Annex E: Indicators of R&D and innovation: the EU's relative performance[1]

E1. Following the framework suggested by the national innovation systems approach, the indicators below test the EU's relative performance in:

i. The supply of ideas and the EU's absorptive capacity.
ii. The demand for R&D and indicators of innovation activity.
iii. Networking – the diffusion of knowledge in the EU

E2. While care should be taken when interpreting indicators, generally these serve to illustrate areas of EU performance which appear to lag its leading competitors, both through a relatively crude 'output' indicator of innovation such as patents, and in its more general innovation performance such as the availability of venture capital and rates of firm start-ups. While some Member States are among the world leaders, taken as a whole, these indicators suggest there are either insufficient incentives (or the presence of barriers) in the EU in the areas identified by the theory outlined in Chapter II.

The supply of ideas: investment in R&D and indicators of the EU's 'absorptive' capacity

Private spending on R&D

E3. While there is no single measure of the effectiveness of R&D expenditure, one of the key factors underlying the overall picture of comparatively weak EU performance is the significant difference in private sector investment in R&D activity between the EU and other OECD countries, in particular the USA [in 1998 1.15% of GDP compared to 2.04% in the US (OECD 2000g)]. As Chart 1 shows, despite generally favourable economic conditions, there has been no growth in the EU during the whole of the 1990s a strong contrast to the large increases seen in the USA. This raises fundamental questions about the incentives and rewards on offer for EU innovators to undertake inherently risky R&D as compared to their US counterparts.

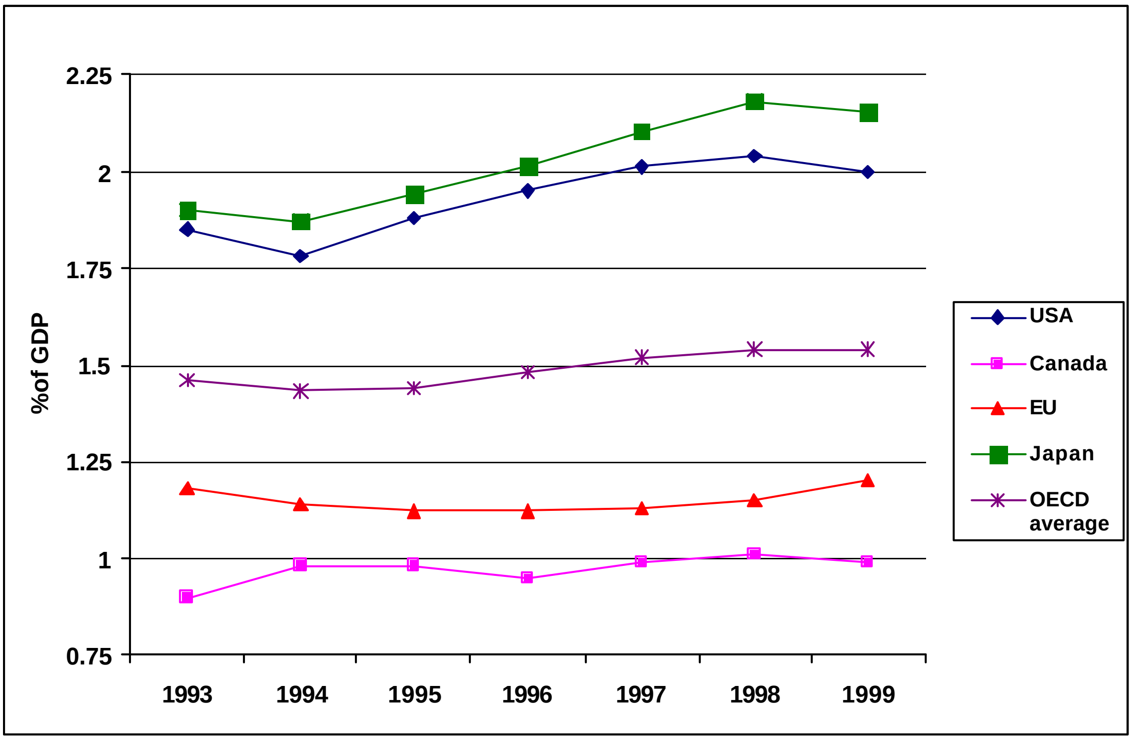
E4. Part of the disparity may be caused by public support for R&D performed by businesses: the US government spends almost three times as much as the Union governments (on average) to finance R&D in the business sector[2]. This disparity is essentially due to the high share of defence-related R&D, much of which is done by private industry. Public support for private R&D is treated differently under US antitrust law compared with EU state aid rules[3].

