CHAPTER 1

CHALLENGES TO THE EUROPEAN EXCEPTION: WHAT CAN S&T DO?

The 7th Framework Programme (FP) was designed against the background of Europeans feeling anxious that Europe is turning from a positive into a negative "exception" at global level. The continent is confronted with a number of important economic, social and environmental challenges. These undermine the European exception in the positive sense, namely what Europeans are most proud of: the progress made so far towards the achievement of valuable societal objectives (e.g. raising standards of living and quality of life). While some (e.g. environmental) difficulties are common to all major world economies, other troubles (e.g. low economic growth and high unemployment) appear to be unique to Europe, turning it into a global exception in the negative sense.

The purpose of this chapter is twofold. It is first of all, and without pretending completeness, to explore in greater detail some of the societal issues affecting Europe. A second objective is to investigate the role that S&T can play in addressing these challenges. This potential role is sizeable, as this chapter will demonstrate. In order for S&T to realise its potential, however, a number of substantial S&T weaknesses will have to be remedied, as will be discussed in the next chapter (Chapter 2).

An analysis of the difficulties society has to deal with, and of the potential role of S&T in addressing them, is key to the development of any S&T policy and programme. The magnitude and nature of the challenges can, for instance, affect decisions on the size and thematic coverage of the programme, and its associated work programmes.

1. EUROPE: TURNING FROM A POSITIVE INTO A NEGATIVE EXCEPTION

Europeans have set themselves ambitious societal objectives:

> The Community shall have as its task . . . to promote throughout the Community a harmonious, balanced and sustainable development of economic activities, a high level of employment and of social protection, equality between men and women, sustainable and non-inflationary growth, a high degree of competitiveness and convergence of economic performance, a high level of protection and improvement of the quality of the environment, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States.[1]

[1] Treaty Establishing the European Community (Consolidated Text), *Official Journal C 325 of 24 December 2002.*

A quick review of the available evidence shows, however, that, while great strides have been made over the past few decades towards the achievement of these goals, Europe is facing significant challenges in most if not all of these areas. Economic growth is slow. Europe's competitive position is feeble. There are not enough jobs, and not enough of them are high-level. Europe is still characterised by significant poverty and regional inequality. An important demographic challenge is emerging. Europeans' health is affected by serious lifestyle and contagious diseases. And the environment is being degraded.

This is undermining what Europeans are most proud of and turning Europe into a negative exception at global level. The term "European exception" is most often used to refer to a European country not acting in accordance with what most other European countries are doing, whatever the field. Sometimes, however, the vocabulary is also used to refer to how Europe behaves differently from other advanced world economies. Usually, reference to the European exception has a positive tone to it. Europeans are proud of their commonly held values, their social model based on egalitarianism and solidarity, their high level of environmental awareness and protection and so on.

However, Europe appears to be the only advanced economy suffering from chronic low growth and high unemployment, and an unceasing lack of dynamism. Its levels of poverty and of individual and regional income inequality are not that far removed from US levels. And this makes Europeans feel anxious, and unsure of themselves, their future and further European integration.

1.1. Slow economic growth

Significant change has characterised the world economy over the past few decades. World trade has been liberalised as both formal and informal trade barriers have been reduced significantly, or disappeared altogether. Capital roams the planet freely in search of the best investment opportunities as barriers to capital mobility have been eliminated. Global communication and transportation networks have become denser and better integrated through a combination of technological and organisational innovation. The speed of technological change has accelerated while technologies are standardised more rapidly and use is made of modular production systems. As the combination of these factors has made it possible to locate the production of goods and services anywhere on the planet and still serve global markets, the global production system is in the process of being reconfigured.

The new international division of labour not only provides both developing and developed countries with ample opportunities, it also has shady sides. On the one hand, low-, medium- and to an increasing extent high-technology manufacturing and services industries are under threat from delocalisation or so-called off-shoring and outsourcing, resulting in at least short-term disruption and unemployment. Employment is also under threat from rapid process innovation leading to productivity increases.[2] On the other hand, rapid product innovation provides developed

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[2] European Commission, *Employment in Europe 2004*, Luxembourg, 2004, p. 77.

countries with opportunities to improve competitiveness and serve global markets by fleeing forward as it were. The race to upgrade the economy is never-ending, however, and innovation-based advantages are fleeting and unsustainable as rapid standardisation and modular production techniques quickly allow the production process to move partially or completely to developing countries.

As reflected in its lacklustre economic growth performance, Europe has not yet adapted to the rules of this new game. In the first half of the post-war period, the European economy grew as fast as the world economy (Fig. 1.1).[3]

In the second half of the post-war period, however, the decline in economic growth was more pronounced in Europe than in the United States, Japan and other OECD economies (Figs 1.1 and 1.2). In the last 15 years or so, Europe has done worse than the United States, while Japan has once again started to outperform Europe, and the large BRIC (Brazil, Russia, India, China) economies and smaller East Asian economies continue to grow rapidly.[4] The growth of output amounted to 1.3 per cent in the Euro area in 2005, substantially lower than the 3.5 per cent in the United States and the 2.7 per cent in Japan, and the 4.8 per cent at world level. Output is projected to grow by a higher 2.0 per cent in the Euro area in 2006, still

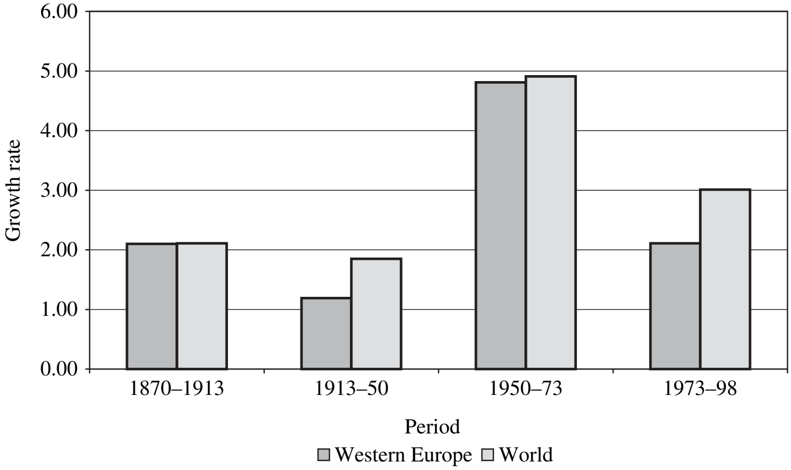

Fig. 1.1. Slow European economic growth in the second half of the post-war period compared to the rest of the world (annual average compound growth rate of GDP, 1870–1998)
Source: DG Research
Data: Maddison, 2001

[3] Angus Maddison, *The World Economy: A Millennial Perspective*, Paris, 2001.

[4] OECD, *Economic Survey of the Euro Area 2005: Outlook and Challenges*, Paris, 12 July 2005: Economic growth in the euro area has been lagging that of the best performing OECD countries since the mid-1990s. It should be acknowledged, however, that some EU countries have performed rather well economically in the past decade. This group includes the Member States formerly classified as cohesion countries (especially Ireland), as well as Finland, the Netherlands and the UK.

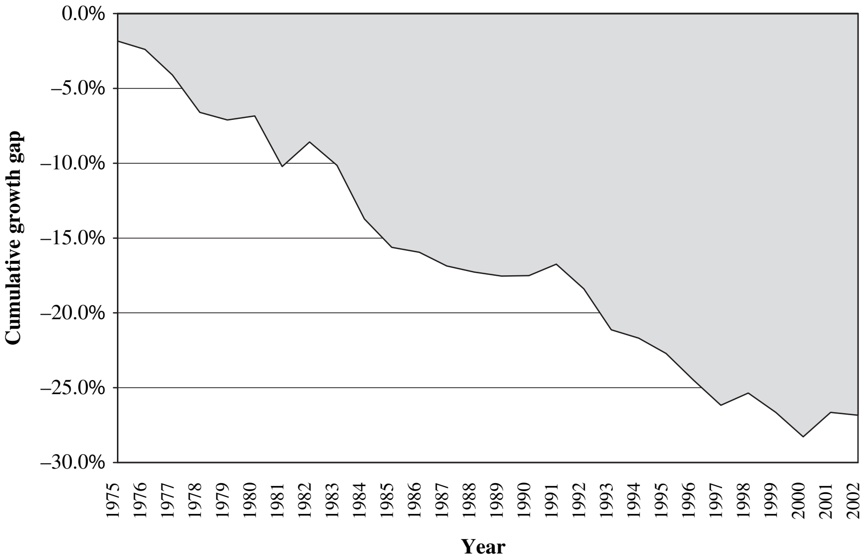

Fig. 1.2. Slow European economic growth in the second half of the post-war period compared to other industrialised countries (cumulative economic growth gap between the EU and the other industrialised countries (current prices and current PPPs))

Source: DG Research

Data: OECD

Note: For both the EU-15 and the non-EU-15 OECD countries, 1974 GDP at current prices and current PPPs (billions of dollars) was taken as 100. For all following years, GDP growth in percentages relative to the 1974 amount was calculated. Then the series for the non-EU15 OECD countries (Australia, Canada, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Switzerland, Turkey, US) was set to 100 and the difference with the series for the EU-15 calculated.

significantly lower than the 3.4 per cent in the United States and the 2.8 per cent in Japan, and the 4.9 per cent at world level.[5] Whenever Europe has been able to increase productivity in the past it has suffered in the field of employment, and vice versa, pointing to the existence of structural barriers to growth.[6]

1.2. A feeble competitive position

Underlying Europe's lacklustre economic growth performance is its weak competitive position. The most common definition of competitiveness refers to the overall capacity to improve standards of living in a sustainable way.[7] By this standard, European competitiveness is not improving. Europe caught up with the United

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[5] International Monetary Fund, *World Economic Outlook April 2006*, Washington, DC, 2006.

[6] *An Agenda for a Growing Europe. Making the EU Economic System Deliver*, Report of an Independent High-Level Study Group Established on the Initiative of the President of the European Commission, Brussels, 2003, pp. 27–28.

[7] European Commission, *European Competitiveness Report 2004*, Luxembourg, 2004, p. 7.

