEST POLICY PRACTICES

HIGHLIGHTS

KEY POLICY MESSAGES

Technological change drives long-term economic growth, productivity and improvement in living standards. At the same time, the emergence and diffusion of new ideas, products and production techniques throughout the economy entails a process of "creative destruction". New technologies destroy jobs in some industries, especially among the low-skilled, while creating jobs which are often in different industries and require different skills. Historically, this process has led to net job creation, as new industries replace old ones and workers adapt their skills to changing and expanding demand. Today's rapid technological change coupled with the extensive restructuring underway in OECD economies leads some to associate technology with unemployment and social distress. However, technology *per se* is not the culprit. Its economy-wide employment impact is likely to be positive provided that the mechanisms for translating technology into jobs are not impaired by deficiencies in training and innovation systems and rigidities in product, labour and financial markets. To realise the full potential of technological change in improving economy-wide productivity, growth and job creation, governments need to make innovation and technology diffusion policies an integral part of overall economic policy.

Knowledge-based economies raise new policy challenges

The report *Technology, Productivity and Job Creation – Best Policy Practices* assesses innovation and technology diffusion policies, identifies "best policy practices" and makes country-specific recommendations. It presents evidence on the extent to which new technologies are transforming the structure of OECD economies and enhancing their ability to grow and create wealth and jobs. Economic activity is becoming increasingly knowledge-based: jobs are shifting from low- to high-skilled workers; productivity and employment growth depend on the conditions for economy-wide diffusion of new products and processes. While aggregate productivity and employment growth remain modest in most countries, those firms that combine technological change, organisational change and upskilling display strong economic performance. With globalisation, the innovation and production systems of different countries are becoming increasingly interdependent; opening up new opportunities while at the same time accentuating the need for restructuring and adaptation. Countries differ with respect to where they stand in this process of structural adjustment, because of different starting points, technological and industrial specialisations, institutions, policies and attitudes to change.

Technology policy: an integral part of the broader structural policy agenda

While a number of countries have undertaken impressive reforms in innovation and technology diffusion policies, current approaches are insufficiently adapted to the characteristics and problems of knowledge-based economies, and the potential contribution of technology to growth and employment remains largely untapped. Technology policies continue to be piecemeal, with insufficient consideration given to linkages within national innovation systems and to the broader structural

reform agenda. To be effective, they need to operate in a stable macroeconomic environment and complement broader reforms. In an increasingly integrated world economy, product market reforms enable more rapid diffusion of technology and information, and strengthen incentives for firms to innovate and adapt goods and services to changing consumer needs. Reforms to financial markets facilitate the allocation of capital to new technology-based entrepreneurial initiatives. Labour-market reforms, combined with measures favouring upskilling and lifelong learning, contribute to further innovation, facilitate the use of advanced technologies, and allow technical change to translate into more jobs.

Wide-ranging policy reforms are required

Enhancing the contribution of technology to growth and productivity, while putting in place the conditions to translate its potential into higher incomes and employment, requires the implementation of wide-ranging and coherent policy reforms. In most OECD countries, current policies in this area focus too much on developing new technologies in the small "high-tech" part of the manufacturing sector and too little on fostering innovation and technology diffusion throughout the economy. There is scope for increasing policy effectiveness, through better use of market-based instruments and improved evaluation efforts. While substantial progress has been made in these areas, much remains to be done. There is a large potential for mutual learning among Member countries from existing "best practices" and the experience of past and current reform efforts.

- The underlying long-term growth rates in OECD economies depend on *maintaining and expanding the knowledge base*, while making it more responsive to economic and social needs. This is particularly important given the recent decline in government funding for research, and the shift of private sector efforts away from basic research and towards more short-term innovative efforts. The reforms required to safeguard long-term technological opportunities include: adequately financing public research institutions within increasingly tight government budgets, while raising their flexibility (by, for example, increasing the share of contract-based resources); and strengthening incentives for university-industry or inter-firm collaboration in pre-competitive research.

- Productivity growth depends on firms' innovative efforts, and all OECD governments have policies in place for the support of industrial R&D. There is significant scope for *improving the efficiency and increasing the leverage of industrial R&D support measures*. Efficiency gains could be obtained by reducing the generosity of R&D tax incentives in some countries, and by reforming support schemes in many others. At the same time, governments should remove impediments to the development of market mechanisms for financing innovation, such as private venture capital, as an alternative or complement to traditional financial R&D support. The leverage of policies can also be increased through greater use of public/private partnerships, provided that their design minimises the potential risks of capture by private sector participants, as well as dead-weight losses. Compared with traditional R&D support, public/private partnerships entail more competitive selection of participants, increased private sector participation in project selection and management, and greater leverage of public funding on private resources.

- Economy-wide productivity and employment gains are generated when new technologies are diffused and widely adopted, making *strengthening technology diffusion mechanisms a key policy priority*. Open trade, regulatory reform and enhanced competition spur diffusion and innovation in areas such as telecommunications, but also in mature sectors. At the same time, better designed and integrated public initiatives can help this process by increasing the ability of firms to access and exploit new technologies. This involves enhancing the effectiveness of technology extension services and information provision through greater industry participation and cost-sharing.

- Complementarity between technology and education and training policies is important for *reducing mismatches between demand and supply for skills* and improving employment performance. This involves measures to reinforce, expand and broaden the content of vocational and technical training in a number of countries, and increased mobility between vocational/technical and academic studies. It also requires involving business more closely in government initiatives to support adoption of new work practices and work organisation as well improving their articulation with education and training programmes. Enhancing mobility of highly skilled and technically trained workers is an important complement to the emphasis on strengthening technology diffusion mechanisms.

- *Improving conditions for the creation and growth of new technology-based firms* increases their direct job-creating potential, while indirectly contributing to economy-wide growth and job creation through higher productivity, lower prices and greater product variety. There is further scope for reducing regulatory barriers to entry and promoting private venture capital industry, including through programmes to leverage private investment. Disincentives to "technological entrepreneurship" (*e.g.* regulations discouraging spin-offs from universities and large firms) and obstacles to risk taking (*e.g.* bankruptcy law which excessively penalises failure) should be removed or modified.

- New industries such as Internet-based services and environmental goods and services play an important role for translating technical change into productivity and employment. Governments should *create an environment conducive to the emergence of demand and jobs in new growth areas* through regulatory reform encouraging flexible technological responses and entry. The combination of infrastructure liberalisation, technological innovation and flexible service conditions has led to job creation in network-based services in a number of countries. In the environmental area, combining a flexible regulatory framework with incentives encouraging innovation has led to the creation of high- and low-skill jobs to supply environmental goods and new services such as eco-auditing.

- *Improving techniques and institutional mechanisms for the evaluation of policies will increase their efficiency.* Few OECD countries systematically evaluate innovation and technology diffusion programmes based on socio-economic criteria and with resource allocation and priority-setting as goals. Others have put in place a number of evaluation initiatives, usually aimed at improving decision making and programme management. In most countries, however, evaluation remains an ad hoc practice; there is a recognised need for the development of better methodological tools as well as improved institutional mechanisms to embed evaluations in policy making.

