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RCN and International Research Co-operation

Background report No 6 in the evaluation
of the Research Council of Norway

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Synthesis report
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Summary

This background report to the evaluation of the Research Council of Norway (RCN) examines the way RCN tackling its mission to ensure adequate Norwegian participation in international research co-operation.

International co-operation is generally understood to be important for three reasons

- International co-operation can provide access to complementary know how and tools – otherwise unavailable within the national innovation system – which in turn drives learning, innovation and scientific breakthroughs
- Participation in international consortia can deliver improved financial efficiency through leveraging national budgets and permitting a higher degrees of specialisation than would be possible through a unilateral policy
- International researcher mobility can be used to attract and retain the high calibre people it contributes to professional development of indigenous scientists
- International research co-operation is understood widely to be a politically neutral and low cost means through which to demonstrate good intentions and build a bridgehead for improved international relations and trade

As a result, EU and EEA member states view international co-operation as an essential component of first-class research in the natural, physical and social sciences. Indeed, one of the Research Council's primary tasks has been to lay the foundation for formalised collaboration by establishing relationships with similar organisations in other countries and concluding formal co-operation agreements.

The Norwegian research community, however, faces important challenges with respect to internationalisation, in both the industrial and institutional research areas.

- The low proportion of the national product devoted to business expenditure on R&D and the correspondingly small share of Norwegian companies' R&D that is conducted abroad means their exposure to international research is limited, and that it is therefore hard to identify and use knowledge generated abroad. The limited role of foreign multinationals, means Norwegian domestic industry has a very limited 'window on the world'
- In institute research, there has been success in selling to foreign business, though the amount of income they obtain from the EU Framework Programme has declined recently. Many of these institutes aim to increase the share of their sales coming from abroad – though it should be noted that equivalent institutes abroad share this ambition
- In terms of publications, Norwegian academic research is less productive than its equivalents in Nordic countries, lying somewhere between the productivity of Germany and the UK. Its impact (in terms of the extent to which others cite it in refereed journals) remains lower than that of research in other Nordic countries, but has been steadily improving through the second half of the 1990s.
- Researcher mobility, which is a key driver of internationalisation, has been declining. Up to 20 years ago, provision for PhD training in Norway was poor. People wanting to do a PhD often had to go abroad. The improvement of the doctoral training infrastructure in Norway means there is less incentive to do this

today. PhD stipends are generous in Norway, so going abroad would mean reduced income for most. While the reforms in PhD training are intended to bring down the age at which people typically defend their doctorate from the 40s to the 20s, most Norwegians studying for a PhD are old enough to have partners. This means that if they were to travel abroad they would be looking for two jobs, not one. Many are over 35, and therefore too old for EU mobility schemes

There has been a strong foreign policy dimension to international research co-operation, which appears to be becoming less dominant as an active research policy takes hold. This shift in emphasis is evident in most European countries and not just Norway.

Norway and the RCN have increased both the policy emphasis and budget available for international research co-operation, with RCN's budget having increased by around a third from in 290 million NOK in 1996 to 390 million NOK.

International research co-operation has been dominated by inter-Nordic activities historically, but Norway has been an active member of the global scientific community for many years too, with an involvement in a comprehensive portfolio of international scientific organisations from the European Space Agency to CERN. Indeed, membership subscriptions consume a high proportion of total Norwegian spend on international research co-operation. We have a small concern that Norway may be too thinly spread given the present budget and that RCN and other government departments are struggling to match the subscriptions with national programmes sufficient to exploit those investments. This is the case especially for the two research organisations mentioned.

Latterly, the policy emphasis switched to the EU RTD Framework Programme, which is an intelligent response to a major new opportunity to secure additional R&D funding from abroad and to extend Norway's scientific relationships and networks in Europe.

RCN's latest internationalisation strategy is committed to building on this success and in particular to pursuing a more broad based involvement in the thematic programmes. We would signal caution on that point, which, while a laudable ambition, may not be straightforward. Norway's success reflects existing clusters of excellence and capability, which underlines the framework programme's ability to distinguish between strong bids and others. Competition is intense and the Framework Programme is not an ideal mechanism for capability building. The accession countries are seeking to do this – as are other smaller European economies such as Austria – but with limited success. They still exhibit highly skewed profiles reflecting technological comparative advantage in collaborations.

Indeed, this is one reason why countries such as Spain and Portugal are increasing their share of a growing international research co-operation budget, directed to bilateral research co-operation, somewhat against the trend evident in Northern Europe. As with many countries, bilateral research co-operation has been very much a residual category in Norway with the Council spending around 7 million NOKs annually on a large number of agreements each supporting a small number of cooperative activities. This small budget is dominated by one bilateral agreement with France (3 million NOKs), and tends to support researcher training and exchanges rather than cooperative research projects.

Bilateral R&D agreements have their origins in foreign policy often times, which may cement international relations but has been less relevant from a scientific perspective.

In essence, there has been an assumption that the decisions about if and how to cooperate on an international level should be managed by researchers themselves if possible. That intergovernmental agreements and international programmes add little value to informal co-operations while adding huge cost and inertia. Formal research co-operation is relevant only under exceptional circumstances, such as is the case with the EUMETSAT or EUREKA. Many other international scientific organisations – for example, ESF, IEA – are international debating chambers and coordinators rather than international programmes.

That said, we believe it would be short-sighted to abandon bilateral agreements simply because in the past they have been of rather limited importance and many aspects are now covered within for example the human resources schemes of Framework 5. Of especial relevance to Norway, bilateral agreements can be an effective route through which to build capability in a specific area through co-operation with a much stronger partner, in return for preferred access to markets or whatever (there will always be a trade).

Bilateral or trilateral agreements can be be a good compromise with respect to multi-sponsor investments in research facilities and equipment. They are easier to set up and cheaper to operate than the equivalent multilateral agreement, while providing a valuable framework from within which to balance demand with the escalating cost of research infrastructure, whether it's a synchrotron or Geant.

We have looked briefly too at researcher mobility, another area where the RCN has been active since its inception and with a good deal of success both through its bilateral programmes and within the Framework programmes. The RCN has its International stipend programme, which covers several types of exchange (short and long term) for new post doctoral fellows and more experienced (but younger than 40). There are bilateral agreements with almost 40 countries in a range of geographical regions from the Baltic to the Americas. There are several other bilateral fellowship programmes, too, such as the STA-stipend (Japan) or the Ruhrgas-stipend (Germany). In addition, Norway makes active use of the researcher training and mobility schemes of the European Commission (e.g. Research Training Networks, Marie Curie Fellowships). We understand that Norway's researchers continue to be somewhat less mobile than their counterparts overseas, but the measures set out in RCN's internationalisation strategy (e.g. a requirement for all PhDs to spend one year of their training at a university or research institute overseas) will make further inroads into this crucial area.

Internationalisation has been on RCN's agenda throughout its existence, with actions to integrate Norway into the EU Framework Programmes being especially important. In 2000, however, the Council decided to increase the priority it gives to internationalisation issues, and prepared a strategy document explaining how it intended to do this. The strategy made four main recommendations and announced a number of specific actions, but critically stated that internationalisation should be 'mainstreamed,' that is, including an internationalisation dimension across funding modes and including it in the terms of reference of all programmes.

The strategy is well informed and ambitious. Of particular note are the decisions to include internationalisation within the criteria for choosing among applicants and in the conditions attached to those awards: a simple, yet powerful means through which to encourage a majority of researchers in Norway to think more about international co-operation. The danger in such a generic measure is that internationalisation is more relevant in some research fields than others and forcing people to do things that are not especially useful is a good way to discredit the whole scheme.

The strategy is perhaps too ambitious to be feasible without a substantial – perhaps even twofold – increase in the share of public sector research expenditure devoted to promoting and doing international co-operation. The challenge is even more daunting when one considers that Norway's emphasis has been on internationalisation in general – as a principle – rather than the more focused and utilitarian approach evident in Ireland for example. Ireland's decision to focus on consolidating its national research capability in just two strategic areas – biotechnology and ICT – has permitted the government to implement several major international co-operation measures quickly, such as the decision to join EMBL and the ESRF. We believe that a greater degree of focus on strategic requirements – such as upgrading and linking research infrastructure into the European infrastructure – would be beneficial to the RCN's ability to deliver on its internationalisation strategy.

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1 Introduction

Reflecting the 1991 – 92 white paper[1] that set out the government's intention to merge the research councils, Article 2 of the council's statutes says that one of its tasks is to promote international research co-operation. Based on input from the Council itself, the 1998-99 White Paper[2] tasked RCN with renewed efforts at internationalisation. This background report to the evaluation of the Research Council of Norway (RCN) examines the way the council is tackling that task. It does so by answering two main evaluation questions:

- How does RCN's work on international research co-operation compare with that on other countries?
- Are the actions on international co-operation now in place at RCN consistent with fulfilling its task in this area and addressing the underlying policy challenges?

We have worked primarily from documentary evidence provided by RCN and other research funders internationally.

2 The Policy Challenges

The Norwegian research community faces important challenges with respect to internationalisation, in both the industrial and institutional research areas.

Norwegian industrial research faces several important internationalisation challenges[3]

- The low proportion of the national product devoted to business expenditure on R&D, which reflects the fact that much of the industrial structure is in comparatively mature, process industry rather than newer, knowledge-based industry. There are of course important exceptions, but this means that, overall, Norwegian industry's ability to generate and use new knowledge is constrained, and it tends to lock the industrial structure into yesterday's industries, rather than tomorrow's
- Correspondingly, the small share of Norwegian companies' R&D that is conducted abroad. This means that their exposure to international research is limited, and that it is therefore comparatively hard to identify and use improvements in knowledge generated abroad. Given that well over 99.5% of the world's research is done outside Norway, this is an important limitation
- The limited role of foreign multinationals in Norwegian industrial R&D expenditure. About 10% of Business expenditure on R&D in Norway is funded by a handful of foreign companies. This, combined with the limited amount of

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[1] St. meld. Nr. 43, *Et godt råd for forskning. Om endringer i forskningsrådsstrukturen*, 1991-92

[2] St meld nr 39 (1998-99) *Forskning ved et tidsskille*

[3] see Stefan Kuhlman and Erik Arnold, *RCN in the Norwegian Research and Innovation System . Background report No 12 in the evaluation of the Research Council of Norway*, Brighton: Technopolis, 2001

Norwegian industrial R&D carried out abroad, means Norwegian industry has a very limited 'window on the world'

Taken together, these factors mean not only that internationalisation is important, but that there are important obstacles to achieving it.

In institutional research, there are also significant challenges.

The techno-industrial institutes[4] achieve an important degree of success in selling to foreign business, though the amount of income they obtain from the EU Framework Programme has declined recently. Many of these institutes aim to increase the share of their sales coming from abroad – though it should be noted[5] that equivalent institutes abroad share this ambition. Globalisation is slowly becoming a reality in the world of the applied research institutes, bringing benefits for research customers and important new competitive challenges for the institute sector.

In terms of publications,[6] Norwegian academic research is less productive than its equivalents in Nordic countries, lying somewhere between the productivity of Germany and the UK. Its impact (in terms of the extent to which others cite it in refereed journals) remains lower than that of research in other Nordic countries, but has been steadily improving through the second half of the 1990s. Small open economies in general – and the Nordic countries and Switzerland in particular – tend to have a high share of internationally co-authored papers in their scientific output. The very fact that these are small research-performing societies drives much of this openness. The Nordic region functions as an extended 'home country' area in many respects, and a high share of international co-publication in Nordic countries actually involves co-operation among the Nordic neighbours. To this extent, the co-publication data give a falsely positive picture of internationalisation. The share of internationally co-authored papers in Norwegian production has risen from 29% in 1989-91 to 40% at the end of the 1990s, making Norway's publication pattern the second most international of the Nordic countries, after Denmark. However, the contribution of the institutes to international publication is comparatively low. Overall, there is a continuing need to maintain and improve international co-operation.

Researcher mobility, which is a key driver of internationalisation, has been declining. Up to 20 years ago, provision for PhD training in Norway was poor. People wanting to do a PhD often had to go abroad. The improvement of the doctoral training infrastructure in Norway means there is less incentive to do this today. PhD stipends are generous in Norway, so going abroad would mean reduced income for most. While the reforms in PhD training are intended to bring down the age at which people typically defend their doctorate from the 40s to the 20s, most Norwegians studying for a PhD are old enough to have partners. This means that if

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[4] see Erik Arnold and Ben Thuriaux, *RCN in the Research and Higher Education Sector. Background report No 4 in the evaluation of the Research Council of Norway*, Brighton: Technopolis, 2001

[5] see, for example, Erik Arnold, Philip Sowden and Jari Kuusisto, *Building a World Class Institute Sector in Sweden: Report to IVF, IVL, SIK and SP*, Brighton: Technopolis, 2000

[6] see Sybille Hinze, *Bibliometric Analysis of Norwegian Research Activities. Background report No 2 in the evaluation of the Research Council of Norway*, Karlsruhe: Fraunhofer ISI, 2001

they were to travel abroad they would be looking for two jobs, not one. Many are over 35, and therefore too old for EU mobility schemes

Norway has participated in the EU Framework Programmes since 1987, initially on a self-financing basis. Entry as a fully associated member into the European Union's 4th Framework Programme in 1994 was an important landmark. Before this time, Norway participated by joining in international collaborations, which applied to the European Commission for funding. Where proposals were successful, the Commission would pay for the parts of the work done in EU countries, while RCN and its predecessors would pay for the work done in Norway. From the perspective of the EU-based participants, Norwegian involvement was costless. Once Norway fully joined the Framework Programmes, it started contributing to the funding 'pot' in Brussels, and had to win money in the same way as EU members. Norwegian participation was no longer 'free' for other consortium members, but had to be traded off against the benefits of involving others. This raises the quality and relevance thresholds needed to become a project participant, so that success in the Frameworks become a much more rigorous test for the Norwegian research community than it was previously.

As we move into the detail planning for the 6th Framework Programme, with the European Commission trying to federate the national research communities to create a European Research Area, Norway faces some important challenges and opportunities.

- In principle, the proposal to concentrate the bulk of funding on large, integrated projects (tens of MEURO) is attractive in terms of (i) increased critical mass and (ii) potential gains in administrative efficiency within the European Commission. In practice, such a uniform response could lead to a monoculture in research activity at the European level around a small number of strategic projects. The threat to diversity in international research co-operation would be greater still given the fact that many areas of science and applied research (from marine science to the humanities) may not yield worthwhile additional benefits if they were to be pursued through such ultra-larger projects. Norway is not alone in challenging the Commission's thinking in this area. We would recommend that they press for greater detail with regard to the nature and extent of the plans for these integrated projects, retaining a concern over the potential negative consequences for flexibility and diversity in international research co-operation. The Commission's mapping of selected fields (scientific excellence)[7] is due to report at the end of 2001, which will provide Norway, and others, with the opportunity to assess the implications of the ERA proposals on both centres of excellence and mega projects.[8]

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[7] In November 2000, the European Commission established a High Level Group dealing with benchmarking of national policies, mapping of scientific excellence and networking of national and joint research programmes.

[8] Research ministers meeting in Brussels on 10th December 2001 have agreed a common position on Framework 6, with an overall budget agreed of 17.5 billion Euro. Ministers agreed that Framework 5 research co-operation instruments will be used in Framework 6, however, the proposed new mechanisms – the large integrated projects and networks of excellence – will be given priority, where appropriate.

- Norway has more experience than most European countries in respect of international co-operation within its national research programmes and as a result ought to be in a good position to play a central role in the detail design of the ERA proposals concerning methods of coordination of national programmes. That contribution may present an opportunity for Norway to influence decisions regarding other aspects of the ERA, where there may be a challenge posed to the Norwegian research base, such as the commitment to forge closer contacts and stronger links between research organisations across Europe. There will be economies to be gained – and risks to be lowered – by concentrating those developments on fields where there are established networks and …
- Norway should look closely at its research infrastructure with respect to international co-operation as there is an opportunity to exploit Framework 6's substantial funding for research infrastructures (665 million Euro). In particular, there is a 200 million Euro allocation for continuation of the Géant high-speed computer network – part funded by the European Investment Bank. This will create a very high-speed trans-European research network, which could be of profound importance to driving up the level of engagement of Norwegian researchers with other European countries' researchers and centres of excellence
- While the Framework programme does leverage national research budgets through its support for trans-European co-operation, the choice of instruments and the level of competition tend to rule out the programmes as a controllable means through which to build national capability in areas where little exists. Framework 6's prioritisation of integrated projects and networks of excellence will reinforce an already clear tendency: one must have high enough quality and big enough capability to have centres of excellence in Norway.

