4 Accelerating technological change: racing into the unknown

The breakneck pace of technological change brings risks and opportunities, not least for developed regions like Europe. These include in particular the emerging cluster of nanotechnology, biotechnology, and information and communication technology. Innovations offer immense opportunities for the environment but can also cause enormous problems if risks are not regulated adequately.

Over the last 50 years the pace of innovation and technological change has accelerated consistently. The time needed for basic inventions to enter mass use has steadily decreased. Cycles of technology-induced societal and economic change are becoming faster. And cycles of innovation and technology change are very likely to accelerate further. The history of technological progress provides compelling evidence that change is not linear but exponential (Kurzweil, 2001). The dynamics will increasingly come from the convergence of sciences and technologies: This acceleration technological change will also affect economic sectors that have been slower to change in the past, notably energy and transport.

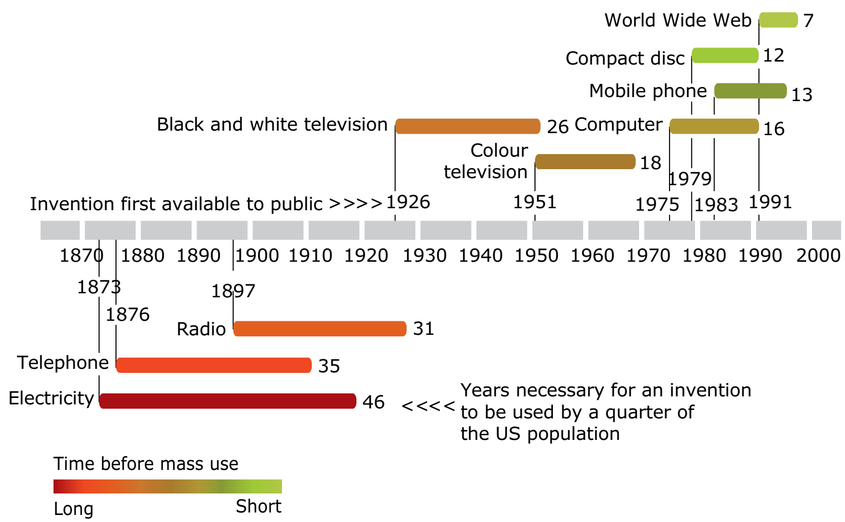
The processes of creating, owning and sharing knowledge are changing in a highly interlinked world; any outlook is fraught with considerable uncertainties. For example, open access to information will continue to empower bottom-up innovation processes, opening new routes for knowledge creation. But private battles may arise, with access to information and user rights becoming more fiercely contested by corporate and private interests.

A digital and technology divide is likely to remain between developed and many currently developing countries. One reason is that many cutting-edge technologies in ICT still depend on infrastructures based on older technologies, for example functioning electricity grids (Kegley and Raymond, 2006). However, more and more often emerging economies are starting to challenge developed economies in

the core areas of their competitive advantage, namely high-technology developments. Competitive pressures will increase as many emerging economies step up their general research and innovation capacities. Increasingly, EU-27 multinationals are competing with technology-based companies from emerging economies in high-end technology markets. Growth rates in patent filings in some Asian economies are beyond the level of several western OECD economies (WIPO, 2009) (Figure 4.2).