Reforms need to be made politically feasible

Achieving consistency and credibility in implementing reforms is key to best policy practice, and requires overcoming institutional inertia as well as addressing transition costs and the redistribution of incomes and jobs associated with technological change. Factors for success include the extent to which co-ordination can be achieved between different ministries and the involvement of various stakeholders. Checks must be put in place against government failure, such as institutions furthering their own special interests, or adopting a partial rather than an economy-wide perspective. Measures to promote upskilling and lifelong learning can raise the mobility and employability of workers, mitigate the costs of job displacement resulting from rapid technological change and reduce resistance to reform. At the same time, policies must be designed so as to avoid undermining incentives for work, upskilling, organisational change and restructuring.

EXECUTIVE SUMMARY

Introduction

Technological change drives long-term economic growth, productivity and improved standards of living. It is however a process of "creative destruction". New technologies destroy jobs in some industries, especially among the low-skilled, while creating jobs which are often in different industries and require different skills. Historically, this process has led to net job creation, as new industries replace old ones and the skills of workers adapt to changing and expanding demand. Today's rapid technological change coupled with the restructuring underway in OECD economies leads some to associate technology with unemployment and social distress. However, technology *per se* is not the culprit. Its economy-wide employment impact is likely to be positive provided that the mechanisms for translating technology into jobs are not impaired by deficiencies in training and innovation systems and rigidities in product, labour and financial markets.

OECD countries increasingly seek wide-ranging and coherent policy reforms to enhance the contribution of technology to growth, productivity and jobs. As of today, this potential contribution remains largely untapped, with policies not yet fully adapted to the characteristics and problems of knowledge-based economies. While weaknesses remain in the framework conditions for technological change, innovation and technology diffusion policies themselves continue to be too piecemeal, with insufficient consideration of the linkages within national innovation systems and to the broader structural reform agenda. There is too much focus on measures assisting the development of new technologies in the small high-tech segment of the economy and too little on fostering economy-wide innovation and technology diffusion. There is also scope for improving policy effectiveness, notably through more use of market-based instruments and hard evaluation of the impact of policy initiatives.

The report assesses the policy reform efforts of OECD countries, identifies "best policy practices" in different technology policy areas and presents recommendations. It is part of the follow-up process to the 1994 *Jobs Study*, which included a number of wide-ranging policy recommendations aimed at reducing unemployment and raising living standards, and formed the basis for in-depth examinations of individual countries. The 1997 report, *Implementing the OECD Jobs Strategy*, examined progress made, and provided suggestions on how to make different policies mutually strengthening and reform more politically feasible, *e.g.* through co-ordination of different policies. In the area of innovation and technology diffusion policies, which formed part of the original *OECD Jobs Study* recommendations, the 1996 *Technology, Productivity and Job Creation* report provided new evidence on the role of technology in economic performance, and recommended further policy action. Building on those findings, this report contributes to the ongoing reform process in OECD countries in two ways:

- by identifying the appropriate roles of government in regard to the linkages among technology, productivity and job creation in a policy environment characterised by increased globalisation, the move to the knowledge-based economy, the systemic nature of technical advance, and changing patterns of government funding and firms' innovative strategies;

- by assessing innovation and technology diffusion policies in OECD countries and providing country-specific recommendations as to how technology policies should be improved, as well as how they could be better implemented and integrated with other reforms (summarised in Table 1).

Box 1. **Summary of main policy recommendations**

***1. Innovation and technology diffusion policies need to become an integral part of the broader policy agenda through**:*

- *better co-ordination with structural reform in product, labour and financial markets and in education and training systems as well as with macroeconomic policy;*
- *openness to international flows of goods, people and ideas coupled with policies increasing the absorptive capacity of domestic economies.*

2. Policy should help realise the productivity benefits of technical change by:

- *improving the management of the science base via increased flexibility in research structures, and strengthening university-industry collaboration;*
- *ensuring that long-term technological opportunities are safeguarded through adequate financing of public research and incentives for inter-firm collaboration in pre-competitive research;*
- *raising the efficiency of financial support for industrial R&D while removing impediments to the development of market mechanisms for financing innovation, e.g. private venture capital, as an alternative or complement to traditional financial R&D support;*
- *strengthening technology diffusion mechanisms by encouraging more competition in product markets and through better design and delivery of programmes ;*
- *strengthening incentives for comparable measurement and reporting by firms of intangible investment to improve the management and composition of investment.*

3. Policy should ensure favourable conditions in which technical progress can contribute to job creation by:

- *helping to reduce mismatches between demand and supply for skills and improving the framework for firms to adopt new organisational practices;*
- *facilitating the creation and growth of new technology-based firms by fostering greater managerial and innovation capabilities, reducing regulatory, information and financing barriers and promoting technological entrepreneurship;*
- *promoting new growth areas such as Internet-based services and environmental goods and services through regulatory reform which encourages flexible technological responses and new entry.*

4. The efficiency and leverage effects of innovation and technology diffusion policy initiatives need to be strengthened via:

- *improving techniques and institutional mechanisms for evaluation;*
- *adopting new mechanisms for supporting innovation and technology diffusion through greater use of public/private partnerships;*
- *removing obstacles to international technology co-operation by improving transparency in foreign access to national programmes and securing a reliable framework for intellectual property rights.*

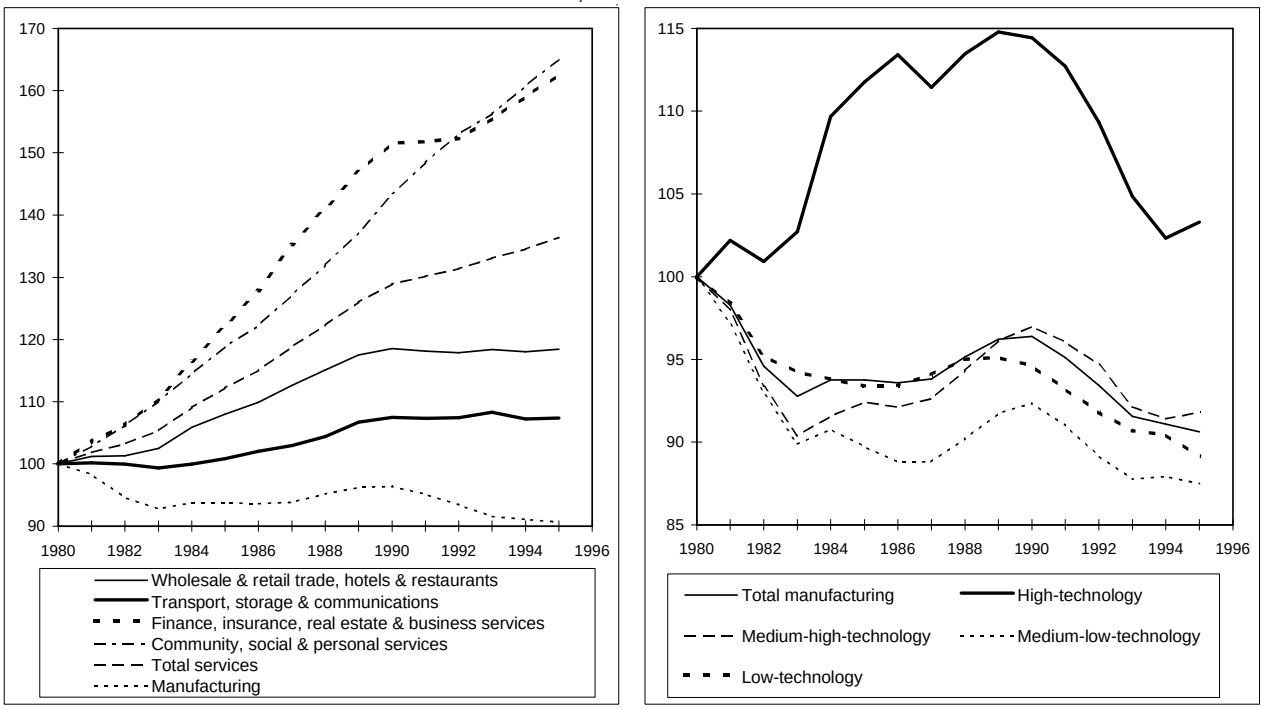
5. Reforms need to be made politically feasible through:

