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International Policy Coordination for Collaboration in S & T

Jakob Edler

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Abstract

This paper discusses an increasingly important, yet challenging development, the international coordination of nationally rooted policies or funding schemes to support international collaboration in science and technology (S&T). It conceptualizes ways in which government ministries or agencies can realise synergies when it comes to supporting international activities of their researchers. Although the principles developed for international coordination can be generalized, it is set in the context of the European Research Area (ERA).

Existing conceptual and empirical analysis has shown that coordination of policy to foster international S&T collaboration is by and large rather poor even *domestically*. The paper argues that *international* coordination of *national* policies for *international S&T collaboration* meets an additional set of challenges that need to be tackled systematically. The conceptual considerations presented in this chapter can lay the basis for an analysis of current coordination activities. They can, however, also be utilised to design systematic coordination schemes for *policies* geared towards international collaboration as they provide the major elements of strategic approach for such an international coordination approach.

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International policy coordination for collaboration in S&T

Jakob Edler

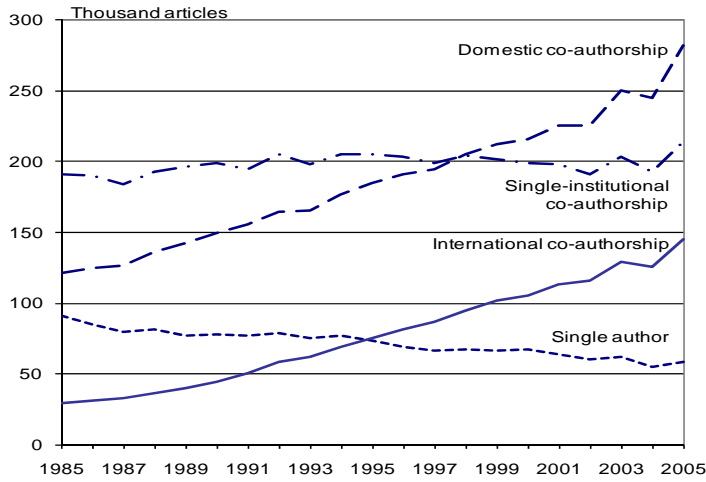
1. Introduction: three mega trends in international S&T policies

This chapter discusses an increasingly important, yet challenging development, the international coordination of nationally rooted policies or funding schemes to support international collaboration in science and technology (S&T¹). It conceptualizes ways in which government ministries or agencies can realise synergies when it comes to supporting international activities of their researchers. Although the principles developed for international coordination can be generalized, it is set in the context of the European Research Area (ERA). This is important since European instruments have provided novel opportunities for coordination, in various forms and with varying success. Some of those coordination activities have targeted or entailed international S&T collaboration by combining two international levels: they have allowed national ministries and agencies to coordinate with other partners from Europe ('international' from the national perspective), in order to better support international S&T activities which have often reached beyond Europe's borders.

The topicality of policy coordination for international S&T collaboration becomes obvious when looking at three related, mutually reinforcing mega-trends. The first mega trend is that international collaboration in science and technology became of increasing importance. All indicators, such as co-publications, co-inventions, and joint research projects, point in the same direction. This is true not only in absolute terms, but also as regards the relative importance of international collaboration which has grown versus single authored publications and national co-authorship. This development is strong within the OECD world and the emerging economies, like the BRIC countries (Wagner and Leydersdorff 2007; Glänzel 2001). Especially China has noted a dramatic rise of international co-publications, with an increase of more than 100 per cent between the period 1995-2000 and 2001 to 2005 (Adams et al. 2007).

¹ For the sake of clarity, the discussion is limited to science and technology and does not include coordination of policies to internationalize innovation activities, as rationales, addressees, related policy domains (trade, industry policy etc.) and related governance actors are quite different in innovation from science and technology.

Figure 1: The rise of international co-authorship, example of natural science



Source: OECD STI Scoreboard 2007, based on NISTEP.

Interestingly, while the share of international, extra-European collaboration is also rising (see table 1), the collaboration within Europe has increased much more than the co-publication with extra-European partners (Mattison et al. 2008). This, it seems, is an important fact, given the global dispersion of specialised knowledge production and it points towards a real need for policy action towards truly international policies – and it renders intra-European coordination of extra-European collaboration the more important.

