UK Innovation Performance: Strengths, Weaknesses, Opportunities, Threats and Main Problems

Summary

UK Innovation Performance

This paper summarises UK innovation performance using a variety of output indicators of achieved technological innovation derived from recent survey evidence. These include the share of businesses that have introduced products, processes or services new to themselves or to their market and the share of UK sales accounted for by innovative products and services or made with innovative processes.

In broad terms, while the proportion of UK businesses who make routine innovations is roughly equal to the EU average, the share of turnover accounted for by new products (intensity of innovation) and the extent of self-reliance for generating new products and services is lower.

Around **50**% of UK businesses are innovators in the sense of recent introduction of technologically new products, processes or services. Around **40% are follower** (catch up) innovators and **10% novel innovators (new to their market)**. These overall figures hide some differences between manufacturing and services and between businesses of different sizes. So 43 % of manufacturers are product innovators (32% follower, 11% novel) and 24% are process innovators (16% follower and 8% novel), while in service sectors some 50% are innovators (43% follower, 7% novel).

International Comparisons (Europe)

UK achieved innovation can be benchmarked against other countries. The Community Innovation Survey (CIS) provides evidence that is broadly comparable across member states, enabling comparisons to be made between the UK and other EU state. Some of these comparisons are shown in the following and annexed tables and charts[1].

The share of innovators in UK manufacturing is somewhat higher than the EU average, whilst well below that of Germany (subject to some data problems there) and considerably higher than France.

The CIS data suggest that the share of innovators in small UK **manufacturing** firms is above the EU average (54% against 44%) but at roughly the same level in the case of medium and larger enterprises. This indicator shows the share of enterprises that have introduced at least one product, process or service that is new to them or new to their market, between 1994 and 1996. But, crucially, it does not show the intensity of innovation - how important the innovation is to the enterprise - or its degree of novelty.

The proportion of UK **service sector** enterprises who are innovators is similar to the EU

[1] Note that the response rate to the Community Innovation Survey was low in Germany, so their results may be distorted. The figures for Germany are probably an overestimate (this was accepted by the Germany representative in CIS discussions). This will tend to bias upwards the EU average figures.

average. However the share of medium and large UK service enterprises who are innovators is below the EU average, with 55% against 73% in large enterprises.

Economic Contribution of Innovation

Around 20% of employment is in the hands of non-innovative SMEs, 6% in non-innovative medium-sized and 11% in large non-innovators. Against this, 21% of employment is accounted for by very large enterprises with at least one novel innovation.

As well as the share of innovative enterprises in employment, we can calculate the share of UK business turnover accounted for by innovative products and services. Around 6 % of UK business turnover is in novel products or services, and 16% in catch up products or services, with 78% in unchanged products or services. The share of innovations in *manufacturing* turnover is substantially lower in the UK than in most other EU countries. The difference between the UK share and the EU average is accounted for mainly by larger enterprises.

To summarise, **although the UK has a broadly similar share of manufacturing enterprises who are innovators, the intensity of innovation is lower, mainly because large UK enterprises, in both manufacturing and services, fail to match their counterparts in the rest of the EU.** To fully understand the role of large enterprises in innovation, they need to be seen in a wider international context. Over 30% of UK manufacturing is foreign owned (with a much higher proportion in some sectors), while UK owned large companies are usually multinational operators. The degree of autonomy in strategic, operational and technology decision making in the UK subsidiaries varies according to sector and to the country of the ultimate parent. There is some research evidence that foreign owned companies in UK manufacturing take a more active approach to technologically based innovation.[2]

The differences between the UK and other countries reflect, in part, the commitment of enterprise resource to innovation. The share of turnover in manufacturing devoted to a range of technological development activities, including intra-mural and extra-mural R&D, purchase of external technology, investment in connection with innovation and industrial design, is on average lower in the UK than the rest of Europe, at **3.2%** of turnover against a European average of **3.7%.** The sources of this difference are explored below in the SWOT analysis. The difference is again mostly accounted for by large enterprises.

In certain "high-tech" service - transport and telecommunications services and R&D and technical service sectors, the position is reversed, with the UK spending 3.8% of turnover against a European average of 2.7%. In these "high-tech" services, it is large and medium UK enterprises that bring up the total figure but this level of spending does not seem to be translated into higher innovation levels - the share of medium and large enterprises in these sectors who are innovators is substantially lower in the UK.

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[2] "Patterns in UK Company Innovation Styles - New Evidence from the CBI Innovation Trends Survey" Rod Coombs and Mark Tomlinson, CRIC, 1998.

Sources of Innovation

Technological innovation is essentially a business strategy decision, utilising the firms' own resources and external sources of knowledge and equipment. As the complexity of goods and services increases, innovation can often take a "distributed" form, involving the co-operation of a number of enterprises. A willingness to be open to external knowledge sources and networks can be a major factor in enhancing business ability to successfully innovate. But the internal resources required to be an "intelligent customer" or effective partner and to incorporate external sources of technology and business best practice into a forward looking business strategy are also essential.

The major sources of **external** technological information, knowledge and co-operation opportunities include the science and technology base, the technology infrastructure and other enterprises.

The strengths of the UK science base (SB) are clear and it widely argued that there is significant scope for greater industrial exploitation of scientific knowledge. Survey data on sources of knowledge for technological innovation summarised below show that enterprises (whatever their level of innovativeness) look more to the "technology base" – intermediary and specialist organisations, "knowledge pools" and the infrastructure of standards and regulation, than directly to the SB, while commercial sources, including customers and suppliers, are the most important external source.

Sources of knowledge for innovation, proportion of enterprises quoting source

Source	Novel innovator	Follower innovator	Non-innovator
Commercial sources	97	50	24
Science base	31	5	4
Technology intermediaries	51	31	14
Knowledge pools	74	27	17
Standards & regulations	51	25	9

The direct use of the science base (SB) increases with the level of innovativeness, although it is difficult to establish from survey data if causation runs from science to innovation or if novel innovators demand science. There is though a prima facie case for looking closely at opportunities for increasing the innovativeness of some enterprises through initiating or increasing links with the SB. The viability and likely success of this route will depend on the enterprises possessing the necessary complementary capabilities.

Other firms, including customers, suppliers, specialists etc are the major sources of external technological knowledge complementary to in-house capabilities.