States during the 1950s and 1960s. But since the 1970s, European standards of living have not increased relative to the United States (Fig. 1.3).[8]

Labour productivity is another common measure of competitiveness. Though, except for a few countries, the productivity gap was never closed in the end, for most of the post-war period the EU somehow caught up on average with the United States.[9] This catch-up has now stopped and is even being reversed. Since 1995, for the first time in three decades, growth in US labour productivity has outstripped that of the Union (Fig. 1.4).[10] This EU productivity downturn is of a structural nature and mainly due to an outdated and inflexible industrial structure slow to adapt to the intensifying pressures of globalisation and rapid technological change.[11]

Deindustrialisation is often taken as a further sign of Europe's deteriorating competitiveness. The fear is that slow labour productivity growth, high labour costs,

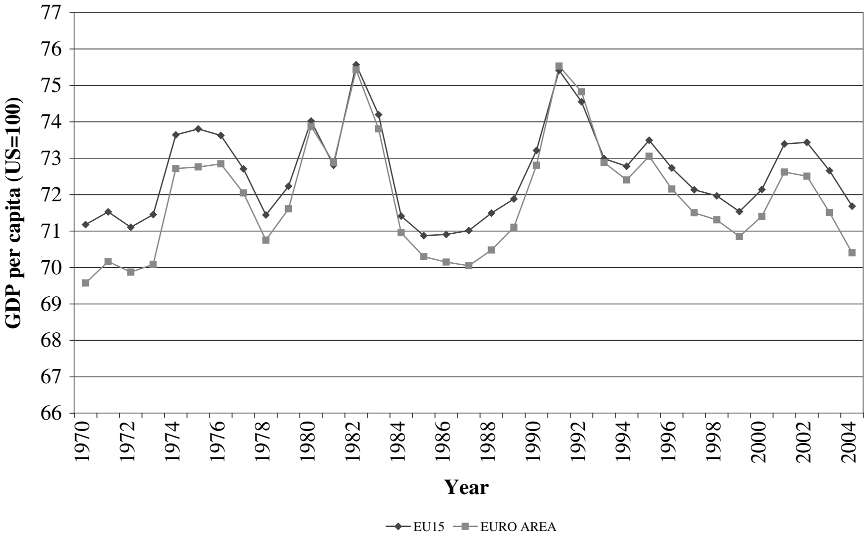

Fig. 1.3. European standards of living are much lower than US ones, and not catching up (GDP per Capita (US=100), EU-15 and Euro Area, 1970–2004 (per head at the price levels and PPPs of 2000 (US Dollars)))
Source: DG Research
Data: OECD

[8] International Monetary Fund, *Euro Area Policies*, 2 July 2004, Washington, DC, p. 14.

[9] Europe has reached past productivity increases to a large extent in a forced manner, by pushing low-skilled labour out of the labour market: *An Agenda for a Growing Europe*, p. 28.

[10] Mary O'Mahony and Bart van Ark (Eds.), *EU Productivity and Competitiveness: An Industry Perspective – Can Europe Resume the Catching-up Process*?, Luxembourg, 2003.

[11] Cécile Denis *et al., The Lisbon Strategy and the EU Structural Productivity Problem*, European Economy, European Commission, Directorate-General for Economic and Financial Affairs, Economic Papers, N° 221, February 2005, p. 4.

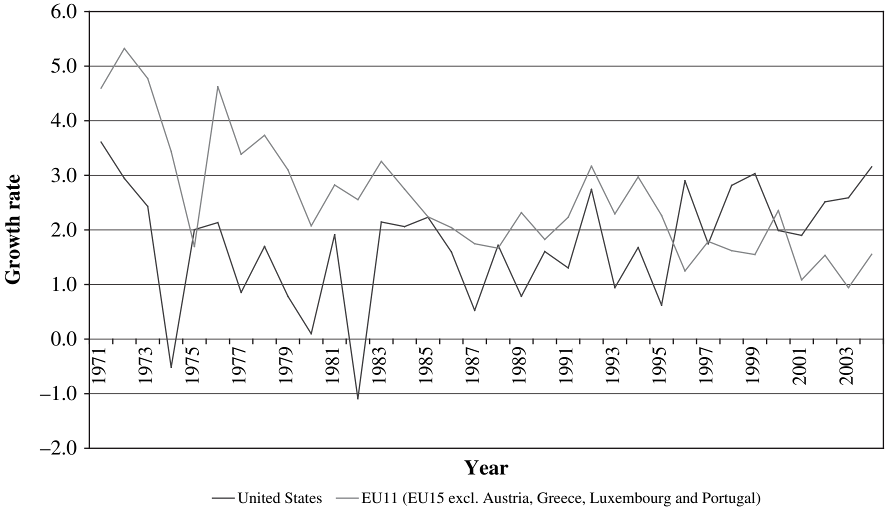

Fig. 1.4. European productivity is no longer catching up with the US one (GDP per hour worked, annual growth rates, EU-11 and US, 1970–2004)
Source: DG Research
Data: OECD

and short and inflexible working hours drive entire industries to low-cost, high-tech countries in Eastern Europe and Asia. The evidence for deindustrialisation is not clear-cut. Some analyses point out that industry still accounts for the same important share of Gross Domestic Product in terms of volume as in the past, while the declining share in terms of value added and employment is due simply to decreasing prices because of productivity gains and exposure to competition higher than that for services. Should it occur, the impact of deindustrialisation would indeed be worrying: the existence of many services depends on the presence of industry; industry pays better wages than services, even for low-skilled jobs; industry accounts for most innovations and technological revolutions; and industry has an important strategic role.[12]

Europe's feeble competitive position is also clear from its weak trade performance, especially that at the high-tech end. Europe's most dynamic export products are generally not those one would closely associate with the knowledge-based economy. The top three products with the fastest growing market share are floor coverings, pork and poultry fat, and hemp. On the other hand, if one looks at products for which market share is in major decline (> 10 per cent loss in market share), the EU has many more (345 product groups) than the United States (65) or Japan (90). What is more, in Europe many technological products are among

[12] CEPII-CIREM, *European Industry's Place in the International Division of Labour*, Report Prepared for DG Trade of the European Commission, July 2004.

them (e.g. air launchers, turbines, insulating glazing, drugs containing alkaloids or hormones, telephones, photographic film).[13] High-tech manufacturing exports represent a much smaller proportion of total manufacturing exports in Europe than in the United States or Japan (in 2002, 19.7 per cent vs. 28.5 per cent and 26.5 per cent respectively).[14] Europe's share of global high-tech manufacturing exports, though increasing, is lower than that of the United States (in 2002, 16.7 per cent vs. 19.5 per cent respectively).[15] And Europe runs a structural deficit in high-tech manufacturing trade, whereas the United States and Japan run surpluses.[16]

1.3. Not enough jobs, and not enough of them high-level

The European employment input is significantly lower than that in the United States. First, though apparently catching-up, the European employment rate is still substantially lower than that of the United States (Fig. 1.5). In 2004, the EU-25 employment rate was 63.3 per cent and the EU-15 one 64.7 per cent, so 6 to 7 percentage points below the target under the Lisbon agenda, compared to 71.2 per cent in the United States.[17] This is mainly due to the limited participation of women, the young, and the elderly in the labour force. At 55.7 per cent and

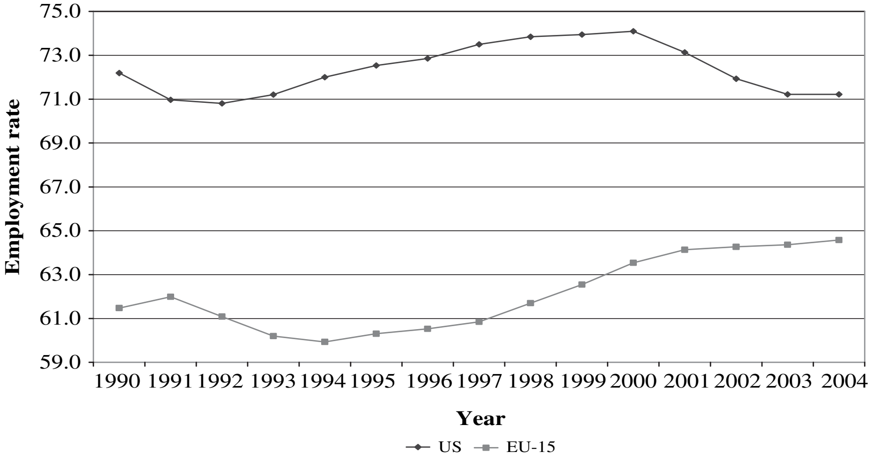

Fig. 1.5. Relatively fewer people are employed in Europe than in the US (employment rate, EU-15 and US, 1990–2004)
Source: DG Research
Data: OECD
Note: Share of persons of working age (15–64 years) in employment

[13] CEPII-CIREM, *European Industry's Place In the International Division Of Labour*.
[14] European Commission, *Key Figures 2005*: *Towards a European Research Area*: *Science, Technology and Innovation*, Luxembourg, 2005, p. 66.
[15] European Commission, *Key Figures 2005*, p. 67.
[16] European Commission, *Key Figures 2005*, p. 67.
[17] European Commission, *Employment in Europe 2005*, Luxembourg, 2005, p. 17.

41.0 per cent, the female and older people's employment rates were about 4 and 9 percentage points below the Lisbon targets for 2010.[18]

Second, Europe also scores lower than the United States in terms of the number of hours worked annually per employee (Fig. 1.6).[19]

For a long time, the low employment rate and number of hours worked annually per employee were explained with reference to the European emphasis on work-life balance. A growing number of authors draw attention to the existence of disincentives to work, however, the main one being the lack of employment opportunities.[20] This lack of employment opportunities is clear from the high unemployment rates. In 2004, about 19.4 million Europeans were out of work. This equalled 9.0 per cent of the labour force, some 4 percentage points higher than the rates in the United States and Japan (Fig. 1.7).[21] The proportion of high-level jobs is also considerably lower in Europe than in the United States.[22]

1.4. The cohesion and enlargement challenges: Substantial poverty and regional inequality

Though Europe likes to pride itself on its superior social model, poverty rates are rather high, and regional inequality is substantial. In 2004, the at-risk-of-poverty

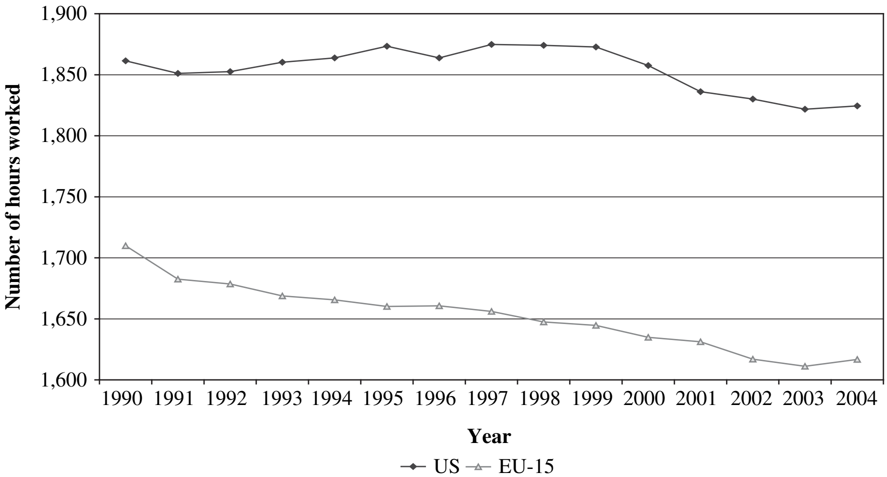

Fig. 1.6. An average European works far fewer hours than an average American (actual hours worked per year per person in employment, EU-15 and US, 1990–2004)
Source: DG Research
Data: OECD

[18] European Commission, *Employment in Europe 2005*, p. 9.
[19] International Monetary Fund, *Euro Area Policies*, p. 14.
[20] International Monetary Fund, *Euro Area Policies*, pp. 14 and 17.
[21] European Commission, *Employment in Europe 2005*, p. 24 and Statistical Annex.
[22] European Commission, *Employment in Europe 2004*, p. 128.