Table 1: Impact of international collaborations in science 1991 vs. 2003

	Evolution of the Relative Citation Rate of internationally co-authored papers of the Tetrads and four dynamic countries			
	1991		2003	
	All papers	International scientific collaboration	All papers	International scientific collaboration
EU15	1.04	1.21	1.04	1.18
US	1.07	1.22	1.1	1.21
Japan	0.97	1.19	0.94	1.1
China	0.67	0.85	1.02	1.11
Korea	0.72	0.91	0.94	1.1
Chinese Taipei	0.75	0.89	0.87	1.12
Brazil	0.75	1	0.86	1.05
Turkey	0.62	0.85	0.9	1.17

Source: Glanzel, Debackere, Meyer (2006, p. 10).

Not only does the share of international co-publications rise, even more importantly, the impact of international collaborations – one measure for scientific excellence and relevance – seems to have grown significantly. Bibliometric data indicates that international activities pay off. The number of citations a published paper receives can be used to approximate the level of impact that it has among peers (Glänzel et al. 2006). The figures show that international collaborations systematically display above-average performances.² In addition, while for the EU15, the US, and Japan a slight decrease is observed, all other countries in the table register upwards trends.

In addition to the scientometric impact, a recent survey of scientists in Germany found that the vast majority of researchers experience a net utility gain from their international activities. Internationalization helps German and foreign researchers to make a name for themselves and to step up their performance (publications, co-operations). They see a direct link between internationalisation and their own careers in research. International activities accelerate the generation of knowledge, avoid duplicated work, increase competencies and increase researchers' (measurable) output (Edler et al. 2007).³ The trend towards international S&T collaboration has been fostered and accelerated by two major political trends which, in fact, have positively changed the landscape for supporting international S&T. One of those trends is global, the other one Euro-centric, but with potential global consequences.

Thus, the second mega trend is that political ambitions to support and utilize international S&T have deepened and broadened. Fostering international S&T is not exclusively linked to science policy goals any more. It is not only about improving the conditions for scientists to create knowledge as such, but about contributing towards solutions for a whole range of global 'grand' challenges (Aho et al. 2006). The traditional drivers of effectiveness (complementary knowledge) and efficiency (shared infrastructure) of knowledge production have been complemented by attempts to integrate international collaboration into problem driven, mission oriented research (Boekholt et al 2009).⁴

The third mega trend constitutes a vast increase and broadening of international and transnational policy initiative and instruments to foster and shape international S&T collaboration. The policy and funding landscape – especially in Europe – has changed dramatically within the last decade and recently we have witnessed a major shift towards flexible, intertwined instrumentation to enable and support international scientific collaboration. For many decades there have been Intergovernmental Research Organizations (IGROs) such as EMBL, CERN etc. in areas with common infrastructure needs and with costs that are too high for individual countries. Within Europe, the Research Framework Programme (FP) has provided the opportunities for small scale trans-border cooperation in application oriented research. This has been accompanied by smaller and less ambitious networking and partly co-financing activities, such as the basic research scheme COST (basic research networks) and the industry focused scheme EUREKA. The ERA dynamics which started in 2000 have catalyzed a move

² Superior performance here implies impact in terms of readership. Whether this implies research of superior quality is a controversial aspect of the academic debate.

³ Similar results are reported from a study on UK researchers (Technopolis 2005).

⁴ The intensified attempts to utilise S&T collaboration within domain based or mission oriented policy areas globally appears obvious, yet we have little systematic knowledge about the ways in which existing domain based organisations such as the International Energy Agency actually contribute to the international production, diffusion and utilisation of scientific knowledge and technologies.

towards more flexible coordination. Firstly, ERA established a new, direct instrument at the European level (the European Research Council, ERC), supported structural integration through Networks of Excellence (NoEs), and worked towards joint large-scale research infrastructures (with ESFRI). Secondly, it offered new possibilities for joined-up actions, namely: ERA-Nets, ERA-Net-Plus and 'Art. 169'-initiatives for funding agencies and ministries. In addition, the policy related discourse of industry has started to Europeanise (as signified by the Technology Platform activities at European level, see below). Companies have realised that in order to optimise their own internationalisation strategies, coordinated efforts between the large industrial players as well as between the national governments are needed.