E5. Also, state support for R&D in the US is helped because most funds are distributed at the federal level - which implies that distortions are less likely to happen than within the EU, where the opposite structure prevails (i.e. the Community funds cover just a small share of total R&D support).

[1] See also the Innovation Scoreboard, published in September 2001 and called for at the Lisbon European Council. This helps to benchmark member states' performance and progress in a number of different areas, including innovation cooperation between SMEs and business expenditure on R&D.
[2] See Jacquemin and Pench (ed.) 2000
[3] However, for state aid to R&D a special regime applies, which facilitates state funding.

E6. However, European research policy is undergoing a major structural change with the advent of the European Research Area, and drives improve the effectiveness of co-ordination and co-operation between existing national policies. For example, the 6th framework programme proposes to implement new measures designed to enhance the structuring effect of EU funded research activities; to enhance and support the co-ordination and mutual opening of national R&D programmes, including the joint implementation of programmes by several member states; and to promote the coherence and effectiveness of national and regional policies through benchmarking and diffusion of good practices and foresight studies.

Chart 1: Business expenditure on R&D

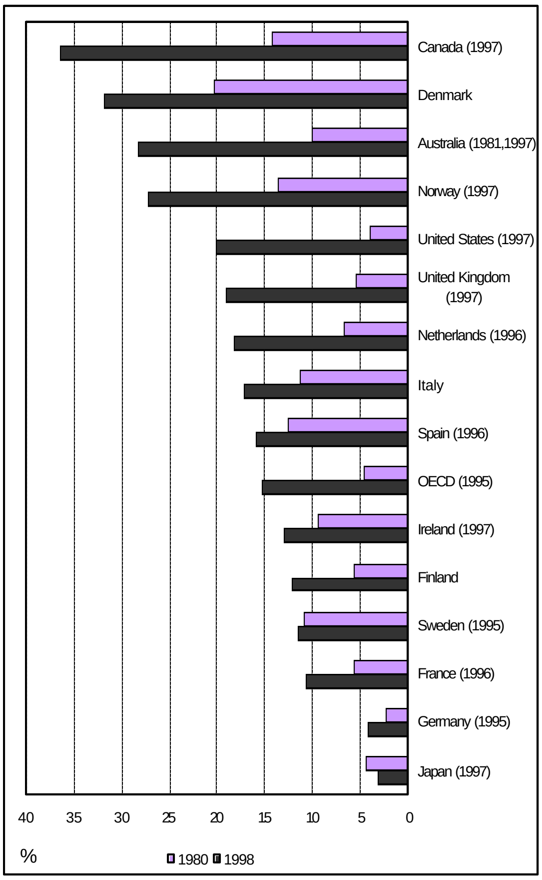


Source: OECD 2000g

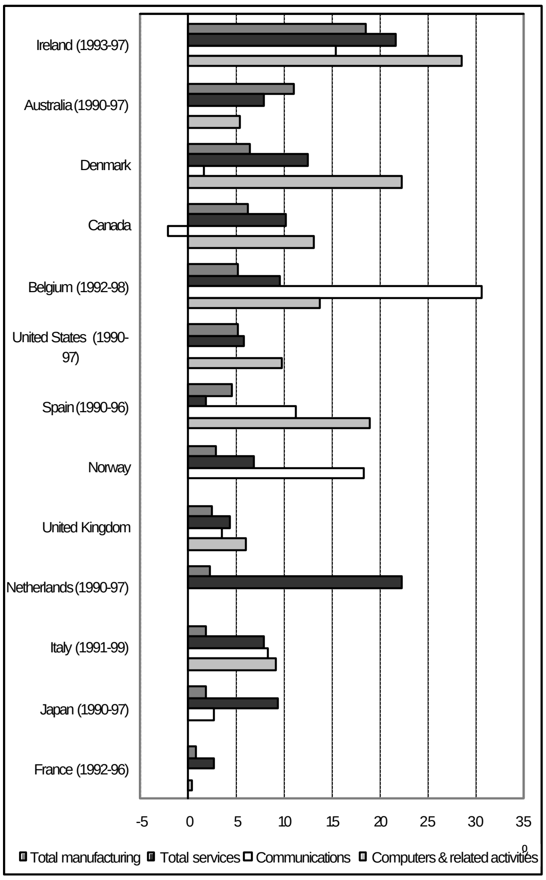
E7. Within the overall business R&D spend has been the significant rise in R&D undertaken by the service sector [see Chart 2]. In the US, the increase in services' R&D activity has been fourfold between 1980 and 1997, with around one third of business R&D carried out in the service sector in some countries [Australia, Canada, Denmark, Norway]. Also, these noticeable rises have tended to occur in countries with significant recent improvements in TFP performance: the US, Denmark and the Netherlands. Two factors go some way to explaining the increased activity of R&D activity in the service sector: first, improvements in measurement that have begun to reveal the true extent of services' activity; and secondly, changes in the classification of certain industries, for example IBM is now classified as a service provider, boosting the level of R&D carried out by services. But beyond that, the evidence shows that service are carrying out more R&D, for example developing new software, with businesses and government increasingly outsourcing their R&D.