Sources of information for innovation, proportion of innovators quoting sources as very important

	Manufacturing		Services	
	UK	EU average	UK	EU average
Sources within the enterprises	43	47	38	52
Other enterprises within the enterprise group	19	25	29	39
Competitors	17	16	20	19
Clients or customers	54	42	65	38
Consultancy enterprises	2	5	10	11
Suppliers of equipment; material; components or software	23	19	27	18
Universities or other higher education institutes	4	4	4	5

The CIS indicates that UK enterprises are relatively more dependent on customers and suppliers as a source of technological knowledge for innovation and relatively less reliant on their own resources. While customer focus is widely recognised as vital for successful innovation, the comparative findings may point to a widespread passivity in approach to the development of new products and services by UK enterprises and to *lack of internal capability and self-confidence in driving innovation forward*. **This finding is consistent with the relatively lower intensity of achieved innovation in UK business**. It is notable that the share of enterprises citing the science base as an important source is relatively low across Europe as a whole, for example, only 6% in Germany. The existence of an "exploitation gap" between industry and universities is not it would seem confined to the UK.

Constraints on Innovation

Survey evidence shows some of the internal or market factors that have led to the delay, cancellation or prevention of particular innovation projects. One or more of these were reported by around 20 % of UK businesses. These included lack of appropriate sources or cost of finance which was cited as an important factor by roughly 50% of those reporting constraints on innovation projects, around twice the European average. High technology businesses were more likely to encounter financial constraints. Shortages of technical and managerial skills was the next most important constraint, while availability of external technology was cited relatively infrequently as a problem by innovating firms. Success in raising finance depends on the ability of companies to make a convincing case as well as on risk aversion by financial institutions, so there is an important absence of interrelationship between technical and managerial capability and raising finance.

Start Ups

Start-ups of new technology or science based businesses can make a contribution to innovation performance through bringing new product or service ideas to the market place early and testing customer reaction. They are in a sense experiments and experiments can fail, so that enterprises are born and die relatively quickly - this phenomenon is known as "churn". To illustrate there were around 12,000 start-ups (new VAT registrations) in manufacturing industry in 1999, but nearly 17,000 de-registrations. It is difficult to get at a figure for the share of start-ups who are science or technology based. As a starting point, it can be estimated from our survey work that some 1,300 enterprises with 10 or more employees were established in high technology sectors in the two years from 1994-1996, concentrated in computer services, telecommunications and precision engineering.

This is an underestimate of the total since the survey did not cover micro firms. Further work is needed to improve these estimates.

SWOT Analysis of Innovation

This section briefly summarises some of the widely recognised structural and institutional characteristics of the UK economy that condition or affect directly the motives and ability of enterprises in this country to innovate effectively.

Strengths

The UK's academic **science base** is world-class. To illustrate this we can consider scientific papers and citations. Scientific papers provide us with an indicator of the production of scientific knowledge and know-how. Citations give us an indicator of the quality of papers.

The UK is a major force in research. In 1999, with only 1% of the world's population, the UK produced 8% of the world's scientific research papers. Our scientific publications are also one of the most heavily cited - attracting 9% of all citations in 1999. The *Citations* chart shows that the UK leads France and Germany and rivals the US and Canada in terms of papers and citations per head. However, this strong performance will also reflect the fact that English is widely read and understood.

Other international comparisons also suggest that our best academics excel. For example, the UK does very well in winning science prizes. We are second only to the US, and well clear of third place Germany, in winning major internationally recognised prizes.

The economic benefits that accrue from the UK science base can be grouped as follows:

- *Graduates*
- *New Instrumentation and Methodologies/Techniques*
- *Professional Networks* - interactions with the world-wide community of leading researchers and linkages with graduates in Industry and Commerce provide the means whereby scientific knowledge from whatever source can accessed and distributed;
- *Technological Problem Solving* - the science base contributes to the economy by helping in the solving of complex technological problems.
- *Increasing the stock of useful information*;
- *Creation of New Firms;* - spin-outs[3].

[3] The UK data on spin-offs should be seen in a different light to the often quoted MIT "spin-out" figures which boast 4,000 MIT-related companies. The definition employed by MIT includes not only genuine spin-offs (owned at least partly by MIT) and companies set-up by MIT staff, but also firms founded by MIT attendees (they did not even have to graduate). MIT-related companies also include those jointly founded by ex-MIT attendees and people educated elsewhere. For example, the two founders of Hewlett-Packard, the largest MIT-related company, had four degrees between them, three from Stanford and only one from MIT.

The UK had about 360 spin-outs (cumulatively) in 1997/8. The data suggest an increase since the mid-1980s in the rate at which businesses have been created from HEIs that has now levelled off at approximately 40 spin-outs per year.

The UK's **communications infrastructure** is world-class and well developed in terms of: land based telecoms network -including cable; mobile telecoms network; as well as, satellite, analogue and digital telecommunications. This infrastructure places the UK in a strong position *vis a vis* the development of the internet.

Inward investment in the UK is increasingly developing a high-value, high-tech character, with recent projects in multimedia; telecommunications; software; pharmaceuticals and financial services. The UK's success in attracting high-tech inward investment springs from inter alia: scientific and technological expertise; excellent R&D facilities; flexible and skilled workforce; highly sophisticated financial markets; telecommunications infrastructure; excellent transport links, and relatively low business taxes.

Improvements in school/university education and increasing investment in training by both firms and government have lead to an increasing supply of **highly skilled manpower** in the UK, while demand for highly skilled workers has steadily risen. In 1981 27% of UK employment was accounted for by white-collar high-skilled jobs. This figure had risen to 36% by 1998.

The UK's highly developed **venture capital** industry is the largest in the EU and is growing - nearly £35 billion has been invested in more than 19,000 businesses world-wide between 1983 and 1999. In 1999 alone, around £7.8 billion was invested across 1,300 companies, an increase of 60% on the 1998 figure. Around 79% (£6.2 billion) of this went to UK firms. However, compared with Germany and the US, relatively little UK venture capital goes into early-stage and technology-based investments.

The UK has a **strong measurement, technical standards and materials measurement** infrastructure which underpins technological innovation and quality maintenance and which also supports consumer and business confidence, international trade, public policy and regulation. (The countries with the three strongest instrumentation industries in the world, including the UK, have the strongest measurement infrastructures).