These initiatives have broadened the tool box for national ministries and funding organizations when it comes to supporting S&T collaboration and they have been catalytical for a development towards flexible internationalization policies. Previously, ministries and agencies provided (limited) access to their programmes (generally without financial support of foreign actors) or encouraged scientists to be mobile and cooperate internationally within their nationally funded projects. Now, ministries – and funding agencies – are defining explicit internationalization strategies. In a recent country survey by CREST (CREST Working Group 2007), 10 out of 22 countries reporting on internationalization strategies claimed to have a comprehensive strategy in place, three of which being part of a general globalization strategy, seven being part of their respective S&T-strategies. Apparently, eight countries were in the process of defining a strategy. However, it also became clear that while strategic aspirations are high, the concrete finalization and implementation rather remains a promise than becoming a reality in most of the countries (CREST Working Group 2007, pp. 12-14). It is interesting to note that the drivers for internationalization strategies are very similar across the countries reviewed, and there appears to be a canon of drivers widely shared within the European countries (CREST Working Group 2007, II-III). In general, the most important drivers are: (1) strengthening (domestic) excellence through access to existing excellence and facilities abroad and through attracting talent into the domestic systems (inward mobility), (2) preparing the ground for domestic innovations to be marketed abroad, and (3) contributing to the solution of global problems.

Consequently, the countries now have started to look systematically for synergies in achieving their internationalization goals within Europe (CREST Working Group 2007; Edler et al. 2008; Boekholt et al. 2009). Those unilateral initiatives are more and more linked to the new forms of coordination as offered at European level. Thus, nationally based internationalization strategies go hand in hand with coordinated activities to think about joint action in order to foster international mobility and collaboration.

It is, of course, far from clear where the combination of those three trends will lead to. One can argue, however, that the interplay of those mega trends marks nothing less than the beginning of a paradigm shift in policies to foster international S&T collaboration across Europe, with flexible combinations of joint activities by different countries, represented by ministries and agencies. Such variable coordination logic not only offers the option of appropriate coordination within Europe and for European researchers, but also helps to define ways and means to support international, extra European cooperation in science and technology more efficiently and effectively.

This opens up a whole range of analytical and conceptual issues, both for policy makers and analysts alike. The efficiency and effectiveness gains to be reaped from coordinating national initiatives can only be realized with a very conscious approach,

with a clear understanding of the nature of coordination and the institutional challenges associated with it. This is what this chapter seeks to support.

The remainder of this chapter starts off with a discussion of a definition of policy coordination (section 8.2.). It then offers some illustrations of international coordination efforts, mainly based on ERA-NETs and European Technology Platforms, the latter being a bottom up, industry driven coordination process with accompanying policy coordination (section 8.3.). Section 8.4. then argues that there are four major conditions that have to be met for successful international policy coordination. In principle, all of those have to do with coming to grips with the complexity of the issue: (8.4.1.) awareness of the multitude of goals in international S&T collaboration from the perspective of those that shall be coordinated, (8.4.2.) understanding of the rationales and contexts of all the (institutional) actors that engage in coordination, (8.4.3.) systematic understanding and conscious choice of coordination functions and modes, and finally (8.4.4.) understanding of the domestic institutional complexity (in itself a horizontal and vertical coordination challenge) as a prerequisite for successful international policy coordination. On this conceptual basis, the chapter ends with a stylized decision model for developing coordination activities (section 8.5.), which should provide a framework for policy-makers to think about design and implementation issues in a systematic way.

2. What is coordination in S&T policy – and what is it not?

The concept of coordination is abundant in political rhetoric, but it is poorly defined and we hardly have a common understanding of what we mean (for many see Peters 1998, 2005; Metcalfe 1994).

'Even if the general meaning is clear, co-ordination is a surprisingly ill-defined concept with imprecise implications. Despite its importance in practice and the key role it plays in theories of administration there is no consensus on how it should be defined and operationalised' (Metcalfe 1994, p. 278).

To define modes of coordination and their best usage, we can start by looking at what it is not, i.e. we can demarcate the notion of coordination from related concepts. First, 'coordination' is quite different from 'collaboration'. Collaboration, in its most general sense⁵ can be defined as 'to work jointly on an activity or project'. In terms of S&T the meaning differs for different levels and actors. On the level of concrete scientific and technological activities it means that two or more researchers work intentionally⁶ together to achieve certain scientific goals, to pool their complementary expertise or resources, thus enhancing the effectiveness or efficiency of knowledge production or even enabling new knowledge to be produced in the first place. There is no need to engage in an in-depth discourse on the intensities and intentionality of working together

⁵ We follow the Oxford Dictionary here.

⁶ It can be argued, as Subramanyam (1983) has done, that by using concepts of colleagues and working in successive steps to accumulate complementary knowledge scientists collaborate all the time, with all they do. However, for the purpose of this chapter I define collaboration as an intentional activity of distinct actors to work together in order to achieve a certain goal.

and forms of collaboration (for a thorough discussion see Katz and Martin 1997), but it is important to keep in mind that S&T collaboration means the working together of scientists to produce scientific and technological knowledge.