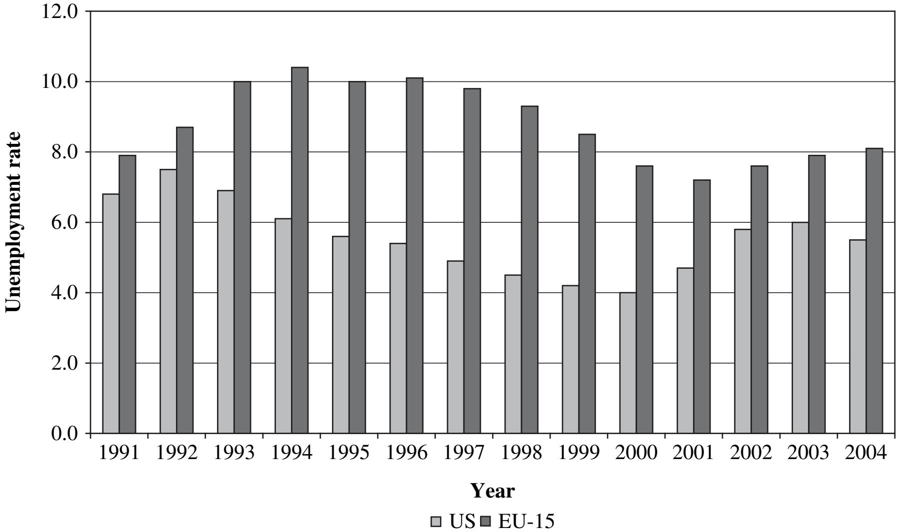

Fig. 1.7. Relatively more people are unemployed in Europe than in the United States (unemployment rate, EU-15 and US, 1991–2004)
Source: DG Research
Data: OECD

rate was 17 per cent in the EU-15, and 16 per cent in the EU-25.[23] In the same year, the 20 per cent of the population with the highest income (top quintile) received almost 5 times as much income as the 20 per cent of the population with the lowest income (lowest quintile) in both the EU-15 and the EU-25.[24] The Gini coefficient – a number between 0 and 1 used to express the degree of income inequality, where 0 corresponds to perfect income equality and 1 corresponds to perfect income inequality – was 0.30 in both the EU-15 and the EU-25 (Fig. 1.8).[25] The share of children living in households with income below the poverty line ranges from 7 per cent in Slovenia and 9 per cent in Denmark to 30 per cent in Slovakia.[26] The proportion of people aged 65 and over with income below the poverty line varies across the EU from 4 per cent in the Czech Republic and under 10 per cent in France, Hungary and Poland to 30 per cent in Spain, over 40 per cent in Ireland, and over 50 per cent in Cyprus.[27]

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[23] Eurostat [The at-risk-of-poverty rate must be understood as the share of persons with an equivalised disposable income below the risk-of-poverty threshold, which is set at 60 per cent of the national median equivalised disposable income (after social transfers)].

[24] Eurostat (Income must be understood as equivalised disposable income).

[25] The Gini coefficient is a measure of inequality of a distribution.

[26] Applica *et al.*, *Network on Social Inclusion and Income distribution – Final Report,* European Observatory on the Social Situation (SS0) – Contract No VC/2004/0462, December 2005, pp. v and vi.

[27] Applica *et al.*, *Network on Social Inclusion and Income Distribution*, pp. v and vi.

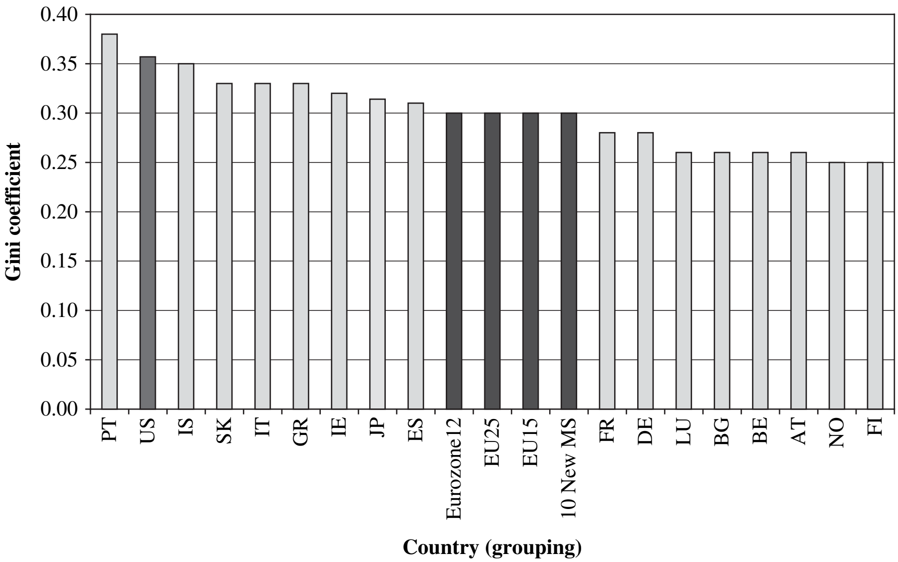

Fig. 1.8. The degree of income inequality is relatively high in Europe (GINI-Coefficient, 2004)
Source: DG Research
Data: Eurostat
Note: The Gini coefficient is a number between 0 and 1 used to express the degree of income inequality, where 0 corresponds to perfect income equality and 1 corresponds to perfect income inequality. Data for US and JP are for 2000 and taken from: Förster, M. and M. Mira d'Ercole (2005), "Income Distribution and Poverty in OECD Countries in the Second Half of the 1990s", OECD Social Employment and Migration Working Papers, No. 22, OECD Publishing. doi:10.1787/882106484586.

Substantial regional diversity and inequality characterises the European Union. In 2004, employment rates ranged from 39.5 per cent in Réunion (France) to 78.2 per cent, or almost twice as high, in Bedfordshire, Hertfordshire (United Kingdom). Unemployment rates, on the other hand, ranged in 2003 from 20.1 per cent in Sicily (Italy), 20.4 per cent in Mecklenburg-Vorpommern (Germany), and 25.5 per cent in the Polish region of Zachodniopomorskie to a mere 3.4 per cent in the Dutch region of Noord-Brabant, 3.7 per cent in Luxembourg and 4.0 per cent in the Budapest area.[28] The EU is also marked by substantial inequality in income levels. In 2002, Gross Domestic Product (GDP) per capita was below 75 per cent of the EU-25 average in 63 out of 254 NUTS 2 regions examined in the EU-25.[29] The highest

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[28] Eurostat.

[29] At the beginning of the 1970s, Eurostat set up the 'Nomenclature of Statistical Territorial Units' (NUTS) as a single, coherent system for dividing up the European Union's territory in order to produce regional statistics for the Community. NUTS subdivides each Member State into a whole number of regions at NUTS 1 level. Each of these is then subdivided into regions at NUTS level 2, and these in turn into regions at NUTS level 3. Leaving aside

regional Gross Domestic Product per capita (Inner London – United Kingdom) was about 10 times the lowest one (Lubelskie – Poland).

Enlargement, for the European Union, is at one and the same time a challenge and an achievement, a "raison d'être" and a "façon d'être". It is a continuation of the historical process that started over 50 years ago with the Communities' inception, developed through several steps (in 1973, 1981, 1986, 1991, 1995), and reached a high point – albeit not an end-point – with the enlargement of the European Union to 10 countries of Eastern and Southern Europe on 1 May 2004. Preparation for that enlargement took several years and by the time they joined, the EU-10 had successfully transformed their economies from centrally planned to functioning free market ones. Compliance with the Copenhagen criteria for accession served as a powerful catalyst for change. This assessment is detailed in a recent stock-taking exercise in which the Commission services have provided strong evidence and analyses indicating that the 2004 enlargement constitutes an economic success for the "old" and the "new" Member States alike.[30] It has to be noted that enlargement has been a dynamic process rather than a discrete event and that its effects will become visible over time.

Figure 1.9 shows that convergence and catching up in real income have been at work throughout the period since the late 1990s. Per-capita incomes are now much closer to EU-15 levels than they were in 1997, the year in which enlargement prospects crystallized in the Commission's Agenda 2000. After the output collapse in the early years of transition, growth rates in the EU-10 have been higher than in the EU-15, but also more volatile. The key contributors to actual and potential economic growth in the EU-10 have been capital accumulation and technical progress (the so-called Total Factor Productivity, TFP), while the contribution of labour has been mostly negative (that being a reflection of weak employment growth and, to a lesser extent, of an ongoing decline in hours worked per employee). In general, and consistent with the convergence hypothesis, Member States with lower initial (1997) per capita income tended to grow faster in the intervening years.

1.5. The demographic challenge: Fertility decline and ageing

Birth rates continue to be low in Europe.[31] Everywhere, the fertility rate is below the threshold needed to renew the population (around 2.1 children per woman),

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the local level (municipalities), the internal administrative structure of the Member States is generally based on two of these three main regional levels. This existing national administrative structure may be, for example, at NUTS 1 and NUTS 3 levels (respectively the Länder and Kreise in Germany, or at NUTS 2 and NUTS 3 (régions and départements in France, Comunidades autónomas and provincias in Spain).

[30] European Commission, *Enlargement, Two Years after – An Economic Success*, Communication from the Commission to the Council and the European Parliament, COM(2006) yyy final, 3 May 2006; European Commission, *Enlargement, Two Years after: An Economic Evaluation*, European Economy, Occasional Papers, No. 24, May 2006.