Major parts of the humanities and social sciences tend to be more nationally oriented due to linguistic and cultural specificities and the absence of an imperative to share the costs of the associated research infrastructure. Work which explores the national literature, music and culture is especially important for a nation as young as modern Norway, but can have limited interest abroad. That said, there has been a growing interest in placing a small but growing share of social science and humanities research onto an international footing: organisations like the European Science Foundation and COST have led the way but there is a growing 'soft research' component within the European framework programme. The most important source of foreign interest here is reflected in the (somewhat limited) funding provided through organs of the Nordic Council of Ministers. Comparative aspects of the social sciences and humanities, such as comparative literature, are becoming more important and nonetheless provide important contributions to knowledge and to cultural understanding. Notwithstanding the real efforts being made by the European Commission and a small number of economic and social science groups around Europe, these aspects remain under-developed in international research co-operations. Interestingly, this is an area of the Framework Programme where Norway has outperformed its anticipated share of project participations (c 2%) by a factor of three. Similarly, much of the more applied social science, relating to specifically national and local issues, may generate limited international interest. Again, the opportunities for comparison provided by this research can easily be overlooked and appear to be under-represented among the institutions of international co-operation.

3 RCN's Strategic Response

Internationalisation has been on RCN's agenda throughout its existence, with actions to integrate Norway into the EU Framework Programmes being especially important. In 2000, however, the council decide to increase the priority it gives to internationalisation issues, and prepared a strategy document explaining how it intended to do this. The strategy made four main recommendations and announced a number of specific actions. The recommendations were

- Internationalisation should be 'mainstreamed' – making it an aspect of all aspects of the council's work and therefore including an internationalisation dimension across funding modes and including it in the terms of reference of all programmes
- Time-limited appointments should be available at Norwegian institutions for highly qualified foreign researchers
- All Norwegian PhD candidates should spend an extended period abroad during their doctoral studies
- Indicators of internationalisation should be used as one of the inputs in deciding the core funding for research institutes funded via RCN

The other actions were to

- Participate actively in international research policy *fora*
- Further develop the knowledge base regarding developments and trends in the internationalisation of research
- Consider how to open up RCN's own programmes to foreign researchers, whether research is performed by foreigners at a Norwegian institution or at a foreign institution
- Consider how research needs, which cannot be met by Norwegian institutions, can be met by institutions abroad
- Consider how foreign research organisations and companies can be stimulated to perform R&D in Norway
- Consider establishing centres of research excellence in Norway, in order to make Norway more attractive as a 'research platform' and host country
- Consider measures which enable Norway to develop, attract and retain knowledge-based industry
- Strengthen the use of international stipend programmes and introduce 'homecoming' grants for those holding EU and other stipends
- Strengthen Norwegian participation in formal international programmes, especially in the EU and the basic research organisations
- Identify and establish areas for closer co-operation and division of labour in the Nordic area, as well as considering closer co-operation with researchers in the USA and other parts of the world

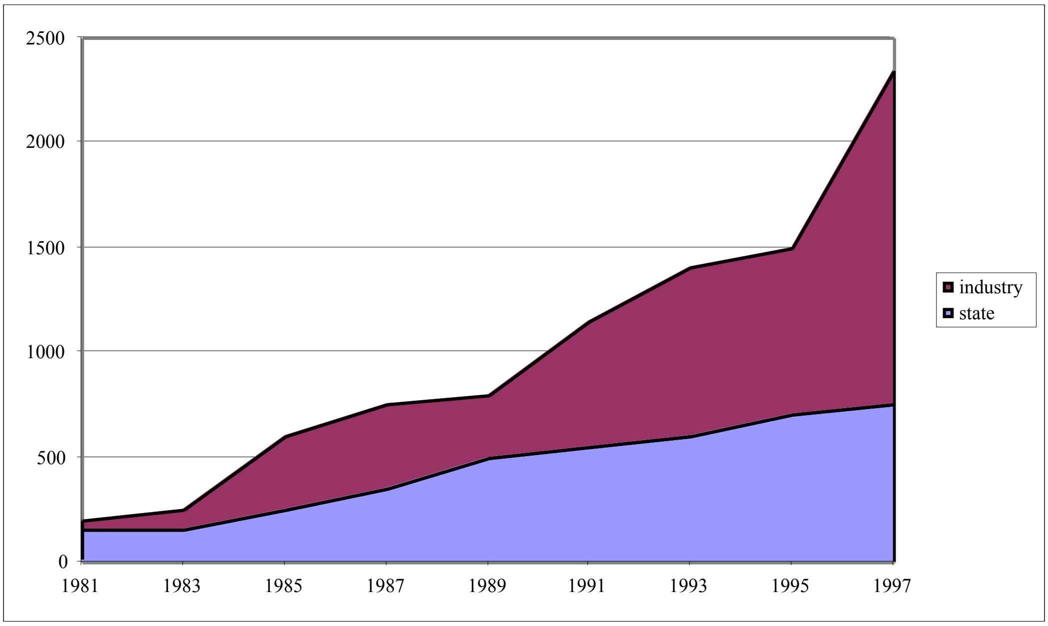
Exhibit 1 Norwegian Funding of International Research Co-operation, by source of funds and regional destination, in 1998 (Million NOK)

	Nordic Area	Rest of Europe	Other	Total
Ministries	30	670	390	1090
RCN	15	115	190	320
Industry	270	260	160	690
Total	315	1045	470	2100

Source: Susanne Lehman Sundnes, *Norges internasjonale samarbeid – en oversikt for 1998*, report 13/98, Oslo: NIFU, 1998

Exhibit 2 shows the growth in Norwegian R&D funding from abroad during the past 20 years, which is dramatic by comparison with growth experienced in most of the larger European countries. Even allowing for inflation growth in expenditure has been strong in both the private and public sector, reflecting Norway's participation in the globalisation process on the one hand and the emergence of the Framework Programme on the other. While government investment has increased five-fold in the period, corporate investments are now around three times that of the state.

Exhibit 2 Trend in R&D funding from abroad, for industry and state (Million NOK current prices)



Source: NIFU working paper 11/2000

This table does not reconcile with the NIFU/RCN data in any of the other exhibits, so it should be omitted perhaps. However, if it is correct, then it is rather important as it shows RCN to be responsible for just 15% of total government expenditure on international research co-operation.

Exhibit 3 Government expenditure on international research co-operation, 1998 and 2000 (Million NOK, current prices)

Programme	Departments		RCN		Total	
	1998	2000	1998	2000	1998	2000
EU	402	486	36	58	438	543
EUREKA	-	-	2	3	2	3
COST	-	-	20	33	20	33
CERN	67	82	9	11	76	93
ESA	189	199	6	6	195	205
EMBL	4	5	7	8	11	13
ESRF	3	3	2	3	5	6
Total	**665**	**775**	**82**	**122**	**747**	**896**

Source: utdannings- og forskningsdepartementet, Naerings- og handelsdepartementet, Samferdsels-departementet

Exhibit 4 Trend in RCN's budget for international research co-operation (Million NOKs, current prices)

	1996	1997	1998	1999	2000	% change 99-00
EU	35.4	32.8	35.8	43.3	57.5	33%
EUREKA	20	25	19.7	20	33	65%
COST	3.8	2.5	2	3.4	2.5	-26%
CERN	11.2	10.4	9	11.3	11.3	0%
ESA	10.2	7.5	6.2	6.3	6	-5%
EMBL	5.7	6.2	7.2	7.2	7.6	6%
ESRF	3.1	2.1	2	2.5	2.5	0%
ESF	1.6	1.7	1.4	1.5	2.2	47%
Cultural agreements	7.7	7.3	6	6.5	6.5	0%
Nordic co-operation	10.9	10.4	14.9	14.1	21.2	50%
Annual bilateral and multilateral	63.4	73.3	70.2	61.1	64.7	6%
Co-operation via research institutions	33.8	22.7	64	92.5	88.1	-5%
	206.8	201.9	238.4	269.7	303.1	12%
Total - formal international co-operation	206.8	201.9	238.4	269.7	303.1	12%
Total - person level co-operation	81	74.4	82.9	86.5	85.5	-1%
	287.8	276.3	321.3	356.2	388.6	9%

Source: RCN quoted in NIFU working paper 11/2000

3.1 Motivation for international research co-operation

International co-operation is generally understood to be important for three reasons

- International co-operation can provide access to complementary know how and tools – otherwise unavailable within the national innovation system – which in turn drives learning, innovation and scientific breakthroughs
- Participation in international consortia can deliver improved financial efficiency through leveraging national budgets and permitting a higher degrees of specialisation than would be possible through a unilateral policy

- International researcher mobility can be used to attract and retain the high calibre people it contributes to professional development of indigenous scientists
- International research co-operation is understood widely to be a politically neutral and low cost means through which to demonstrate good intentions and build a bridgehead for improved international relations and trade

As a result, EU and EEA member states view international co-operation as an essential component of first-class research in the natural, physical and social sciences.

Indeed, one of the Research Council's primary tasks has been to lay the foundation for formalised collaboration by establishing relationships with similar organisations in other countries and concluding formal co-operation agreements. In 1997, for example, agreements were signed with Centre National de La Recherche Scientifique (CNRS) of France, the Russian State Committee of Science and Technology, and Consiglio Nazionale delle Ricerce (CNR) of Italy. Norway is a member of a number of international research organisations, and participates in numerous international research programmes.

The view of the Economic and Social Research Council (ESRC) in the UK is typical of research councils in the EEA, and is worth quoting in part because it relates to the value of international co-operation in the social sciences rather than to the physical sciences:

> "… strongly believes that research in the social sciences flourishes in an open and internationalist perspective, when it is ready to derive lessons from comparisons across countries and cultures and from the best current contributions to social science, whatever their provenance. The best of British social science has always been carried on within such a perspective. Across Europe and worldwide there are social scientists with expertise and knowledge beyond that held by British experts. The Council has therefore affirmed its support for a broad and comprehensively internationalist approach in all the research it supports, while retaining a strong orientation towards promoting its own Thematic Priorities."

This presumption of co-operation as being intrinsic to research means that the majority of scientific administrations in the EU provide their respective constituents with access to a range of international mobility schemes to facilitate co-operation among researchers. In addition, most administrations test all grant applications – national and international – on their international strengths. While few of those national funding organisations foresee the possibility of sponsoring non-national researchers within the terms of a national research project, a growing number do see the merit in permitting and endorsing the creation of active links between national and international research groups and facilities within national projects.

Where member states do see the need for a formal agreement to structure international co-operation, those agreements are predominantly multilateral rather than bilateral. Multilateral intergovernmental agreements relate to R&D organisations such as the European Space Agency (ESA) or the European Molecular Biology Laboratory (EMBL) or the soon-to-be launched Global Biodiversity Information Facility (GBIF). The multilateral imperative results from one or more of the following factors:

- The magnitude of the scientific challenge (e.g. particle physics)
- The universal importance of the topic for government, business and society (e.g. climate change)
- The scale of the financial investment required over time (e.g. space)

In such cases, member states argue that the additional cost and bureaucracy is justified.[9] There are few instances where there was a scientific imperative underlying a formal intergovernmental bilateral R&D agreement where a national programme had been considered to be insufficient and a multilateral initiative unwarranted.

European researchers have the further option to participate in international research projects on an ad hoc basis through the CEC RTD Framework Programme. This excerpt from an interview with an Austrian official is typical of the situation in many smaller European states.

> "… the Austrian government has concluded a number of formal bilateral R&D agreements however, this mode of co-operation is not at the top of the agenda with respect to international research activities. Rather, the government has placed much greater emphasis upon Austria's integration into the European Research System. As such, the CEC RTD Framework Programme and other multilateral schemes (from ESA to Airbus) dominate research policy."

Taken together – researcher exchange and mobility schemes, international R&D programmes and multilateral R&D agreements – policy makers have little need for other cooperative instruments.

3.2 Changing international context

Many developments in science and technology are the result, in part, of international collaboration. Indicators show increasing links among world scientists to conduct joint research, share data, conduct international meetings, develop common standards, and transfer technology. Data suggest that this activity is not just increasing, but is changing the conduct, organisation, and outputs of scientific research around the world.

Scientific research is becoming

- More global – increasing numbers of countries are building their scientific capabilities and participating in world science;
- More collaborative—a growing proportion of projects and the publications they produce result from collaborations by investigators from a mix of nations; and
- More "distributed" – scientific teams are collaborating across greater distances and involve more widely dispersed expertise.

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[9] The management requirements are sufficiently demanding in most cases for the signatories to the intergovernmental agreement to create a dedicated secretariat financed out of the annual subscriptions. The additional management cost associated with bilateral agreements is rarely so high as to justify a separate management unit with its a budget line written in to the international agreement

These shifts challenge the notion of a nationally based science and technology (S&T) policy: national boundaries have diminishing significance for scientific activities, and the results of research are not necessarily exploited at their origin. Norway is, on one hand, benefiting from the increasing dynamism of world science; on the other hand, it is more difficult to show direct benefit for NOKs spent.

The increasingly global and international character of scientific research is raising difficult questions for national investment in S&T:

- Should nations identify specific areas of S&T for national support when it is uncertain where R&D will be conducted and whether it will be exploited domestically?
- Is international co-operation serving national goals when the knowledge and expertise associated with it are distributed and disbursed worldwide?
- Does the location of R&D spending have an impact on its use, dissemination, and impact? Can the government be sure that the taxpayer is benefiting from international co-operation investments?
- Does the international co-operation portfolio complement domestic spending?

The decision to sponsor international S&T is at the crux of two tensions within the R&D policy environment. The first of these is created by the desire for control and rationality. While recent studies call for infusing more balance and a rational priority-setting process into R&D allocation,[8] the complexity of R&D spending and the increasing numbers of global interchanges confound rational organisation. The concept of tying public funding more closely to national goals has an intuitive appeal as does the idea of balancing spending across disciplines. At the same time, however, the global, collectivised, interdisciplinary, and distributed practice of science makes it harder to rationalise spending, identify where funds are spent, or track outcomes. The second tension is created by a desire to ensure that the benefits of public spending are accounted for and accrue directly to taxpayers. The requirements for accountability and value for money, recently endorsed in Norway's science strategy, are being devolved in part to the research institutes and researchers, as contractually-binding descriptions of outputs and outcomes become part of the requirements of doing science. Yet, the increasingly international nature of science makes it difficult to show how benefit is accruing directly to or within any single national economy.[10] Efficiency is perhaps being served, but it is harder to demonstrate outcomes when the conduct of R&D is widely distributed. While, on one hand, international co-operation increases the chances that researchers are leveraging new knowledge created anywhere in the world, it also sanctions the rationalisation/reduction of aggregate public sector research and reduces domestic influence. Furthermore, to the extent that the tacit knowledge created by research is responsible for regional economic growth, as has been suggested in a number of studies[11], the location of R&D may come to matter greatly to national and regional governments: they will need to know where research is taking place and decide what kinds of research the region/nation wants to retain and foster.

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10 Steven Popper, Caroline Wagner, Donna Fossum, William Stiles, Setting Priorities and Coordinating Federal R&D Across Fields of Science: A Literature Review, RAND, DRU-2286-NSF, April 2000.

11 See for example, Annalee Saxenian, Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Cambridge: Harvard University Press, 1994.

Norway has taken an active role in S&T assistance programs designed to build and maintain capacity in developing countries. Many strategies have been employed over time and in key countries in the Nordic and Baltic areas, South Asia and Africa. Activities like training and education, investments in centres of excellence, networking activities, support to scientists and institutions, and data sharing have helped move countries from the role of aid recipient to one of collaborator.

The complex system of international S&T is difficult to characterise, but, just as the scientific method seeks to isolate and study particular factors in a complex system, so it is important from a policy perspective to understand the whole and the parts of the global S&T system. If a government is going to have a rational R&D policymaking process, it is more important than ever to know what input is being derived from international co-operation activities and what leverage we are gaining or advantage we may be losing by funding ICRD.

Moreover, this means that it is important to know where relevant science of a high quality is being done abroad so that this knowledge can be tapped to solve a national problem. Finally, the use of S&T as a tool for development may need redefinition.

The progression of current trends in Norway and in Europe generally has made it more important to track international cooperative R&D activities. In order to understand the role of international co-operation in benefiting Norway and in supporting global S&T, a number of information building blocks must be put in place, including the following:

- How much Norway spends on international co-operation in R&D;
- Which agencies spend it;
- Where the funds are spent; and
- What derives from this spending.