On the level of S&T policy the concept of collaboration is more complex. The major element, again, would be to work together on a concrete, distinct project on the policy level in order to achieve common goals. This could manifest itself in joint monitoring of international activity, sharing a foreign contact office etc. or – in fact – joining forces in some additional, new joint activity. Policy collaboration would not entail any shift of competencies to a new policy level. Competencies and autonomy would remain within each collaborating policy actor (a ministry or agency).

A shift of competencies or autonomy to a new, a common level would indicate 'integration' which is again distinct from coordination – even when the boundaries are blurred. Integration describes a process of combining activities or structures so that they then form a 'new whole' (Nedeva et al. 2006). In institutional terms it means that individual elements come into a common participation in a new institution or body. To understand what this might mean in terms of policy, we can turn to European integration theory (see for example Wiener and Dietz 2004), which has taught us that integration is a process that involves a transfer of competencies and loyalty from one level to the integrated level, with the various parts of the new whole to arrange for a common governance structure. This means to delegate authority and to assign the new integrated structure with its own actor capabilities.

At the level of concrete R&D activities, integration would be the complete merger of research capacities (e.g. research institutions merge into a new virtual or physical institution, or researchers merge their programme lines altogether). At the level of R&D policies and programmes, integration would mean to create a new programme, together as a group, and to have this programme managed and further developed at the new, the integrated level. 'Art. 169'-activities, should they develop self-standing, sustainable structures and legally binding rules that are decided upon at the new, integrated level, are one potential form of integration, where the integrated activity (that is the 'Art. 169'-programme) and the national activities (these are the national programmes) will co-exist (for a detailed account of one example see Edler et al. 2008).

Coordination involves elements of both, integration and collaboration, but still is distinct from both concepts. In a very general definition coordination means to bring different elements (of a complex activity or organization) into a 'harmonious' or efficient relationship.⁷ This may involve negotiation (with coordination partners) in order to match or to harmonize. The major characteristic here is that the various elements are still autonomous, they do not strive to be merged into one new entity, and they still engage in their individual activities. It is not so much joint activities that are the key here – this would be collaboration if focused on concrete activities, or integration if aimed at structural merger of some sort. International S&T policy coordination would mean to undertake activities in order to adjust and combine individual activities in a certain area so that they better interact and synergize with activities of other countries in the same area. However, it might involve or lead to concrete collaboration (in targeted activities) and it might develop into partial or full integration (for example of programmes, labs etc.). At the same time, however, it can remain in a state of mutual information and minor adjustments in national programmes

⁷ Again as defined by the Oxford Dictionary.

or future design of programmes, or it might simply mean mutual opening up of national activities and the like. But it is important to make these distinctions as all too often analysts and policy-makers talk about integration when they mean coordination in a more narrow sense – and vice versa.

Before discussing the conceptual challenges of international S&T policy coordination, the following section provides some recent illustration of various coordination modes. They refer mainly to European research policy and entail industry driven modes of coordination which, however, receive support from policy-makers and in a way force them into coordination activities as a consequence of transnational discourse.

3. Some illustration of international coordination in the ERA⁸

3.1. ERA-Nets as a means to coordinate international S&T collaboration

The Sixth Research Framework Programme (FP6) introduced the ERA-Net instrument. Its aim is to bring together programme owners and managers of a group of countries that share a common interest in a specific research area in order to explore possibilities of coordinating their efforts, in some cases leading to jointly funded calls (ERA-Net-Plus). The instrument was originally not part of the internationalization agenda of FP6. However, a couple of ERA-Nets developed into instruments to coordinate member state activities vis-à-vis third countries or regions. In addition, a range of other ERA-Nets in FP6 had considerable international activities. Some examples are given in the table below.

Table 2: International dimension of ERA-Nets

ERA-NET (CA)						Joint calls / programmes		
Name	Contract	Area	Start date	End date	Countries	Done	Launched	Planned*
CO-REACH	16185	Europe and China	01/05/2005	30/04/2010	9	-	Not yet	-
ERA-ARD	517837	Agricultural Research for Development	01/04/2005	31/03/2009	14	-	Not yet	-
EULANEST	36271	Latin American Network	01/07/2008	30/06/2010	5	-	Not yet	-
SEE-ERA-NET	515805	Southeast Europe	01/09/2004	31/08/2009	14			1

*) "Planned calls" are calls for which concrete planning has already started, which means that most of these calls are to be launched in 2007. Some ERA-NETS have foreseen further calls at a later stage, in some cases described in the Description of Work.