[31] Ageing also threatens a developing country like China, see Howard W. French, As China Ages, a Shortage of Cheap Labor Looms, In: *The New York Times*, 30 June 2006.

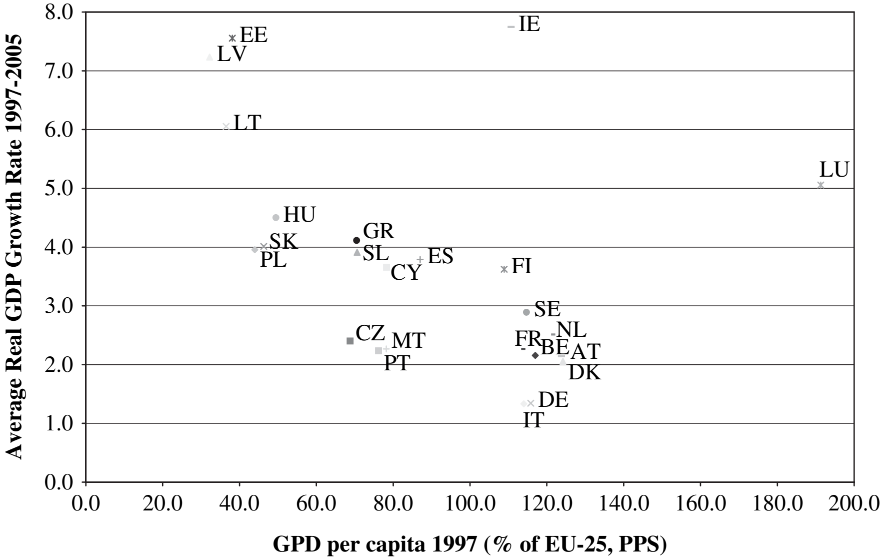

Fig. 1.9. The enlarged Europe is converging in terms of real income
Source: DG Research

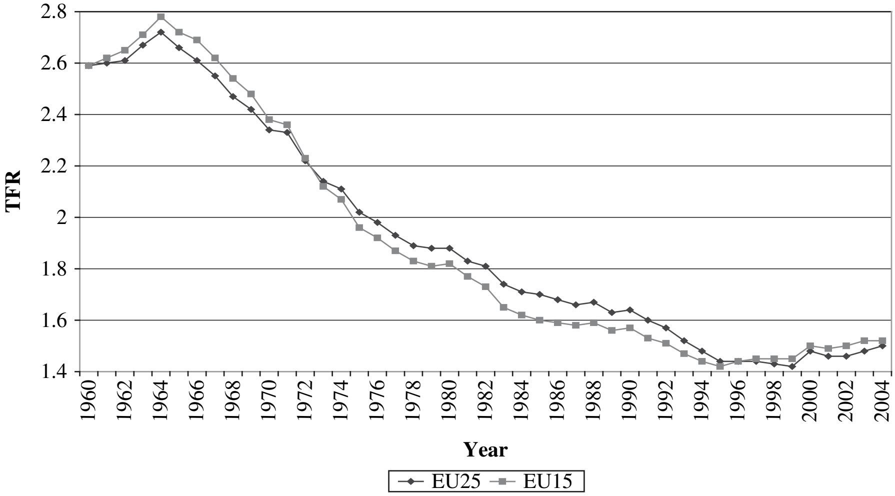

Fig. 1.10. European fertility is declining (total fertility rate, EU-15 and EU-25, 1960–2004)
Source: DG Research
Data: Eurostat

and in many Member States it has even fallen below 1.5 children per woman (Fig. 1.10). In 2003, the natural population increase in Europe was just 0.04 per cent per annum, and in many countries the population would shrink if it were not for immigration. Except for Cyprus and Malta, all new Member States already saw falling populations. The Union's population is set to grow just slightly up until 2025, thanks to immigration, before starting to drop: 458 million in 2005, 469.5 million in 2025, and 468.7 million in 2030. Between 2005 and 2030, the total working age population (15–64 years) is set to fall by 20.8 million. At the same time, as average life expectancies are increasing, the demographic dependency rate will rise from 49 per cent in 2005 to 66 per cent in 2030, putting pressure on pension and health care systems. Ageing could cause potential annual growth in Gross National Product in Europe to fall from about 2 per cent now to 1.25 per cent in 2040.[32]

1.6. The public health challenge: Lifestyle and communicable diseases

The health of European citizens is negatively affected by lifestyle as well as communicable diseases. For both men and women in the EU-25, circulatory diseases are the major cause of death. They accounted for 1.8 million or 42 per cent of all deaths in the EU-25 in 2002 (38 per cent of male deaths and 46 per cent of female deaths).[33] Cancer is the second most frequent cause of death in Europe. In 2002, it was responsible for a quarter of all deaths (29 per cent of deaths for men and 22 per cent of women).[34] In the same year, for every 100,000 men in the EU-25 311 new cases of cancer were reported, and for every 100,000 women 232 new cases.[35] The chronic disease diabetes (mellitus) and its complications have become a major public health problem in all countries. It causes significant physical and psychological morbidity, disability and premature mortality among those affected and imposes a heavy financial burden on health services. The prevalence of diabetes is rising. In the EU, there were an estimated 12.7 million diabetics in 1995 projected to rise to 19.6 million by 2010. In 2000, an estimated 4.1 per cent of the EU population were diabetics.[36]

Communicable diseases killed some 15 million people worldwide in 2002, of which some 225 thousand in Europe.[37] HIV/AIDS is the most important communicable disease of our times, followed by tuberculosis and malaria. In 2005, the number of people living with HIV, for instance, was estimated at 40.3 million worldwide, and that of people newly infected with HIV at 4.9 million. The number

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[32] European Commission, *Green Paper "Confronting Demographic Change: A New Solidarity between the Generations"*, Communication from the Commission, COM(2005) 94 final, 16 March 2005.

[33] European Commission, *Health in Europe – Data 1998–2003*, Luxembourg, 2005, p. 63. European Commission, DG Health and Consumer Protection, *Public Health, Disease and Conditions Information Sheets: Cardiovascular Diseases*.

[34] European Commission, *Health in Europe*, p. 63.

[35] European Commission, *Health in Europe*, p. 33.

[36] European Commission, DG Health and Consumer Protection, *Public Health, Disease and Conditions Information Sheets: Diabetes*.

[37] WHO, *The WorldHealth Report 2004*, Geneva, 2004, Annex Table 1.2.

of AIDS deaths was estimated at 3.1 million.[38] In Europe, the number of newly reported HIV infections is increasing, while that of newly diagnosed AIDS cases is decreasing. In the 17 EU countries with data available for 1996 and 2003 for both HIV infections and AIDS cases, the number of newly reported HIV infections increased by almost 75 per cent (from 7641 to 13,257) while the number of newly diagnosed AIDS cases fell by over 55 per cent (from 4 085 to 1 772).[39] Europe is also affected by other communicable diseases including SARS and avian influenza.

1.7. The environmental challenge: Water, climate change, and biodiversity

One of the most worrying challenges for Europe, and indeed for the whole world, concerns the deterioration of the environment. European citizens overwhelmingly agree that the state of the environment influences their quality of life (72 per cent), that policy-makers should consider the environment to be just as important as economic and social policies (85 per cent), and that policy-makers should take into account environmental concerns when deciding policy in other areas such as the economy and employment.[40] "A high level of protection and improvement of the quality of the environment" is a European Community objective (see above). Europe has been implementing environmental action plans and pursuing sustainable development strategies at both national and European level for quite some time now. It plays a leading role in the fight against global warming.[41] And it occupies a strong position in the field of environmental technologies.

Yet, because of population growth; consumption patterns; market, policy and political failures; features of existing technologies; and world views and values, Europe and the world at large are still far removed from a development trajectory that is truly sustainable, that is, which satisfies the current needs of society (growth, competitiveness, employment, etc.) without compromising the needs of future generations.[42] European citizens worry most about water pollution (of seas, rivers, lakes, underground sources, etc.) (47 per cent); man-made disasters (major oil spills, industrial accidents, etc.) (46 per cent); climate change (45 per cent); and air pollution (45 per cent).[43] The Sixth Environment Action Programme of the European Community 2002–2012 (6*th* EAP) identifies four priority areas for urgent action: (1) climate change; (2) nature and biodiversity; (3) environment and health and quality of life; and (4) natural

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38 UNAIDS, *AIDS Epidemic Update: December 2005 – Global Summary of the AIDS Epidemic*, Geneva, December 2005.

39 European Commission, *Health in Europe*, p. 35.

40 European Commission, *Special Eurobarometer – The Attitudes Of European Citizens Towards Environment*, Luxembourg, April 2005, Annex Tables.

41 Though, in contrast to its image in the outside world, Europe still relies to a large extent on coal. See for instance: Mark Landler, The Energy Challenge – Europe's Green Image Clashes with Reliance on Coal, In: *The New York Times*, 20 June 2006.

42 Robert L. Olson and Jessica Biamonte, *New Global Agenda: An Analysis of Major Overview Studies of the Global Environment*, A White Paper Prepared for the Foresight and Governance Project, Woodrow Wilson International Center for Scholars, Washington, D.C., August 2004.

43 European Commission, *Special Eurobarometer*, pp. 5–6.

resources and waste. The environmental objectives of the EU Sustainable Development Strategy include: (1) addressing climate change; (2) better management of natural resources; and (3) making transport more sustainable. A 2004 review of nine recent comprehensive analyses of global environmental problems (Table 1.1) showed near-unanimous agreement that the three problems posing the greatest threats to the global environment and continuing economic development include: (1) water quality and access; (2) climate change; and (3) loss of biodiversity.[44] Climate change forecasts indicate that, if the level of emissions is not curbed, the temperature level will rise and risks such as water shortage, malaria and hunger will increase and affect millions of people by 2080 (Fig. 1.11).

Addressing such environmental problems is highly complex. One of the premises of sustainable development is that environmental problems interact with each other, as well as with economic and social issues. Climate change affects agriculture, forestry, water availability, marine systems, terrestrial ecosystems, health and, last but not least, the economy. Forests and oceans act as climate regulators but also harbour a wide diversity of species. Decisively tackling the issue of biodiversity will require i.a. making forestry sustainable, addressing pollution, and dealing with climate change. Pollution negatively affects health, from allergies and infertility to cancer and premature death. In the mid-1990s damage costs to the EU caused by air pollution originated in the EU (see Table 1.2) were calculated to be around 2 per cent of EU GDP (ranging from 0.3 to 3.2 per cent) and damages to EU and non EU countries caused by air pollution originated within the EU were estimated to be 2.6 per cent of EU GDP (with ranges between 0.4 and 6.9 per cent), with health damages accounting for the largest share.[45] An animal and human health problem like aviary flu also constitutes a threat to biodiversity.