Chart 2: Business expenditure on R&D

Share of services in business R&D, 1980 and 1998



R&D growth in selected service industries and total manufacturing – average annual growth rate 1990-98



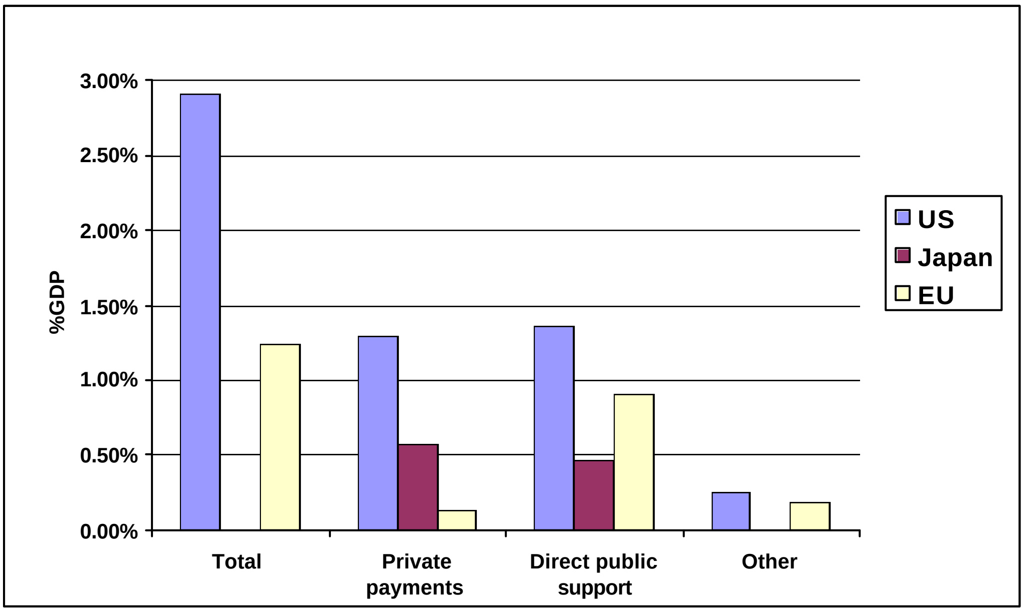
Source: OECD, ANBERD database, May 2000; Annex Tables.

E8. When comparing countries' R&D performance, however, it is important to appreciate the difference between each country's national innovation system. For example, it would be expected that countries with a predominance of small firms, or with a higher concentration of industries lower down the value chain, would invest a lower amount in R&D. For such countries, a higher policy priority might be to facilitate the diffusion of knowledge of improve networking.

Skills: the tertiary education sector

E9. While at the general level the EU matches the educational standards of the US, a key difference is the higher US investment in its tertiary education sector [see Chart 3]. A key factor behind the difference is the level of private payments to universities, reflecting the different cultural attitude in the US towards the funding the university system through private endowments. But even direct government support runs at a higher level. The numbers of students enrolled in tertiary education is similarly greater: in 1997, 38.8% of US 20-29 year olds were in tertiary education, compared to 22.7% in the EU and 20.7% in Japan. In terms of the ideas driven growth theory, and the importance of an economy's **absorption capacity** for new technological advances, these factors may have important implications, especially for smaller EU countries, for determining the ability to move toward the technological frontier.