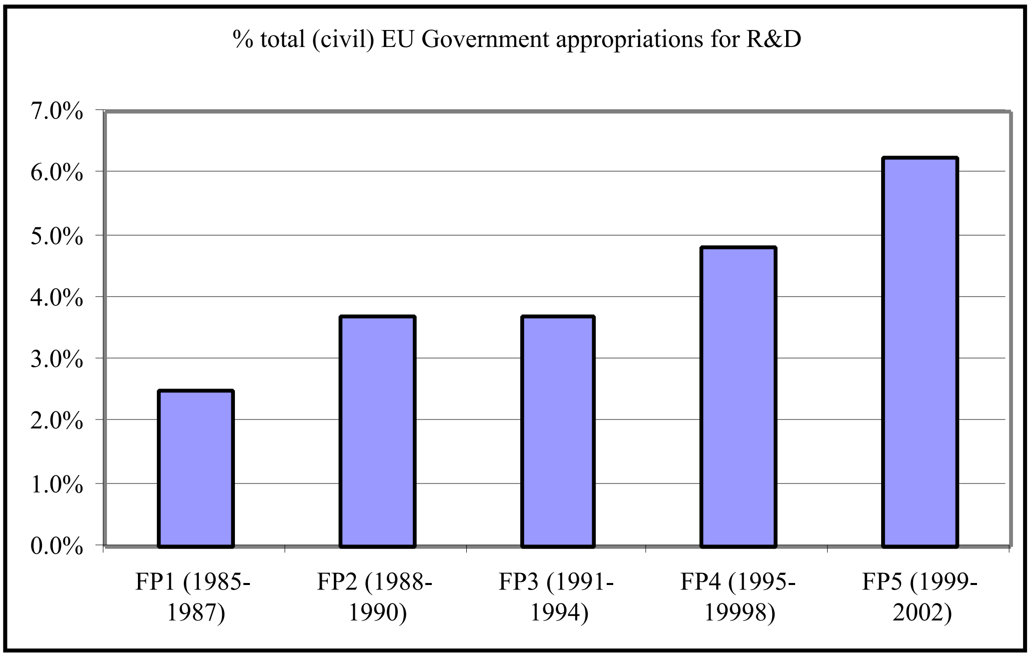
Government spending on ICRD is worth monitoring on a continuing basis in order to understand these factors and how Norway might use ICRD as a tool for domestic and foreign policy.

4 EU RTD Framework Programme

4.1 5th Framework Programme

The EC RTD Programmes have become more important through time, rising from around 2.5% of total civil R&D expenditure (government and higher education) in FP1 (1985-1987) to around 6.5% in FP5.

Exhibit 5 % of total (civil) EU government appropriations for R&D



Source: DG Research

The fifth framework programme has a combined budget of around 15 billion Euro, which is around 10% of all public sector R&D expenditure in the EU. It is more significant still when one considers that this money is not tied to particular institutions or facilities. Exhibit 6 shows FP5 is divided into four 'activities' and seven programmes. The first activity is composed of four 'thematic' RTD programmes, one of which is split into two distinct parts. The other three activities, each containing one programme, complement the thematic programmes. The four thematic programmes are each associated with a specific technology area and between them they cover: life sciences and agriculture; information and communication technologies; industrial and transport technologies; environmental issues; and energy research. Each theme includes key actions, generic technologies and measures to promote better use of infrastructure. All of these programmes support "shared-cost" research, which will constitute the bulk of funding from FP5.[12]

[12] "Shared cost" projects involve the cost of an RTD project being shared between the project participants and the European Commission, with the Commission paying about 50% of the allowable project costs.

Exhibit 6 Indicative breakdown of FP5 budget, by programme for the period 2000-2004

	Euro (M)
Indicative breakdown of the four 'thematic' RTD programmes	
Quality of Life and Management of Living Resources	2413
User Friendly Information Society	3600
Competitive and Sustainable Growth	2705
Environment and Sustainable Development (4A)	1083
Energy (4B)	1042
Total for thematic RTD programmes	10843
Horizontal and other programmes	
International Co-operation	475
Innovation and SMEs	363
Human Resource Potential and Socio-Economic Research	1280
Euratom (Fusion, Fission and JRC part of Euratom)	1260
Joint Research Centre	739
Total	4,117
Total budget, all programmes, for life of FP5	14,960

Source: DG Research

Exhibit 7shows Nordic participations in FP5 for the year 2000. In terms of the total number of participations, Norway has secured between 25% and 100% fewer than the three other Nordic countries with Sweden outstripping everyone. Norwegian participation is strongest in the energy and environment thematic programmes at around one third of all Norwegian participations, where the other Nordic countries have performed better – relatively – in the Quality of Life Programme. In absolute terms, Norway's performance in EESD has matched that of Sweden and come close to Denmark. RCN has recommended that promotional and support activities be stepped up in the other thematic areas.

Exhibit 7 Nordic 'participations' in FP5, for the year 2000

	Denmark	Finland	Norway	Sweden
'Thematic' RTD programmes				
Quality of Life and Management of Living Resources	178	144	88	239
User Friendly Information Society	66	100	60	114
Competitive and Sustainable Growth	79	108	61	199
Environment and Sustainable Development (4A)	64	53	87	78
Energy (4B)	101	44	57	67
Total for thematic RTD programmes	488	449	353	697
Horizontal and other programmes				
International Co-operation	16	13	14	4
Innovation and SMEs	14	11	8	21
Human Resource and Socio-Economic Research	101	49	47	124
Total	131	73	69	149
Total budget, all programmes, for life of FP5	**619**	**522**	**422**	**846**

Source: DG Research

Exhibit 8 shows the same data compiled in a different way, to show relative success rates of applications by country of origin of the lead partners. It is clear from this table that Norway is performing well within the programme in terms of overall application success rate, with only Finland performing markedly better. This suggests that Norway's lower levels of participation in FP5 are the product of fewer submissions rather than under-performance of those submissions. In essence, it reflects the finite resources and capabilities of the Norwegian research base.

Exhibit 8 Application to project award ratios in FP5, for selected countries, for the year 2000

Application with participation from:	number of applications	number of projects	application: project awards, ratio (%)
Finland	1353	399	29.5%
The Netherlands	3233	824	25.5%
Germany	6436	1615	25.1%
France	5213	1304	25.0%
Sweden	2249	560	24.9%
UK	6591	1575	23.9%
Norway	1101	253	23.0%
Denmark	1685	381	22.6%
Spain	4078	889	21.8%
Italy	5012	1083	21.6%
Iceland	146	30	20.5%
Czech Republic	691	138	20.0%
Hungary	654	124	19.0%
Poland	955	148	15.5%

Source: European Commission

Exhibit 9 Number of coordinators within all Norwegian participations in FP5, for the year 2000

Programmes	number of Norwegian participations	number of Norwegian coordinators	% of coordinators
Quality of Life and Management of Living Resources	95	14	14.7
User Friendly Information Society	124	13	10.5
Competitive and Sustainable Growth	147	16	10.9
Environment and Sustainable Development (4A)	125	25	20
Energy (4B)	73	8	11
Total for thematic RTD programmes	198	33	16.7
International Co-operation	14	7	50
Innovation and SMEs	45	3	6.7
Human Resource and Socio-Economic Research	8	0	0
Total	631	86	13.6

Source DG Research

4.2 Relative performance in 4th and 5th framework programmes

Germany, Finland and Italy have increased their share of EU research activity while the Netherlands and Portugal have seen decreases. This is the finding of an analysis submitted to France's ministry for research on 7 November 2001 by the Observatoire des Sciences et des Techniques (OST). The good news for France is that it has increased its share, overtaking the UK in the top rank of EU nations.[13]

According to the study, France is home to 15 per cent of the EU participants in the 1,908 research projects approved to date under Framework 5. France's level of participation has risen by 4 per cent compared with Framework 4, and is second only to Germany (18.6 per cent). In terms of participants it is ahead of the UK (14.8 per cent), Italy (12 per cent), Spain (7.9 per cent) and the Netherlands (6.3 per cent). Comparison with Framework 4 shows that Germany has seen the largest increase in participation (16 per cent), followed by Finland (15 per cent) and Italy (14 per cent). Those member states with a reduced share, include Portugal, with a drop in participation of 30 per cent, the Netherlands (down 19 per cent) and Belgium (down 18 per cent). Countries not in the EU represent 11 per cent of all participants in Framework 5, the largest shares coming from Switzerland and Norway.

Exhibit 10 Share of 'participations'(%)

	Framework 5		Framework 4		
Country	**All**	**EU**	**All**	**EU**	**change**
Germany	16.6	18.6	14.4	16	116
France	13.4	15	13	14.4	104
UK	13.2	14.8	15.1	16.7	88
Italy	10.7	12	9.6	10.6	114
Spain	7	7.9	6.8	7.6	105
Netherlands	5.6	6.3	7	7.8	81
Sweden	4	4.5	4.2	4.6	98
Greece	3.9	4.4	3.8	4.2	105
Belgium	3.5	3.9	4.3	4.8	82
Finland	2.8	3.1	2.5	2.7	115
Denmark	2.6	3	2.9	3.2	91
Austria	2.3	2.5	2.1	2.3	110
Portugal	1.7	1.9	2.5	2.8	70
Ireland	1.6	1.8	1.8	2	89
Luxembourg	0.2	0.2	0.2	0.2	92
Total EU	89.1	100	90.2	100	100
Non EU	10.9	n/a	9.8	n/a	

Source: Analyse des participations françaises au cinquième PCRD, Etude menée par l'Observatoire des sciences et des techniques (OST) pour le compte de la direction de la technologie du ministère de la Recherche, Vincent Charlet, Septembre 2001

Notwithstanding these changes, countries mostly achieve shares within a few percentage points of their relative net national income.

If the share of project coordinators is examined, the UK is found to have the largest share of all EU countries (19 per cent), followed by Germany (18.5 per cent), while France has 14 per cent. Looking closer still, while UK teams coordinate 35 per cent

[13] The OST report is available on the web at http://www.obs-ost.fr/ost_fr/actu.htm

of the projects in which they participate, the share falls to around 30 per cent for Germany, France and the Netherlands, to 25 per cent for Belgium and Italy, and 15 per cent for the three Scandinavian countries. The OST's analysis of relations between countries (based on numbers of projects where both cooperate) shows a tendency for the larger economies to cooperate, but when cooperative intensity is considered (counts multiple participation in projects) the picture changes dramatically and the smaller dynamic economies – Denmark, Sweden, the Netherlands, Ireland – loom large as important partners.

Exhibit 11 Number of 'participations' in the 4th Framework Programme by Member State and by Specific Programme, (1994 - 1998)

Specific Programmes	EU-15	D	D	F	F	No	No	UK	UK
Agriculture & Fisheries	5412	552	10%	740	14%	43	2%	910	17%
Biotechnology	3374	580	17%	547	16%	17	2%	654	19%
International co-operation	3321	460	14%	530	16%	10	1%	603	18%
Environment & Climate	4685	687	15%	616	13%	65	3%	814	17%
Biomedicine & Health	2811	423	15%	447	16%	19	2%	587	21%
TMR	5704	772	14%	1101	19%	68	2%	1493	26%
Marine Research	1345	148	11%	230	17%	44	1%	295	22%
Standards & Testing	2603	456	18%	314	12%	95	2%	476	18%
Non-Nuclear Energy	8018	1255	16%	946	12%	19	1%	1273	16%
T. Socio-Economic Res.	1113	123	11%	135	12%	43	7%	183	16%
IMT	13579	2440	18%	2030	15%	61	3%	2394	18%
Nuclear Fission Safety	1503	325	22%	241	16%			243	16%
Thermonuclear Fusion	750	273	36%	93	12%	12	2%	56	7%
Information Technologies	10513	1817	17%	1649	16%	11	4%	1661	16%
Transport	2505	374	15%	366	15%	71	2%	373	15%
ACT	6722	1100	16%	1033	15%			956	14%
Dissemination of Results	3376	472	14%	456	14%	30	2%	356	11%
Telematics	14680	1954	13%	1922	13%	35	4%	2190	15%
Totals	*92014*	*14211*	*15%*	*13396*	*15%*	*643*	*6.5%*	*15517*	*17%*

Source: DG Research 'Key Statistics' and Commission Annual Report 2000
Note 1: The figures for Norway (No) relate to the period 1994-1995, rather than the whole 4FP where the total number of participations was 865.
Note 2: The blanks relate to EURATOM, which is not included in the EEA Agreement

Exhibit 11 shows the number of participations in 4FP for selected countries and shows that Norway performed at around the 2% level across the programme, but that it went far beyond its 'natural' share in the targeted socio-economic research and transport programmes.

Exhibit 12 shows the change in participation between the fourth and fifth framework programmes. At this stage in the fifth framework, the university sector is at around half of all participations achieved by the same group within the 4FP, while industry is already more than 10% ahead. While this is from a lower base, Norwegian industry participations are now on a par with the research institute sector and some way in advance of the university sector.

Exhibit 12 Change in Norwegian participations between 4th and 5th RTD Framework Programmes, by Type of Institution (1994-1998, 2000)

	4th Framework		5th Framework		Change in share
	%	number	%	number	%
University	36.3	314	23.1	150	-13.2
Institute	37.5	324	36.5	237	-1
Industry	22.1	191	34.8	226	12.7
Govt.	3.4	29	4.3	28	0.9
Number	0.8	7	1.4	9	0.6
Total	100	865	100	650	

Source: European Commission

Exhibit 13 Contract appropriations and participations in the 4th FP 1995-1996: Total programme and Norway's share (shared cost actions)

Specific Programmes	All contracts		Norwegian participation		No of Norwegian participations	
	MNOK	%	MNOK	%	Number	%
Agriculture, fisheries, aquaculture	2,200	6.6	47	6.7	43	6.2
Bio-medicine and health	800	2.7	18	2.6	17	2.6
Bio-technology	2,200	6.8	17	2.4	10	1.6
Communications Technology	1,900	5.8	66	9.4	65	10.1
Dissemination of results - innovation	500	1.6	11	1.6	19	3.0
Environment and climate	2,000	6	49	7	68	10.6
IMT	5,100	15.6	48	7	44	6.8
Information Techn.	7,000	21.2	150	21.4	95	14.8
International co-operation	700	2.1	7	1	19	3.0
Marine research and technology	1,000	2.9	67	9.6	43	6.2
Non-nuclear energy	2,500	7.7	78	11.1	61	9.5
Nuclear fission*						
Standards, measurement and testing	600	1.9	10	1.4	12	1.9
Targeted Socio-Economic Res.	200	0.5	8	1.1	11	1.7
Telematics	2,500	7.7	45	6.4	71	15.6
Thermonuclear Fusion*						
Training and mobilitity	2,600	7.8	44	6.3	30	4.7
Transport	1,000	3.1	35	5	35	5.4
Total	**32,800**		**700**		**643**	

*EURATOM is not included in the EEA Agreement

Exhibit 14 shows the number of collaborations by member state, based on an analysis of FP5 awards to date. There is an emphasis on co-operation with the larger EU-member states, but the distribution is sufficiently consistent to suggest that it is research capacity (demand for research income) that drives the geographic make up rather than relative quality or strategic specialisation of a particular member state's research base.

Exhibit 14 Number of 'participations' in the 5th Framework Programme by Member State, (1999 - 2001)

	Germany	Denmark	Finland	France	Italy	The Netherlands	UK	Sweden
Germany		2.9	4.2	20.4	13.4	8.6	18.7	6.5
Austria	24.7	3.3	3.5	11.7	12.5	5.9	14.3	4.3
Belgium	17.3	3.4	3.3	18.1	11.6	8.1	16.1	4.3
Denmark	15.6		5.4	12.1	8.4	9.2	20.6	7.4
Spain	19	2.8	4.1	16.3	16.1	6	15.6	4.6
Finland	19.8	4.8		10.7	10.1	6.1	16.2	9.3
France	24.4	2.7	2.7		13.5	7.2	19.2	6
Greece	19.2	2.1	3.8	12.8	15.1	5.1	16.2	3
Ireland	15.9	4.6	3.4	11.8	11.7	6.8	20.1	4.6
Italy	20.4	2.4	3.3	17.3		6	17.4	5.2
Luxembourg	10.4	3.3	2.7	18	13.1	6	13.7	3.3
The Netherlands	21.8	4.4	3.3	15.3	9.9		18.7	5
Portugal	17.8	2.5	2.9	16.5	9.1	6.6	14.3	5.6
UK	21.5	4.4	3.9	18.5	13.1	8.4		5.8
Sweden	21.1	4.4	6.3	16.1	11	6.3	16.2	

Source: OST report, op cit

5 Intergovernmental multilateral research co-operation

5.1 Introduction

Intergovernmental S&T co-operation stands apart from international co-operation more generally in that such an agreement denotes the highest levels of significance, from a policy perspective.