The pattern of innovation level and intensity varies between **UK regions**, suggesting scope for policy action to promote dissemination of best practice from high to lower performing regions. However, R&D carried out in one region is frequently exploited in another.

There is a **regional dimension to knowledge networks**. Business development can be promoted by the flow of knowledge, competitive pressures and availability of pools of experienced staff when businesses cluster together.

The UK already possesses a number of high-tech **clusters** of importance. These include the biotechnology and genome clusters in: Cambridge, Oxford and Dundee, as well as pharmaceutical clusters in: London, Liverpool and along the M4 corridor. Older clusters such as ceramics in Staffordshire have been revived, partly through the application of improved technologies by major companies. Moreover the advent of the RDAs and development of their regional innovation strategies offers a chance to bring a much greater coherence to the range of public and private sector initiatives, intermediaries,

support organisations and networks. In February 2001 the DTI published "Business Clusters in the UK - A First Assessment", which is the first systematic assessment of UK clusters. Its purpose is to provide a snapshot of existing clusters across the UK to inform the thinking of Lord Sainsbury's Clusters Policy Steering Group and the development of clusters policy. It will also be used by the RDAs as a base source of information for their clusters development work.

Weaknesses

Expenditure on R&D is one measure of the extent to which business is developing and exploiting new technology and ideas. UK firms spend less per worker on R&D compared to their major competitors in the G5 group of countries. Since 1981, the record of UK firms has worsened especially vis-à-vis the US and Japan. UK BERD spending has also been declining as a percentage of GDP - see the appended BERD chart.

Evidence on **international comparisons of R&D intensity** in combination with the wider anecdotal picture, suggests there are a significant share of medium to large UK companies lack ambitious leadership focused on long-term profitable growth where innovation and R&D are an integral part of the business strategy and are supported accordingly - however, this does not hold for all sectors. Rather, the inference seems to be that the emphasis sought by a number of UK companies and their shareholders -including institutional shareholders - is for short term high return to capital, often at the expense of low R&D intensity and low growth.

R&D spending tends to vary by sector, so poor performance overall could reflect different mixes of economic activity across countries. In order to take account of this problem, R&D can be examined as a proportion of gross value added by industrial sector. However, even when this is done, UK business only spends proportionally more on R&D than the other G5 countries in the pharmaceutical sector.

Patents are one means of protecting the intellectual property invested in an innovation, but are a better measure of invention than they are of innovation. But even the relationship between patenting and invention is far from perfect. Industries and countries also differ in their propensity to patent. The UK under-performs nearly all its major competitors in terms of number of patents granted or filed per head of population. Our record is significantly worse in both the US and EU than the US and Japan. Looking at countries of roughly similar size, the UK's level of patenting is lower than Germany and France but better than Canada and Italy's.

The danger that **QSEs may be lacking in certain management and leadership skills** - to allow them continued advancement in companies - due to over-specialisation in their specific science or engineering field has long been a concern of in the UK.

There is a limited **supply of trained craftsmen/technicians/IT specialists** and some other specialist groups. Craftsmen fall within the high-skilled blue-collar bracket and as can be seen, the UK's share of this category in the workforce is well behind that of the US and Germany.

There is evidence of limited **in-house technological and management capability** to exploit advanced technology, including slow response to the opportunities afforded by advances in ICTs. Amongst the SMEs responding to the UK CIS, some 75% of

manufacturing SMEs employed no graduate scientists and engineers (QSEs) while over 90% of service sector SMEs employed no QSEs. The extent of QSE employment is positively associated with the intensity of technological innovation, with novel innovators averaging around 12% of their employment as QSEs, against around 1% for non-innovators.

An International Benchmarking Study commissioned by the DTI showed that in 2000 the connectivity[4] of UK businesses overall, at 81%, was slightly below the levels for Canada (84%), the USA and Sweden (both 83%), and just ahead of Germany (80%). These countries were well ahead of Japan, France and Italy. Considerable progress was made among micro businesses (0-9 employees) in the UK: their connectivity level rose from 15% in 1999 to 55% in 2000, the same rate as in France and much closer than in 1999 to the connectivity levels of the USA, Canada, Sweden and Germany (between 60% and 65% in 2000). Small businesses (10-49 employees) in the UK, with 70% connectivity, remained behind the USA (80%) and Sweden (83%), but were around the same level as Germany and Canada and well ahead of France, Italy and Japan.

Business use of the internet and web-sites has increased by around 150% in the UK since 1997, compared with around 80% in the more mature US market. Growth rates in Germany and France were even faster, albeit from a much smaller base. Ecommerce is still in its infancy in Europe, and whilst the UK is on a par with Germany and Japan in terms of total ecommerce as a percentage of GDP, we are well behind the US (UK at 0.05% and the US at 0.3%), although that gap is expected to narrow significantly (in proportionate terms), over the next few years.

There are some gaps in the capital market's coverage of the **financing needs of technology-based small firms**. Bank and trade finance are the most important source of finance for most smaller firms. However, where a firm is involved in projects perceived to be of high risk, or where lead times are long, bank finance is often not appropriate or available and trade finance will be too short-term. For this type of firm equity finance is often more suitable: as it avoids the cash flow problems associated with debt finance and allows the finance provider a share of any upside. The British Venture Capital Association produces estimates of the amount of start-up and early stage formal venture capital. After falling back in the early 1990s, there has been a substantial increase in the amount of this type of finance in recent years. However, there remain areas of concern:

- flows of UK venture capital funds are heavily biased towards MBOs/MBIs (by amount of venture capital actually invested) rather than early stage and start-up funding;

- the UK venture capital industry has tended to invest much less heavily in high-tech companies compared to US venture capital (although there are signs through an increasing focus on and flow of funds into high-tech enterprises more recently);

- obtaining venture capital in smaller amounts can present a problem. Relatively high fixed transaction costs in the formal venture capital industry mean that smaller enterprises find it difficult to attract less than £0.5million investments.

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[4] Connectivity has been measured using the 'Connectivity Indicator'. This Indicator measures the number of businesses within the benchmarked countries that either have a website, make frequent use of external e-mail or use EDI (Electronic Data Interchange).