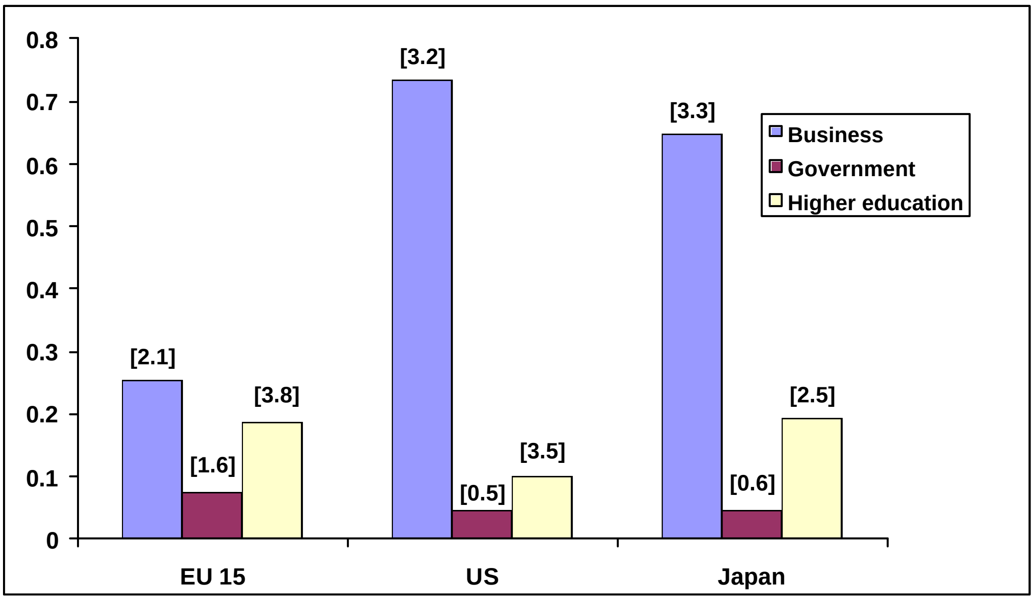
Chart 3: Tertiary expenditures by source as % GDP, 1997



Source: DG Research

E10. Though wage differentials play a part in the final allocation of labour, one of the results of this diverging pattern of education investment is reflected in the numbers of research scientists and engineers employed by the business enterprise sector [see Chart 4]. Most striking is the skewed distribution of US technical experts within the wealth creating sector, suggesting a greater potential for the US private sector to use and apply R&D in the innovation process.

Chart 4: Number of research scientists by sector as a percentage of the labour force [annual average growth rates, 1990-98, in brackets]



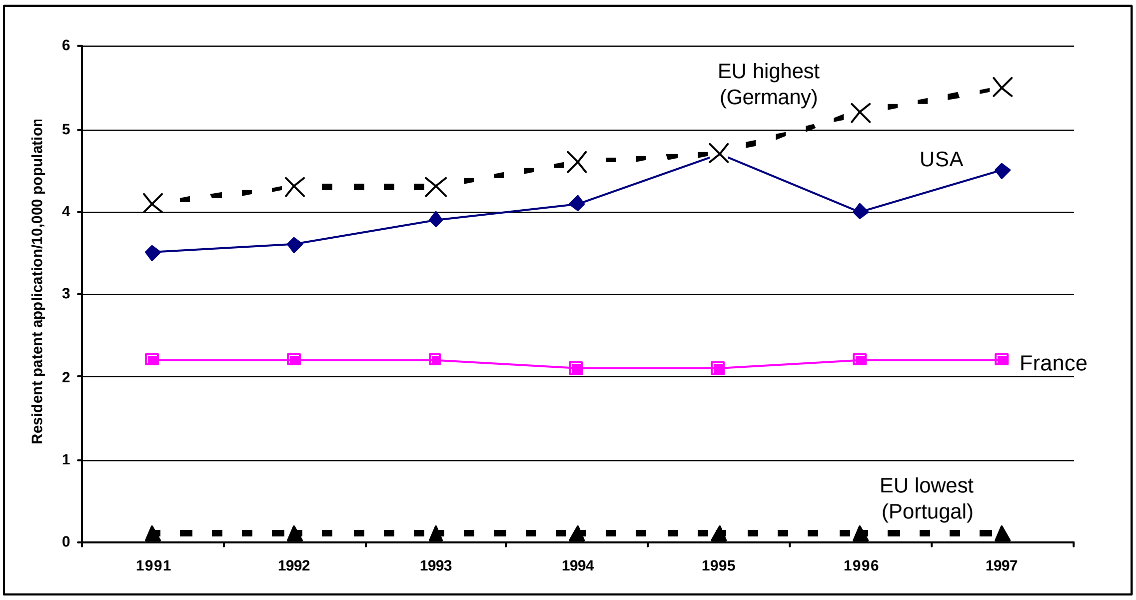
Source: (adapted from) DG Research

The demand for R&D and innovation: indicators of innovation activity

Patenting

E11. Part of the consequence of this greater investment in R&D and the accelerating patenting activity of US universities is reflected the persistent, higher patenting activity in the US [Chart 5]. The chart also demonstrates the wide variety of performance within the EU. Perhaps most important is the long term significance of the gap in terms of the expected future stream of profits that US innovators might enjoy, providing further incentives for them to innovate and to create wealth.