Norway, often represented by officials of RCN, is an active participant in most European scientific organisations and several major international organisations with a strong science brief (e.g. International Energy Authority).

Exhibit 15 International scientific agreements and organisations in which Norway participates through the officers of the RCN (2001)[14]

	Scientific organisation	Norwegian commitment (Euro million) estimated
CERN	European Organisation for Nuclear Research	9.9
CGIAR	Consultative Group on International Agricultural Research	5.8
COST	European co-operation on scientific and technical research	
EISCAT	European Incoherent Scatter Facility	0.4
EMBL/EMBC	European Molecular Biology Laboratory	0.7
ESA	European Space Agency	25
ESF	European Science Foundation	0.1
ESRF	European Synchrotron Radiation Facility	0.65
EU 5FP	EU fifth framework programme in RTD	32
EUREKA	EUREKA	
IEA	International Energy Authority	

Depending on the definition used, Norway is a member of more than 30 international schemes and governmental organisations. In terms of numbers of schemes, the majority relate to Nordic countries but Norway is present in many major international scientific organisations such as ESA and CERN.

Taken together, these multilateral initiatives represent a very large and long-term research investment – on the order of 3 billion Euro in Europe and double that globally – which present substantial opportunities to secure both scientific and commercial benefit. The challenge for smaller countries is likely to be one of selectivity – which represent the most important and strategic opportunities – an issue that can be difficult to disentangle in factual terms and all but impossible in political! Nevertheless, it is a real question. A 10 million Euro annual subscription to the European Space Agency, for example, is unlikely to produce much of value for Norway, beyond points for good citizenship, unless it is matched by an

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[14] Norway is a member of several other major international technology undertakings such as the European Centre for Medium range Weather Forecasting (ECMWF) and the European Meteorological Satellite organisation, EUMETSAT. RCN is just one of several agencies involved in CGIAR.

equivalent investment in domestic research and development to exploit ESA programmes.

Historically, the majority of international research co-operation has been focused on the Nordic political grouping though there has been a substantial investment in a wide range of European and international scientific organisations, from CERN to EUREKA. Clearly, those priorities change with time and are be reflected in support for these international research organisations. Norway's participation in the EUREKA programme may be a case in point. In the past 10 years, Norway has moved from a position where it was one of the three most active member states (by a big margin), when judged against the number of 'participations' in newly approved projects to just being one of the member states where in 1999 it was involved in less than the average number of newly announced projects.

Exhibit 16 Distribution of national 'participations' (for selected EUREKA member states) in newly announced projects (NAPs), 1990 - 1999

	1990	**1992**	**1996**	**1997**	**1998**	**1999**
Denmark	7	14	23	41	17	11
Sweden	24	26	30	32	32	16
Finland	28	34	41	25	17	17
Norway	**43**	**35**	**20**	**13**	**27**	**18**
United Kingdom	22	74	40	65	45	19
Netherlands	23	46	49	63	51	47
Germany	74	43	81	82	63	57
Spain	21	30	48	36	70	65
France	46	37	79	80	74	76
Average, for all member states	16	17	24	26	28	22

Source: EUREKA secretariat return to Technopolis questionnaire survey, January 2001.

This may be explained in many different ways, for example, from a more qualitative perspective wherein Norway has finite capacity to participate and there is a periodicity to participation that the aggregate statistics do not reveal. Or that the growth in smaller projects and SME-led initiatives has made EUREKA less relevant in the Norwegian context.

Current policy emphasis has been to build up a much greater presence in European research through national actions to support increased Norwegian participation in the Framework Programme

5.2 Intergovernmental S&T organisations

Intergovernmental S&T agreements tend to be about the creation of critical mass (of interest and capability) in specialised yet strategic areas. They are strongly bottom-up in character offering European scientists and technologists access to funding systems that enjoy a high degree of autonomy from other policy agendas. In the main, they tend to be administered by scientists for scientists, in pursuit of scientific excellence. The S&T agenda is defined bottom up: either wholly in response to demand or through widespread consultation of member state scientists and engineers informed by long-range planning.

They are governed by constitutions that are based on contracts or memoranda of understanding signed by all member countries and as such any material change in mission or budget requires the support of a majority – or even all – member states.

The programmes and institutions have life cycles measured in decades rather than years, which is the case for national administrations, and a high-degree of operational autonomy, where a more flexible approach to scientific administration is believed to be appropriate at the member state level. As a result, the approach to scientific and technical questions is an evolutionary one that achieves equilibrium conditions through extended periods of time.

On the output side, these international facilities and programmes have a consequential impact on science and research at a European level and even globally.

The *raisons d'etre* for intergovernmental S&T co-operation in the various areas are broadly as follows:

- The activity concerned is too costly to be pursued by any member state in isolation. This is the case for ESA and CERN, for example
- To promote co-operation between S&T groups in different member states (COST, EMBL), perhaps where activity is too costly for a single organisation (EUREKA)
- Transnational and co-ordinated service to member states (for example in weather forecasting)

These objectives overlap to some extent, and more than one of them applies to most of the organisations covered here. The organisations are diverse in many of their attributes. Exhibit 17 presents an overview of some important dimensions along which the organisations contrast most strongly.

The diversity of mission and scale provides an important clue to the policy purpose of this type of agreement, which is that they arise on an ad hoc basis where there is a strategic requirement to invest at scale or in concert. Moreover, that requirement is judged by the prospective signatories to the intergovernmental agreement as not being met by existing policies and instruments and unlikely to be addressed in the foreseeable future.

Exhibit 17 Overview of major European intergovernmental S&T organisations

	CERN	COST	EISCAT	EMBL	ESA	ESRF	EUREKA
Type of organisation	Facility	Programme	Facility	Distributed facility	Distributed facility	Facility	Programme
HQ Location	Geneva, Switzerland	Secretariat in Brussels	Kiruna, Sweden	Heidelberg, Germany	Paris, France	Grenoble, France	Secretariat in Brussels
Date set up	1954	1971	1981	1973	1975	1985	1985
Mission	To advance understanding of deep structure of matter	To facilitate concertation of national scientific research in Europe	To advance understanding of the ionosphere and upper atmosphere	To advance molecular biology in Europe through leading edge facilities and research; and advanced training	To promote co-operation among European states in space research and technology and their application	To provide x-ray source for fundamental research in the fields of chemistry, physics, materials and the life sciences	Strengthen European comp by promoting 'market-driven' collaborative RTD in strategic sectors
S&T area	High energy physics	Various	Upper atmosphere	Molecular biology	Space research and research in space	Properties of matter	Various
Main S&T outputs	Publications, research students	Publications, standards	Publications	Publications, research students	Publications, patents	Publications	Patents
Member states	20	32	7	16	14	12	26
Basis for calculating quota	GNP	No quota	Expected use	GNP	GNP	Fixed	No quota
Expenditure (Meuro)	585	12	3.4	65	2650	65	2.5
Number of actions	60 experiments	200 Actions	c 40 experiments	c. 100 experiments	60	Not disclosed	c. 700
Typical action budget, KEuro	100-100,000	60-80	100	100-10500	50000	Not disclosed	2000

Source: Technopolis questionnaire survey of EU intergovernmental organisations, spring 2001

Exhibit 18 Weighting of different S&T goals for European international research organisations

	CERN	COST	EISCAT	EMBL	ESA	ESF	ESO	ESRF	EUREKA
Type of MPRS[15]	LSF	ICS	LSF	LSF	LSF	ICS	LSF	LSF	ICS
Mode of operation[16]	Bottom-up	Bottom-up	Bottom-up	Bottom-up	Hybrid	Hybrid	Bottom-up	Bottom-up	Hybrid
Rules on access[17]	Open	MS	Open	Open	MS	MS	Open	Open	MS
Advance scientific understanding	H	H	H	H	M	M	H	H	L
Advance public/political understanding	L	L	L	L	L	H	L	L	L
Build global S&T capability	H	M	M	H	H	M	H	H	H
Build European S&T capability	M	H	L	M	H	M	L	M	H

[15] The organisations have been allocated to one of two categories, large-scale research facility (LSF) or international co-operation scheme (ICS). The ESF is the main exception in that it is an international scientific association. However, we have included it with the second category for convenience here.

[16] This row classifies each organisation's primary mode of operation. The majority operate in response mode (a mechanism that allows the best quality projects to be chosen within a wide scientific or technological remit, it does not define the goals or outcomes), with several adopting a hybrid strategy with highly specific thematic targets pursued through open competitions.

[17] The organisations fall into one of two categories. Those that are open and permit applications from any research group, whether or not they are located in a member state, and those where only member state researchers are eligible.

5.3 Evolution of intergovernmental S&T organisations

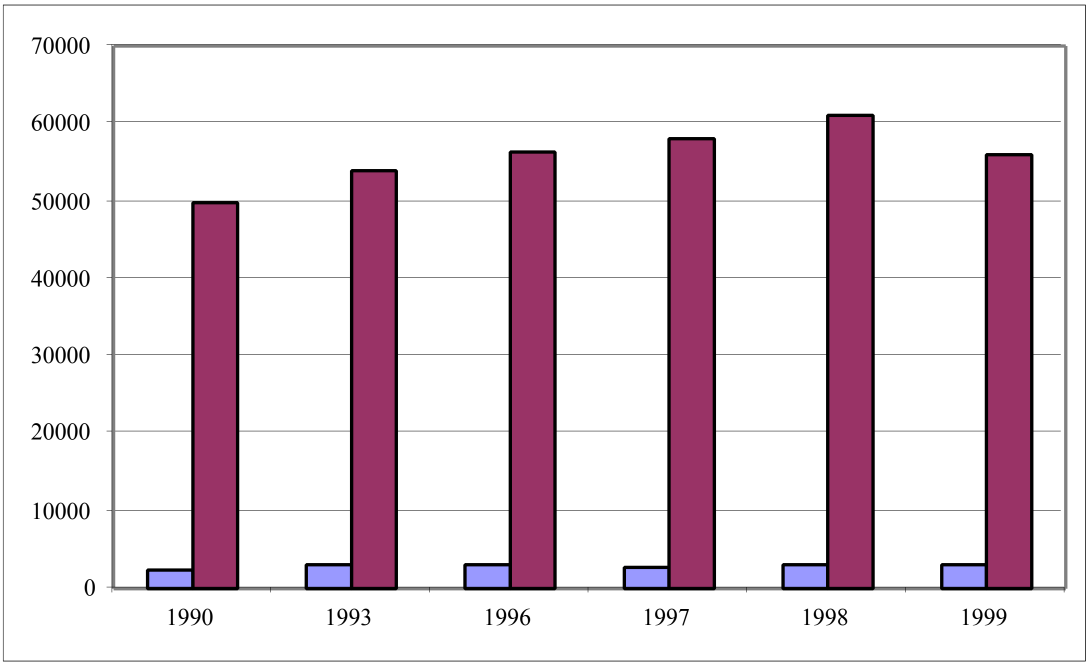
Intergovernmental organisations have emerged in waves, as policy and scientific agendas have moved forward. Policy concerns about national security and energy have been joined (and supplanted to some extent) with concerns about competitiveness and quality of life. The science and technology has evolved too. Large-scale facilities in the 1950s and 1960s in the areas of nuclear and high-energy physics (e.g. CERN and ILL) were followed by major investments in biotechnology and space exploration in the 1970s (EMBL and ESA). The 1970s saw the emergence of several scientific networks (e.g. COST and ESF). The picture of the last 30 years has been one of extension, from big science to big and little science and from large facilities to facilities and networks. Similarly, concern with basic scientific questions has evolved to include technology application and is evolving further to include socio-economic issues.

Demand for access to the facilities and programmes sustained through these intergovernmental agreements is strong and growing. With respect to 'little science', there is evidence to suggest that more areas of the physical and natural sciences are recognising the opportunities presented by access to larger, more sophisticated research facilities. During the period since 1990, the growth in general demand for access to specialist facilities – within and across disciplines – has been accompanied by an escalation in the costs of establishing and maintaining those facilities. Within that context, increased EU (and international) coordination holds out the prospect of securing more cost-effective access to the appropriate state of the art facilities at local, regional or international levels (e.g. Nordic Synchrotron or Nordic Optical Telescope). In addition to increased demand for access to existing agreements and programmes, new intergovernmental agreements are being signed. The Global Biodiversity Information Facility (GBIF) is a case in point. GBIF is a thoroughly modern incarnation of an intergovernmental agreement with its 'virtual' character and a scientific and technical focus directed to societal and sustainability objectives.

The combined income of EU intergovernmental S&T organisations was around 3.2 billion Euro in 1999. Together, the intergovernmental agreements amount to around 5% of total annual government R&D expenditure in the EU. Apart from a dip in 1997, there is a general upward trend of almost 1 billion Euro in the period 1990-1999. Much of this growth occurred in the early 1990s and was driven in large part by expansion at ESA (25% increase) and the ramping up of EUMETSAT activities (300% increase 1990-1993).

Individual EU countries contribute to many of the organisations in proportion to their GDP. As a consequence of this, Germany is the largest contributor overall, followed by France, the UK, and Italy. Of the non-EU countries, Switzerland, providing some 3-4% of the income of several of the organisations, is the largest contributor, followed by Norway (1.5%-2%). Contributions from non-European countries are small in relative terms in all cases though CERN has secured substantial contributions towards the Large Hadron Collider (LHC) from North America, India and Japan.

Exhibit 19 Trend in annual income of 10 EU intergovernmental S&T organisations compared with trend in EU-15 Government R&D Budgets (current Million Euro)



Source: Intergov-10 data were derived from the Technopolis questionnaire survey, spring 2001. The Government figures are EUROSTAT GBAORD figures from R&D Annual Statistics 2000.

Most intergovernmental organisations operate some means of dual funding, whereby member states will contribute to the capital and operating costs of the programme or facility on something approaching an 'affordability' basis, while financing particular research activity on a 'user pays' basis. For ESA, this is achieved through the operation of mandatory and optional programmes (split 25:75). For facilities like CERN, EMBL, ESRF, ILL a core group of member states finances the operation while the research itself is defined through open international competitions with most of the staff costs and project-specific capital (e.g. instrumentation) paid for by the scientists' member state. For COST and EUREKA, a member state has the option to choose to endorse and or sponsor its domestic scientists and engineers' participation in a multilateral proposal, on a case by case basis.

The total number of research staff increased from 2486 in 1996 to 2621 in 1999, which is less than 1% of the total population of public sector researchers in the EU. The total number of researchers employed by these intergovernmental organisations has increased by around 5% in the period to 1999, whereas total public sector research employment in the EU has grown much more quickly in the same period by around 34%. In this sense, the intergovernmental organisations have become less important as direct employers of researchers in the EU during the 1990s. However, the relationship between employment and research activity is not a linear one and people that are not employees conduct much of the research that is facilitated by these intergovernmental organisations. This is evident in the different trends for the 10 organisations' contribution to EU R&D expenditure (stable at around 5% of total EU spend) as compared with R&D employment.

Exhibit 20 Trends in budgets and membership of European MPRS

	CERN	COST	ECMWF	EISCAT	EMBL	EMBO	ESA	ESF	ESO	ESRF	EUMETSAT	EUREKA	ILL	NI
MPRS Budget, (1999 Meuro)	585	15	32.9	3.4[18]	65	15	2650	6.5	93	65	2630	2.5[19]	55	7.33
MPRS Budget, trend in past 5 years	↘	→	↗	↗	→	↗	↘	→	↗	→	↗	↘	→	↘
MPRS Budget, trend in next 5 years	→	↘[20]	↗	→	→	→	→	→	↗	→	↘	↗	↗	↘
Number of member states, (1999)	20	32	18	7	16	24	14	22	8	12	19	26	3[21]	5
Membership changes, (last 5 years)	↗	↗	→	↗	↗	↗	↗	↗	→	→	→	↗	↗	→
Future membership, (next 5 years)	↗	↗	→	↗	↗	↗	↗	↗	↗	↗[22]	→	↗	↗	→

18 Data for EISCAT and ESRF refer to year 1998

19 This is an estimate, as the official figures are not published.

20 The COST budget for 1999 until end 2002 has been allocated so that the reduction compared to 1998 is not dramatic, to ensure current commitments can be met. But the budget has been cut compared to the previous five-year period and so for 2000-2002 the annual budget will be rather lower at around 12 million Euro.

21 The ILL has three core members and there are no plans to add to this group. However, ILL scientific membership has increased in the past five years and ILL is in negotiation with a number of third parties that have expressed an interest in joining as new scientific members.

