Science in the European Community—the extent of collaboration

Subbiah Arunachalam

The year 1992 is a watershed in the history of Europe. Before the end of the year the twelve member nations of the European Community (EC) would have become an integrated single market. This development, no doubt, will lead to greater cooperation in science and technology.

Europe's record in scientific research remained unequalled till very recently. Most of the important scientific discoveries before 1900 were made by Europeans in Europe[1]. Britain, France, Germany, Italy, the Netherlands and Switzerland had between them won 45% of all Nobel prizes from their inception until 1985—Americans won 39% in the same period[2]. However, there has been a marked decline in European supremacy in science. This is most marked in Britain, particularly during the Thatcher years. In technology too the position is no better; for example, Japan applied for a larger number of patents in the United States in 1988 (29,613) than all EC countries put together (28,402). However, in 1989 gross expenditure on research in EC (US$ 92,325 million) was much higher than that in Japan ($ 57,740 million) and much less than that in the United States ($ 144,820 million). In terms of expenditure per head of population, however, Europe ($ 201) falls far behind both Japan ($ 469) and the United States ($ 582)[3].

Need for cooperation

The hope in Europe is that there will be greater collaboration and that eventually Europe will regain the first place in science. European leaders clearly recognize that research is vital for economic development and that without better collaboration they cannot increase Europe's industrial competitiveness. That is why Community spending on EC-level research has been climbing sharply since the mid-eighties. The general theme of the ministerial level meeting of the OECD (Organization for Economic Cooperation and Development) Committee for Scientific and Technological Policy held in Paris in March 1992 was 'Science and technology policies in the 1990s—the interrelatedness of the national and international dimensions'. The meeting emphasized the need for 'stronger and increased international scientific and technological cooperation'. Another meeting organized by Forum Europe in Brussels on 2 April 1992, 'The horizons of research: the future of cross-border R&D in the European Community', addressed questions such as promotion of EC-wide research cooperation, and the impact of R&D on EC competitiveness.

The idea of building international R&D networks and internationalizing R&D activities to take advantage of available talents, wherever they reside, has been gaining popularity for some time, especially in the academically strong United States, which often gets pipped at the post when it comes to converting its scientific ideas into commercially viable technologies, products and profits.

One of the most daunting tasks before a united Europe is to win back the lead it once enjoyed in science and to hold its own against the United States and Japan in the race for technological supremacy and favourable trade balances. Increased collaboration in R&D should be a key element in Europe's strategy.

The idea of networking is not new to European science. In fact, one of the most successful collaborative large-scale organizations in science anywhere is the Conseil Européenne pour la Recherche Nucléaire, CERN, which was founded

Table 1. Numbers of papers published by EC and G-7 countries and numbers of papers jointly authored with EC- and G-7-country collaborators

Country	Total number of papers	Collaboration with: EC partners Number	%	G-7 partners Number	%	G-7 and EC countries Number	%
Belgium	5643	1643	29.1	1837	32.5	2298	40.7
Denmark	5102	1092	21.4	1479	28 9	1687	33.0
France	30,102	4321	14.4	5875	19.5	7129	23.6
Germany	40,378	4200	10 4	6759	16 7	8280	20.5
Greece	2071	451	21.7	648	31.2	720	34 7
Ireland	1274	308	24 1	367	28 8	436	34 2
Italy	17,803	2794	15.6	4038	22 6	4886	27.4
Luxembourg	20	20	100.0	17	85.0	23	115 0
Netherlands	12,875	2347	18.2	3192	24.7	3769	29.2
Portugal	881	364	41.3	367	41 6	471	53.4
Spain	9370	1681	17 9	3801	40 5	2423	25.8
UK	52,150	4621	8 8	7300	13 9	9351	17.9
Canada	27,181	237	8 2	5651	20.8	6111	22 4
Japan	44,521	459	3.3	4042	9 0	4339	9 7
USA	224,955	4395	6.4	17,465	7.7	20,629	9 1

Data from *SCI 1991*. If a paper is coauthored by authors from more than one country, then each country is counted as a collaborating country. Hence, the numbers of collaborative papers shown here may be slightly larger than the actual numbers.

in 1954 to bring European particle physicists together and give them facilities to practise their expensive science. It is widely believed that CERN effectively saved European high-energy physics from extinction! And it certainly demonstrated that European countries could collaborate on a scientific endeavour that was beyond the means of individual countries. Another example of European cooperation, this one in the life sciences, is the European Molecular Biology Organization (EMBO), founded in 1963 essentially to regain the initiative in molecular biology that was by 1962 passing rapidly to the United States from Europe, where many of the early key discoveries were made.

Some indicators

About two years ago researchers at the Philadelphia-based Institute for Scientific Information (ISI) looked at the cross-national citation network of the 12 EC countries[4]. They concluded that the EC had some way to go before it could claim to be a thoroughly integrated single market and that the EC could be divided into two unequal halves—a group of eight well-integrated and semi-integrated scientific 'haves' and four peripheral scientific 'have-nots'. The ISI science analysts used the number of times a nation's scientists quoted the work of another nation's scientists as the yardstick.

I present here some data on international collaboration among EC scientists as seen from jointly authored journal articles covered in ISI's *Science Citation Index 1991*. Table 1 presents the total numbers of journal articles (including letters, notes, review articles, etc.) authored by researchers with an address in the EC or Group of Seven (G-7; the US, Canada, Japan, the UK, Germany, France, Italy) industrialized countries, and the numbers of papers coauthored with EC-country and G-7-country collaborators. The major players among the EC nations are the UK, Germany, France and Italy—all four also members of G-7. Table 2 is a matrix showing the number of papers coauthored by scientists from at least two of the 15 countries considered.