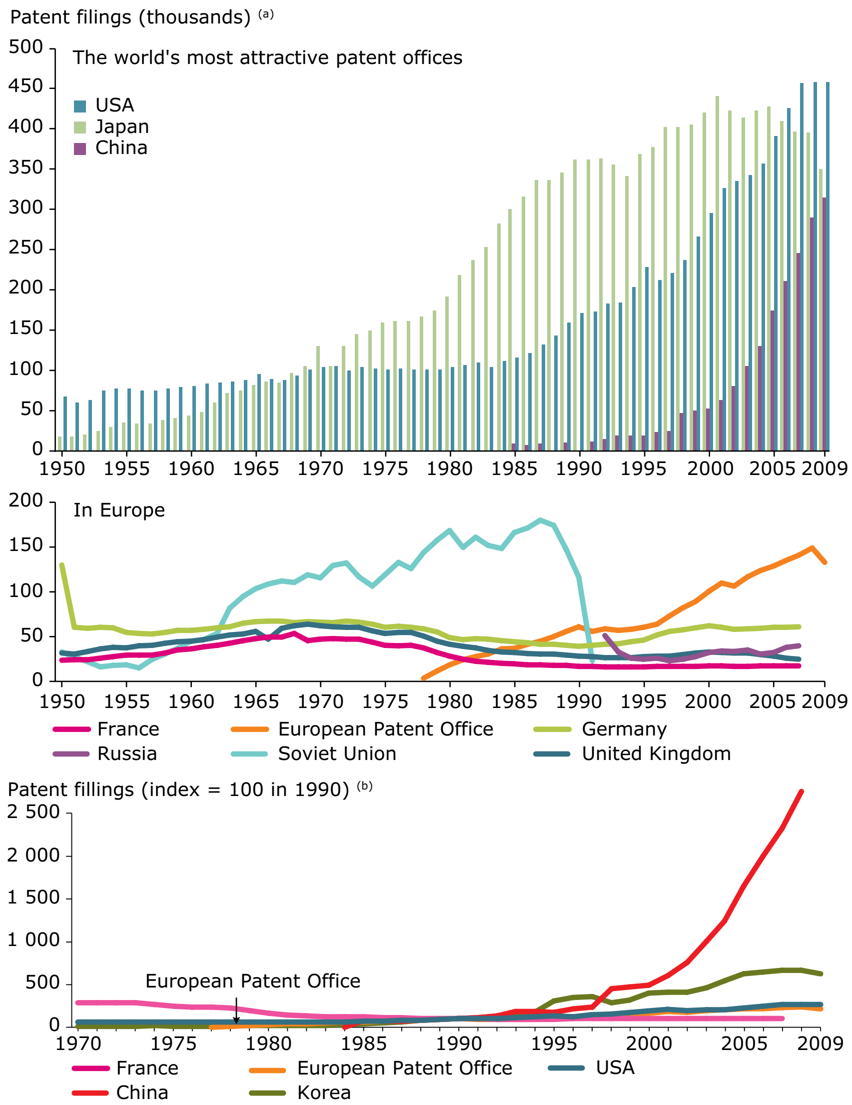
The dynamics of global innovation create an accelerating race into the unknown. This race offers tremendous opportunities for solving pressing environmental problems. But it also increases external dependencies and risks, particularly given the under-investment in water, energy and transport, which underpin most of our economic and technological activities. Risk regulators will increasingly operate under conditions of great, and often irreducible, uncertainty (OECD, 2010).

Figure 4.1 Shortening time lapse before mass adoption of new technologies



Source: Kurzwell, 2005.

Figure 4.2 Patent registration trends



Note: (a) These figures mostly reflect the popularity of patent offices.
(b) Please note that the time scale and the verticale scale are different from the graphics above.

Source: WIPO, 2009.

This balance of opportunities and risks is particularly evident for the cluster of rapidly emerging and converging sciences and technologies in nanosciences and nanotechnologies, biotechnologies and life sciences, information and communication technologies, cognitive sciences and neurotechnologies (the so-called NBIC cluster) (EEA, 2010d; Silberglit et al., 2006). Learning from nature is gaining increasing relevance as a scientific paradigm.