22 ESRF does not foresee an increase in the number of its Core Members, but does expect steady expansion in its second category of member – 'scientific member.'

Specifically, significant increases occurred at CERN (up 105 to 1030), ESO and ESRF. Expansion at these major employers has been offset by a steady reduction in ESA's scientific staff in the period since 1993. CERN also saw a significant increase in its research students over the period (from 140 to 215, but a significant drop in its technicians (1129 to 946) and, even more dramatically, in its 'other staff' (662 to 289). EMBL saw a rise in technicians and students, while ECMWF and EISCAT showed little change in any staff categories.

Exhibit 21 Scientific Research Staff 1990-1999 (head count)

	1990	1993	1996	1997	1998	1999
CERN	831	876	925	949	1000	1030
ECMWF	34	35	35	35	36	36
EISCAT	5	5	4	4	4	3
EMBL			109	107	101	102
ESA	1167	1266	1145	1116	1092	1083
ESO		56.1	60.2	67.1	74.7	80.6
ESRF	66	147	208	213	221	238
			4482.2	4488.1	4526.7	4571.6

Source: Technopolis questionnaire survey of EU intergovernmental organisations, spring 2001

Researchers are overwhelmingly EU nationals. Most of those that are not EU nationals are from other European countries, notably Norway and Switzerland. Typically, less than 2% of staff are non-Europeans. Posts tend to be awarded to member state scientists, often in line with the proportion of financial support. Competition for research is more open geographically and the regional profile of research students and research visitors is more mixed. There are issues with employment law too, which make it less easy for these organisations to employ directly non-Europeans.

The organisations facilitate or sponsor R&D in a wide range of scientific disciplines and fields, from economics of standardisation (COST) to solar physics (ESA). The profile of activities is broadly stable across the period 1990-1999, which reflects the ability of these intergovernmental agreements to commit policy makers and scientific communities to long-run periods of investment.

Most of the organisations have shown an increase in publications over the period, CERN in particular showing a significant increase. Intergovernmental organisations report very little income arising from the commercialisation of intellectual property (e.g. sale of licences or royalties). The absence of data for the majority is not unduly surprising, as the ownership of the Intellectual Property (IP) will tend to rest with the project participants – and often their employers – rather than the intergovernmental organisation. This situation has meant that the subject is not tracked systematically by the intergovernmental organisations in question.

Intergovernmental S&T organisations are among the largest employers of research staff in the EU and EEA and as such it is important to understand the evolution in their role as employers, incubators (for students) and forces for attraction of new students and world class scientists. In particular, as international centres of excellence – with the intellectual and financial conditions to match – they play a central role in attracting and retaining world class scientists and engineers within the European labour market. Most of the organisations believe that they have the potential to play an even more significant role in the realisation of the policy objectives set out in the Communications, 'Towards a European Research Area, for example through:

- Introducing a European dimension into the careers of a larger proportion of EU researchers
- Making the EU a more attractive base to an increasing number of the best researchers from the rest of the world
- Improving the volume, quality and efficiency of post-doctoral research training

Seven of these organisations have set up a coordination and collaboration group (EIROFORUM) with their top executives (Directors General or equivalent) as members. They include CERN (particle physics), EMBL (molecular biology), ESA (space activities), ESO (astronomy and astrophysics), ESRF (synchrotron radiation), ILL (neutron source) and EFDA (fusion, not covered in this report). According to the EIROFORUM Charter, the main aims of the collaboration are to:

- Encourage and facilitate discussions among its members on issues of common interest, which are relevant to research and development.
- Maximise the scientific return and optimise the use of resources by sharing relevant developments and results, whenever feasible.
- Co-ordinate the education outreach activities of the organisations, including technology transfer and public understanding.
- Take an active part, in collaboration with other European scientific organisations, in taking a forward-look at promising and/or developing research directions and priorities, in particular in relation to new large-scale research infrastructures.
- Simplify high-level interactions with the European Commission (EC) and enable an effective response to specific requests for expert advice in the areas covered by the member organisations.
- Provide co-ordinated representation to the outside world including the general public, national governments, non-European countries etc.

EUREKA is concerned primarily to seed projects that will lead to the creation of pan-European strategic technologies. It operates on a 'bottom-up' basis, with projects initiated by participants themselves. To the extent that projects are publicly funded, the finance is arranged by individual Member States.

6 Bilateral R&D agreements

6.1 Introduction

Intergovernmental bilateral R&D agreements are formal contracts, treaties or memoranda of understanding between national administrations in two countries, which are concerned to promote increased research co-operation between the scientific communities of the partners, either exclusively or as one of several key policy goals. Each agreement is based in a written, declaration signed by a senior official of a government department or national scientific administration.

Intergovernmental bilateral R&D agreements fall into one of two broad categories:

1 *Goodwill* agreements, where the motivation is to express a willingness to collaborate, and to facilitate collaboration, over a broadly specified range of scientific and or technological areas
2 *Strategic* agreements*,* which have a specific scientific objective of strategic importance to the parties. This type of bilateral agreement includes joint facilities and joint research centres

Intergovernmental bilateral R&D agreements foresee a range of types of international research co-operation, including:

- Exchange visits and fellowships for researchers, for study and research, where travel costs (and perhaps living expenses) are provided
- Joint research projects, where researchers will typically do most of their own work in their own country
- Organisation of scientific and technological meetings or workshops, including the provision of training
- Arrangements for the exchange of scientific and technological information, not necessarily involving the movement of people
- Joint development and or sharing of infrastructure or facilities, to take advantage of 'economies of scale' and avoid wastage caused by unnecessary duplication of effort in the countries involved.

In practice, the majority of agreements are directed to researcher mobility in one form or another, from study visits to seminars. Within these types of network-building activities, support might be in the form of a general stipend, or be restricted to a particular source of expense such as travel. The latter dominates. These financial rules make it less likely that joint research projects (or programmes) will emerge under the auspices of the agreements.

Exhibit 22 shows an agreement between the Swedish Medical Research Council and the Netherlands Council for Medical and Health Research concerning incentive grants for collaboration between Swedish and Dutch researchers. While the agreement is unusual in that it indicates an annual budget and the number of awards anticipated, it is typical inasmuch as the emphasis is on support for researcher mobility (in any subject within health research). Plus, this particular MoU provides a good example of the frequency and scale of co-operation that is anticipated by such international agreements.

Exhibit 22 Memorandum of Understanding between the Swedish Medical Research Council and the Netherlands Council for Medical and Health Research

Collaboration between Swedish and Dutch researchers in Medical and Health Research

To stimulate collaboration between research groups in Sweden and the Netherlands in the fields of clinical research and epidemiological research, by awarding grants for travel and living expenses for short research visits. Grants are available for joint meetings with and short (minimum stay one week, maximum stay three months) research visits to the collaborating group.

Budget
Yearly at least 40,000 Dutch guilders and 155,000 Swedish Kroner respectively will be made available by the councils. Each council finances its compatriots.

Application
Applications can be done once a year, deadline 1 March. Swedish and Dutch groups that want to collaborate apply simultaneously, each to their national council. The application contains:
A Names of collaborating research groups and participants
B Intended research program, experimental approach and practical investigation scheme
C Purpose of collaboration and the motivation for collaboration with that particular research group
D Requested support.

Selection
Each council sends each application to at least two peers to review the research program and intended collaboration. A small group of representatives of both councils rates the applications in categories A (to be funded), B (to be funded if budget available) and C (rejected) – based on the total impression of the parallel applications and reviews – and makes the final selection and decides about the amount to be awarded.

Financial support
Each selected proposal receives funding for two years. The amount is not fixed although an indicative maximum of 15,000 Dutch guilders or 60,000 Swedish Krone per council might be considered. This indicates that yearly about six to eight applications can be awarded.

Evaluation
After three years the co-operation will be evaluated.

Exhibit 23 outlines the purpose and arrangements associated with a research co-operation agreement between Norway and South Africa. It is interesting in that the programme envisaged will sponsor collaborative research projects – not just research visits – in several areas of strategic importance for Norway (e.g. aquaculture) where South Africa has a good research tradition as well as in topics of more immediate relevance to South Africa.

The majority of agreements are based on memoranda of understanding rather than legal contracts; the former is easier to create and more flexible than the latter. On the other hand, an intergovernmental treaty in law brings a number of benefits compared with a Memorandum of Understanding, notably it permits the signatories to create legal entities (to run the secretariat, laboratory or whatever) that are incorporated in international law. An international body can provide both parties – and their research constituencies – with privileges and immunities that do not hold at the national level with respect to rules on personal tax, employment, intellectual property and so on.

There are national preferences at work too, so for example, the German government and national research administrations have a preference for legal contracts while the Sweden, Norway and Finland prefer MoUs. In addition, there is some correlation between legal formality and the small number of strategic and facility-oriented agreements, many of which are based on legal contracts with more specific goals.

Exhibit 23 Memorandum of Understanding between the Norwegian Agency for Development Co-operation and the South African Government

Norway and South Africa research co-operation agreement

A four-year research co-operation programme was signed on Thursday 22 of November 2001 between the South African Government and NORAD (Norwegian Agency for Development Co-operation), as representative of the Norwegian Government.

The programme will provide financial support for common Norwegian/South-African research projects. It is intended to lay the basis for a sustainable research co-operation between the two countries that will last beyond the period of NORAD assistance.

NORAD is contributing NOK 30 million towards the programme, while relevant ministries in South Africa (e.g. DACST) will contribute directly into the different aspects of the programme, with the intention of matching the Norwegian sponsorship. The programme will concentrate on themes of common research interest in the two countries, including the following:

- Health and Medicine
- HIV/AIDS
- Information and Communication Technology
- Aquatic Research
- Environment, Ecology and Energy
- Governance, Democratisation and Social Development
- Economic Growth and Globalisation
- Education

The National Research Foundation in South Africa and the Research Council of Norway will be responsible for implementing and administering the programme.

6.2 Expenditure on R&D co-operation within bilateral agreements

The annual volume of cooperative activity taking place within the terms of these agreements is estimated to be around 200 million Euro.[23] This figure is dwarfed by domestic R&D activity and amounts to less than 5% of all international cooperative R&D expenditure. For the several countries that do have aggregate data for R&D

[23] The estimates are based on a very partial data set and, while we believe them to be indicative, they must be treated with care. Estimates may be subject to sizeable errors due to difficulties associated with grossing up (using ratio estimation with government R&D expenditure as the auxiliary variable) and mis-reporting of expenditure, as a result of uncertainties with respect to our definition of an intergovernmental bilateral agreement).

expenditure that occurs within the terms of a formal bilateral agreement, the figures are modest by comparison with total government expenditure on R&D. For example, Belgium committed around 5 million Euro in 2000 while in Finland, the equivalent figure is estimated at less than 3 million Euro, which contrasts with an annual spend of around 250 million Euro in 2000 for *all* international R&D co-operation. The larger figure includes bilateral programmes, multilateral programmes (e.g. for ESA) and an attribution for Finnish contributions to the EU RTD Framework Programme. At the other end of the spectrum, we estimate the equivalent annual expenditure figure for Germany to be around 50 million Euro.

From the limited data available, the number of bilateral R&D agreements appears to be stable at the EU level. This is in contrast to trends international co-operation in research generally, in both the academic and the business sectors.[24] There are indications of an increase in the use of bilateral agreements within science policy when one considers individual EU member states and regions: Italy, Spain and Portugal have increased their attention to international co-operation in the past three years. Formal bilateral agreements are singled out as an important policy instrument within a broader commitment to increase the level of national engagement with relevant international communities. Each of these three countries has stated that the number of bilateral R&D agreements concluded in the three-year period to June 2000 had increased over the previous period and that the stock of current agreements had increased. The situation appears to be broadly stable in the US too. In contrast, international co-operation is in the ascent in Japanese policy circles, albeit from a low base compared with the situation in the US or EU and policy interest in bilateral S&T co-operation agreements is increasing (though still limited).

6.3 Bilateral R&D co-operation policy

EU member states make only limited use of formal bilateral R&D agreements, *goodwill* or *strategic*.

In science policy terms, bilateral agreements tend to be a residual category of mechanisms to promote international research co-operation where a formal agreement is deemed to be necessary and no relevant agreement exists; either

- Where national researchers have demonstrated, in principle at least, the scientific value of strengthening relationships and networks with non-national researchers resident in a country with which there is no applicable agreement (e.g. multilateral scientific or bilateral trade). In some Asian and Central and Eastern European countries, there is a presumption on the part of national scientific administrations that government can only sponsor its national researchers' participation in international projects where there is a current intergovernmental R&D agreement in place.[25] In part, this reflects a presumption that government

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24 See Chen, S H (1997) "Decision making in research and development collaboration" *Research Policy,* 26, 121-135 and Hicks, D and Katz, S (1996) "Science Policy for a highly collaborative science system", *Science and Public Policy*, 23, 39-44.

25 In most cases, governments agree to finance only those eligible costs incurred by their national research teams, though there are exceptions. Austria for example has several bilateral agreements with central European governments where it is foreseen that the Austrian scientific administration will bear 2/3 of the total eligible costs associated with the collaboration. Similarly, Japan has tended to finance a high proportion of the total costs of co-operation. The

should be in a position to regulate all international co-operation. In addition, there is a tendency for these emerging economies to use agreements as a means to persuade partners to set aside a dedicated budget.[26]

- A joint venture that is of strategic importance – and will involve a high level of commitment and or investment to succeed – and yet falls outside the scope of existing multilateral and bilateral agreements with the envisaged partner country

There is a divergence between member states in the North and those in the South, with respect to the importance attached to *formal* intergovernmental R&D agreements. In the South, international co-operation is a focal point for policy makers who are concerned to build national capability and strengthen their presence in the European and international scientific panorama. In the North, most devote comparatively little effort to formal co-operation agreements at the national level, because there are more direct and cost-effective means through which to ensure their research communities maintain an international perspective. Germany and France are the main exceptions, each of which maintain a high proportion of bilateral R&D agreements with a specific scientific focus and set of policy objectives.[27]

6.4 National profiles of bilateral R&D agreements

One can see markedly different profiles of bilateral agreements across the EU member states, which suggests that:

- Cultural ties and colonialism play a significant part in the profile of bilateral agreements, with the French case being typical in that there are several agreements with Morocco and Tunisia or the Netherlands and Belgium (Flanders region) having agreements with South Africa.
- Geographical proximity is an influence. This factor is more pronounced when we consider individual agreements rather than agreements grouped by region. So, for example Finland has a high degree of collaboration with the ex-USSR and the Netherlands has a high proportion of agreements with regional governments in countries with which it shares a border (e.g. Belgium, Germany). This factor can work in the opposite direction too. As an example, there are no formal bilateral agreements between Germany and Austria even though they are neighbours and Germany is Austria's most important foreign partner. Similarly, there is no current bilateral agreement between the USA and Canada

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majority of bilateral agreements will cover the costs of travel, subsistence and some equipment. Proportionately few agreements pay salary or overhead costs.

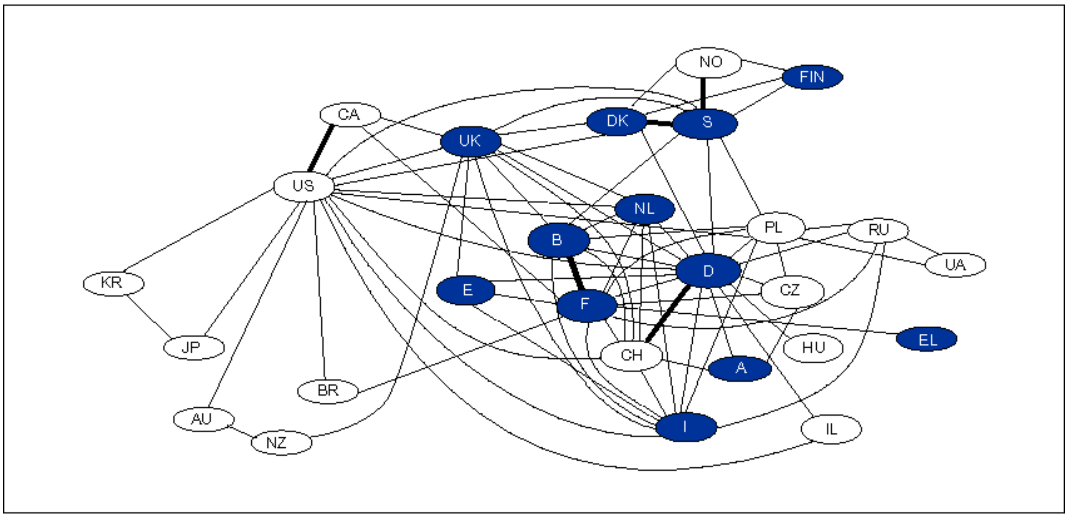
[26] Where there is no predefined budget, bilateral proposals have to compete on equal terms with national and international bids. The allocation of a budget to a bilateral agreement means that competition will operate between programmes rather than projects and that the agreement ought to be able to sustain a higher level of activity as a result.