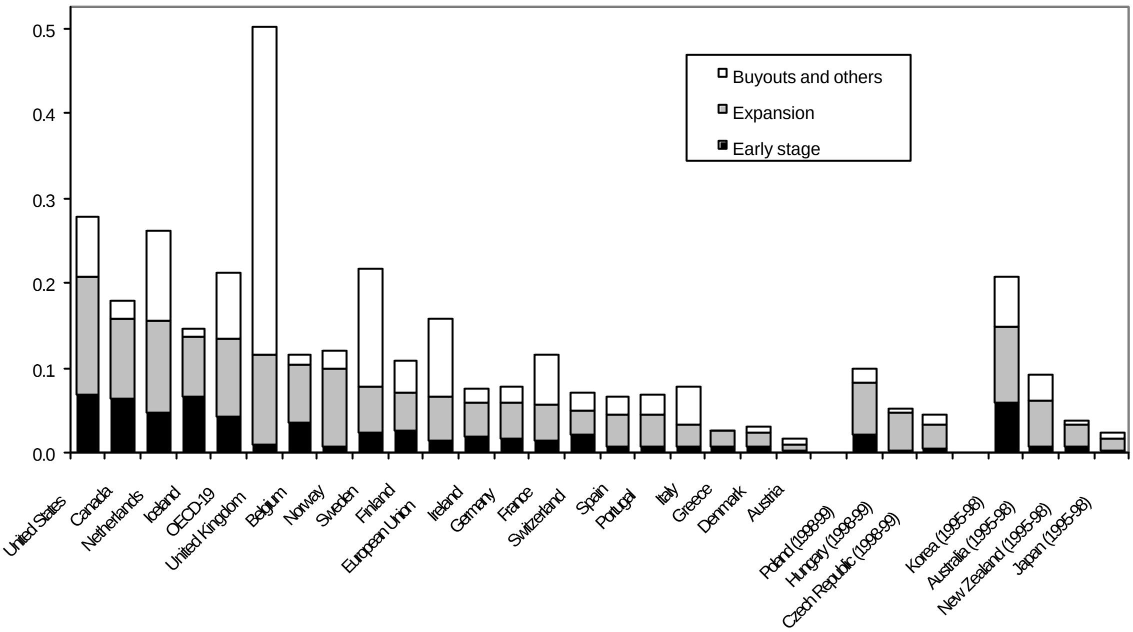
Chart 5: EU and US 'inventiveness': number of patents/10,000 population (source: OECD 2000g)



E12. Some of the surge in US patenting can be accounted for by changes in legislation [software can now be patented], and institutional factors [a culture of 'first to patent' in the US compared to a 'first to file' in the EU that creates a strong incentive to register patents]. For the most part, the drivers behind the surge were ICT and biotechnology where the US is relatively strong: 31% of US patents in the period 1992-1999 were accounted for by ICT, an annual growth rate of around 20%; and biotechnology patenting grew at an annual rate of 9%, and represented 14% of total patents over the same period**.** But the evidence (Kortum and Lerner 1998) also shows that high innovation performance is widespread in all sectors of the US economy. If patenting is a reflection of the wider incentives to innovate, then the underlying reasons behind the divergent EU-US performance deserves careful attention.

Venture capital

Chart 6: Venture capital investment ("country of management" approach) by stages as a percentage of GDP, 1995-99 [source: OECD 2000g]