There are signs of a relative **lack of commercial awareness within universities**, although HEI/business interaction has improved to some extent in recent years; more HEIs are undertaking collaborative research, establishing business networks, running courses of industry, developing incubation, exploitation and spin-off companies and paying increased attention to the skills needs of business. The HEI/business interface can only operate effectively for the diffusion, transfer and exploitation of knowledge and know-how, where both partners are willing and able to interact. The challenge for public policy is therefore to create an environment where business and HEIs are able to forge links with each other, often with the participation of intermediaries from the technology base. However, nearly all the major industrial countries are concerned to improve the interface between HEIs and industry and there is no evidence that UK HEIs are less well orientated towards industry than the majority of their foreign counterparts. A more important problem is the lack of ability of UK industry to exploit the results of scientific research.

Opportunities

As the **stock of S&T knowledge expands**, its scope to be applied to less high-tech products and markets increases. This in turn expands the potential markets for countries who possess a comparative advantage in knowledge - such as the UK.

The growth in **internet usage** in the UK allows more and more companies access to huge amounts of information and codified knowledge. The opportunities afforded by rapid digitised knowledge transfer and e-commerce appear immense.

Some areas of **biotechnology** offer opportunities for improving the quality of life and being a major creator of growth and high quality jobs for in UK. The UK leads Europe in biotechnology (yet still lags the US). The UK currently has **275 specialist biotechnology companies**, increase of 50 % since 1997, estimated to employ more than 16,000 people.

Globalisation of S&T and the rise of Internet trading (which will lower costs of accessing new markets) plus earlier globalisation of trade, finance and investment together with the emergence of developing economies providing UK based firms with a massive expansion in business opportunities overseas. UK companies have established more technological alliances with foreign firms than have companies in Canada, Germany, France or Italy.

The volume of **e-commerce** is forecast to increase dramatically over the next few years, although the history of new technologies suggests that the early phase entrants are not always the survivors or dominant players in the longer run. The UK is currently on a par with Germany and Japan in terms of internet commerce as a percentage of GDP. But e-commerce is not just an activity for dot.com companies. 27% of all UK businesses are trading online[5], and this is on a par with the US. Ecommerce is not simply an add-on to existing business practices. In order to exploit fully the advantages offered by ICTs, businesses will need to transform their working practices.

Stricter **environmental standards**, be they mandatory and/or consumer driven, appear to provide an opportunity for domestic innovation as UK companies are at the forefront of

[5] Trading online is engaging in both paying and ordering online with either customers or suppliers.

environmental technologies. More specifically the "Kyoto mechanisms" provide UK firms with an opportunity to export their current environmental technologies - especially to developing countries - as well as providing a greater incentive to advance these technologies. "Greening" of consumers and the likely spread of business concepts such as "natural Capitalism" are likely to enhance the drive to **sustainability** as a major business driver.

Threats

It is vital that UK firms, as well as embracing developments in S&T and investing in the relevant skills and knowledge, also appreciate the need to change **management and organisational practices** required to successfully adopt new technologies and to thrive in a market place where consumers and competitors have instant access to a wealth of critical market information.

The **globalisation of markets and the rapid projected growth of e-commerce** provide a great competitive threat to companies in many industries who have, to date, been used to competing mainly with domestic (and a limited number of foreign) rivals. Only if companies respond to the new competitive environment promptly will it be a positive driver for UK innovation.

Inadequate understanding of science and technology and the inability to cope with technological change may slow down the rate of scientific and technological progress;

The paths towards more and better innovation are through:

- Strategic commitment to innovation and effective management of the process across the UK's sectors:

- Raising the amount and quality of business resources going to innovation and the capabilities of UK firms to innovate and exploit new technology;

- Stimulating the flow of knowledge between the science and technology bases and industry and between companies;

- An optimal combination of these factors that will be partly firm specific but also affected by the industry/sector and location.

MAIN INNOVATION POLICY ISSUES

Intensity of innovation: In comparison with the EU average a lower proportion of UK manufacturing turnover is accounted for by novel or improved goods and services. This lower intensity of innovation is one feature of a syndrome of interrelated problems which not only inhibit our performance at innovation but in turn help to explain our poor productivity performance and detract from our international competitiveness. These problems include:

Low strategic priority for innovation: Lack of strategic commitment to innovation, new business development and organic growth particularly among many large quoted companies. Lack of ambition and appreciation of the need to keep up with technological

change by many SMEs.

Internal resource constraints: Inability/failure to invest sufficiently in R&D and workforce skills and in-house technological capability generally.

Management and organisation: Failure on behalf of many companies to adopt up to date business best practice and state of the art product and process technology.

These problems interact in a variety of ways. For example the lack of new products means lower profits and an inability to resource the developments of new products for the future and past failure to invest in R&D, skills, best practice etc. makes innovation difficult and therefore unattractive.

Highly innovative and fast growing SMEs are more likely to encounter difficulties in raising finance than other firms.

Skills gap: Shortage of well educated and trained technicians and craftsman, deficiencies in the education and training of many managers and a lack of business training of qualified scientists and engineers constrain the innovation options of many businesses.

These **weaknesses** not only undermine the UK's current innovation performance but will also make it more difficult for UK firms to meet the opportunities and threats which arise from the increasingly rapid pace of scientific and technological change, globalisation and the rise of E-Commerce. Firms which lack experience of innovation, growth and managing change and which have not invested in the upgrading of knowledge, skills and in-house technological capabilities will find it difficult to cope with the radical changes in organisation, business practices, skills and knowledge base which our future will frequently require.

Rapid growth in the stock of scientific and technological knowledge: This provides scope to apply advanced technology to every aspect of economic and social life including many sectors currently regarded as medium or low technology. However successful adoption of novel and/or advanced technology frequently requires significant changes to the organisation, business processes, human resources and strategies of firms. Such transitions offer considerable commercial and economic benefits but are risky and difficult to manage and pose many barriers both real and psychological to firms.

The most obvious example of this of **e-commerce** which may penetrate at an relatively rapid rate for a new technology offering the prospect of major economic gains across a wide range of sectors but necessitating major changes to the organisation and 'business model' of many firms both large and small.

Better exploitation of the strengths of the UK science base: UK business often fails to exploit the output of the SB research outputs (note that the SB also contributes in terms of trained people, participation in technological networks, problem solving and research methodologies etc.). The main reason for this are weaknesses in the overall innovation performance of UK business (see above) but a contributory factor is patchiness in the links between HEIs and business.