- *improved inter-ministerial co-ordination, involving major stakeholders and monitoring of implementation, to ensure consistency and credibility in policy formulation.*

Box 2. **The changing policy environment in knowledge-based economies: key findings**

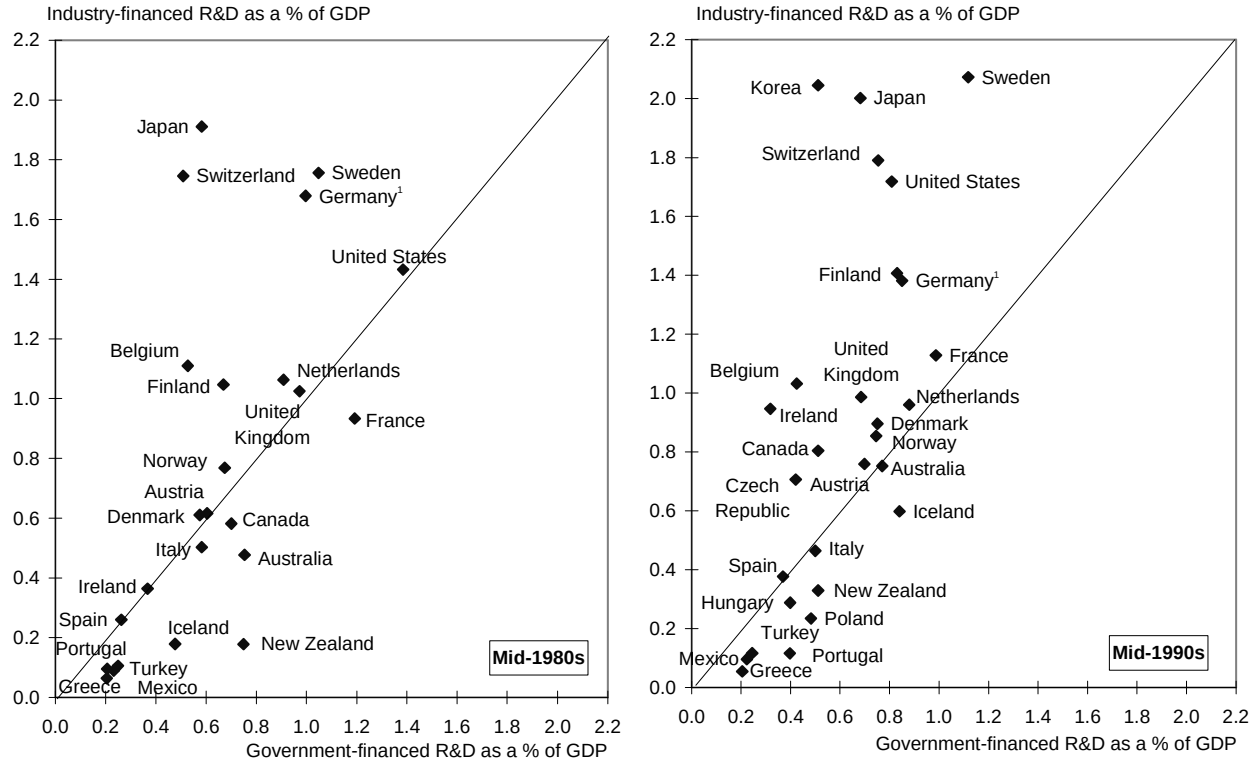
- *Many OECD countries show weak employment growth and/or increasing income inequality, with an employment structure shifting towards high-skilled workers.* Growth in white-collar, high-skill jobs (*e.g.* professionals) has been very dynamic in most countries, although in some low-skill employment has also increased, and in others employment in some high-skilled occupations has declined. More generally, the content of skills in both high- and low-skilled occupations is changing rapidly.
- *OECD economies are increasingly knowledge-based, with a shift of economic activity to services, and to high-tech and innovative activities.* Two-thirds of OECD production and 70 per cent of jobs are in services, whose nature is being transformed by information technologies, innovative efforts and upskilling. Most of employment growth is also in services (Figure 1). While manufacturing has declined in importance, its high-tech segment is very dynamic in terms of output and productivity, although less so in terms of jobs. Technology-based industries in manufacturing and services accounted directly for between one-quarter and one-third of G7 output growth between 1980 and 1995. But their economy-wide impact is most notably felt through the diffusion of new products and processes, generating productivity and employment gains throughout the economy.
- *Aggregate productivity growth remains modest, but the combination of technological change, organisational change and upskilling helps many firms achieve strong productivity growth and job gains.* Evidence from firm-level studies suggests that R&D-performing and/or technology-using firms have higher than average productivity and employment growth, but that other factors, such as worker training, organisational structures and managerial ability, are critical. There is a tendency for a smaller average size of firm, and small and medium-sized enterprises (SMEs) are of increasing importance for net job creation, although their average productivity remains lower than that of larger firms.
- *Globalisation is knitting dense and diversified linkages among national innovation systems*. The technology content of international trade is rapidly increasing, with the share of high-tech products growing faster than any other commodities, and technology embodied in imported capital and intermediary goods contributing significantly to productivity growth. International technological alliances and purchases of foreign patents and licences have grown. Corporate innovation activity remains predominantly located close to firms' headquarters; nevertheless, there is a marked tendency towards internationalisation of R&D, mostly by firms based in smaller home countries.
- *Government financing for R&D declined in many countries*. The share of R&D financed by government stagnated since the early 1980s (Figure 2), with its level declining in real terms in many countries (including all G7 countries except Japan). This affected support for technology more than for science as funding for defence and economic objectives fell while that for health, environment and the advancement of knowledge rose. As government-financed R&D in industry declined, closer links have developed between business and scientists, and scientific research has become the leading source of innovations in fields such as biotechnology, blurring the distinction between science and technology.
- *Private-sector R&D has generally levelled off, and there are signs of an orientation away from basic exploratory research towards more market-driven and short-term innovative efforts*. Slower economic growth, declining government support for industrial R&D and high interest rates caused a stagnation of private R&D expenditures in the mid-1980s/early 1990s. The recent recovery has not led back to previous R&D intensities. There are also indications of a re-orientation away from basic exploratory research towards more market-driven, short-term efforts. Market pressures, on the other hand, have in many cases raised the efficiency of R&D. While no serious adverse consequences have been felt to date (since it is mainly long-term research which has suffered), such effects may show up in the future.