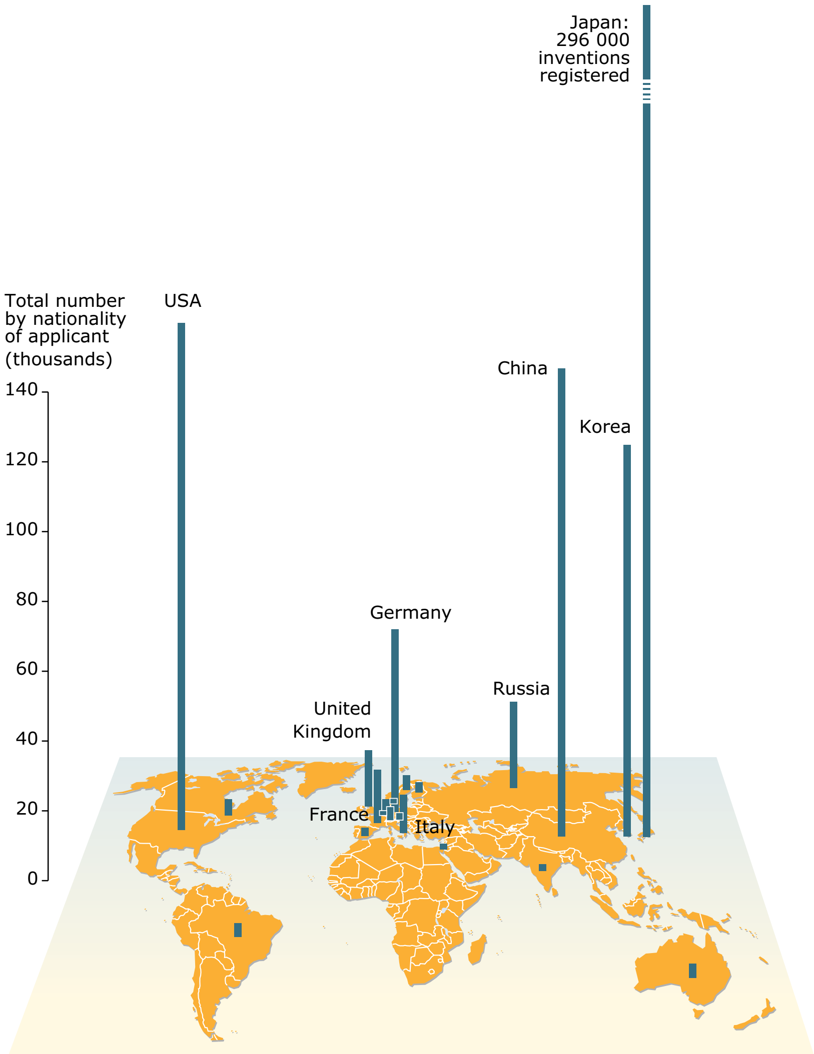
The NBIC cluster is increasingly quickly moving from innovation to application (e.g. nanomaterials) (Nightingale et al., 2008). In spite of all the uncertainties, in 2040–2050 nano- and biotechnologies are likely to be pervasive, diverse and incorporated into all aspects of our daily lives. Expectations range from moderate scepticism to broad enthusiasm, and even include far-reaching assumptions about the control of matter and genes, ubiquitous intelligence and a huge potential to accelerate access to sustainable energy, food supply and universal health-care (Subramanian, 2009).

Many observers agree that the NBIC cluster is likely to form the backbone of the next long-term wave of innovation and growth, changing the ways in which we work, live and communicate. The component elements are very likely to affect many approaches to environmental problem solving.

Nanotechnologies are especially relevant because with decreasing size the properties of materials change. Being able to design and manufacture materials and increasingly complex structures and devices at the scale of atoms and molecules offers many approaches and tools that can vastly enhance our ability to detect and remedy environmental deterioration. Examples include nanotechnologies for energy conversion and storage (for example dye-based solar power cells); replacement of toxic materials; new, lighter materials; and environmental remediation technologies (UBA, 2010).

There is also no end in sight for the increase of computing power: silicon-based chips are likely to be replaced with faster technologies (for example optical or molecular computers), which are capable of much higher speeds. They will greatly improve human abilities to understand and monitor environmental change and develop problem-solving strategies.

Figure 4.3 Patent families [a] registered in 2007



Note: Only countries with more than 1 000 applicants are shown.

([a]) A patent family is a set of inter-related patent applications on the same subject. Statistics based on patent families eliminate double counts (i.e. when the same invention is registered in different patent offices).

Source: WIPO, 2010.