[27] The differences are driven by many factors, most of them seemingly external to bilateral R&D co-operation. For example, the funding rules of national administrations may differ so while Denmark, The Netherlands and France will subsidise the entry of EU research students to their universities this is less the case in the UK or Italy. Indeed, in the UK the emphasis is on recruiting non-EU students as they pay fees that are wholly additional to national institutional funding. Equally, other policy issues can impact internationalisation so education policy in France and industrial policy in the UK both tend to encourage students (including research students) to seek out positions in nationally-located businesses.

- Ireland, Portugal and Sweden have a relatively high proportion of intra-EU agreements (more than 40% of a small total). Other EU member states are more reliant on the CEC RTD Framework Programme and multilateral agreements such as EUREKA or COST or CERN
- France, Germany and Spain, have a below-average representation with Central and Eastern Europe and the countries of the former Soviet Union
- Germany has an unusually large number of agreements with the USA
- Co-operation with central- and Eastern-European countries is largely for foreign policy reasons, to assist with their future integration into the EU
- Far-Eastern 'emerging' economies are favoured partly because of their economic position as expanding markets, and partly because of their technological dynamism – close contact with them is regarded as competitively advantageous
- Both groups of countries are more inclined than most Western industrialised economies to enter into formal agreements, sometimes as a means of facilitating the funding of international co-operation within their own countries. It is easier for researchers to get permission to travel where such an agreement exists.

Exhibit 24 reveals patterns of copublication (co-authorship) for those countries with a national publications output of at least 2,500 publications in all fields combined in 1995. Links stronger than 5% are indicated by bold lines, while links stronger than 2% are indicated by solid lines (ie all other links shown). The position of the countries represents largely a 'natural' geographic order. For several EU-15 member states intra-EU co-operation is more important than is co-operation with the US. Within the member states, one can obsever strong groups between language groups, for example, Denmark, Norway and Sweden.

Exhibit 24 Co-publication patterns of the most active countries (1995)



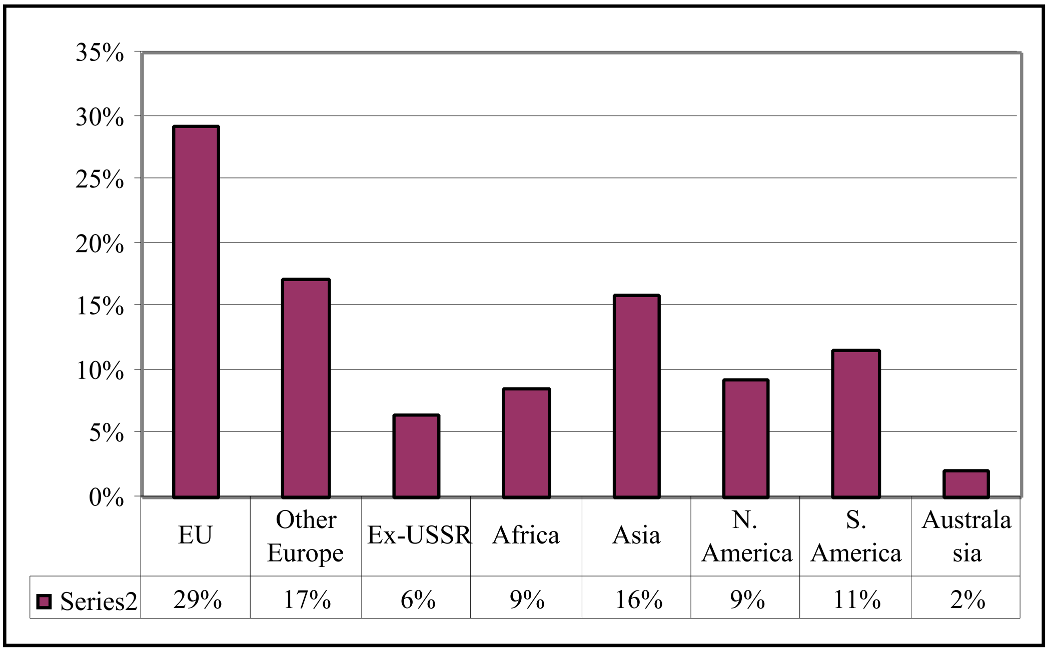
Source: Wolfgang Ganzel, 'Science in Scandinavia: a bibliometric approach', Scientometrics, Number 48, June 2000.

6.5 Distribution of EU bilateral R&D agreements

A count of the 'Numbers of agreements' is a long way from being a perfect measure of the quantity and quality of collaboration that occurs under these formal bilateral agreements.[28] However, it is the one group of data that scientific administrations maintain in a consistent and comprehensive manner and does provide a worthwhile indicator with which to gauge the differing motives and priorities.[29]

Exhibit 25 shows that the majority (c 50%) of all EU bilateral R&D agreements involve two European countries, though links with Asia are numerous too. Though not shown here, there is a degree of concentration within these regional blocs. China, Korea, Brazil are dominant partners within their regions and are attractive as large emerging markets, while Japan is a scientific and technological leader in many research areas. Regarding the Africa/Middle Eastern bloc, Israel (with 25% of EU bilateral agreements) stands out and South Africa is increasingly important too; no other partner country in the region approaches this number of agreements.

Exhibit 25 Regional distribution of all EU bilateral R&D agreements (2000)



Source: Technopolis survey of officials at EU national research administrations, summer 2000.

6.5.1 Distribution of member state agreements, by region

Exhibit 26 shows the number of bilateral agreements for each EU member state, grouped by region in the world. The diversity of nations with which EU countries have bilateral agreements is wide. In addition, Exhibit 26 shows that Germany has more active bilateral R&D agreements – with all countries – than is the case for any other EU member state. In addition to Germany, France, Spain and the UK have 100

[28] For example, Japan's agreements with the USA underpin perhaps as much as 100 times more research activity than would be the case for the bilateral agreements it has concluded with China. Equally, Finland concluded identical framework agreements with China and South Korea at roughly the same time, but the former agreement has resulted in around ten times more cooperative ventures than has been the case for the latter.

[29] In several EU member states, a high proportion of bilateral agreements have been in existence for several decades and have become "facts of life," which are not promoted actively and encourage a minimal amount of cross-border co-operation. On the basis of rather too few data points, we can speculate that as much as 25% of all bilateral R&D agreements may be dormant.

or more agreements. If one were to weight the number of agreements by national government expenditure on R&D, Germany and Spain are dominant and formal bilateral agreements are less common in the Nordic.

Exhibit 26 Number of bilateral R&D agreements, EU Member State – World Regions (June 2000)

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	UK	TOTAL EU
Other Europe	18	22	3	0	23	28	8	2	19	0	5	2	22	1	17	170
Ex-USSR	7	6	3	1	5	9	3	0	8	0	2	0	5	1	14	64
Africa	4	2	0	0	24	20	0	0	14	0	1	4	10	0	6	85
Asia	10	14	0	3	22	54	1	0	14	0	6	2	3	3	26	158
N. America	3	5	0	1	9	54	0	1	4	0	0	4	3	1	7	92
S. America	1	18	0	0	26	23	0	0	10	0	0	4	28	0	4	114
Australasia	1	0	0	0	6	6	0	1	2	0	2	0	0	1	1	20
Total exc. EU	44	67	6	5	115	194	12	4	71	0	16	16	71	7	75	**703**
EU	18	14	3	4	52	46	11	10	16	0	16	16	41	12	31	**290**
TOTAL	**62**	**81**	**9**	**9**	**167**	**240**	**23**	**14**	**87**	**0**	**32**	**32**	**112**	**19**	**106**	**993**
% exc-EU	71	83	67	56	69	81	52	29	82	0	50	50	63	37	71	71
% EU	29	17	33	44	31	19	48	71	18	0	50	50	37	63	29	29

Source: Technopolis survey of officials at EU national research administrations, summer 2000.

The ratio of EU-EU agreements to EU-rest of world agreements is typically 30:70 in favour of the links with the rest of the world. Ireland and Denmark have an inverse ratio, which may reflect the pattern of historical relationships.

Exhibit 27 Number of bilateral R&D agreements, EU Member State – EU Member State (June 2000)

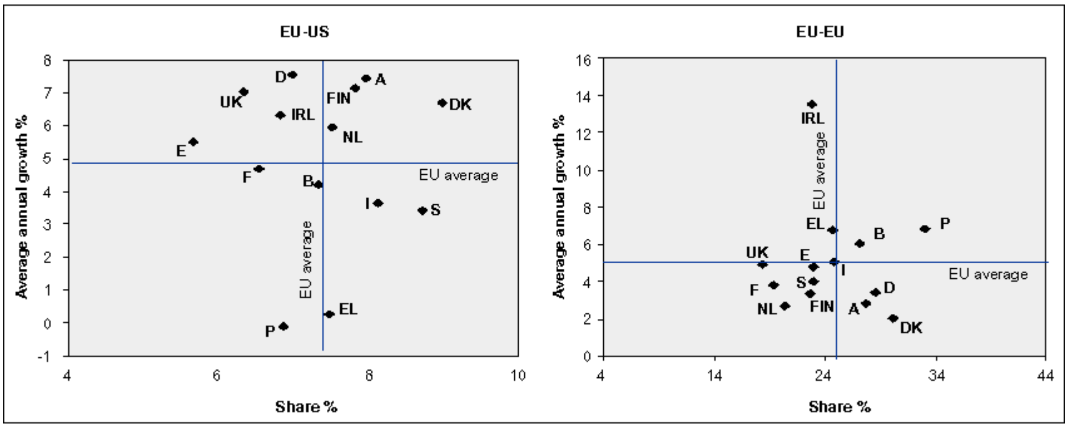
	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	UK	TOTAL EU
Austria	0	1	0	1	2	3	0	1	2	0	1	0	3	1	3	**18**
Belgium	1	0	0	0	6	0	0	0	1	0	1	0	1	0	4	**14**
Denmark	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	**3**
Finland	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	**4**
France	2	6	1	2	0	11	2	2	4	0	4	5	6	3	4	**52**
Germany	3	0	0	1	11	0	4	1	1	0	5	2	9	5	4	**46**
Greece	0	0	0	0	2	4	0	0	1	0	0	0	3	0	1	**11**
Ireland	1	0	0	0	2	1	0	0	1	0	0	0	1	0	4	**10**
Italy	2	1	0	0	4	1	1	1	0	0	0	1	4	1	0	**16**
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Netherlands	1	1	0	0	4	5	0	0	0	0	0	0	2	1	2	**16**
Portugal	0	0	1	0	5	2	0	0	1	0	0	0	6	0	1	**16**
Spain	3	1	0	0	6	9	3	1	4	0	2	6	0	0	6	**41**
Sweden	1	0	0	0	3	5	0	0	1	0	1	0	0	0	1	**12**

UK	3	4	1	0	4	4	1	4	0	0	2	1	6	1	0	**31**
TOTAL	**18**	**14**	**3**	**4**	**52**	**46**	**11**	**10**	**16**	**0**	**16**	**16**	**41**	**12**	**31**	**290**

Source: Technopolis survey of officials at EU national research administrations, summer 2000.

Turning to scientific co-operation with the USA, Exhibit 28 shows Denmark, Austria, Finland and the Netherlands to be the EU member states where levels of co-operation – as indicated by co-authorship – exceeds the EU-15 average, both in percentage terms and in rate of growth. In terms of EU-EU co-operation, Portugal, Belgium, Greece and Italy stand out because of the relatively high proportion co-publications with other member states and the high rates at which that co-operation is growing.

Exhibit 28 Growth and share of co-publications between the US and Member States and between Member states, 1988-1997 (%)



Source Research DG

Notes: Average annual growth and shares are calculated for the whole period 1988-1997. A country's share of all EU-EU co-publications is the percentage of all EU-EU co-publications in which a researcher based in that country is a co-author (and for EU-US).

7 International researcher training and mobility

7.1 Prompts for interviews on 4.12.2001

We have case studies on the UK and the US, but we have obtained very little information on Norwegian policy and schemes nor those of the RCN.

The RCN has its International stipend programme, which covers several types of exchange (short and long term) for new post doctoral fellows and more experienced (but younger than 40). There are bilateral agreements with almost 40 countries in a range of geographical regions from the Baltic to the Americas. There are several other bilateral fellowship programmes, too, such as the STA-stipend (Japan) or the Ruhrgas-stipend (Germany). In addition, Norway makes active use of the researcher training and mobility schemes of the European Commission (e.g. Research Training Networks, Marie Curie Fellowships).

The RCN web site provides some partial data on activity and expenditure levels, but not sufficient to estimate total activity with respect to international researcher training and mobility.

7.2 United Kingdom

Compared with other EU member states, the UK is in a strong position in terms of attracting international students/researchers. The strength of the science system, along with the presence of both reputable universities and centres of excellence has meant a steady inflow of researchers into the system.

Policies to attract international researchers consist mainly of efforts to ease rules of immigration and obtaining work permits. However, there is a large budget allocated to the funding of foreign researchers in the UK, which improves the opportunity and in turn the numbers of researchers that gain positions within the UK. This is needed, as tuition fees paid by foreigners can be double those for UK and EU nationals.

The UK is spending roughly £270 million[30] (423 MEUR) on 'national' students (which include students from other EU countries, which have to be treated as nationals due to EU non-discrimination rules). However, statistics show that 6% of all 'national' students come from other EU member states, thus, by removing 6% out of the £270 million British students receive approximately 398 MEUR. This is for all graduate students, not only PhDs. Adding up the amounts spent on foreign students, (roughly 90 M Euro) plus 8 MEUR over three years for the international marketing campaign, we calculate that the UK spends just under 100 million Euro on foreign students. Despite having universities with a world class reputation already, Britain continues to invest substantially in measures to attract and support foreign graduate students.

[30] Information made available from the Department for Education and Employment and the British Council

The most active institution in the field of promotion is the British Council, whose task it is to promote education in the UK abroad, to advertise its grant schemes, to select people to come to the UK, and to assist UK scholars wanting to study abroad. The Royal Society and the British Academy also support foreign researchers in the natural and the social sciences respectively. In addition, the six UK Research Councils offer a limited number of grants to international students. However, most of their researcher mobility activities are geared towards assisting UK researchers secure placements and visiting fellowships abroad. In addition to these national funding organisations, most individual universities offer a variety of support schemes to attract international students.

Britain's past and present efforts to support foreign students and graduates are strongly linked to its colonial history and its diplomatic missions. In a 1999 speech, the British Prime Minister Tony Blair confirmed his commitment to attracting more international researchers to the UK. In his view, foreign researchers *"promote Britain around the world, helping our trade and our diplomacy. It is easier for our executives and our diplomats to do business with people familiar with Britain."*

However, in the most recent Science and Technology White paper issued by the Department of Trade and Industry (DTI) in July 2000, the only new measures to attract foreign scientists and engineers relate to the selective easing of the conditions applied to people from outside the EU-15 seeking work permits. The most important points concern:

1. The streamlining of the visa process
2. The improvement of work permit applications: Researchers who qualify for a work permit should be able to get one without leaving the UK
3. The removing of the requirements for separate permits for supplementary work: Foreign academics should be able to work more easily in the private sector, for example as consultants or entrepreneurs

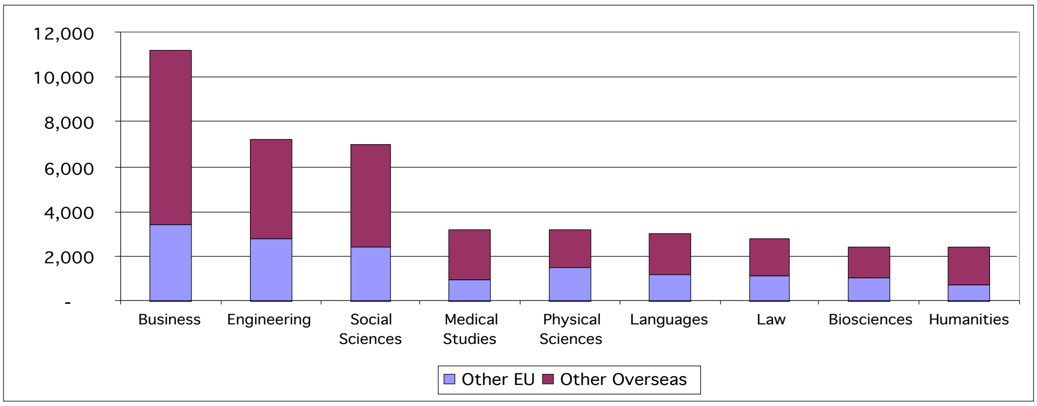
7.3 Research System

38% of all full-time postgraduates[31] in the UK are foreign and 36% of these come from other EU-countries. The bulk of non-EU international researchers come from the Commonwealth. More than 7000 foreign postgraduates pursue studies in both Engineering and the Social Sciences, followed by lesser numbers in Medical Studies, Physical Sciences, Languages, Law, Bio-sciences and the Humanities (Exhibit 29 shows this distribution).