Figure 1. **Employment trends by industry, total OECD**
Indices, 1980 = 100



Source: OECD, STAN, ISDB databases and Labour Force Statistics database, 1997.

Figure 2. **The evolution of public and private R&D efforts between the mid-1980s and the mid-1990s**



1. Data prior to 1991 cover western Germany only.
Source: OECD, MSTI database, 1997.

Best policy practice and main policy recommendations

The purpose of innovation and technology diffusion policy is to create the conditions in which new ideas, products and processes can translate into maximum economic and social benefits. This requires fostering a strong knowledge base, innovative capacity and behaviour on the part of firms, and conditions for diffusion and adoption of technology throughout the economy. Traditionally, governments have intervened in this area so as to provide for public goods as well as to address externalities, inefficient market structures, barriers to entry, imperfect markets for information, etc. However, there are limits to effective government action and the existence of market failures does not necessarily mean that action is justified. The nature of the factors shaping technical progress increasingly calls for policy measures to address "systemic failure", which occurs when there are mismatches between the different components of innovation systems, such as conflicting incentives of markets and non-market institutions.

The main features of the changing environment for innovation and technology diffusion policies are laid out in Box 2. OECD economies are experiencing a wave of technological change as indicated by the swift pace of scientific discovery, high patenting activity by the private sector, the rapid diffusion of new technologies, notably information and communication technologies, and a growing share of knowledge-based industries. However, this report shows that the economic outcome of technical change crucially depends on how technology is diffused, absorbed and used throughout the economy, as well as by structural impediments to job creation. There are marked differences between countries in how these processes take place, partly reflecting differences in the specialisation and structure of innovation systems.

This changing environment calls for the actions which go beyond innovation and technology diffusion policy defined in a narrow sense, encompassing only those government actions and regulations that are directly technology-related, and whose main instruments are managed by ministries and public agencies with technological development or diffusion as their main mission. The present report extends the boundaries of technology policy to include all measures targeting innovation and technology diffusion, irrespective of institutional arrangements and division of labour within government (for example, an R&D tax incentive is included even when managed by the Ministry of Finance), as well as related policies with a different primary goal (*e.g.* education or training). Figure 3 illustrates actors and linkages in countries' innovation systems.

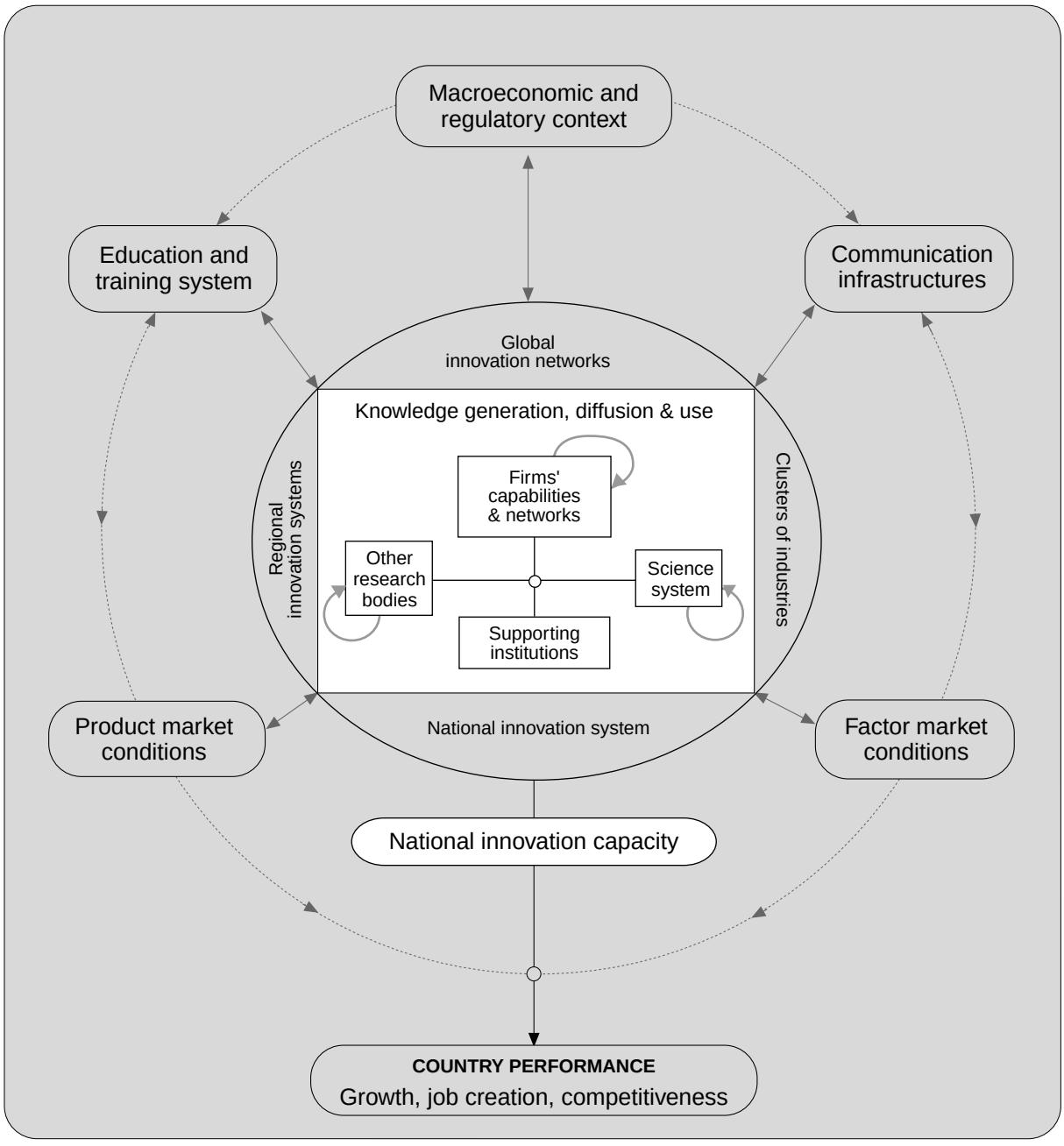
Technology policies need to become an integral part of the broader policy agenda

The impacts of innovation and technology diffusion policies will be modest unless they are consistent with, or complemented by, broader reforms. In this respect policy-makers should:

- *Ensure complementarity between technology policy and reforms in product, financial and labour markets, as well as in education and training.* In an increasingly integrated world economy, product market reforms enable more rapid diffusion of technology and information, and strengthen incentives for firms to innovate and adapt goods and services to changing consumer needs. Financial market reforms facilitate new technology-based entrepreneurial initiatives. Labour market reforms, combined with measures favouring upskilling and lifelong learning, contribute to further innovation, facilitate the use of new technologies, and allow technical change to translate into more jobs. There is a need for technology policy to act in concert with further structural reform, such as product and labour market reform in many European countries, broad-based upskilling in a number of countries including the United

Kingdom and the United States, regulatory reform of product and financial markets in Japan and Korea as well as in Europe, and comprehensive strengthening of framework conditions in transition economies.