Environmental degradation contributes to the increase recorded in the number of disasters and, in relation to this, to a heightened sense of vulnerability (see Fig. 1.13 in the last section of this chapter). Disasters can be man-made or natural and include wildland fires, earthquakes, volcanic eruptions, landslides/debris flows, floods, extreme weather, tropical cyclones, sea and lake ice, coastal hazards including tsunamis, pollution events, and so on. During the period 1990–1999, disasters killed 500,000 people and caused 750 billion dollars of damage.

2. GREAT EXPECTATIONS OF S&T AS REGARDS TACKLING THE MULTITUDE OF CHALLENGES

Throughout history, the relation between science and society has been marked by both continuity and change.[46] The continuity is situated in the tension between the

[44] Robert L. Olson and Jessica Biamonte, *New Global Agenda*.

[45] This was demonstrated by a number of FP-funded projects In particular, GARP II funded under FP4 and GREENSENSE funded under FP5 applied the ExternE methodology to the calculation of national damage accounts.

[46] This and following paragraph based on Andrew Ede and Lesley B. Cormack, *A History of Science in Society – From Philosophy to Utility*, Toronto, 2004.

Table 1.1. What are the main environmental challenges?

Source	Major problems							
	Water quality and access	Climate change	Biodiversity	Indoor air quality	Air pollution	Food production/soil degradation	Over-fishing	Deforestation
World Resources Institute *et al.*, World Resources 2000–2001: People and Ecosystems. Washington, D.C.:WRI 2000.	■	■	■		♦	♦	♦	♦
Organisation for Economic Co-operation and Development, Environmental Outlook, Paris: OECD, 2001.	■	■	■		♦	♦	■	■
The World Bank. World Development Report 2003: Sustainable Development in a Dynamic World. New York: World Bank, 2003.	■	■	■		■	■	■	■
Ehrlich, Paul and Anne Ehrlich. One With Niveneh: Politics, Consumption, and the Human Future. Washington, DC: Island Press, 2004.	■	■	■		♦	♦	■	♦
Speth, James Gustave, Red Sky at Morning: America and the Crisis of the Global Environment. New Haven: Yale Univ. Press, 2004.	■	■	■		♦	♦	♦	

United Nation Environment Program. Global Environment Oultook: Past, Present, and Future Perspectives. London: Earthscan, 2002.	■	■	■			♦	♦	♦
Central Intelligence Agency, Global Trends 2015: A Dialogues About the Future with Nongovernmental Experts. Washington, D.C.: CIA, 2000.	■	■	■		♦	■		♦
National Advisory Council for Environmental Policy and Technology (NACEPT). The environmental Futures: Emerging Challenges and opportunities for EPA. Washington, D.C.: NACEPT, 2002.	■	■	■	■	♦			
Brown, Lester R. Plan B: Rescuing a Planet Under Stress and a Civilization in Trouble. New York: W.W. Norton, 2003.	■	■			♦	■	♦	♦

■ Problem is a serious threat to the global environment and continued economic development.
♦ Problem is a threat to the global environment.
Source: Robert L. Olson and Jessica Biamonte, New Global Agenda, 2004.

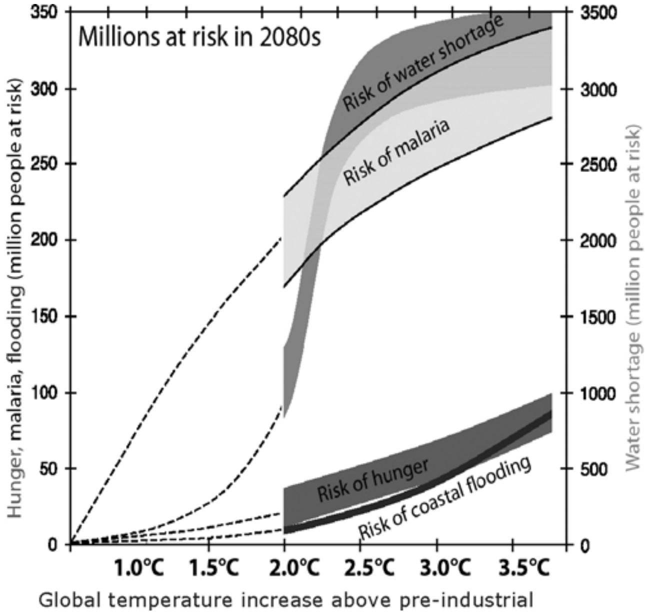

Fig. 1.11. The number of people at risk from global warming in 2080
Source: Parry, Martin *et al.*, Millions at Risk: Defining Critical Climate Change Threats and Targets, In: *Global Environmental Change*, 11, 3, 2001, pp. 181–183.

philosophical and intellectual pursuit of and search for knowledge on the one hand, and the desire of researchers and their supporters to make scientific knowledge useful and apply it on the other hand. This tension was first recognised by the ancient Greek philosophers, and has been reflected in recurring calls from philosophers and scientists throughout history, including today, for more "research for its own sake". Within the context of this tension, the change has been located in what has constituted or better what has been considered useful knowledge in each age, in other words in "the changing social expectation of science": "What counts as useful knowledge differed from patron to patron and society to society, so that Cosimo de Medici and the United States Department of Energy looked for quite different 'products' to be created by their clients, but both traded support for the potential of utility".

From century to century, societal expectations of S&T have not just changed. They have also increased. In the era of the ancient Greek philosophers, societal expectations of S&T were rather low. S&T was a highly controlled activity carried out by a small elite group of people for philosophical or religious objectives. At present, however, it is considered a powerful tool for political, economic, and social change. In between, S&T helped exploit worldwide resources as trade empires and colonies expanded (18th century); helped expanding and consolidating trade empires and colonies, and turn their natural resources into wealth, or make up for the lack of trade empires and colonies (19th century); helped fight wars (First World

Table 1.2. What air pollution is costing us

Member States	Damage costs (Million euro)		Damage costs per GDP (%)	
	To EU-15	To non EU-15	To Eu-15 + non-EU-15	TO EU-15
Austria	1200	1800	1.8	0.7
Belgium	4400	400	2.4	2.2
Denmark	1200	400	1.2	0.9
Finland	300	100	0.5	0.4
France	23200	2000	2.2	2.0
Germany	34400	17000	2.9	2.0
Greece	2100	3700	6.9	2.5
Ireland	700	0	1.5	1.5
Italy	15800	6800	2.6	1.8
Luxembourg	300	0	2.3	2.3
Netherlands	4900	500	1.8	1.7
Portugal	1600	0	2.1	2.1
Spain	13500	400	3.3	3.2
Sweden	500	300	0.4	0.3
UK	24700	1200	3.0	2.8
Tot. EU	128800	34600		
Average EU	16100	4325	2.6	2.0

Source: DG Research, GARP II, and GREENSENSE.

War and Second World War); and helped producing consumer goods, consumer medicines, exploring space, addressing environmental challenges, exploring the human genome, and so on (post-war period).

It is no exaggeration to say that as a result today societal expectations of S&T have never been higher in industrial countries. In the United States, the *Carnegie Commission on Science, Technology, and Government* listed in 1992 no less than 25 major societal goals to which S&T can contribute (Table 1.3). And a *National Academies* report noted in 2005 that "the nation increasingly looks to the scientific and engineering communities for solutions to some of its most intractable problems, from chronic disease to missile defence, to transportation woes, to energy security, to ensuring clean air and clean water. Expectations for S&T are perhaps higher than at any other time in our history and are placing unprecedented demands on leadership".[47] In Japan, the 2004 White Paper on Science and Technology noted that "what is needed…is for science and technology to respond flexibly to the

[47] Committee on Ensuring the Best Presidential and Federal Advisory Committee Science and Technology Appointments – Committee on Science, Engineering, and Public Policy – National Academy of Sciences, National Academy of Engineering and Institute of Medicine of the National Academies, *Science and Technology in the National Interest, Ensuring the Best Presidential and Federal Advisory Committee Science and Technology Appointments*, Washington, DC, 2005.

Table 1.3. To which societal goals can S&T contribute?

Quality of life, health, human development, and knowledge
Education and diffusion of knowledge
Personal and public health and safety
Personal development and self-realisation
Exploration and expansion of knowledge
High standard of living
Creation and maintenance of civic culture
Cultural pluralism and community harmony
Population stabilisation
A resilient, sustainable, and competitive economy
Economic growth
Full employment and workforce training
International competitiveness
Modernised communications and transportation
International cooperation and action
Environmental quality and sustainable use of natural resources
Worldwide sustainable development
Resource exploration, extraction, conservation, and recycling
Energy production and efficiency in use
Environmental quality and protection
Provisions for public recreation
Maintenance and enhancement of productivity of the biosphere
Maintenance of urban infrastructure
Energy security and strategic materials
Personal, national, and international security
Personal security and social justice
National and international security
Individual freedom
Worldwide human rights

Source: Carnegie Commission on Science, Technology and Government, *Enabling the Future: Linking Science and Technology to Social Goals*, 1992.

needs of society as they change over time, or in other words, to become a 'science and technology for society' ".[48]

Things are no different in Europe. In 2000, the European Commission remarked that "expectations of science and technology are getting higher and higher, and there are few problems facing European society where science and technology are not called upon, one way or another, to provide solutions".[49] Starting with that year's Lisbon European Council, this trend has if anything only strengthened. In the past few years, a great number of high-profile analyses have been carried

[48] Ministry of Education, Culture, Sports, Science and Technology, *Science and Technology and Society in the Future*, White Paper on Science and Technology 2004, Tokyo, 2004.
[49] European Commission, *Science, Society and the Citizen in Europe*, Commission Working Document, SEC(2000) 1973, 14 November 2000, p. 5; see also Biotechnology: Europeans Start to Believe the Health Benefits, In: *Europe Information Service*, European Report No. 3108, 20 June 2006.

out of the challenges Europe is facing, and recommendations have been made on how to address them. Time and again the same wide range of urgently to be addressed challenges is identified. The reports are also near-unanimous in the key role assigned to S&T in this respect, as will be seen in Chapter 3. In other words, great expectations are held of S&T as regards the tackling of the multitude of challenges Europe is facing. This will be developed in Chapter 3 as part of the new policy context that enabled the genesis of the Lisbon Strategy as well as of the 7th Framework Programme.

3. THE ROLE THAT S&T CAN PLAY

The role that S&T can play in addressing all these challenges is expected to be substantial. This section will show that S&T indeed has the potential to contribute to a range of economic, social and environmental challenges: it can improve economic performance, promote employment, improve public health, tackle demographic, cohesion and environmental challenges, and so on.