The UK has a **world class IT and telecommunications infrastructure** and continues to lead in the deployment of cutting edge technologies, such as third generation mobile telephony, digital television and pervasive computing. Yet UK businesses are not currently

taking full advantage of the opportunities which this opens up.

Improved interface between Industry and technology intermediaries and suppliers: The UK has a considerable number of technological intermediaries (Research and Technology Organisations - RTOs), specialist suppliers, and public sources of technological knowledge which could be more effectively used to support the innovation activities of UK firms, help more of them to address gaps and deficiencies in in-house technological capabilities and act as a conduit for the outputs of the Science Base. With an increasing number of technologies being incorporated in any given product even the most successful firms are increasingly resorting to external sources of technology.

Exploitation of UK Technological Infrastructure: Government importantly determines the business environment in which firms operate and innovate, for example through business and employment law, regulations, standards and national measurement systems. An important part of innovation policy is to continue to improve governments' structural contribution through these routes, as well as seeking new discretionary policy initiatives. A major example is that an up to date set of measurement and product specification and safety standards which are traceable to an authority independent of any commercial interest and respected both here and abroad is a necessary requirement for the effective use of advanced technologies and is itself a proven source of innovation and competitive advantage.

Sustainable Development: Growing consumer demand for greener products, public concern about the environment allied and international regulatory pressure combined with the strength of the UK measurement system provides considerable opportunity for UK firms.

Annex A

Supplementary Charts and Tables

Proportion of manufacturing enterprises who are innovators, by size and country, 1994-1996

Size of enterprise (employment)		Germany	France	UK	EU average
10-49	Small	63	34	54	44
50-249	Medium-sized	70	48	59	58
250 +	Large	85	75	81	79
	All	69	43	59	51

Proportion of service sector enterprises who are innovators, by size and country, 1994-1996

Size of enterprise (employment)		Germany	France	UK	EU average
10-49	Small	41	25	40	37
50-249	Medium-sized	60	33	37	49
250 +	Large	83	73	55	73
	All	46	31	40	40

Proportion of turnover due to innovative products, manufacturing only, by size and country, 1996

Size of enterprise (employment)		Germany	France	UK	EU average
10-49	Small	30	8	14	15
50-249	Medium-sized	31	14	21	22
250 +	Large	47	25	25	35
	All	43	21	23	31

Proportion of turnover devoted to technological development activities, manufacturing, 1996

Size of enterprise	UK	EU average
Small	3.3	2.5
Medium-sized	2.9	2.3
Large	3.2	4.2
All	3.2	3.7

Proportion of turnover devoted to technological development activities, services, 1996

Size of enterprise	UK	EU average
Small	6.9	2.9
Medium-sized	2.7	2.3
Large	3.7	2.9
All	4.0	2.8

Sources of knowledge for innovation, proportion of enterprises quoting source

Source	Novel innovator	Follower innovator	Non-innovator
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Universities or other higher education institutes	4	4	4	5

Enterprises registering and de-registering for VAT by industry, 1999

Thousands

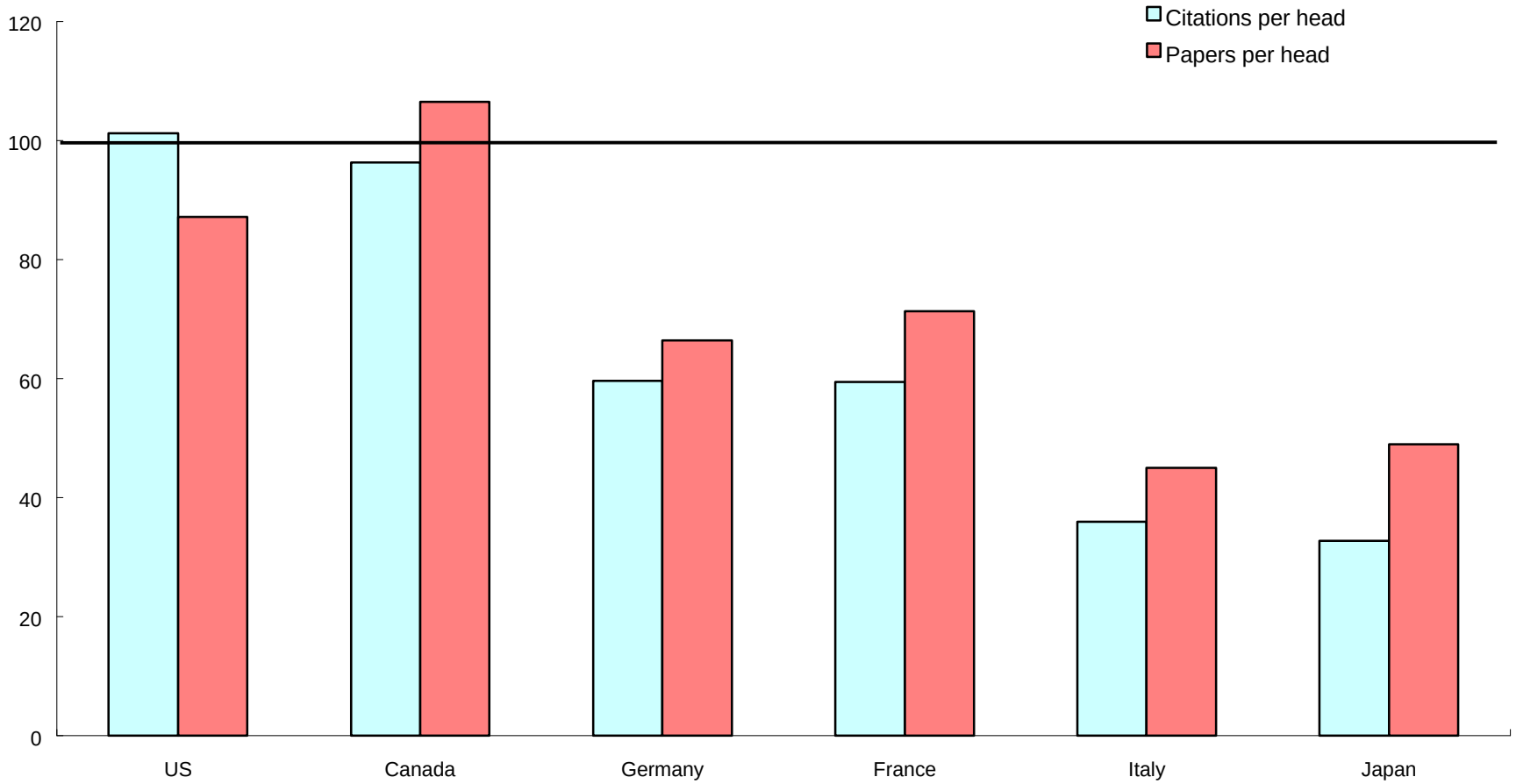
	Registrations		*De-registrations*	
	1999	Change on 1998	1999	Change on 1998
All Industries	178.5	-7.8	172.0	16.0
Agriculture, fishing	3.5	-0.5	5.8	-0.1
Mining, Energy	0.2	*	0.3	*
Manufacturing	11.9	-0.7	16.6	1.7
Construction	17.8	-0.6	19.3	1.9
Wholesale, retail, repairs	38.3	0.6	44.0	2.3
Hotels, restaurants	17.6	0.8	17.1	0.8
Transport	9.4	0.1	9.0	0.8
Finance	1.8	*	1.9	0.2
Business services	60.8	-6.1	42.7	8.3
Education, health	2.2	0.1	1.8	-0.1
Other services	15.1	-1.5	13.7	0.1