Some other ERA-NETS cooperate with third countries without it being their primary focus, for example:

- iMERA (metrology) included a number of third countries in a joint call (incl. USA and Japan)
- ECORD (deep sea ocean drilling) coordinates the participation of European countries in the International Ocean Drilling Program (IODP), set up by USA and Japan.
- BONUS (Baltic Sea Research) has a Russian partner
- EUROPOLAR (polar research) has a Russian partner
- ERA-SAGE (Societal aspects of Genomics) has a Canadian partner
- EraSysBio (Systems biology) has a Russian partner
- EU-SEC is coordinated by UNICRI

Source: Wittke (2008)

⁸ This section builds on Edler (2008).

In a survey of the European Commission conducted in 2006, 20 per cent of the responding ERA-Net indicated to have at least one international partner and almost 50 per cent of the ERA-Nets would welcome a global dimension of their network, especially if there was a sound coordination across Europe as a preparatory step (Wittke 2008). The activities of the four ERA-Nets mentioned in the box above indicate that new forms of joint action with partner regions are being developed (see the example of 'Co-Reach' below), joint action that links to the Framework Programme and is flexible in terms of participation by clustering member states regionally.

Box 1 indicates the flexible forms of coordination used by the Norwegian Research Council (NRC). The NRC employs different kinds of instruments for different areas, thus, the coordination landscape is tailored to the needs of the various areas. The NRC has a three tier arrangement, with bi-lateral activities to foster concrete and specific needs, regionally coordinated approaches to take advantage of similar needs and networks of neighbouring countries when it comes to global cooperation partners and options, and finally, the NRC engages in multi-country schemes using established international frameworks.

Box 1: The coordination matrix of the Norwegian Research Council

CO-Reach – an ERA-Net in FP 6 as means to coordinate for international collaboration

CO-Reach brings together 16 European partners and almost the same number of Chinese counterparts (ministries and funding organisations and Academy of Science etc.), with the following mission:

‘This network is intended to create coherence and synergy in Europe’s S&T relations with China. It will do so by promoting the co-ordination of China related policies and associated research funding programmes of individual European countries, and integrating these efforts with those of other multi-lateral European initiatives, including the programmes and agreements of the European Commission.’

The first pilot activities, two joint programmes in social science and sustainability, have been launched in 2008 and the network has come to provide a dynamic information system on scientific and funding activities, a whole range of high level joint events and a platform for multilateral and bilateral Chinese schemes (www.co-reach.org). The coordination gain is not only through new funding programmes, but through reducing complexity, through pooling expertise and networks CO-Reach established the ground for further multi-lateral and bi-lateral activity. While there is still a way to go for a clearer identity of the network, it has already changed the way the science and funding discourse between Europe and China is led, without distorting the flexibility of single country approaches or of smaller country groupings to develop their own strategies.

The following matrix shows how the *Norwegian* Research Council organises their strategy towards international collaboration with China, taking advantage of the coordination instrument CO-Reach, but also using bi-lateral and multi-lateral coordination schemes as appropriate for certain issue areas and policy goals (Kveseth 2008).

THEME LEVEL	<i>Energy, Environment, Polar Research</i>	<i>Hydrology, Water Management</i>	<i>Economy, Welfare, Regional Development</i>
EU FP-7 and other international frameworks	CO-REACH, OECD-Project, INNO-Net and others	CO-REACH, OECD-Project, INNO-Net and others	CO-REACH, OECD-Project and others
Nordic framework and initiatives	Nordic Centre Fudan, NORIA- Net and other Nordic Organisations	Nordic Centre Fudan, NORIA- Net and other Nordic Organisations	Nordic Centre Fudan, NORIA- Net and other Nordic Organisations
Norwegian MoUs, links, cooperation	MOST, NSFC, CAS, other MoUs, BILAT	MOST, NSFC, CAS, other MoUs, BILAT	MOST, NSFC, CASS, other MoUs, BILAT

3.2. Coordinating international collaboration with and for industry: the role of European Technology Platforms

European Technology Platforms (ETPs) offer new options for joint coordination approaches between the industry and policy makers. ETPs are targeted at and used by firms, but coordination takes place in a joint approach with national policy makers and the European Commission. ETPs support a systematic discourse and the development of future strategic research agendas (SRA) for certain technologies or sectors. Between 2002 and 2006 31 ETPs have been established. In FP7 five ETPs have been transferred into Joint Technology Initiatives (JTIs) that now constitute a new forum for public private partnerships between the Commission, the member states and industry with a view to industry-led coordination of research activities in a certain technology. Industry-led coordination from bottom-up is accompanied by country mirror groups challenging the responsible national policy makers that have a strong representation within the ETPs to engage in some sort of accompanying policy coordination. Some evidence suggests that coordination at European level is a catalyst for domestic coordination or at least fosters the discourse between stakeholders.