3.1. S&T, economic growth and competitiveness

Modern mainstream economic theory – whether neoclassical, endogenous or evolutionary – has recognised for quite some time now that technological progress and innovation are the main engines of economic growth. According to Baumol, innovation explains much of the extraordinary economic growth record under capitalism. The reason is that in important parts of the economy, competition is based on innovation rather than price. Firms are therefore forced by market pressure to support innovative activity systematically and substantially.[50] According to Romer, productivity growth is driven by innovation resulting in the creation of new though not necessarily improved product varieties.[51] And under the Schumpeterian paradigm, growth results from “quality improving innovations that render old products obsolete, and hence involves the force that Schumpeter called ‘creative destruction’ ”.[52] Even basic research generates several direct economic benefits. It is a source of useful new information; it creates new instrumentation and methodologies. Those engaged in basic research develop skills which yield economic benefits when individuals move from basic research carrying codified and tacit knowledge. Through participation in basic research, access is granted to networks of experts and information. Those trained in basic research may be good at solving complex technological problems. And, finally, on the basis of basic research, spin-off companies are created.[53]

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50 William J. Baumol, *The Free-Market Innovation Machine. Analyzing the Growth Miracle of Capitalism*, Princeton, NJ and Oxford, 2002, viii–ix.

51 Philippe Aghion and Peter Howitt, *Appropriate Growth Policy: A Unifying Framework*, 9 August 2005, pp. 2–3.

52 Aghion and Howitt, *Appropriate Growth Policy: A Unifying Framework*, p. 3.

53 Ben Martin *et al.*, *The Relationship between Publicly Funded Basic Research and Economic Performance,* A SPRU Review, Report Prepared for HM Treasury, July 1996, p. vii.

There is also empirical support for the contribution of S&T to economic performance (see tables and sources in annex). Estimates of private returns to firms' own investment in R&D still produce varying figures, but there is an emerging consensus that gross returns between 20 and 30 per cent are common and plausible (Table 1.4). Microeconomic studies confirm the existence of significant spillovers of knowledge from the firms that perform the R&D to other firms and industries. Taking account of measured spillovers typically raises the estimated gross rate of return on business investment into the range of 30 to 40 per cent (Tables 1.5–1.7). Macroeconomic studies, which by definition cover all sectors of the economy, also find significantly higher returns to R&D in OECD countries, with estimates ranging from 50 per cent to over 100 per cent. A recent Austrian report found that the rise of corporate spending on R&D from 0.8 per cent to 1.1 per cent of Gross Domestic Product in the second half of the 1990s produced a boost of three tenths of a per cent in growth.[54] Both microeconomic and macroeconomic studies find that an important source of productivity growth in all OECD countries comes from the international diffusion of technology. A country's ability to absorb those foreign technologies is enhanced by investment in education and by investment in own R&D.

3.2. S&T and employment

The economic literature is not conclusive on the employment effects of innovation, since process innovation (the introduction of labour-saving technologies) is likely to have a negative effect on employment, assuming all other factors remain constant, while product innovation creates new markets and employment opportunities.[55] But empirical evidence suggests that technological change promotes employment. Such evidence includes a recent study of the Directorate-General Employment which found that the rate of growth of total factor productivity (due to improvements

Table 1.4. Private rate of return to R&D

Author	Year	Rate of return (%)
Bernstein and Nadiri	1991	14–28
Bernstein and Nadiri	1988, 1989	9–27
Mansfield	1977	25
Nadiri	1993	20–30
Sherer	1982, 1984	29–43
Sveikauskas	1981	10–23
Terleckyj	1974	0–29

Source: Robert M. Margolis and Daniel M. Kammen, Evidence of under-investment in energy R&D in the United States and the impact of Federal policy, In: *Energy Policy* 27, 1999, 575–584.

[54] Federal Ministry of Education, Science and Culture, together with Federal Ministry of Transport, Innovation and Technology, and Federal Ministry of Economics and Labour, *Austrian Research and Technology Report 2004*, Vienna, 2004, p. 2.

[55] European Commission, *Employment in Europe 2004*, p. 77.

Table 1.5. Social rate of return to R&D

Author	Year	Rate of return (%)
Bernstein and Nadiri	1988, 1989	10–160
Bernstein and Nadiri	1991	56
Griffith, Redding and Van Reenen	2000	Canada: 57.2 Denmark: 67.9 Finland: 95.2 France: 54.9 Germany: 49.9 Italy: 71.6 Japan: 70.8 Netherlands: 49.6 Norway: 75.6 Sweden: 68.0 UK: 80.5 US: 41.7
Griliches	1964	35–40
Griliches	1994	30 (on own R&D)
Griliches and Lichtenberg	1984 (Interindustry ...)	71 (30 on own R&D plus 41 on used R&D)
Griliches and Lichtenberg	1984 (R&D and ...)	34 (on own R&D)
Hall	1995	33 (on own R&D)
Mansfield	1977	56
Nadiri	1993	50
Scherer	1982	103 (29 on own R&D plus 74 on used R&D)
Sveikaukas	1981	17 (on own R&D)
Terleckyj	1974	48–78
Terleckyj	1980	107 (25 on own R&D and 82 on used R&D)

Source: Rachel Griffith, *How Important Is Business R&D for Economic Growth and Should the Government Subsidise it*?; Charles I. Jones and John C. Williams, *Measuring the Social Return to R&D*, February 1997; Charles I. Jones and John C. Williams, Measuring the Social Return to R&D, In: *The Quarterly Journal of Economics,* November 1998; Robert M. Margolis and Daniel M. Kammen, Evidence of Under-Investment in Energy R&D in the United States and the Impact of Federal Policy, In: *Energy Policy* 27, 1999, pp. 575–584.

in the efficiency of production or to pure technological progress) has a positive impact on the employment rate, with a one-year lag, and that both in the short- and long-term, countries with higher than average total factor productivity growth tend also to have higher than average growth in employment.[56] Clear evidence exists that more computerised or R&D-intensive industries increased their demand for college-educated workers at a faster rate in the 1980s. Such high-skilled workers also command higher wages, as the consensus is that the increase in the schooling wage premium and the rise in wage inequality are driven by technological change.[57]

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56 European Commission, *Employment in Europe 2004*, p. 80.

57 European Commission, *Human Capital in a Global and Knowledge-Based Economy – Final Report*, Luxembourg, 2003, pp. 14–15.

Table 1.6. Rate of return to public R&D

Author	Year	Rate of return (%)
Bredahl and Peterson	1976	36–47
Evenson	1979	45–130
Evenson and Welch	1964	55–60
Griliches	1958	20–40
Norton	1981	27–132
Peterson	1967	21–25
Schmitz and Seckler	1970	16–46
Smith, Norton, and Havlicek	1983	22–61
Sundquist, Cheng, and Norton	1981	97–118

Source: Keith Fuglie *et al.*, Economic Returns to Public Agricultural Research, In: *Agricultural Research and Development: Public and Private Investments under Alternative Markets and Institutions*, Agricultural Economics Report AER735, May 1996.

Support also comes from the observation that all Member States saw employment levels in the high technology sector rise between 1997 and 2002, leading to an increase of almost 2 million for the Union as a whole, with employment in high-tech services accounting for 1.4 million of this total (Fig. 1.12).[58]

Table 1.7. R&D and innovation

Author	Year	R&D and innovation
Mansfield	1991	11% of new products and 9 % of new processes could not have been developed in the absence of academic research without substantial delay
Mansfield	1998	15 % of new products and 11 % of new processes could not have been developed without a substantial delay in the absence of academic research
Beise and Stahl	1999	One-tenth of the firms that produced product or process innovations between 1993 and 1995 would not have done so without public research
Autant-Bernard	2001	Public research increases private innovation directly, and indirectly by increasing private research. These effects are geographically localised
Tijssen	2001	Approximately 20% of private sector innovations are partially based on public sector research

Source: Alister Scott *et al.*, *The Economic Returns to Basic Research and the Benefits of University-Industry Relationships – A Literature Review and Update of Findings*, Report for the OST by SPRU.

[58] European Commission, *Employment in Europe 2003*, Luxembourg, 2003, p. 42.

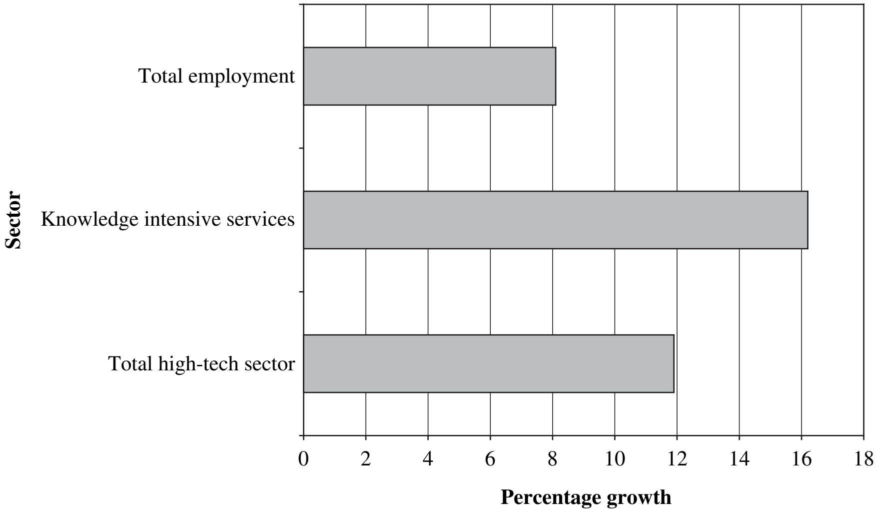

Fig. 1.12. Knowledge-intensive industries and services create more jobs (changes in employment in % (1997–2002, EU-15))
Source: DG Research
Data: European Commission, *Employment in Europe 2003*

3.3. S&T and the ageing and poverty challenges

Through its contribution to product, process and service innovation, productivity growth, and the creation of more and higher paid jobs, research and innovation can also help meet the challenges of ageing and cohesion. Higher employment rates and levels of productivity – to which S&T can contribute – would allow for maintaining or increasing living standards, and for the absorption of increasing medical and pension costs. Doubling the growth of productivity over the next few decades would allow for maintaining current levels of industrial production and average per capita income with some 40 million elderly in the EU.[59]

The best solution to poverty is investing in education.[60] For instance, in general the lower the illiteracy rate, the higher per capita income.[61] Higher levels of educational attainment enhance the chance of finding work and enjoying a decent standard of living. However, education is not yet accessible for everyone and often only to those who can afford it. Improving access to educations takes time and

59 Paraskevas Caracostas and Ugur Muldur, *Society – The Endless Frontier*, Luxembourg, 1998, pp. 94–95.

60 UNICEF, *The State of the World's Children 2005*, New York, 2005; World Bank, *World Development Report 2000/2001*, Washington, D.C., 2000.