Source: Small Business Service (Research Unit)

Papers and citations per head of population

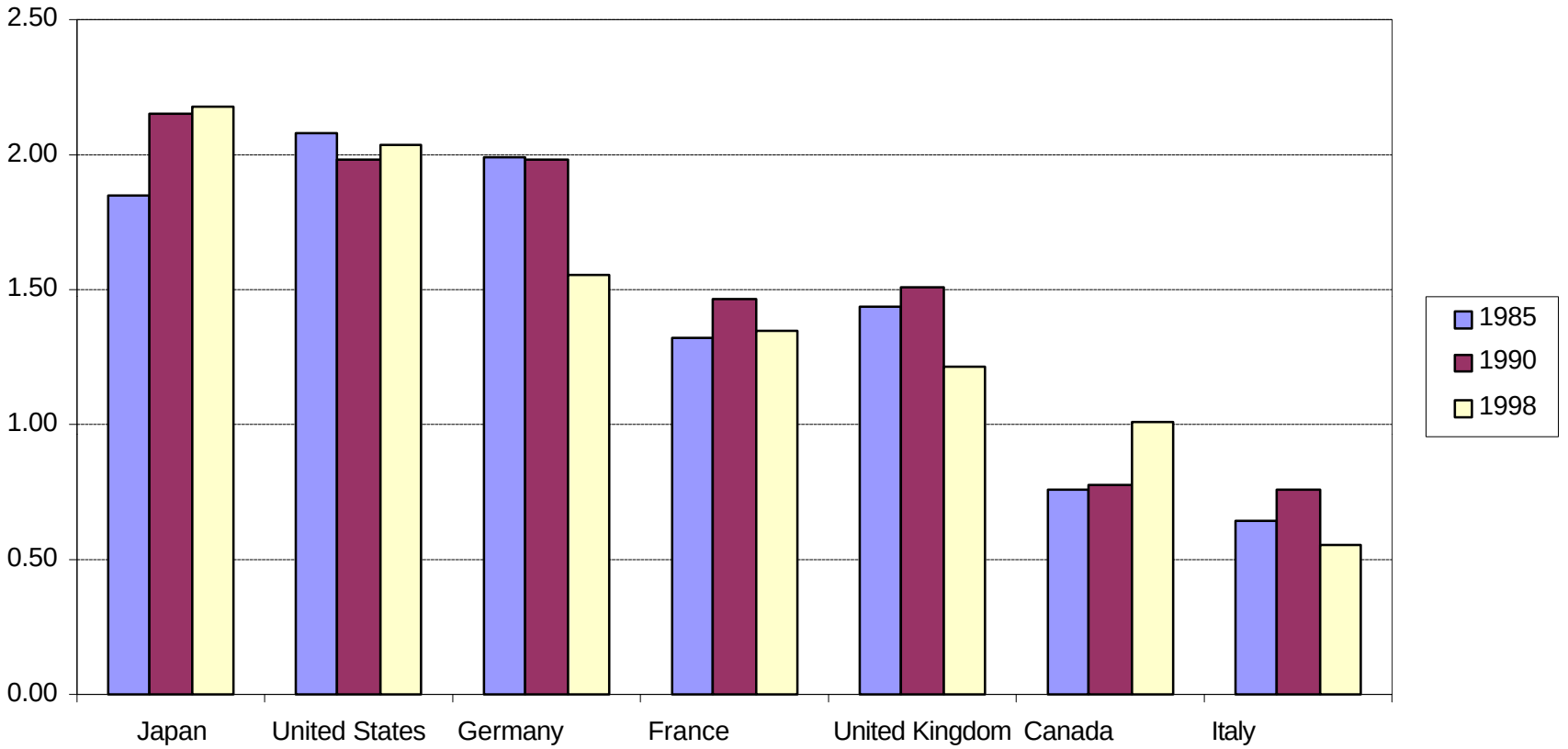
G7 comparison, 1993-1998

Index, UK=100



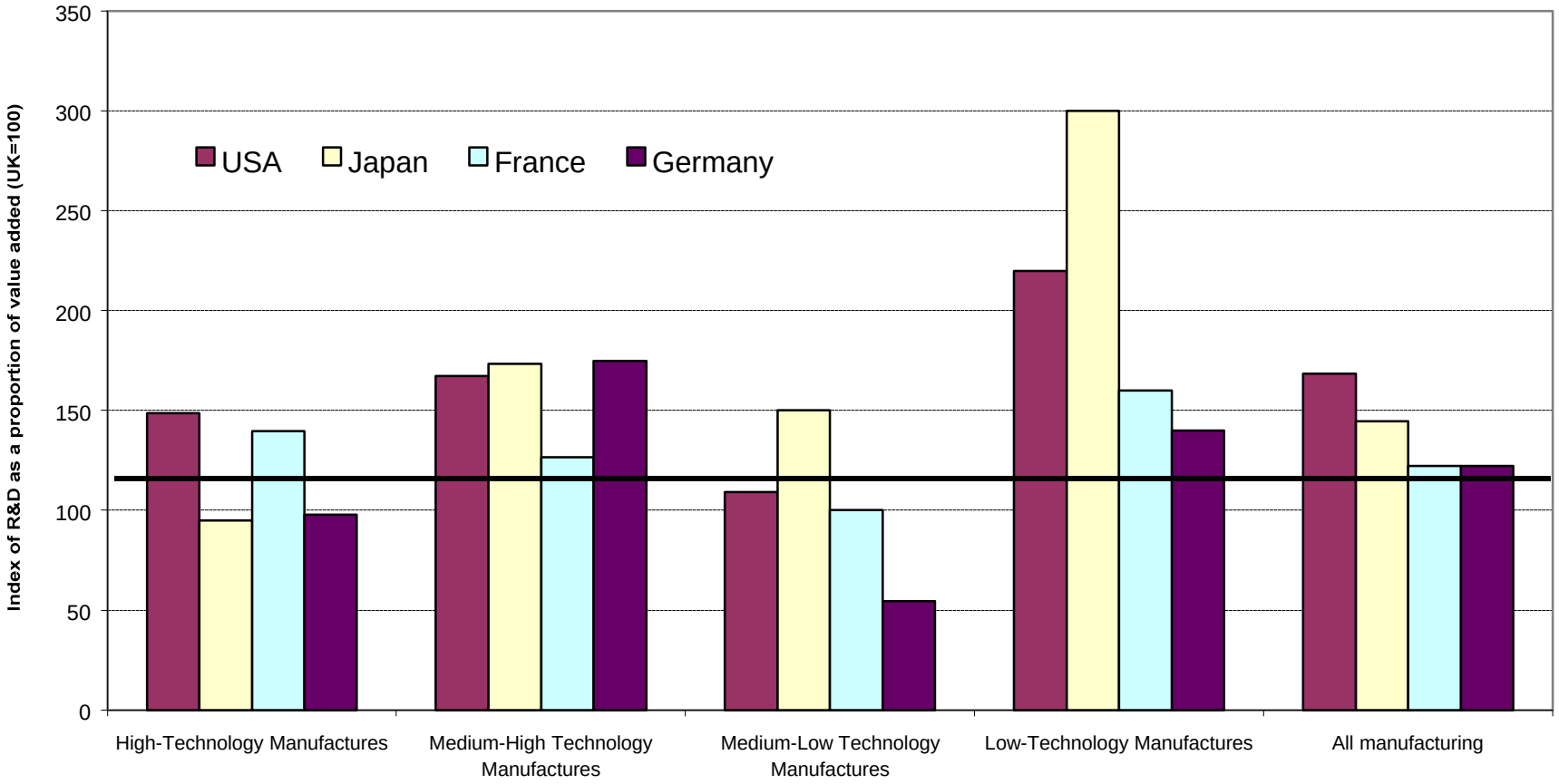
Source: OST

BERD as a percentage of GDP



Source: OECD

R&D as a proportion of value added, 1997



Source: OECD (STAN, ANBERD)

Manufacturing R&D intensity (R&D spend as a percentage of sector value added)

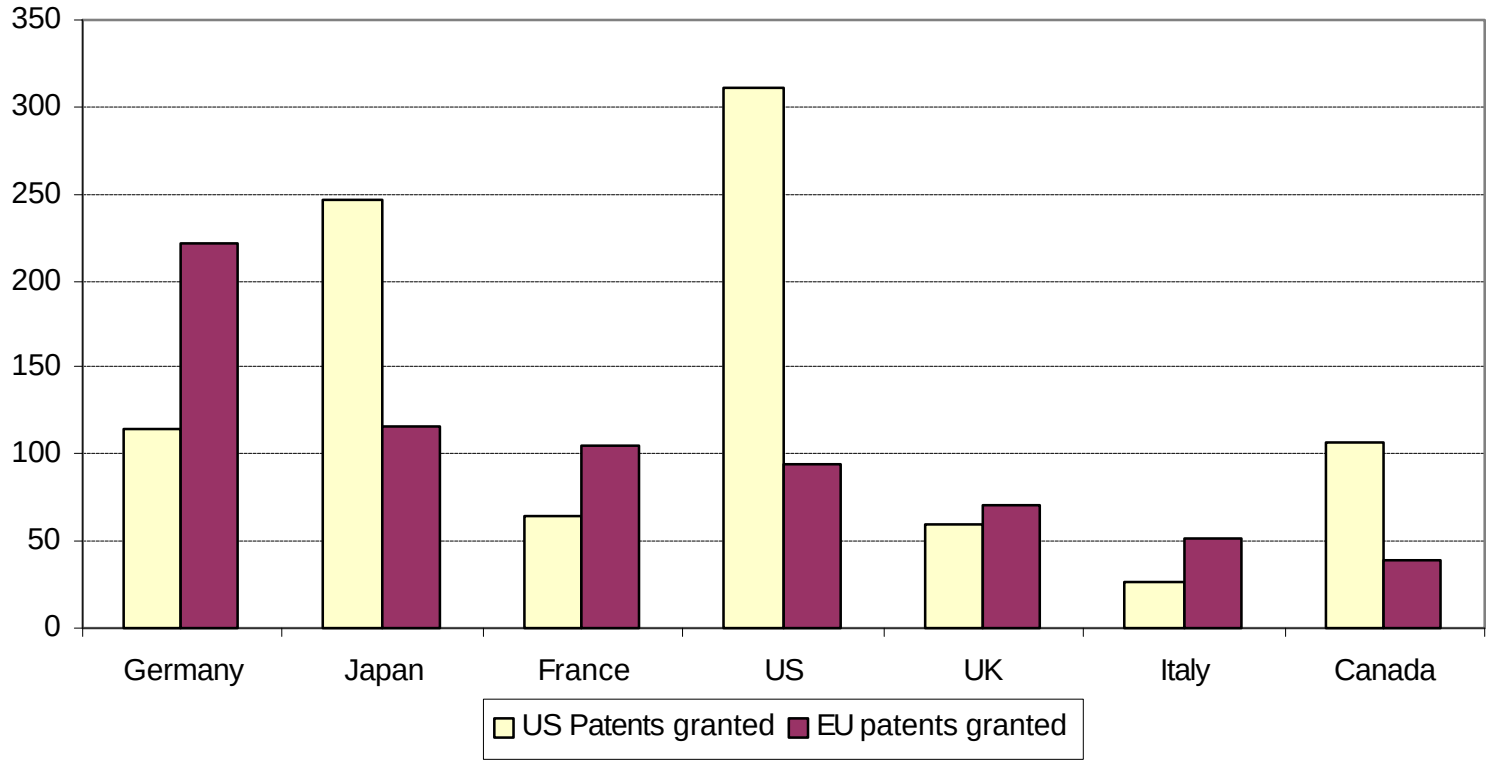
		UK		France		Germany		Japan		US	
		1997	Change since 1990	1997	Change since 1990	1997	Change since 1990	1997	Change since 1990	1997	Change since 1990
Manufacturing		5.4	-0.7	6.6	0.3	6.6	0.4	7.8	0.4	9.1	0.5
of which:	Food	0.9	-0.4	0.9	0.0	0.5	0.1	1.9	0.0	1.4	0.1