Figure 3. **Actors and linkages in the innovation system**



Source: OECD Secretariat.

- *Co-ordinate technology policy and macroeconomic policy*. A sound macroeconomic environment is a necessary precondition to innovative behaviour and investment in technology. Technological progress, on the other hand, affects macroeconomic performance and policy in a number of ways, including via its impacts on growth, prices, measurement of output and inflation, and the stability of tax bases. International technology co-operation (for example in

the context of the European integration process) can spur technology diffusion, industrial restructuring and long-term economic performance, helping to make structural reform feasible and strengthening the credibility of macroeconomic policy. Policy-makers should look for positive synergies between technology policy and macroeconomic policy, for instance, in fostering more reliable conditions for long-term investment and innovation. In some cases, severe economic shocks have helped to muster support for improved policy co-ordination as a means to break out of vicious circles (Finland, Japan).

- *Build on the globalisation process through openness to international flows of goods, people and ideas and policies increasing the absorptive capacity of domestic economies.* To fully benefit from the internationalisation of trade, investment and knowledge, policy-makers, especially in small countries, need to foster a strengthened interplay between absorptive and innovative capacity. Virtuous circles in technology, growth and employment can be set off by openness to foreign direct investment, as in Ireland. Japan and Korea have benefited from technology imports and incremental innovations, but now need to upgrade their innovative capacity. This requires comprehensive reforms in several areas, including competition policy, frameworks governing universities and industry relations and their approach to sourcing of foreign technology. In Germany, public investment in the R&D infrastructure must be complemented by broader structural reforms so as to effectively raise inward flows of R&D and know-how.

Realising the productivity benefits of technical change

Technology directly increases the productivity of innovating firms, and indirectly raises economy-wide productivity through its diffusion and adoption. As information and communication technologies become pervasive, the potential for economy-wide productivity gains shifts from high-tech manufacturing to the overall economy, and notably to the expanding service sector. The realisation of these potential productivity gains can be helped by policies which either directly encourage technology development and diffusion or seek to remove obstacles to such activities arising from market, policy and systemic failure. They involve regulatory reforms in product and factor markets, policies that allow domestic firms to take advantage of international sources of technology, and also encompass direct policy initiatives providing services to firms aimed at increasing their capacity to absorb new technologies, as well as to engage in collaborative research with other firms.

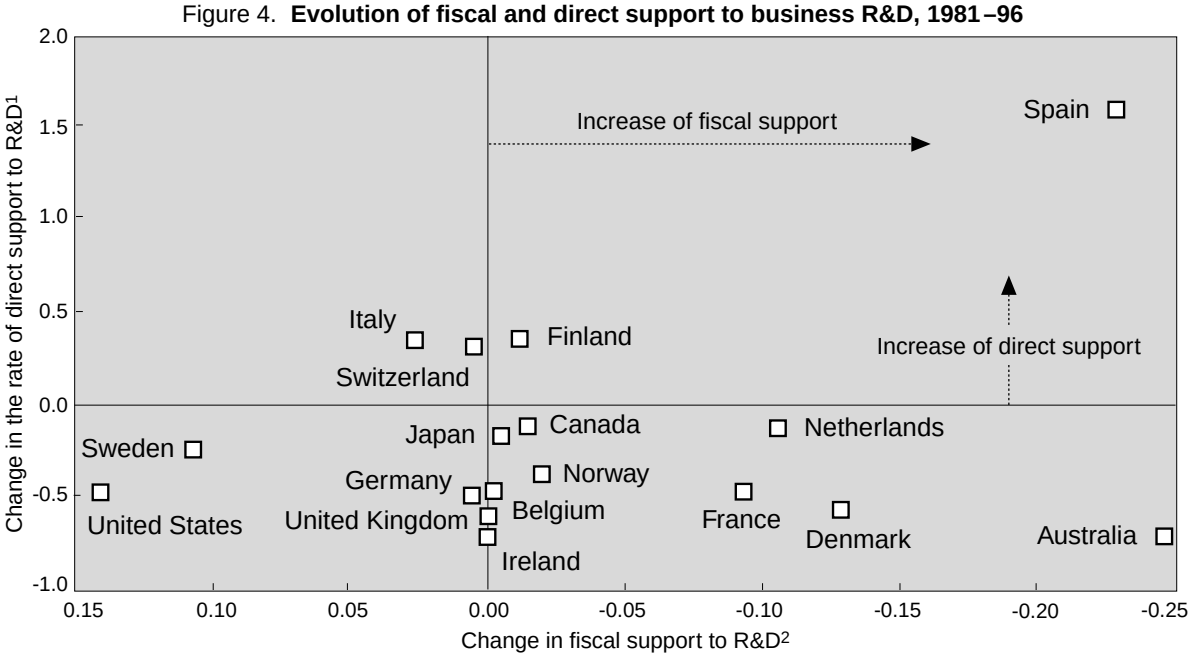
Policies are needed not simply to encourage the efficient diffusion of and exploitation of technology, but also to encourage innovation and growth in the knowledge base of an economy. This involves initiatives aimed at improving the management of the science base, as well as reforming support schemes of industrial R&D so as to increase their leverage effect on firms' R&D efforts and consequently improve productivity. However such policies will only be fully effective if complemented by measures which help firms improve their performance in terms of non-technological aspects of innovation, *e.g.* adoption of new organisational structures and upgrading workforce skills. Policy-makers need to:

- *Improve the management of the science base* via increased flexibility in research structures and incentives for university-industry collaboration. An important current issue is the appropriate balance between core and contract-based resources in financing research institutions. While in some countries there is a risk that the share of contract-based resources becomes excessive, in many others (notably in Continental Europe) increasing that share will stimulate flexibility and the responsiveness of research structures to economic and social needs. There are benefits from greater involvement by industry and other stakeholders in setting research priorities (including cross-disciplinary research). The experiences of Australia, Canada, Sweden, the United Kingdom and the United States are instructive in this respect. The research Framework Programmes of the European Union have for the last 15 years focused on supporting co-operation between universities, research centres and firms as well as the international mobility of scientists. The organisation of research in universities and government laboratories should both stimulate scientific excellence and facilitate mobility of ideas and people. A number of countries need to take measures concerning the status and training of university researchers, their conditions of employment, and other factors influencing mobility, including possibilities for creating their own firms.