61 Per capita income in countries with a literacy rate less than 55 per cent averages about $600 whereas per capita income in countries with a literacy rate between 55 and 84 per cent is $2400. Source: World Bank, *World Development Report 2000/2001*.

effort. Education is, therefore, in its own right not powerful enough to solve the poverty problem.

In the meantime, contributions to a solution to poverty can also be expected from Science and Technology. Besides investing in education and developing skills, this means dedicating research programmes to find ways to fight inner-city poverty, to relieve the effects of urbanisation, to diminish the impacts of ever increasing mobility on our environment, and to improve the quality of life of the vulnerable groups in society, such as the handicapped and the ill, the elderly and the young. In developing countries this can take the form of helping to improve the productivity of natural and physical assets, for example, by protecting farmland against erosion and desertification, preserving an area's natural resources, building easy-to-maintain water storage facilities and de-salinisation installations, and strengthening farmers' diagnostic capabilities in relation to livestock diseases, to name a few.[62] That these advances have important impacts on farmers' income levels has been repeatedly demonstrated by the different targeted activities across the Framework Programmes.[63]

3.4. S&T and the public health challenge

Science and Technology can also make a large contribution to the improvement of public health. It can assist in prevention (e.g. through the development of vaccinations), it can play an important role in the quicker and more reliable diagnosis of diseases (e.g. through the further development of medical imaging), and it can find treatments for diseases or, in the absence of treatments, it can help finding ways to control them (e.g. HIV/AIDS retroviral drugs). S&T can also help to lessen the impact of disease. Furthermore, S&T can help to find new ways to deliver treatment (e.g. ambulant rather than hospital treatment) and can provide better tools for health care system management. A good illustration of the way in which Science and Technology can make a positive contribution to public health is the Article 169 EDCTP[64] initiative referred to in Chapter 4.

It is also useful to take a step back here. Globalisation in this regards also means the globalisation of infection transmission. As travel of people (and goods) intensifies, communicable diseases constitute challenges which it is increasingly difficult to confine. Interconnectedness is a defining feature of our modernity. As a case in point, healthcare systems are indeed organised as systems – which can lead to catastrophic failures such as the consequences of HIV-infected blood supplies that took a particular prominence in France but did in fact strike many countries. Ours is a vulnerable society. While that vulnerability is most strikingly epitomized by Ebola-type viruses, with diverse profiles of outbreaks, it is also revealed through

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62 World Bank, *World Development Report 2000/2001*.

63 The International S&T cooperation with third countries (INCO) is one of those programmes which have been developed around the idea that poverty can be overcome by successfully developing human and institutional resources.

64 European and Developing Countries Clinical Trials Partnership.

the rise of nosocomial infections (i.e. ills originating in the very places which are devised to heal). These further illustrate the flipside – or paradoxical unanticipated consequences – of healthcare as interconnected systems. Yet, while avian flu and SARS together with the above examples represent the globalisation of infection transmission, they also point to the globalisation of the means to tackle public health challenges. The relative containment of avian flu and SARS, and even more so the eradication of smallpox (the variola virus), constitute inspirational successes in that regard.

3.5. S&T and the environmental challenge

There is no doubt that the solution to the environmental challenge has to come first and foremost from elsewhere than from new technological development. Available technological best practices should first of all be disseminated as widely as possible. A change of mentality is also required leading to less consumption of more carefully selected resources and increased reuse and recycling within the limits of the current technological frontier.

Yet it does not seem unjustified to expect a contribution from new technological development. Technology is already used in a variety of ways when it comes to the environment, and everywhere there is great scope for improvement. Technology in the form of satellites is used to monitor the global environmental situation and change therein. Technology in the form of super computers is used to develop climate models and make predictions. Technological development has made industrial production less resource intensive. It has also reduced the energy consumption of machinery (e.g. cars). S&T has been successful at developing alternatives for harmful substances (e.g. within the context of fighting ozone depletion). Technological development has increased the extent to which a larger variety of goods can be recycled. The production of green energy is wholly dependent on technological development. And S&T is needed to mitigate the impacts of environmental degradation. This need for a joint undertaking – combining existing technologies, technological innovations, as well as political innovations – is illustrated in Fig. 1.13 in the case of climate change (the fight to curb greenhouse gas emissions, that is).

As the next chapter will further examine, S&T is not only an indispensable source for the evidence base on challenges such as environmental degradation, they are also taken to be one of the causes of such predicaments. One can undoubtedly point to the lack of societal controls on the use of S&T, to environmentally harmful production and consumption patterns, and to other types of failures in this regard. Nonetheless, the outlook can change fundamentally if one can conceive of S&T as part of the solution rather than the problem.

The "precautionary principle" is a useful notion to mark that double perspective. It can first be taken as stifling innovation in the name of environmental protection; but more interestingly, it can be understood as promoting innovations that take account of social and environmental difficulties, taking account of risks as well as benefits, taking account of less tractable, longer-term consequences. Its emphasis – even with its origin in German environmental legislation in the 1970s – was as

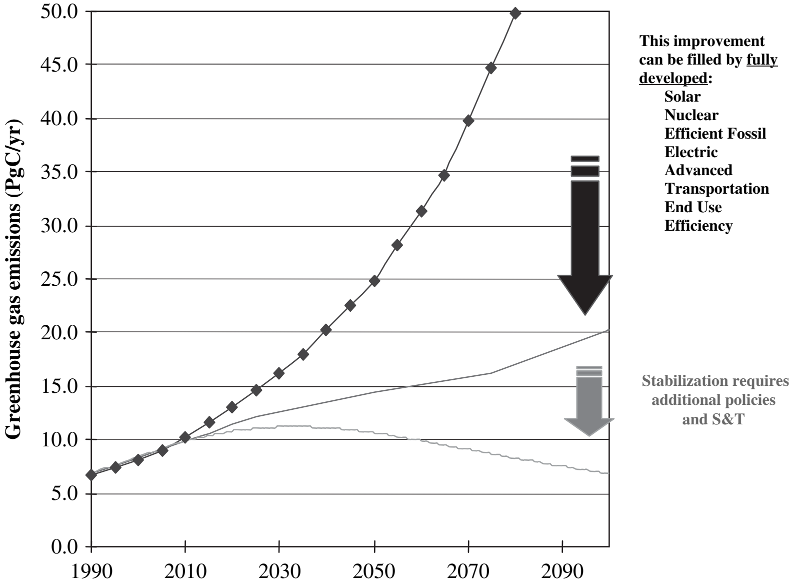

Fig. 1.13. Cutting back on greenhouse gas emissions – new technologies needed
Source: Joint Global Change Research Institute, *The Technological Challenge of Climate Change*, 2003

much on environmental protection as on gaining a competitive advantage through innovations on the backdrop of environmental regulation. Indeed, although this remains a fiercely debated question, a recent survey of the literature[65] indicates that a transparent and non-discriminatory regulatory framework, coupled with high environmental standards, is an engine for innovation and business opportunities. This engine functions notably through the creation of lead markets.[66] The story of the catalytic converters provides a compelling example of such R&D-based win-win.

A first step in that perspective consists in acknowledging the need to sever the link between economic growth and environmental degradation. The endeavour of a duly responsible polity – with a concern for the quality of life of present and future generations – is then to optimise the effects of its economic activity, that is to minimise adverse externalities without sacrificing part of its material well-being or endangering economic growth.

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65 Conseil d'Analyse Économique (D. Bureau *et al.*), *Politiques environnementales et compétitivité*, Paris, 2004. Knut Blind *et al.*, *New Products and Services: Analysis of Regulations Shaping New Markets*, Luxembourg, 2004.

66 As discussed in European Commission, *Innovation Policy: Updating the Union's Approach in the Context of the Lisbon Strategy*, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, COM(2003) 112 final, 11 March 2003.

A second step consists not in ignoring the above "limits to growth" understanding, but in researching other links between development and sustainability. This move is at the heart of the role of S&T in relation to the environment – and is indeed at the heart of the Lisbon Strategy as underscored in the Conclusions of the 2001 Göteborg Summit. The potential of technology to create synergies between environmental protection and economic growth was emphasised by the October 2003 European Council. That well-established premise is taken to its most fruitful operational conclusions in the Environmental Technologies Action Plan.[67] More recently, the benefits of S&T for the economy and environment alike were further examined in the "Towards a more sustainable EU" report for the Dutch Presidency and indeed in the Kok report of November 2004.[68] In fact Europe occupies a strong position in the field of environmental technologies. Of course this also relates to the fragile but powerful synergies, introduced above, between environmental promotion/protection, S&T, and growth and competitiveness.

These potential benefits can also be of great importance for developing countries. With appropriate technology transfer they can provide these countries with affordable solutions for reconciling their desire for strong economic growth with the need to do so without increasing the pressure on the local – or the global – environment. This North–South dimension highlights the sustainable development predicament as differentiated yet common. The question of sustainable development can be posed along two main lines: a question of adapting – or otherwise innovating – appropriate "clean" technologies, and a question of redefining needs and lifestyles.

Now it is interesting to re-consider the climate change issue in the light of the above remarks. The European Union has taken a leading role in the international process to tackle global warming so as to promote environmentally responsible choices by all actors. The EU has ratified the Kyoto Protocol early on, joined by almost all of its international counterparts on this course – most recently Russia. Its successes are also the planet's successes. The EU is committed to meet its Kyoto emissions reduction targets[69] and continues to show leadership on this issue. The role of S&T is set to become even more central in the post-Kyoto (post-2012) regime, for which negotiations are starting now. The need for new and cleaner technologies as an indispensable means to tackle energy demands and CO_2 emissions was the main message of the latest yearly report of the International Energy Agency.[70]

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[67] European Commission, *Stimulating Technologies for Sustainable Development: An Environmental Technologies Action Plan for the European Union*, Communication from the Commission to the Council and the European Parliament, COM(2004) 38 final, 28 January 2004.

[68] The September 2004 report for the Dutch Presidency and Environment Ministry *Towards a More Sustainable EU: The Need for Investments that Benefit Economy and Environment Alike* is available at: http://www.rivm.nl/en/milieu/internationaal/Towards_a_more_sustainable_EU.jsp.