The smaller nations seem to have a greater propensity for collaboration. For example, out of the 881 papers authored by Portuguese researchers 364

Table 2. Matrix showing numbers of papers coauthored by scientists from at least two of the 15 EC and G-7 countries. [Data from *SCI 1991*]

	Belgium	Denmark	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	UK	Canada	Japan	USA
Belgium	5643	41	472	292	22	18	158	4	290	17	69	260	80	64	511
Denmark		5102	120	225	10	11	84	1	94	11	40	455	73	52	470
France			30102	1097	105	35	652	7	388	71	516	858	551	264	2453
Germany				40378	89	44	582	4	570	52	245	1000	387	423	3270
Greece					2071	6	40	0	18	5	11	145	43	6	220
Ireland						1274	19	0	23	2	9	141	15	6	107
Italy							17803	1	281	29	236	712	175	117	1800
Luxembourg								20	1	0	0	2	0	0	3
Netherlands									12875	37	114	531	161	123	1138
Portugal										881	32	108	16	10	81
Spain											9370	409	72	36	634
UK												52150	664	358	3708
Canada													27181	260	3614
Japan														44521	2620
USA															224955

resulted from collaborations with scientists from other EC countries. More than 300 of the 1274 Irish papers and 451 of the 2071 papers from Greece also resulted from inter-EC country collaboration.

Among the big four in the EC, Germany had 1097 papers coauthored with French researchers, 1000 papers with collaborating authors in the UK, and 582 joint papers with Italian authors. The French had 858 papers coauthored with researchers in the UK and 652 joint papers with Italian scientists. Authors from Italy and the UK collaborated in 712 papers. Apart from these four, other EC countries which are prominent in inter-EC-country collaborative scientific publication are the Netherlands and Spain.

The United States appears to be a favourite partner for collaboration. This is not surprising as the US dominates world science, and US universities and corporate research centres attract students and research scientists from all parts of the world. Besides, the United States has many international bilateral and multilateral collaboration agreements with other countries. Authors from US laboratories coauthored more than 3000 papers in 1991 with researchers from each of three countries; viz. the UK, Germany and Canada. American scientists also collaborated with more than 2600 scientists with a Japanese address and over 2450 French scientists. The Netherlands, Switzerland and Sweden also recorded over 1000 papers jointly authored by American scientists.

Canadian researchers had 664 papers coauthored with British scientists and 551 joint papers with the French, which is not surprising in view of Canada's history. But less expected is that researchers from Canadian and German laboratories would have jointly written more than 380 papers in one year. Japanese scientists had relatively fewer papers jointly authored with collaborating authors in EC and G-7 countries, except the US. More than 5.5% of Japanese research papers covered in *SCI 1991* were coauthored with researchers in the United States. The second largest collaborator of Japan was Germany, with 423 jointly written papers. Incidentally, Germany, like Japan, is strong in terms of number of patents filed per 100,000 of population, and is investing heavily in R&D. In fact, Germany's per capita expenditure on research ($431 per year) is next only to those of the US ($582) and Japan ($469).

Among countries with more than 9000 papers in 1991 (Table 1), the Netherlands, Italy, Spain, France, Germany and the UK had the largest percentage of internationally coauthored papers. The percentage of internationally coauthored US papers seems to be low; but if we consider countries outside of the EC and G-7 then the figure for the United States will be considerably higher. A quick count, considering 25 other countries, gives a figure of over 31,600 (or over 14% of the total number of papers from the US).

The limited data presented here show the well-known proximity factor in international collaboration in science. About 13% of all Canadian papers are coauthored with researchers in US laboratories; over 8% of all Belgian papers are jointly written with French collaborators; the Dutch have collaborated more with Germans than with other EC partners; and the Spaniards have coauthored more papers with the French than with any other EC partner. However, it is not mere geographical proximity that is important. For example, Americans do not write as many jointly authored papers with their Mexican neighbours as they do with Canadians.

Time-series data for several years on inter-EC-country collaboration would reveal trends. But the one-year data indicate that EC countries collaborate to a much greater extent with the United States than with their own neighbours!

The fact that the world's economy is emerging into a tripolar system—one of the three members, viz. the EC, being a group of nations trying to maximize their collective advantage through resource sharing and increased collaboration—has many implications for the rest of the world. For one thing, it would considerably limit whatever little elbow room the developing countries enjoyed (in matters of technology development and trade) in the previous dispensation of a politically bipolar and economically multipolar world. India is already facing the adverse effects in the form of the US's Super 301 sanctions, unfavourable duty structure on drug export to the United States, and uncalled-for difficulties in the purchase of a rocket engine from Russia for her space programme. Conditions are not likely to change. Clearly, the poorer countries of the world must evolve a strategy that will help them at least survive, if not become competitive!

1. Smith, R., *Br. Med. J.*, 1992, **304**, 899.
2. Advisory Board for the Research Councils, Royal Society, and Economic and Social Research Council, *Evaluation of National Performance in Basic Research*, ABRC, London, 1986.
3. Organization for Economic Cooperation and Development, *Main Science and Technology Indicators*, OECD, Paris, 1991.
4. *Science Watch*, 1990, **1**, (no. 7), 1.

Acknowledgement. Mr N. Meyyappan assisted in the preparation of the tables. I am grateful to Prof. S. K. Rangarajan for drawing my attention to some deeper issues and to Dr Eugene Garfield for a gift of *SCI 1991* and all the issues of *Science Watch* published so far.

Subbiah Arunachalam is in the Central Electrochemical Research Institute, Karaikudi 623 006, India.