	Textiles	0.4	-0.1	1.0	0.6	1.5	1.0	1.9	0.3	0.9	0.3
	Paper and printing	0.2	-0.1	0.3	0.0	0.6	0.3	0.9	-0.1	1.2	0.3
	Industrial chemicals	6.3	-1.5	10.6	2.0	11.7	-1.3	12.2	13.3	6.3	8.4
	Pharmaceuticals	32.3	-2.2	28.6	0.0	18.3	-4.1	19.0	0.4	23.8	0.7
	Plastic and rubber products	0.9	0.0	4.8	0.7	2.3	0.3	4.9	0.1	2.8	-0.6
	Non-electrical machinery	3.9	-0.6	6.1	2.2	9.5	1.6	7.5	0.8	4.6	1.5
	Computers	4.8	-15.3	9.7	-0.3	27.1	11.8	27.0	4.3	57.6	46.7
	Electrical machinery	7.1	-3.4	4.1	4.1	9.2	-1.4	11.7	-0.2	8.0	-1.2
	Communications and semiconductors	13.7	-2.5	32.1	-0.2	11.5	-2.8	15.7	2.4	20.3	2.9
	Motor vehicles	10.8	1.9	11.6	10.4	11.2	1.9	12.2	0.0	18.5	-4.6
	Aerospace	18.0	-1.4	32.2	-13.3	86.4	39.9	27.0	-3.4	37.3	-2.7