In terms of the institutions attracting the most international postgraduates, the London School of Economics is the pre-eminent institution in the UK, followed by Oxford and Cambridge. However, universities such as Birmingham, Warwick and Manchester also rank high in that respect. Exhibit 30 shows the top 10 universities in attracting foreign students.

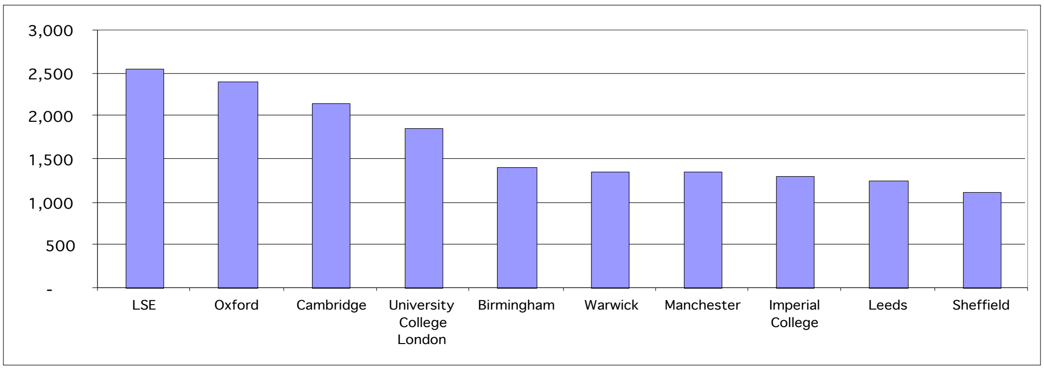
[31] In the UK, the term postgraduate is used to describe students having completed their first degree and engaging in further studies towards either a Master's or a Doctoral degree. A postdoctoral researcher is a member of academic staff involved in research who has completed their doctoral degree.

Exhibit 29 Number of non-national post-graduate research students in the UK (full time), by Subject of Study (1999)



Source: Higher Education Statistics Agency (HESA)

Exhibit 30 Top Ten Recipient Universities (by Total Number of non-national Postgraduates)

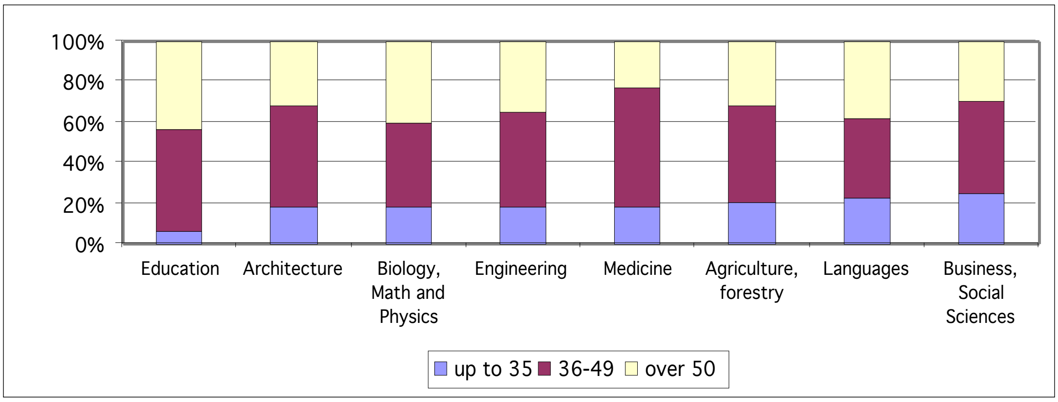


Source: HESA

Foreign students in the UK pay higher fees than UK and EU students, who pay a 'home fee'. The international fee is sometimes considerably higher than the home fee. At Cambridge University, for example, postgraduates from the UK and the EU have to pay £2,740 (4,300 EUR) in tuition fees, while non-EU students are charged £7,000 (11,000 EUR) or more, depending on the subject.

Exhibit 31 looks at the age profile of academic staff broken down by their subject groups, each subject group is further broken down by staff pay scales. The area of education is particularly affected, and the figures indicate there will soon be a crisis in teacher training provision. The age profile of academic staff in subjects needed for the 'knowledge based economy' – such as biological, mathematical and physical science, and engineering and technology – is also of concern. However, at this point not much has been done, and the only solid initiative has been early retirement packages, which have been introduced at some universities. This apparent lack of will to address the problem is manifested in the most recent Science and Technology White paper, which does not mention the problems related to the age profile of academic staff, the level of their pay or their increasingly casualised careers.

Exhibit 31 UK Academic Staff Age Profile 1997-1998



Source: Association of University Teachers, 2000

7.4 United States

Foreign born scientists and engineers contribute significantly to the the United States (US). According to a National Science Foundation (NSF) brief[32] 29 percent of doctoral students conducting R&D in 1993 were non-nationals: Exhibit 32 shows the breakdown of the sector and location of these scientists. There is a large percentage (overall 68%) of foreign-born scientists engaged in R&D who gained their education at an American institution.

The large foreign component of US human intellectual capital has been linked to the ability of US higher education to attract, support, and retain foreign students.

Exhibit 32 US and foreign-born scientists & engineers in R&D, in the US by sector and location of S&E degree (1993)

	Total		Education		Industry		Government	
Scientists & Engineers in US R&D	All degree levels	PhDs	All degree levels	PhDs	All degree levels	PhDs	All degree levels	PhDs
Total engaged in US R&D	2685000	345000	592000	179000	1747000	135000	346000	31000
US born	2254000	244000	470000	128000	1477000	90000	307000	26000
Foreign Born	431000	101000	122000	51000	270000	45000	39000	5000
Location of S&E Degree								
Foreign School	138000	32000	41000	16000	87000	14000	9000	2000
US School	293000	70000	81000	35000	183000	31000	29000	4000
Foreign born as % of total in R&D	16.1	29.3	20.7	28.5	15.5	33.2	11.2	17.3
US school as % of foreign born	67.9	68.7	66.1	67.9	67.6	69.6	75.8	69.2

Source: NSF Issue Brief, 98-316, June 22, 1998.

Foreign graduate students between 1990-1997 have averaged around 25% of all S&E students. This situation has provided a strong interest from students wishing to continue study in the US, and developed an environment that promotes the US as a

32 National Science Foundation, Divisions of Science Resource Studies, International Mobility of Scientists & Engineers to the United States – Brain Drain or Brain Circulation, Issue Brief, NSF 98-316, June 22, 1998.

choice of foreign students.[33] The number of foreign S&E doctoral recipients that graduated from US universities has doubled from over 5,000 in 1986 to 10,000 in 1996, translating into an 8% average annual increase.[34]

For the period 1992-96, the NSF Brief showed that the proportions of foreign doctoral recipients planning to remain in the United States had increased: over 68 percent planned to locate in the United States, and nearly 44 percent had firm offers to do so. To a large extent, the definite plans of foreign doctoral recipients to remain in the United States revolve around postdoctoral study rather than employment. Among students born in those countries accounting for the largest numbers of foreign doctoral awards, the majority of definite plans to remain in the United States were for further study (58 percent on average between 1988 and 1996). This was followed by employment in R&D (27 percent), teaching (7 percent), and other professional employment (8 percent).

Before starting it is useful to outline that in the American case students are not provided an across the board payment for tuition and living expenses. The system provides for a large number of funding possibilities through a large number of agencies. These funds can be for tuition, living expenses, or both. They are available from Federal institutions, but can also be made available from university funds. According to the employment department at UCLA, the university, as in most universities in the US, is highly departmentalised. In a number of instances the departments receive their own federal funding – usually for research projects, and in this case have funding to support post-doctorates etc. in the form of researchers posts specific projects.

Graduate students generally incur greater expenses than undergraduates, with most attending for a calendar year rather than for an academic year, increasing tuition costs. In 1999-2000, nine-months' tuition at Massachusetts Institute of Technology (MIT) cost $25,000 (26,7000 EUR). Graduate students' costs for housing, food, books, medical insurance, and incidentals vary greatly, depending on marital status, quality-of-life expectations, and housing arrangements. Typical monthly expenses range from as low as $1,500 (1,600 EUR) to $2,500 (2,670 EUR).

"Growth in academic employment over the past half a century in the US reflected both the need for teachers, driven by the increasing enrolments, and an expanding research function, largely supported by federal funds."[35] The average age of doctoral academic science and engineering faculty and postdoctoral positions continues to rise, those 55 years or older constituted 13% of the total in 1973, and 26% in 1997. This was due to the rapid pace of hiring young PhDs into academic faculty positions during the 1960's to accommodate increasing enrolments, combined with lower rates in the later years, Exhibit 33 clearly shows this. In this respect it is important to

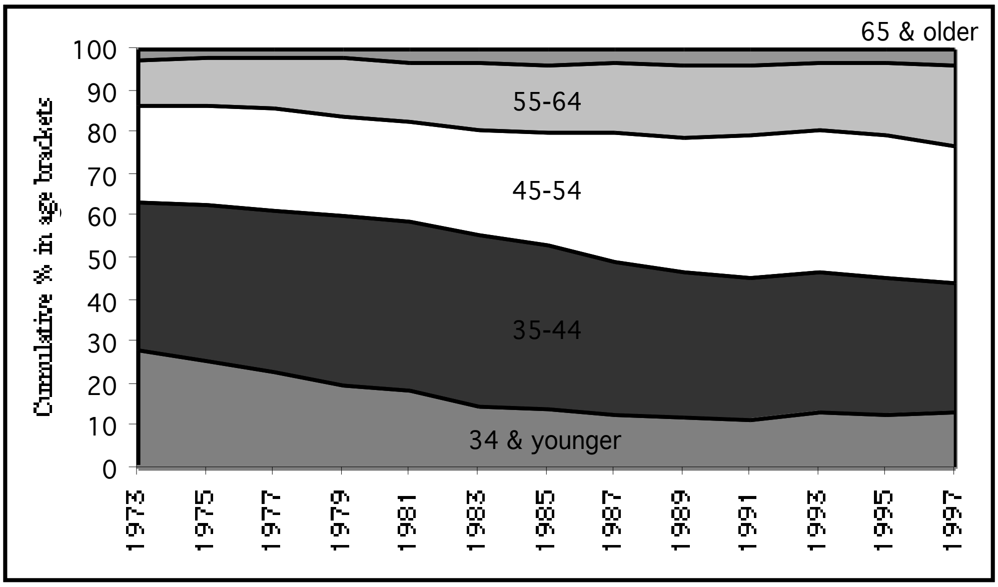
[33] Johnson, Rapoport & Regets, U.S. Graduate Education, 2000

[3] NSF, Division of Science Resource Studies, Graduate Education Reform in Europe, Asia, & the Americas & International Mobility of Scientists & Engineers: Proceedings of a NSF Workshop, NSF, 00-318, April 2000.

[35] National Science Board, Science & Engineering Indicators – 2000. Chapter 6. Academic Research and Development: Financial and Personnel Resources, Support for Graduate Education, and Outputs, Arlington, VA: National Science Foundation, 2000 (NSB-00-1)

continue to attract young researchers to academic faculty positions to ensure that there will continue to be suitable levels of teaching staff in the future, to in turn ensure an expanding the pool of trained manpower for the future.

Exhibit 33 Age Distribution of academic doctoral scientists and engineers



Source: National Science Board 2000, Science & Engineering Indicators - 2000

This ageing of R&D faculty is even more problematic in that university scientists are increasingly performing a major part of basic research. And the Science and Engineering Indicators report showed that US universities and colleges are an indispensable resource in the R&D system, they conduct 12 percent of the national total R&D, 27% of its basic and applied research, and 48% of its total basic research. And in 1997 an estimated 164,000 S&E doctorate holders employed by universities were engaged in some sort of R&D, a 7% growth since 1995, with 86,000 identifying research as their primary work responsibility.

Financial support available from academic research activities appears to be a major factor associated with attracting foreign students to U.S. doctoral programs. The NSF brief on international mobility (1998) reports than 75 percent of the 10,000 foreign doctoral recipients at U.S. universities in 1996 reported universities as the primary source of support for their graduate training. Further, of those who did so, the majority reported their primary support came in the form of research assistantships. The financial resources for these research assistantships are provided to universities by Federal Government agencies, industry, and other non-federal sources in the form of research grants. This funding has been growing and from 1985-96, academic research expenditures increased from $13 to $21 billion in constant (1992) dollars (13.8 22.4 billion EUR). During the same period, the number of foreign doctoral students primarily supported as research assistants more than tripled—from 2,000 in 1985 to 7,600 in 1996.

Support comes from a number of sources whose relative contribution has been changing over the past several decades. The NSF has shown[36] that the main sources of financial support for academic R&D are at the federal and institutional level. The federal government is a major financial supporter of both academic research and development, and science and engineering graduates. In 1998 it provided an estimated 60% of academic R&D funds, and was the primary source of financial support for 30% all full-time S&E graduates (excluding those who were self-funded).[37] And in 1997, 39% of the academic doctoral scientists and engineers reported receiving federal funding for their research.

The NSF report of December 1998 on sources of funding for academically performed R&D showed that institutional funds constitute the second largest source of academic R&D funding. The major sources of institutional R&D funds are: general-purpose state or local government appropriations, particularly for public institutions; general-purpose grants from industry, foundations, or other outside sources; tuition and fees; and endowment income. Other potential sources of institutional funds are income from patents or licenses and income from patient care revenues.

Financial aid for graduate students is provided in most cases by individual departments, and the amount of aid available varies significantly among disciplines. Financial support includes fellowships, traineeships, teaching and research assistantships, and loans. The definitions and terminology of these financial supports are:

1 Fellowships – which include any competitive award (often from a national competition) made to a student that requires no work of the recipient.
2 Traineeships - educational awards given to students selected by the institution.
3 Research assistantships - support given to students for which assigned duties are primarily devoted to research.
4 Teaching assistantships - support given to students for which assigned duties are primarily devoted to teaching.
5 Other mechanisms of support include work/study, business or employer support, and support from foreign governments that is not in the form of one of the earlier mechanisms.
6 Self-support is support derived from any loans (including Federal loans) or from personal or family contributions.

At UCLA "Academic Apprentice Personnel" is the term applied to registered graduate students who have fulfilled the University's established criteria for appointment to teaching or research assistantships. These apprenticeships are intended to provide qualified students with relevant training experience for academic and academic-related careers in teaching and research and to augment limited resources from within the University for graduate student support. As a matter of University policy, apprentice personnel in both the teaching and research series are considered primarily as students being professionally trained.

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[36] NSF, Division of Science Resources Studies, What are the Sources of Funding for Academically performed R&D?, Issue Brief, December 23, 1998.

[37] NSF, Division of Science Resource Studies, What is the Federal Role in Supporting Academic Research and Graduate Research Assistants?, Issue Brief, April 16 1999.

Teaching assistants receive a monthly salary of approximately 1815 Euro whereas research assistants receive from nearly 1400 Euro up to 1784 Euro depending on their experience.

Postdoctoral fellow standing is normally for a period of one to three years. At UCLA it is limited to a period not to exceed five years. Postdoctoral scholars are eligible to receive University administered funds in the form of a fellowship or traineeship award, or a salaried appointment. The type of support is determined by the terms stipulated by the funding agency and is categorised as either a stipend or salary. The following annual stipend rates apply to individuals receiving support through institutional or individual National Research Service Awards:

Exhibit 34 Postdoctoral Trainee Salary Scale for 2000-2001

Postdoctoral Years of Experience	Annual	Monthly	Yrs.	Annual	Monthly
0	$26,916	$2,243	4	$36,936	$3,078
1	$28,416	$2,368	5	$38,628	$3,219
2	$33,516	$2,793	6	$40,332	$3,361
3	$35,232	$2,936	7+	$42,300	$3,525

Exhibit 35 Postdoctoral Associate Salary Scales for 2000-2001

Step	Annual	Monthly	Step	Annual	Monthly
1	$30,888	$2,574	6	$38,460	$3,205
2	$32,208	$2,684	7	$40,308	$3,359
3	$33,696	$2,808	8	$41,736	$3,478
4	$35,124	$2,927	9	$43,692	$3,641
5	$36,732	$3,061	10	$45,828	$3,819

Postdoctoral fellowships are considered taxable income by the Internal Revenue Service (IRS), travel and health insurance payments issued as fellowship reimbursements are also fully subject to federal and state income taxation.