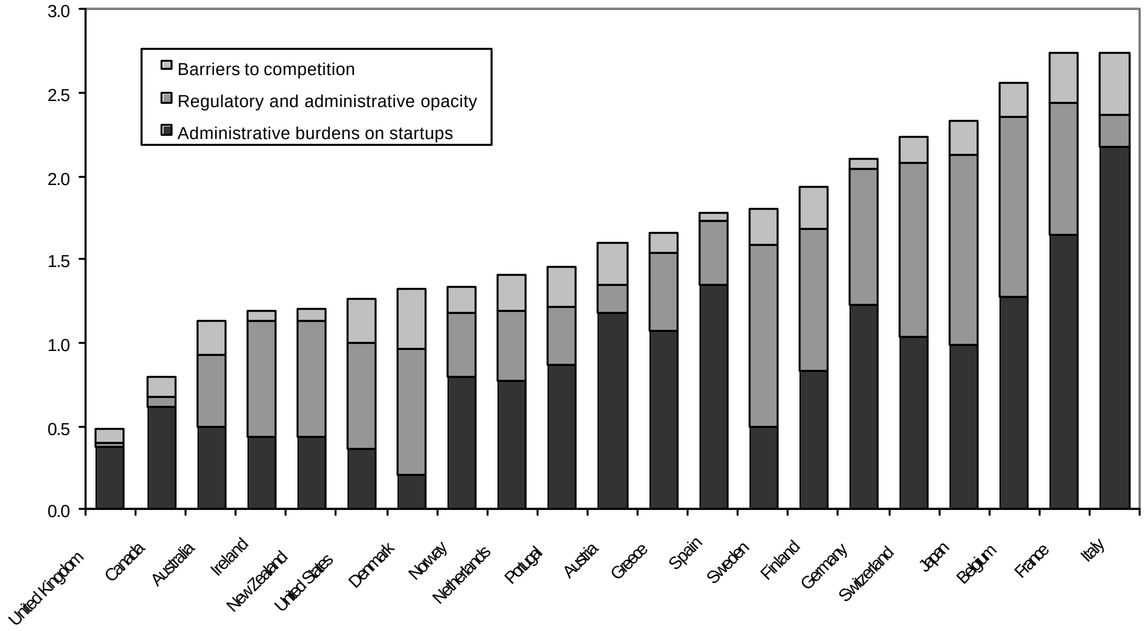
Source: EVCA, various Yearbooks, NVCA, various Annual Reports, Canadian Venture Capital Association (CVCA), Asian Venture Capital Journal, *The 2000 Guide to Venture Capital in Asia.*

E13. The availability of venture capital has been viewed as a key advantage enjoyed by US innovative firms over their EU counterparts. This is especially noticeable in availability of start-up and expansion funds, important factors behind high levels of innovation and growth in the ICT and biotechnology sectors in the US. Venture capitalists share the risks of innovative companies, adding their expertise to business planning while exerting budget discipline on entrepreneurs as they seek further funds. But as Chart 6 shows, though progress has been made in recent years in increasing start-up and expansion funds in the EU [notably in Belgium and the Netherlands], the EU continues to lag far behind the US in terms of venture capital availability, suggesting that further progress is needed in liberalising financial markets through early implementation of the Risk Capital Action Plan.

Barriers to enterprise

E14. On OECD measures, barriers to enterprise, in terms of lack of competitive pressures and the weight of state intervention, appear higher in most EU countries compared to the EU's leading competitors [the US, Canada]. These barriers will dampen enterprise and innovation, and lessen the healthy process of 'creative destruction' of firms that helps ensure resources are efficiently allocated and sufficient incentives to invest and innovate are in place.

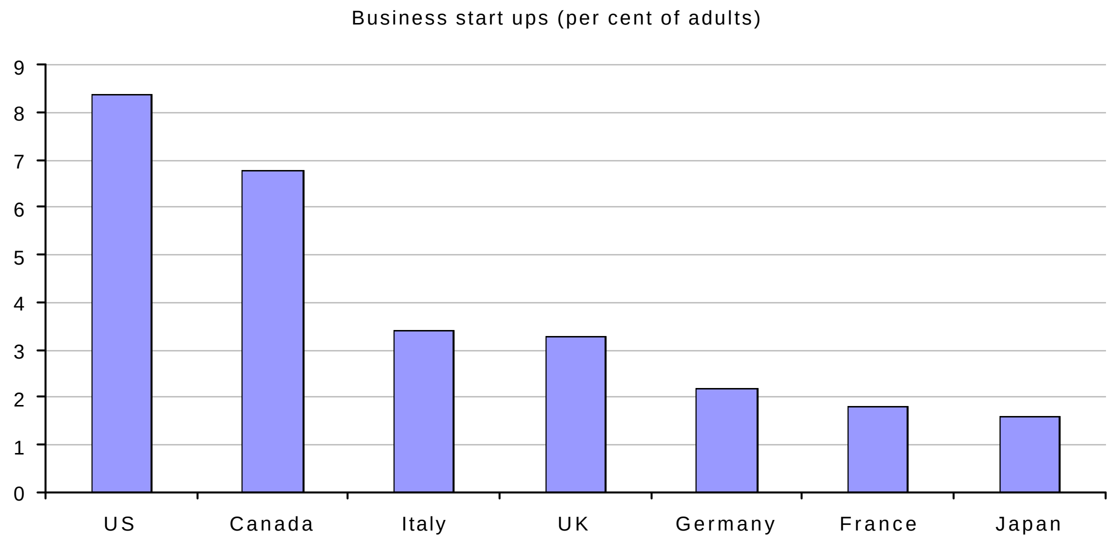
Chart 7: Barriers to entrepreneurship, around 1998 [source OECD 2000g]



The indicator ranges between 0 (no barriers) and 6 (highest possible barriers).
Source: own calculations, based on the OECD International Regulation Database and the weights from Nicoletti, Scarpetta and Boylaud (1999)

E15. Furthermore, EU countries have a far lower number of adults participating in business start-ups [see Chart 8], which also suggests that competitive pressure on existing firms (and the consequent need to innovate) is lower in the EU.