Yet scientific committees in Europe and elsewhere, for example the US National Research Council, have expressed major concerns about the environmental and health issues arising from new technologies (SCENIHR, 2009). For instance, the rapid transformation that nanoparticles could undergo when released into the natural environment may render traditional approaches to describing air or water quality inadequate (RCEP, 2008). Currently, there is an increasing gap between the need for and the availability of relevant data and testing methods to understand, for example, the toxicology and exposure paths of novel materials in the environment (McGarvin, 2010).

Box 4.1 Why is the accelerating pace of technological change important for Europe?

The 2010 *State of the Future Report* from the Millennium Project (Glenn et al., 2010) observes that while humankind is devising ever more sophisticated ways to improve the human condition, global problems seem to be increasing in complexity and scale. Innovation is a key driver of economic growth and increasing welfare, and can contribute directly and indirectly to damaging or improving the environment. Many promising technological solutions are already available or could be available in a short time but are being poorly implemented. In general, R&D efforts have increased globally but environmental R&D retains a low share of the total. Similarly, environmental patenting is not keeping pace with the growth in overall patenting (Johnstone et al., 2010).

Approving new technologies in regions with weaker risk assessment and governance structures can create risks that could easily spread across our highly interlinked world. Unclear delineation of public and private responsibilities is likely to magnify controversies about risk control and associated costs. This challenge particularly concerns the NBIC cluster.

While new technologies are an indispensable part of any strategy to address problems of global environmental change, previous experiences with technological fixes show the possibility of simply shifting the source of the problem and creating new problems along the way. However, the legal requirement to apply the precautionary principle in the EU helps manage potentially harmful technologies and stimulate smarter, less threatening innovations.

Key drivers and uncertainties

Efforts to accelerate basic technological development cycles are driven by better access to information and increasing scientific cooperation, building upon continued economic growth and trade. The value creation and competitiveness of many companies in the OECD world is determined not just by the price of their products but also their ability to innovate and remain at the forefront of technological progress. Rising levels of education together with increased per capita incomes in many parts of the world mean that demand for new products is growing, leading to shorter product innovation cycles.

The general acceleration of innovation and technological change is a stable trend. But the concrete direction and speed of innovation and diffusion is very uncertain. Technological constraints are key uncertainties — many of the NBIC technologies are still in the laboratory. But there are also important uncertainties regarding the availability of R&D funding because of public and corporate budget constraints, public policy development and the availability of a sufficiently skilled labour force, which could be affected by barriers to international migration. Many applications of NBIC technologies might also trigger ethical concerns.

5 Continued economic growth?

Rapid growth accelerates consumption and resource use. But it also creates economic dynamism that fuels technological innovation, potentially offering new approaches to addressing environmental problems and increasing resource efficiency.

Virtually all mainstream outlook studies assume that economic growth will be positive on average across the globe in the coming decades. The rate of growth seems more uncertainty than previously, however, given the depth of the 2008–2009 economic crisis, which was unprecedented since 1945. Due to developments such as ageing and the need for more controls on financial markets, growth may be less than usually assumed in the past, in particular in the developed world. For example the European Commission's 2009 report on the implications of ageing in the EU revises the EU's average Gross Domestic Product (GDP growth expectations in the period to 2060 downward — from 2.4 % to about 1.8 %) (DG ECFIN, 2009).

IMF data show that the world economy grew by 3.2 % annually on average in the period 1980–2010. Developed economies grew 2.6 % annually on average, while China and India grew by 10.0 % and 6.2 % respectively in the same period. Although the gap in terms of GDP per capita (in purchasing power parity terms) between the USA and China has decreased considerably, it still is wide, standing at USD 45 000 in the USA and USD 5 400 in China. Poverty in China has been reduced considerably but in 2005 10 % of Chinese people still lived on less than USD 1 a day, against 35 % in 1990 (IMF, 2010). Although developing economies now account for a larger share of the world's GDP, some regions, in particular Africa, have lagged behind due to trade barriers in agricultural markets.