Source: OECD

Patents granted and applications

G7 Comparison, 1999

per million of population

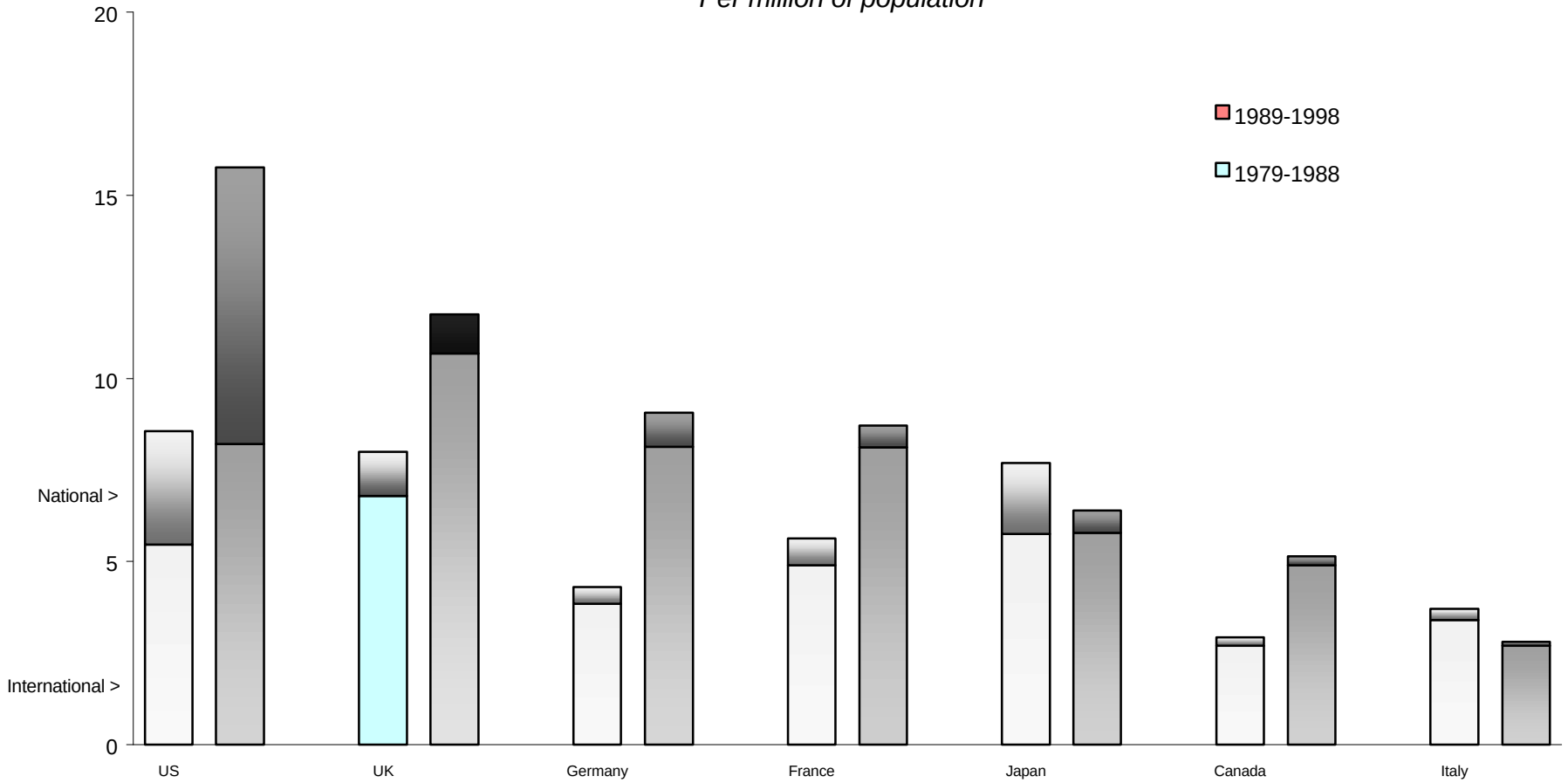


Source: US Patent and Trademark Office, European Patent Office

Technological alliances

G7 comparison, 1979-1998

Per million of population



Source: MERIT