Chart 8: % of adults participating in business start-ups



Source: Global Entrepreneurship Monitor 1999

Networks: indicators of the diffusion of knowledge

E16. As discussed in Chapter II, the degree that technology and knowledge flows across public and private sectors strongly affects the overall impact of technology on economic performance (OECD 1998). Directly measuring diffusion is hard. But using patenting data, for instance cross border ownership of patent, does go some way in helping to reveal the extent of international research co-operation and knowledge flows.

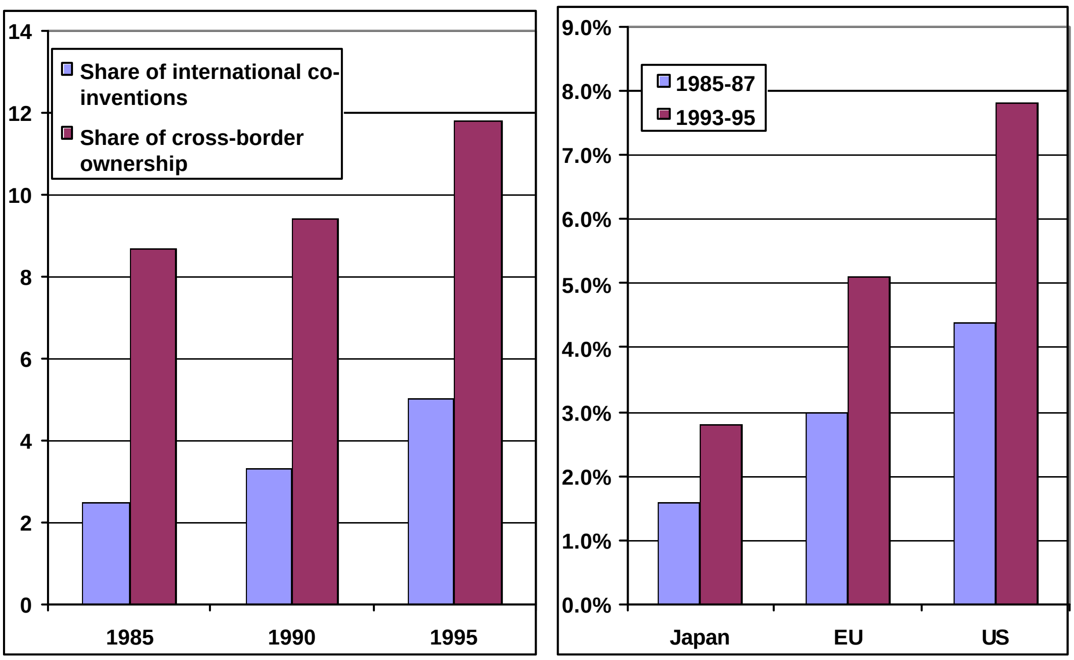
Ownership of patents

E17. Chart 9a shows that there has been a strong global trend towards greater shares of patents with cross-border ownership or based on international co-inventions, between 1985 and 1995. But Chart 9b indicates that this international cooperation has not developed equally in all countries - the gap between the EU and the US has widened over that period.

Charts 9a and 9b: Global trends in the internationalisation of technology (data to be confirmed)