- *Ensure that basic, exploratory research is kept at a level which allows technological opportunities to be maintained in the long run.* Increasing market pressure on firms has led many to improve the efficiency of their research activities in terms of economic outcomes. However, it has also reduced the funding of basic, exploratory research, whose outcomes are uncertain or difficult to appropriate. In addition to the appropriate funding of public research within increasingly tight government budgets, it is important that policy induce research by firms, or at least does not deter them from undertaking it. Many public programmes (the Advanced Technology Programme in the United States, the Framework Programme and Eureka in Europe) aim at encouraging co-operation between firms, and sometimes universities, on such "generic technologies". The regulation of concentration (mergers and acquisitions) and R&D co-operation increasingly takes this aspect into account. Antitrust policies in Europe, Japan and the United States have adapted to such concerns since the early 1980s. Still, governments generally need to improve the balance between allowing co-operation upstream, where it helps to keep research costs down and allows partners to benefit from each other's competencies, and enforcing competition downstream, when it comes to production and marketing, where it allows consumers to benefit from lower prices.

- *Raise the efficiency of financial support for industrial R&D while better weighing its merits relative to other instruments for financing innovation.* While there is a sound economic rationale for some public support to industrial R&D, in the form of either tax incentives or targeted R&D subsidies, in most countries there is room for improving such schemes. (Figure 4 shows the evolution of the two types of support over the last 15 years in a number of countries.) Efficiency gains could be obtained by reducing the generosity of R&D tax incentives in some countries (Canada, Spain), or by fine-tuning their inducement mechanism (Australia, France, Japan). A common weakness in measures to support pre-competitive R&D is that funding mechanisms remain relatively crude, in contrast with the increasing sophistication of market financing tools (*e.g.* venture capital). Many programmes to promote near-market R&D on a project basis have had mixed results; this explains recent efforts to streamline or reform them (*e.g.* Austria). As removing the impediments to the development of market mechanisms for innovation financing becomes increasingly attractive, countries should assess the appropriateness of the current scope and design of their financial support for industrial R&D.

Figure 4. **Evolution of fiscal and direct support to business R&D, 1981–96**



1. Percentage change in the rate of direct support to R&D, measured as the percentage of business R&D financed by government.
2. Change in the value of the B–index. The B–index is an indicator of the generosity of R&D tax treatment. The lower its value, the more generous the R&D tax treatment.

Source: OECD Secretariat.

- *Strengthen technology diffusion mechanisms by fostering competition in product markets and through better design and delivery of programmes.* Technology diffusion can be strengthened through open trade, competition and regulatory reform. Better designed and integrated public initiatives can help this process by increasing the ability of firms to access and exploit technologies. Enhancing competition and liberalisation of infrastructure has a strong potential for spurring innovation and diffusion in growing sectors such as telecommunications as well as in mature sectors, particularly in Austria, France, Germany and Spain. Australia, Finland, the Netherlands and the United Kingdom have consolidated the institutional infrastructure for diffusion policies so as to reduce overlap, while in France there exists a potential for overlap between national and regional initiatives. Denmark, the Netherlands and Spain have taken measures to improve the functioning of technology transfer centres. Technology extension services and information provision have been made more effective through greater industry participation and cost-sharing in Canada, Germany, Switzerland and the United States, although in Germany many technical centres remain heavily dependent on public support. Australia, Canada and the United States have integrated diffusion issues more explicitly in technology development projects; similar action is warranted in Korea, Mexico and Spain. Schemes to promote greater technology uptake have been made more effective in Austria, the Netherlands, Norway and the United Kingdom through evaluation and a better targeting of firms.

- *Strengthen incentives for comparable measurement and reporting by firms of intangible investment to improve the management and composition of investment.* While investment in intangible assets underpins productivity growth, there may be a tendency for firms to underinvest because of the lack of visibility of such assets in reporting practices. Strengthened incentives for their disclosure can improve resource allocation through better internal

management and improved external capital market assessment. There are scattered examples of good practice at the firm level, for example in Swedish firms, and experimentation in US firms. However, there are also disincentives to reporting, such as not wanting to reveal strategic information, concerns about taxation treatment and about becoming locked into static reporting practices Denmark is pioneering initiatives to encourage firms to disclose more systematic comparable information, based on current best practice. Similar initiatives in other countries will be important for further progress, and to enable a better understanding of the benefits of improved reporting, as well as a more favourable balance between its costs and benefits. However, in the absence of government initiatives, it is unlikely that individual efforts by firms will lead to internationally comparable reporting practices.

Ensure the conditions for technical progress to contribute to job creation

Technology policies must not aim at direct employment goals at the expense of productivity and competitiveness; nevertheless, a number of OECD countries are in need of policy adjustment in order to strengthen job outcomes. Reducing the potential mismatch between the skills in supply and those in demand, while ensuring complementarity between technology and human capital policies is one area for reform. Technology policy can also help improve the conditions for the creation and growth of new technology-based firms (NTBFs), which contribute directly to job creation, but even more importantly, create and diffuse new goods and services, thereby instilling a culture of innovation, encouraging investments in skills and improving economy-wide dynamic allocative efficiency. Policy measures in this respect involve fostering greater managerial and innovation capabilities, removing regulatory, information and financing obstacles and promoting technological entrepreneurship. More broadly, an important role for policy is to help create an environment conducive to the articulation of demand and jobs, including in new growth sectors such as Internet-based services or environmental goods and services. Policy should:

- *Help overcome mismatches between demand and supply for skills and improve the framework for adoption of new organisational practices.* The productivity and job gains associated with new technologies are best realised when firms make complementary investments in organisational change and upskilling. Canada, New Zealand, the United Kingdom and the United States have improved previously uneven performance in this respect; nevertheless, to varying extents they still need to expand and improve vocational and technical education and training. Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) and many continental European countries as well as Japan have traditionally done well in these respects but a number of them must combine greater firm-level flexibility with improvements in vocational education and strengthen its links with business. Expanding or improving the content of vocational and technical education is an issue for Austria, Belgium, Germany, Iceland, the Netherlands, Norway and Switzerland, improving links with business an important issue for Finland and France, while Austria, Germany, Japan and the Netherlands should facilitate mobility between vocational/technical and academic studies. Expansion and improvement of vocational education is of prime importance for the group of "catch-up" countries, including Italy, Greece, Portugal and Spain. Nordic and continental European countries and Japan have a strong infrastructure and traditions supporting diffusion of information on new work organisation and work practices, but this institutional infrastructure needs to reinforce its links with business and become more demand-driven as well as more closely co-ordinated with education and training programmes.

- *Facilitate the creation and growth of new technology-based firms by fostering greater managerial and innovation capabilities, reducing regulatory, information and financing barriers and promoting technological entrepreneurship.* Governments must address the specific factors which restrain the number of valuable entrepreneurial technology-based projects, raise obstacles to their transformation into business start-ups, and weaken subsequent market selection processes to the detriment of firms with growth potential. Increasingly this must include measures which spur greater management and innovation capabilities within firms, raising their potential for growth and investment in technology and skills. Regulatory barriers to entry should be reduced, and private venture capital industry promoted (including specialised financial market segments and "business angel" networks). This may be achieved through programmes to leverage private investment (*e.g.* in Australia, Germany and the Netherlands), or relaxing investment rules for pension funds, banks and insurance companies (*e.g.* in Australia, Finland and Italy). Direct financial support should be concentrated on early stages of innovative ventures (seed capital or pre-investment appraisal). Disincentives to "technological entrepreneurship" (regulations discouraging spin-offs from large firms and universities) and obstacles to risk-taking (*e.g.* bankruptcy law which excessively penalises failure, lack of stock options which improve the risk/reward ratio for highly qualified staff) should be removed.