[69] For a prospective state of play, see European Environment Agency, *Greenhouse Gas Emission Trends and Projections in Europe 2004 – Progress by the EU and Its Member States Towards Achieving Their Kyoto Protocol Targets*, Luxembourg, 2004.

[70] OECD and IEA, *World Energy Outlook 2004*, Paris, 2004.

More widely, S&T plays an important part in the EU's capacity to shape – and implement – international agreements.

By way of conclusion, it is worthy of note that the answers which science and technology can bring to environmental problems are increasingly judged with reference to the changes they bring in society. They demand choices of policies and governance, the impact of which on economic and social groups must be measured in terms of effectiveness and efficiency, the spread of costs and benefits, and social or regional equity. This is only possible if research also seeks to develop the knowledge-base and methodologies needed by such analyses.

3.6. S&T and the Knowledge Society: The ultimate answer? The ultimate challenge?

As the previous discussion of the contribution of S&T to employment or environmental challenges has shown, it is not always clear-cut where problems start and where solutions end. Or to put these tangled matters even more simply in this case: the role that S&T can play is manifold. And nowhere is this manifoldness better encapsulated than in the predicament of the "Knowledge Society".[71] Here the challenges, the expectations, and indeed the role of S&T in eliciting and addressing them, are brought together in ways that it is most illuminating to examine.

First, this section probes the mutual shaping of science and culture. Second, it foregrounds some collateral features of the knowledge society, and in particular the vulnerability that accompanies its emergence. This will lead up, in Chapter 2, to a discussion of our modernity – or modernities –as characterised by a distribution of goods but also of ills or risks, and of knowledge or claims thereon. Indeed, in this subsequent chapter, the problematic and ambivalent relations between S&T and the public at large will be considered in the perspective of the weaknesses of European S&T. But firstly we must examine the crucial place of S&T within our Knowledge Society in the making.

The mutual shaping of culture and S&T The examples in this chapter have already shown how profoundly our culture is marked by S&T developments. At the same time as S&T shapes our society, they are themselves produced, taken up, reconfigured, shaped by society. That is one (double) way in which culture is decidedly scientific culture, and thus in which S&T is at the heart of this nearly eponymic "Knowledge Society". But to allow all sections of society to benefit from those advances – as well as to take part in that shaping process – individuals need to be provided with the appropriate equipment, in terms of education, skills, awareness, and appreciation for the stakes in S&T endeavours. Vital for a democratic society

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[71] On the genesis of this labile notion, besides the seminal work of Peter Drucker (Peter F. Drucker, *The Age of Discontinuity. Guidelines for a Changing Society*, London, 1969), see Michael Gibbons *et al.*, *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, London, 1994, and European Commission, *Building the Knowledge Society: Social and Human Capital Interactions*, Commission Staff Working Paper, SEC(2003) 652, 28 May 2003.

in this day and age, such demands point towards another crucial sense for scientific culture, also exposing the acute need for it to be developed. Actions to foster a thorough public grasp of what is science and how it contributes to society are thus *sine qua non* to a full-fledged democratic society.

Importantly, S&T developments accompany and affect lifestyle changes in societies. In this respect the taking up of mobile phones or GSM provides interesting illustrations.[72] The GSM has strikingly changed the way people communicate with their loved ones, organize their work and outings, and live everyday. As regards research, innovation, and competitiveness, the rise of the GSM standard provides an inspiring example of European leadership.[73] In effect, new information and communication technologies open up opportunities for new lifestyles and new ways of working.[74] Remote working or online trading decouples economic activity from a particular geographic location (be it the office, capital cities or structurally favoured regions). Moreover, such technologies can facilitate access to employment – and other forms of social inclusion/participation[75] – among sections of society (people with physical disabilities, the elderly) who may otherwise be excluded. Key to achieving those benefits is ensuring that people are equipped with the necessary skills to get involved. Much information society literature[76] also hypothesises that "eWork" (remote working) may contribute to environmental sustainability as, in addition to other dematerialisations, travelling to work is reduced. On the other hand, transport technologies themselves – from the wheel through to the airplane – continue to have a central role in society, for example in enabling communication.

The quality of human life is made up of many more components than the ones already mentioned: greater access to knowledge, better nutrition and health services, more secure livelihoods, clean air to breathe, security against crime and physical violence, satisfying leisure hours, political and cultural freedoms and sense

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72 International Development Research Centre, *Information and Communication Technologies for Development in Africa: Trends and Overview*, 2001. United Nations Research Institute for Social Development, *Information and Communication Technologies and Social Development in Senegal: an Overview/Les technologies de l'information et de la communication et le développement social au Sénégal: un état des lieux*, 2000.

73 It is thanks to the political determination of the EU that this unassuming technical standard – in fact this far-reaching technical and commercial and political endeavour – was brought to fruition. GSM now stands for "Global System for Mobile Communications", it originates in the acronym for the "*Groupe Spécial Mobile*" hosted by the European Conference of Postal and Telecommunications Administrations, and its specifications where defined by the European Telecommunications Standards Institute in the late 1980s. Commercial operation began – and the world's first GSM phone call was made – in 1991 with Radiolinja in Finland.

74 European Foundation for the Improvement of Living and Working Conditions & PREST (Manchester Business School), *The Knowledge Society Delphi: EUFORIA Project Report*, 2004.

75 e-Government Strategic Support Unit (Office of the Deputy Prime Minister, UK), *Engaging the Community in e-Government*, 2004. European Commission, DG JRC – Institute for Prospective Technological Studies (C. Centeno, R. van Bavel and J.C. Burgelman), *eGovernment in the EU in the Next Decade: Vision and Key Challenges*, 2004.

76 European Commission, DG INFSO, *Impact of ICT on Sustainable Development*, 2004.

of participation in community activities. S&T can contribute to improvements and bring lasting solutions in each of these areas. For example, investment in research and new technologies to achieve sustainable transport solutions generates desirable impacts on the quality of life worldwide: less energy consumption; fewer air pollution; less respiratory diseases; lower noise levels; increased space and security for pedestrians and cyclists resulting in more friendly cities for children and older people; less congestion; fewer road accidents; and so on. Besides, it is S&T which makes possible the novel lifestyles – and indeed the novel society – discussed above.

It may be that, in solving some age-old problems, S&T has created the possibility for new problems to emerge. Yet even to address these new problems we can hardly do without S&T. But we can – and rightfully do – concern ourselves with the consequences of the solutions we devise.

The vulnerable society and the knowledge society S&T has brought a mix of benefits and risks. In the modern world heightened wellbeing and security are accompanied by increased vulnerability and insecurity. This vulnerability can take many forms, from loneliness or travelling accidents to industrial disasters or the twisting of human rights in a totalitarian state. Fig. 1.14 provides an illustration of the rising challenge represented by disasters. Here "disasters" include both technological and natural events.[77]

The dramatic increase shown on the graph may be due not only to the consequences of concentrated urbanisation, climate change, and so on, but also

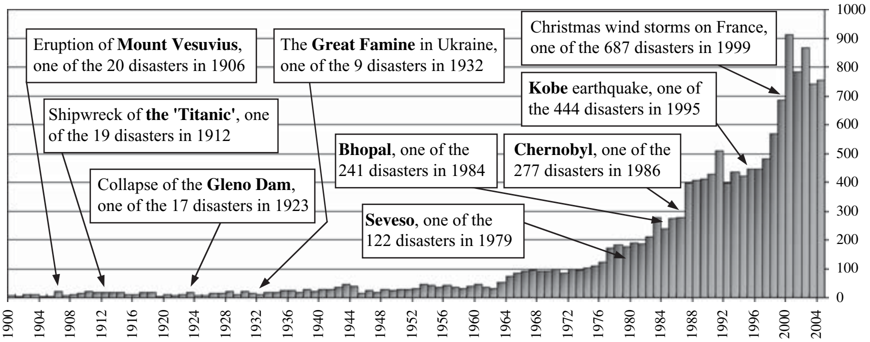

Fig. 1.14. The number of disasters reported is increasing (total number of disasters reported (1900–2004))
Source: DG Research
Data: EM-DAT – The OFDA/CRED International Disaster Database

[77] For a disaster to be entered into the database and thus shown on the figure, at least one of the following criteria must be fulfilled: 10 or more people reported killed; 100 people reported affected; declaration of a state of emergency; call for international assistance.

to a heightened sense of vulnerability and risk, together with a better ability to measure disasters.

Hence the emerging knowledge society will have its problems too. Besides, it will not depend solely on S&T but also on governance and on the citizens who will make up our society – and shape it. Yet it is characterized by an increasingly pivotal role for S&T. The knowledge society requires a revolution in our understanding of knowledge: not only with regard to S&T researchers, but also concerning a democratisation or broadening of knowledge production.[78] This has profound implications for decision-making, for the lay-expert divide, for the handling of risks and uncertainties, and indeed for the relations between citizens and institutions of governance, as every individual should be recognized as – and given the means to be – a *person of knowledge*. Europe finds itself in a peculiar situation in this regard, and the following chapter will unpack the paradoxical relations between S&T and its citizen.

CONCLUSION

This chapter has explored in greater detail some important economic, social and environmental challenges Europe is facing, the expectations held of S&T in addressing these challenges, and the role that S&T could potentially play. The 7th Framework Programme was designed against the background of Europeans feeling anxious because the continent is experiencing a number of important economic, social and environmental challenges – or indeed against the background of a Europe turning from a positive into a negative "exception" at global level. Economic growth is slow. Europe's competitive position is feeble. There are not enough jobs, and not enough of them are high-level. Europe is still characterised by significant poverty and regional inequality. An important demographic challenge is emerging. Europeans' health is affected by serious lifestyle and contagious diseases. And the environment is being degraded.

As will be further examined at the end of Chapter 2 and in Chapter 3, expectations of S&T have never been higher than they are now. Such expectations held of S&T are partially justified. S&T can indeed play an important role in addressing societal economic, social and environmental challenges. S&T is the engine of economic growth and competitiveness. The employment effects of S&T are positive. S&T can play a major role in addressing the consequences of ageing, and the cohesion and public health challenges. S&T can play a key role in addressing environmental challenges. S&T is part and parcel of our lives, be they framed in a Knowledge Society or otherwise, and they are the linchpin of the latter's emergence.

However, as will be seen in the next chapter, for S&T to be able to realise its potential, some serious S&T weaknesses will have to be addressed.

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[78] Jim Dratwa, Taking Risks with the Precautionary Principle: Food (and the Environment) for Thought at the European Commission, In: *Journal of Environmental Policy and Planning* (Special Issue on Risk and Governance), Vol. 4 No. 3, 2002, pp. 97–213.