7.5 Mechanisms to attract research graduates

7.5.1 Federal level

On the Federal level the main policy strategies focus on the regulatory framework: immigration rules and taxes.

Foreign graduates have tax exemptions during their stay in the US. The United States imposes a payroll tax on most wages to pay for old-age pensions and medical benefits. This tax is known as the "social security tax"; its technical name is the Federal Insurance Contribution Act Tax (FICA). All persons who earn income in the US are required to pay social security taxes on that income. The current rate is 15%, half of which is paid by the employer and half by the employee.

There are two important exceptions: foreign students are exempt from Social Security Taxes for the period of time they are non-resident aliens for tax purposes, and if their employment is directly related to their purpose for being in the US. Generally, this means that authorised employment of foreign students, including practical and academic training, is exempt from social security taxes, provided they are a non-resident for tax purposes (i.e. they have been in the US for less than 5 years).

The US also has a "Specialty Occupation Workers and Immigration Possibility"[38]. This immigration rule provides the possibility of employing special occupation workers for US employers (classified as H-1B workers). The H-1B is a non-immigrant classification used by an alien who will be employed temporarily in a specialty occupation. A specialty occupation requires theoretical and practical application of a body of specialised knowledge along with at least a bachelor's degree or its equivalent. For example, architecture, engineering, mathematics, physical sciences, social sciences, medicine and health, education, business specialities, accounting, law, theology, and the arts are specialty occupations.

In June 2000, the INS released a report that showed the leading employers of specialty workers between October 1999 and February 2000.[39] This showed that universities were making use of speciality workers, with seven universities listed in the leading 100. In actual terms this represents 113 workers for the highest-ranking university (position 42) and 61 workers for the university ranked as number 99.

7.5.2 The National Science Foundation

The National Science Foundation funds research and education in science and engineering, through grants, contracts, and co-operative agreements. The Foundation accounts for about 20 percent of federal support to academic institutions for basic research, with approximately 80% of its funding going to research projects.

The NSF has no direct policy for funding foreign students and/or researchers. However, through its research grants to a large number of universities and research institutions it indirectly allows for the utilisation of foreign scientists. There are no statistics available on the share of NSF funding that goes to foreign research graduates. It is up to the institutions to recruit the staff for their NSF funded projects, and the NSF does not require information on the individuals conducting the research.

NSF does focus on the internationalisation of American scientists by providing a number of grants and awards, one in particular is the International Research Fellow Awards Program (IRFAP).

7.5.3 University response

The U.S. biotechnology industry leads, or is at least competitive with the rest of the world in terms of its size and the development of innovative products and processes. During the past few years venture capital funds have directed additional funds toward the European biotechnology industry as academics and governments there adopt a more entrepreneurial approach to the exploitation of basic scientific findings. Although the situation in 1996 saw the U.S. biotechnology industry at least four times larger than the European biotechnology in terms of revenues, R&D expenses,

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38 Information found on the Immigration and Naturalisation Service (INS) web pages

39 INS Leading Employers of Specialty Occupation Workers (H-1B): October 1999 to February 2000, June 2000.

and number of employees, it was only twice as large in terms of the number of companies.[40]

In 1998, the number of people working in the biotechnology industry in the United States was estimated to be 153,000, a 9 percent increase over the preceding year[41] and according to NRC information is currently estimated at approximately 172,000. Employment has been growing at between 9 and 17 percent per year over the past 4 years and is expected (conservatively) to grow annually at 8.5 percent for the next decade.

The intellectual backgrounds needed to develop biotechnology products or processes need to come from a large pool of experts, biotechnology is therefore built upon a strong scientific foundation. As a result, the general biotechnology workforce responsible for product development requires a relatively high level of education than does for instance the IT workforce. In most cases, biotechnology scientists must have years of training in experimental work. It is estimated that at least half of the employees in the biotechnology industry are scientists and/or technicians and involved in R&D or production.[42] In the smaller, more research-intensive companies, the proportion of scientific/technical skills of the workforce may be even higher.

The biotechnology industry has used H-1B visas to recruit staff in the areas of skill shortages, and according to data presented by the Committee on Workforce Needs in IT[43] the use of H-1B visa holders is much higher in the biotechnology industry than first thought. Of the 25,000 employees who work in San Diego biotechnology/ biopharmaceutical companies, 6.4 percent are H-1B visa holders. The information further shows smaller companies have reported up to 17 percent of their workforce as foreign nonimmigrant workers, and in a number of cases have sponsored staff for resident status. These figures reflect the affect immigration rules can have on reducing skills shortages, particularly in specialty areas such as biotechnology.

Whitehead Institute for Biomedical Research[44]
The Whitehead institute is one of a number of institutes that are affiliated with MIT. All Whitehead Members have faculty appointments at MIT, but carry out their research programs at the Whitehead Institute, which is solely responsible for their support. The annual budget of the Whitehead Institute is approximately $30 million. Endowment funds from a variety of sources provide the seed money

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[40] National Research Council, Committee on Workforce Needs in IT, Building a Workforce for the Information Economy, Appendix A – Biotechnology, 2000.

[41] Ernst & Young. 1998. Biotech 99: Bridging the Gap. 13th Biotechnology Industry Annual Report, Palo Alto, p.4. in National Research Council 2000 – footnote 12 - Available online at http://www.ey.com/global/vault.nsf/International/Biotech99:BridgingTheGap/$file/biotech99.pdf

[42] Dibner, Mark D. 1999. "Career Alternatives for Scientists." Nature Biotechnology 17(8):825. In National Research Council 2000 – footnote 54

[43] Steve Dahms, San Diego State University, interview on March 8, 2000, and testimony at the meeting of the Committee on Workforce Needs in Information Technology, September 22-24, 1999, Santa Clara, Calif. In National Research Council 2000 – footnote 54

[44] Information found on the Whitehead web pages and interviews

necessary to develop new directions in science. And according to the institute the flexibility resulting from these resources has played a central role in their development.

According to the Public Affairs Office of the Institute it has been a pioneer in science education, and the Whitehead Fellows Program allows promising young scientists with exceptional research agendas to pursue independent research programs as an alternative to traditional post-doctoral positions. The programme is seen as a successful model for bringing the very best young scientists to maturity ahead of their time, allowing increased flows into the workplace.

International Researchers at the Whithead Institute[45]

Whitehead does not specifically target international candidates, although some of the media they use internationally is accessible. Overall they use various professional publications and other print and electronic media resources for position opening advertisements. However, due to the reputation of both the institute and its faculty members, international researchers frequently contact the institute for research possibilities. Faculty members are often seen as the draw card for this international interest.

The Whitehead Institute is however active in promoting international researchers once contact has been established. In some circumstances they pay for candidates to travel to Whitehead to interview for a position, as well as pay for relocation expenses. They also have an immigration specialist on staff who guides international candidates and employees through the process of determining eligibility for, and acquiring work authorisation visas. They do not have a practice, however, of paying for the process involved in gaining Permanent Resident ("green card") status for employees, although they will work together with the attorney that a researcher/fellow has hired to assist however they can.

The University of California (UCLA)

What began in 1919 as the southern branch of the University of California is today one of the leading universities in the world—renowned for education and innovation. UCLA offers a graduate course of study and research and postdoctoral studies. The following information gives some indication of the levels of financial support for its graduate students, (of which international students are eligible) and more specifically additional mechanisms directed at international students/researchers.

Firstly UCLA offers a number of fellowships and grants to cover tuition fees. Further, if a graduate takes the opportunity to serve in teaching assistant or graduate student researcher title for at least 25 percent of an entire academic quarter they are eligible to receive paid medical insurance coverage.

To encourage and support the academic careers of students in all academic areas, the University of California Office of the President and the UCLA Graduate Division provides funds for graduate research fellowships. Applicants must be U.S. citizens or permanent residents. This program is intended for doctoral students who are not advanced to candidacy, to assist them in acquiring and developing sophisticated research skills under faculty mentorship. Students selected for this program for 2001-2002 will receive a stipend of $15,000, plus mandatory fees (excluding tuition).

[45] Information for Whithead Institute – Public Affairs Office

UCLA also has an Advancement to Candidacy Restricted Program. Funding from this program is awarded only to students who have advanced to doctoral candidacy. Selection of students to receive this funding, and the size and type of award, are at the discretion of each graduate program.

Non-resident tuition for doctoral students who have advanced to candidacy is automatically reduced by 75% for up to three years beginning when the student formally advances to candidacy. This benefit is only available to non-resident PhD candidates.

Appendix A International R&D co-operation in the US

A.1 U.S. spending on ICRD

The federal government spent approximately $4.4 billion on ICRD in FY97. This amount constitutes about 6 percent of the total federal R&D budget of $72 billion. The $4.4 billion total represents a marked increase from the $3.3 billion identified in FY95. It is not clear, however, whether this higher figure corresponds to an actual increase in expenditures. There may be some increase, but just as likely, it reflects an increased awareness of the importance of international S&T and therefore improved reporting from agencies as well as improved knowledge and collection methods.

The U.S. government funds a wide range of research-related activities that involve some form of international co-operation. These include research collaboration, technical support, operational support, conferences, database development, technology transfer, and standards development. The majority of these activities, while international in character, still take place in the United States. Research collaboration, in which scientists from different countries work together to address a common research problem, accounts for over 90 percent of all U.S.-funded

ICRD. Collaboration takes two forms: bilateral collaboration between Norwegian scientists and those of one other nation; and multinational collaboration, involving participants from more than two countries.

A majority of spending on bilateral collaboration involves U.S. scientists in cooperative projects with Russian scientists. In FY97, $350 million was spent on ICRD projects involving U.S. and Russian scientists. The amount devoted to collaboration with Russia represents a significant increase over FY95. The second-largest amount spent on bilateral collaboration was $100 million, spent on collaborative projects with Canada. In contrast to bilateral projects, multinational collaboration is often characterised by large-scale projects such as space-related science, high-energy physics, and environmental studies and projects.

US spending by fields of science

When ICRD spending is categorised by field of science, aerospace dominated spending in FY97 and represented more than half of the spending by scientific field. A distant second was biomedical science, followed by the engineering sciences, and ‘other life sciences’.

US agency support for ICRD

Fourteen agencies and one independent institution (the Smithsonian) devote substantial amounts (more than $1 million each) of federal R&D to international activities. By far the foremost spender is NASA, which spent $3.1 billion on ICRD projects in FY97. NASA, however, represents a special case. Many large NASA projects include but are not exclusively devoted to ICRD. Rarely do NASA ICRD funds leave the United States - these projects are multinational activities where other countries contribute equal funding or in-kind equipment to joint activities. Excluding NASA, the principal funding agencies for ICRD in FY97 were:

- the Department of Defense (DoD) ($263 million)
- the Department of Health and Human Services ($215 million)

and three other agencies that spent approximately $200 million each:
- the Agency for International Development
- the National Science Foundation, and
- the Department of Energy.

Notable in this area was the decrease in spending by the DoD, from about $450 million in FY95. This change may represent difficulties with the data, since DoD did not provide detailed FY97 project-level funding data. Between FY1995 and FY1997, U.S. spending for ICRD increased from $3.3 billion to $4.4 billion. However, this result may point less to an actual increase in spending and more to improved reporting on the part of U.S. government agencies and better data collection. The only notable change during the time period studied appears to be the substantial increase in cooperative scientific activity with Russia, tied heavily to space-related projects.

Many ICRD activities are still undercounted. Agencies generally do not report international activities as such – these activities are embedded within mission programmes. Likewise, in some fields of science, international co-operation may occur informally, in which case the ICRD figures are understated. Moreover, there are a number of international activities with scientific or technical content that are not budgeted as "research and development" and are therefore not counted in the inventory. We estimate these S&T activities to be half again as much spending or perhaps $2 billion as the activities identified in this inventory. These other activities include USDA foreign assistance, scientific data collection by the National Oceanographic and Atmospheric Administration (NOAA), and mapmaking activities by the U.S. Geological Survey.

The United States takes an active part in ICRD. In volume terms, U.S.-based scientists publish more internationally co-authored articles than those of any other country by a factor of three.[46] Though, in relative terms this huge output is less than that of other leading scientific countries, representing about 18% of all articles published by U.S. scientists compared with the United Kingdom at 30% or France at 36%. Smaller countries like Estonia and Lithuania pay even more attention to international co-operation and more than 50% of their scientific publications are internationally co-authored.

The United States is such a large player in S&T that there is less need to look abroad when seeking a partner. In fact, RAND has estimated that, worldwide, the degree of internationalisation is roughly inverse to the size of the scientific enterprise in a particular country, with larger countries being less likely than smaller countries to collaborate internationally (see Appendix B of the RAND report).

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[46] Data from the National Science Board, Science and Engineering Indicators—1998, Arlington, VA: The National Science Foundation, Table 5-52.

Dispersed scientific excellence, while one important factor, alone cannot account for the level and increasing trend in the internationalisation of S&T. International contacts, while stimulating, can be more costly in terms of time and travel and more cumbersome in terms of cultural and language differences. The increasing facility of communications and travel has contributed to increased ties, but even here, it is difficult to say that this is a primary factor affecting internationalisation. There may be changes in the manner in which science is conducted that are having an even more basic and fundamental influence on the internationalisation of science.

Current ICRD shares some features with historical scientific collaboration: Both seek to share knowledge and leverage discovery through a co-mingling of knowledge and capability. However, current collaboration is more often motivated by a need to share equipment, to access foreign natural resources, or to serve a corporate, government, or national mission other than advancement of understanding. The scale and scope of some research projects, activities like global climate change or earthquake research, require sharing research efforts, data sets, and equipment. In addition to sharing resources, there also may be structural reasons for the internationalisation of S&T. The advance of knowledge has come to depend on the active collaboration of scientists with specialised skills drawn from a number of research areas. Research on infectious disease control, for example, requires knowledge of immunology and bacteriology as well as the climate and weather of a specific region, the cultural context of disease, and the demographics of affected populations.

Although influenced by different factors than those affecting the internationalisation of academic and government-funded science, corporate scientific R&D is also increasingly international. Research shows that international R&D alliances are up more than eightfold since the mid-1980s. In the late 1980s and continuing into the 1990s, joint non-equity R&D agreements became the most important form of partnership for companies. The formation of these strategic technology partnerships has been particularly extensive among high-technology firms in such critical areas as information technology, biotechnology, and new materials.

Governments also have reasons for sponsoring collaboration that go beyond the most efficient or effective conduct of science. These missions include the foreign policy needs of government, economic competitiveness and trade, humanitarian aid, and more broadly, national security. These motivating factors have been in place for many years. However, the extent to which ICRD is helping to meet these goals has been difficult to analyse because of a lack of project-level data. Without this level of detail, ICRD has been characterised as consisting largely of two kinds of activities: "big science" projects involving a number of countries in building and sharing large-scale equipment; and (2) development assistance programs helping developing countries to apply S&T to specific problems.[47]

What is different now, is the increasing role of distributed, scientist-to-scientist collaboration, a work among equals, that takes place on an interdisciplinary, team-based level. Project-level data make it possible to examine the nature of these

[47] Research by John Hagedorn, quoted in John Jankowski, "R&D: Foundation for Innovation," in Research Technology Management, Vol. 41 No. 2, March–April 1998, p. 18.

activities, as well as to explore the extent to which this is truly a different kind of scientific collaboration from big science or development assistance. Moreover, such examination makes it possible to craft metrics for this third type of activity, metrics that will be different from the measures that government has used to judge the usefulness of big science and S&T for development.[48]

Even within this third ICRD category of distributed, scientist-to-scientist R&D projects, activities are usually not funded or conducted simply for the sake of sponsoring international activities. While international collaboration is generally viewed favourably by granting institutions, the U.S. government's S&T activities usually meet specific mission requirements or build scientific capabilities central to national interests. Activities like space science, energy research, disease control, and ocean and environmental studies are conducted collaboratively because they help meet the goals of governments or enhance scientific excellence. ICRD is simply, at times, the best way to reach a national goal.

[48] A discussion of metrics that could profitably be applied to ICRD can be found in International Co-operation in Research and Development, RAND, MR-900-OSTP.

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