- *Promote new growth areas such as Internet-based services and environmental goods and services through regulatory reform which encourages flexible technological responses and new entry.* The emergence of new industries to replace declining ones is important for growth and job creation. In new areas such as network-based services and environmental goods and services, government measures have helped to foster market-driven innovation, technology diffusion and economic expansion. Policies to facilitate growth need to integrate and co-ordinate different policy targets (encouraging positive social impacts of Internet-based services, the goals of environmental and technology policy), combine consistent regulation and economic incentives covering supply- and demand-side market behaviour of individuals and firms, and avoid lock-in to particular technologies. Jobs in network-based services have been created in access providers and new media due to infrastructure liberalisation, technological innovation and flexible service conditions. Best practices are found in Canada, Finland, the United Kingdom, the United States and the European Commission. High- and low-skill jobs are similarly being created to supply environmental goods and in new services such as eco-auditing; the distribution of jobs is shaped by combining flexible application of regulations with economic incentives encouraging innovation. Best-practice policies are found in Canada, Germany, Japan, the Netherlands, New Zealand, Nordic countries and the United States.

Improve the efficiency and leverage effects of innovation and technology policy initiatives

There is a need for improvement in the efficiency and leverage effects of innovation and technology diffusion policies via:

- *Improved techniques and institutional mechanisms for evaluation.* The increasing emphasis on evaluation partly reflects tight government budgets, but is also emblematic of a trend towards more accountability, transparency and the desire to minimise distortions from government policies while maximising their leverage effect. Only a few countries (Australia, Canada, the United Kingdom and the United States) systematically evaluate the whole range of technology programmes based on socio-economic criteria and with resource allocation and priority-setting as goals. While evaluation in these countries is mature and institutionalised, further efforts are

needed to allow better comparison of the relative efficiency and effectiveness of different policy tools. In Europe, the European Commission has helped to put evaluation on the policy agenda in certain countries, by developing methodologies and supporting networks of evaluators. Among European countries, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden and Switzerland have well developed evaluation practices, but tend to use evaluation mainly for improving programme management. Their approach provides part of the information necessary for managing the systemic nature of modern innovation systems, but fails to provide a sufficient basis for allocating public funds between competing uses. The approach taken to evaluation in New Zealand is similar, while in Japan a number of recent initiatives take a more rigorous methodological approach to evaluating socio-economic impacts of programmes. In Greece, Ireland, Italy, Portugal and Spain, as well as in the Czech Republic, Hungary, Mexico, Poland and Turkey, evaluation remains ad hoc, and there is a need to institutionalise the process by developing the methodological tools and mechanisms that will help embed evaluations in policy making.

- *Adoption of new mechanisms for supporting innovation and technology diffusion through greater use of public/private partnerships.* Public/private partnerships seem particularly well suited for correcting market failures in certain areas (*e.g.* development of generic industrial technologies) while minimising some systemic failures, by fostering co-operation between different actors (examples of such programmes exist in Australia, Austria, Japan, the United States and the European Commission). In comparison with traditional R&D subsidies, they entail a more competitive selection of private participants, an increased influence from the private sector on project selection and management, as well as greater leverage of public funding on private resources. Public/private partnership schemes have the potential to enhance synergies between market-driven R&D and R&D responding to governments' needs in accomplishing their direct missions (*e.g.* defence, public health, environment, etc.), provided that they can be designed so as to minimise the potential risks of capture by private sector participants, as well as dead-weight losses. Realising this potential is of particular importance for countries with a large public research sector (*e.g.* France, the United States). It involves different types of adjustment to policy practices, for example: the need to improve synergies between mission-oriented national programmes and diffusion-oriented regional initiatives (*e.g.* in Austria, Germany and the Netherlands), or to make the technology diffusion infrastructure more flexible in supporting diffusion, adoption and innovation in a broad range of firms and activities (*e.g.* in Nordic countries).

- *Removal of obstacles to international technology co-operation by improving transparency in foreign access to national programmes and securing a reliable framework for intellectual property rights.* International discrepancies in the access of foreign firms to government-funded research programmes have been reduced, especially following positive initiatives in Japan. Rules (*e.g.* reciprocity requirements or conditions regarding exploitation of research results) and practice now differ as much from programme to programme as from country to country. They should be made more transparent, especially in the United States where each of the many agencies involved in technology policy applies its own eligibility criteria. There is scope for improving other aspects of the regulatory framework for trans-border co-operation among private enterprises, especially in the area of intellectual property rights. Despite progress in harmonization under the aegis of the World Intellectual Property Organization (WIPO) and the World Trade Organization (WTO), the lack of predictability in intellectual property rights and standards, enforcement and litigation still hampers firms' global operations, particularly in new technology fields.

Making reforms politically feasible

Achieving consistency and credibility in implementing reforms is key to best policy practice, and requires overcoming institutional inertia as well as addressing transition costs and redistribution of incomes and jobs resulting from technical change. A fundamental question is whether the signals sent by policy to individuals and firms are consistent and credible. Factors for success include the extent to which co-ordination can be achieved between ministries and also involve various stakeholders. New forms of interaction with the private sector have helped dynamise research policies and innovation systems and better link them to economic and societal goals in Denmark, Finland, Germany, the Netherlands, the United Kingdom, the United States, as well as within the framework of the new Innovation Action Plan of the European Union. Many countries could further implement checks against government failure, use financial pressures to spur change in governance as well as "audits" and international benchmarking to induce critical self-examination.

Policy-makers should pursue international policy co-ordination, which may help achieve consistency in national reforms and secure broad public acceptance. Governments also have an important role to play in ensuring that mobilisation of efforts takes place at the regional and local levels, *e.g.* through the design of administrative and fiscal frameworks. Along with the goal of transparency of policies and resulting impacts, governments should put in place incentives which spur competition among local authorities in initiatives for improved framework conditions rather than in mere attraction of financial support.

Technology policies need to be part of a broader package, developed in consultation with the social partners to ease transition problems. One strategy is to begin with those measures which appear to be the most feasible, universally supported and whose effects are likely to be the most evident. Once these measures have been in existence for some time and their effects have been evaluated, necessary corrections can be implemented and more difficult decisions can be pushed through. Science and technology policies in Finland, Iceland, Japan and the Netherlands have been able to evolve along these lines. Even when "big bang" policies have been introduced, technology policy has generally evolved gradually over a period of decades (*e.g.* New Zealand). On the other hand, the ability to advance may hinge on the political will to push through difficult decisions, handle the associated transition costs and demonstrate positive outcomes. In some countries, a crisis situation has helped muster support for reform (*e.g.* Finland, Japan). It is important that policy-makers exploit such opportunities as they arise, thereby preventing conditions from deteriorating to a degree which makes it extremely difficult to repair the damage.