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

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

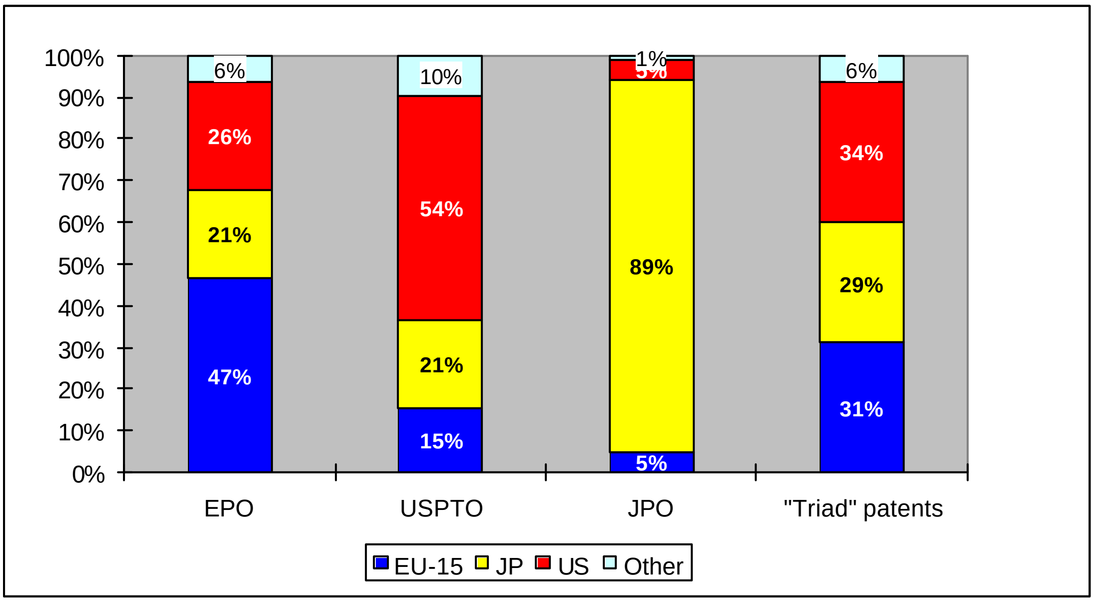


Source: OECDg. Data are based on patent applications to the European Patent Office, by date of priority.

Origin of patent applications by country

E18. Patent application figures provide an indicator of firms' intention to distribute new technology to a particular market, and therefore to some extent suggest trends in knowledge diffusion. Chart 10 indicates that a greater percentage of European patents originate from the US than vice versa. And despite their differences in size, more US patent applications originate from Japan than from the EU, by total volume.

Chart 10: ***Share of the EU in European, US, Japanese and "Triad[1]" Patents[2], 1998***

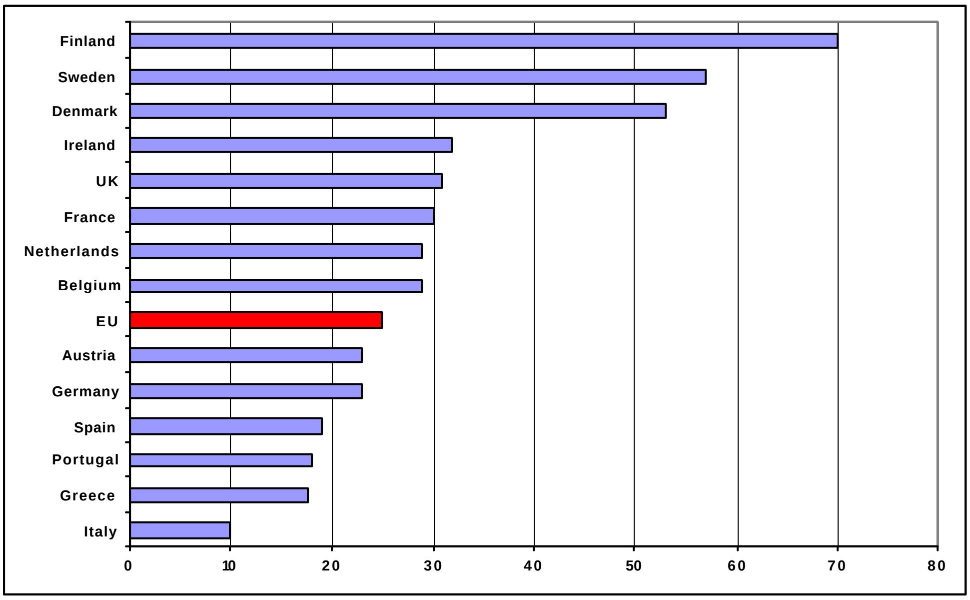


Source: Research DG

Co-operation between firms

E19. Although patent application data can indicate technological diffusion, they are unable to reveal the level of co-operation between innovating firms and other private and public sector organisations within national innovation systems. Chart 11 measures these cooperation patterns that may contribute to the strengthening of transfers of knowledge and innovation. Data from the US and Japan is not available, but the figures show that there is significant variation within the EU. While on average 25% of innovative EU firms co-operate with other firms, universities and public research institutes, in Finland, Sweden and Denmark more than 50% are involved in such co-operation, whereas for four MS these figures are below 20%.

Chart 11: Percentage of innovating firms cooperating with other firms, universities or public research institutes (1996)



Source: Eurostat (CIS2)

E20. The charts above illustrate imperfectly comparisons and trends in knowledge diffusion. But the EU's underperformance in this area compared to the US, both statistically and anecdotally, is arguably a key reason for its relatively poor innovation performance in general.