Measures that promote broad-based upskilling and lifelong learning can help to raise the mobility and employability of workers and mitigate the costs of job displacement resulting from rapid technological change. To the extent that innovation and technology diffusion contribute to economic performance and increased job creation overall, they should help improve social cohesion. Social security programmes and transfers protecting social cohesion will nevertheless continue to play an important role in preserving a social fabric conducive to trust; itself a major building block for risk-taking, innovation and creativity in a broader sense. At the same time, such policies must not undermine incentives for work, upskilling, organisational change or restructuring. OECD countries face a major challenge in putting into place, and successfully communicating to the public, a comprehensive policy framework which allows for a mutual strengthening of social cohesion, on the one hand, and technological progress and change on the other.

Overview of the main country-specific findings

Table 1 presents an overview of the main country-specific findings of the report. It shows national strengths and weaknesses and serves as a guide to the best practices and policy recommendations in the background report. In summarising the evaluation of national challenges and policies in different innovation and technology diffusion policy areas, it distinguishes between five situations: *(i)* case of best policy practice; *(ii)* partial best practice policy, with minor policy recommendation; *(iii)* minor policy recommendation; *(iv)* partial best practice policy, with remaining major weakness; *(v)* major weakness.

This report defines best policy practice as a learning tool rather than a normative concept; the table should not be interpreted as a ranking of countries. Neither can it be used to prioritise policy reforms within individual countries since it is not based on a series of country reviews and does not cover all areas of innovation and technology diffusion policy. Identified best practices are examples of successful national responses to generic problems that comprise elements (*e.g.* the general approach or a specific instrument) which could be emulated, with appropriate adaptation, in other countries. The report provides numerous examples of such best practices, although there are fewer in some areas than in others.

Areas where best practices are few and far between are precisely those where a systemic policy approach is inherent to success, namely: the institutional settings for policy formulation, implementation and evaluation, as well as the promotion of NTBFs and new demand. In other areas, such as technology diffusion or the management of the science base, where examples of best practices abound, they do not everywhere translate into satisfactory performance because their impact depends in part on conditions created by other policies. For example, efforts to make the science base contribute more to economic growth must be echoed by an increasing uptake of scientific inputs by the business sector – especially by NTBFs and in new growth areas. Industrial renewal brought about by firm creation and expansion of new markets will in turn enhance the effects of schemes for promoting technology diffusion.

For each country, the table gives indications on where policy adjustment and learning from best practices of other countries is required. Broadly speaking, three groups of countries can be distinguished. Some countries (*e.g.* Australia, Canada, Finland, the United Kingdom and the United States) exhibit few pronounced weaknesses and generally require only incremental improvements. However, except in the case of Finland, vocational and technical education and training constitute a weak point of the innovation systems of these countries and threaten long-term performance, requiring further expansion and improvement or reductions in drop-out rates. In Finland, as in Sweden, an important challenge is to make the infrastructure for diffusion better serve interactions between small and large firms. In Canada, financial support to industrial R&D should be rationalised. There is also room for improvement of the overall co-ordination in innovation and technology diffusion policies in most of these countries, including the United States.

By contrast, a number of OECD countries face a comprehensive agenda of far-reaching policy reforms. They include all new Member countries (the Czech Republic, Hungary, Korea, Mexico, Poland), where the institutional set-up for innovation and technology diffusion policies is still incomplete; European countries with less policy experience in this area (Greece, Ireland, Portugal, Spain, Turkey); but also more advanced countries such as Austria and Italy which face lasting problems of policy co-ordination that weaken efficiency in every technology policy area. The remaining Member countries, including Japan and other European OECD countries, fall somewhere in the middle and show more contrasted profiles of strengths and weaknesses. The weaknesses, *e.g.* in France, Germany and Sweden, partly reflect rigidities in the public research sector and related difficulties in adjusting financing and regulatory policies to the requirements of the emerging entrepreneurial model of knowledge generation and use.

Table 1. **Overview of best policy practice and policy recommendations in individual areas of innovation and technology diffusion policy** [1]

	Chapter 5[2]	Chapter 6	Chapter 7	Chapter 8	Chapter 9	Chapter 10	Chapter 11		Chapter 12
	Institutional framework for policy formulation and implementation	Evaluation	Managing the science base	Financial incentives to industrial R&D efforts	Technology diffusion policies and initiatives	Promoting new technology-based firms	Facilitating growth in new demand		High-performance workplaces and intangible assets
							Internet-based	Environment	
Australia	●/□	●	●/□	●	●/□	□	●/□	□	❍
Austria	❍	❍	□	□	●/□	❍	□	□	□
Belgium	❍	□	□	❍		❍	□	❍	□
Canada	●/□	●	●/□	●/❍	●/□	●/□	●	●	●/❍
Czech Republic		❍	❍		❍	❍		❍	
Denmark	□	□	●	□	●/□	□	□	□	●
Finland	●	□	●	●/□	□	●	●	●	●/□
France	□	□	❍	●/❍	●/□	●/❍	□	□	□
Germany	□	□	□	□	●/□	●/□	□	□	●/❍
Greece	❍	❍	❍		●/❍	❍	❍	❍	❍
Hungary		❍	❍		❍	❍		❍	
Iceland			●				□	□	□
Ireland	□	❍	●	□	□	□	❍	❍	●/□
Italy	❍	❍	❍	❍		□	❍	❍	❍
Japan	❍	□	●/❍	❍	●/□	❍	●/□	●	●/❍
Korea	□	❍	❍	□	●/❍	❍	□	❍	□
Luxembourg							□	□	
Mexico	❍	❍	❍	●/❍	❍	❍	□	❍	❍
Netherlands	●/□	□	●	□	●/□	□	●	●	●
New Zealand		□	□				●/□	●/□	□
Norway	□	□	□	□	●	□	□	●	●
Poland	❍	❍	❍	❍	□	❍	□	□	❍
Portugal	❍	❍	□				❍	❍	❍
Spain	❍	❍	●/❍	❍	●/❍	❍	❍	❍	❍
Sweden	□	□	●/□	□	□	❍	●/□	●	□
Switzerland	□	□	□	●/□	●/❍	❍	□	□	□
Turkey	❍	❍	❍	□	□		❍	❍	❍
United Kingdom	□	●	●/□	●/□	●	□	●	□	●/❍
United States	❍	●/□	●/□	●/□	●/□	●	●	●/❍	●/❍
EC	●/❍	●/□		●/□	●/❍	□	●	●	●

Key: ● represents case of best policy practice; □ represents minor policy recommendation; ❍ represents major weakness calling for policy adjustment.

1. The table should be interpreted with caution and not be read as a ranking of countries. Five situations are distinguished: *(i)* case of best policy practice; *(ii)* partial best practice policy, with minor policy recommendation; *(iii)* minor policy recommendation; *(iv)* partial best practice policy, with remaining major weakness; *(v)* major weakness. A blank means that available information was insufficient to draw conclusions.
2. This column is also based on judgement derived from other chapters.