ETPs have an in-built international dimension. First, many of the leading companies are multi-national firms active on a global scale. Through bundling those companies together into the ETPs, the definition of a European strategic research agenda has automatically been linked to the global dynamics. Second, through developing systematic activities to define future research directions and technology options, ETPs have taken into account the global developments especially when it comes to the definition of future potential global lead markets. Third, some of the JTIs (for example, Artemis⁹, ENIAC¹⁰) have their roots in EUREKA clusters that had partners from countries outside the EU (see also European Commission 2008, p. 46).

Fourth, ETPs have started to develop international activities and integrate extra-EU partners. The latest EU status quo report on ETPs (European Commission 2007) obliges ETPs to report on their international activities. On this basis, one can get some indication as to the strategic aspiration as for international collaboration. A systematic scan of those short reports shows that 21 out of the 31 ETPs have concrete international activities on an operational level or even strategic aspirations. For 10 ETP the international activities are either not mentioned at all or only mentioned in a superficial way, seeing the international dimension in terms of market opportunities to be secured. Most of the 21 ETPs that have a more pro-active approach to international cooperation see themselves as a European focal point and hub for international discourse and partnering in the future with strategic ambitions, others have strategically incorporated international organizations in their membership in order to link up with and influence global strategies (and regulations). Some have already entered a whole range of collaboration projects, many of which are explicitly linked to international cooperation projects of FP6. Two examples of strategic approaches for international collaboration in ETPs are given in box 2.

⁹ <http://www.artemis.eu>.

¹⁰ <http://www.eniac.eu>.

Box 2: The international dimension of FP6 ETPs – two examples

ARTEMIS – the international dimension of an ETP in FP6 (prior to its launch into a JTI)

The objective of the ARTEMIS international co-operation strategy is to define “modalities” for interaction between the European R&D community, and the main international players in the area, including research institutions, professional organisations (ACM, IEEE), standardisation bodies (e.g.: OMG, IEEE), large consortia, funding agencies (e.g.: IST, NSF, DARPA).

International Collaboration covers a potentially wide range of activities, from the organisation of technical meetings, high-level meetings, conferences, schools, and joint international projects. These may have various aims, including education and training, dissemination, definition of standards, and development of joint R&D activities. It is clear that International Collaboration should fit into a global win-win strategy, for achieving the participants’ long-range aims. Dedicated actions are carried out with regard to co-operation with Nanoelectronics platforms in the USA and the Far-East (see, e.g. www.inc-conf.net) ENIAC is actively involved in the INC Conferences, which target international collaboration / co-operation in the field of Nanoelectronics and Nanotechnology.

Hydrogen and Fuel Cell Platform – the international dimension of an ETP in FP6

The International Partnership for the Hydrogen Economy and the IEA implementing agreements for hydrogen and fuel cells are the main fora for research co-operation beyond the EU. The former is established by ministerial charter signed by 17 members, including several EU members. It aims to further international co-operation on hydrogen and fuel cell technologies and support activities of common interest, such as safety, codes and standards, and analysis in support of policy-making. The work of the HFP platform has provided a European focus for these international co-operation activities and the European partners' contributions to the definition of common research priorities in the IPHE has drawn heavily on the work of the SRA, Deployment Strategy and the Implementation Plan. International co-operation is very important in specific areas, notably where there are challenging technical barriers, or issues of common interest (e.g. sustainability, safety, standards).

These activities of ETPs may indicate a tidal change, and their international ambition will further feed back to policy making. European industry not only develops common foresight and planning activities, but speaks with one voice (at least in technology-oriented global discourses), has a hub and focal point in various key technologies, thinks about strategic global partnering and links this partnering with considerations

about markets and competitiveness. This is not free of tensions as some of the less active ETPs clearly illustrate. However, it helps to improve the role of Europe in industry-driven, future-oriented global discourses, regulation and cooperation. There is of course no automatism towards new joined strategy creation across Europe, but the opportunity structure provided through ETPs may pave the way for new forms of international S&T coordination involving private and public stakeholders alike and leading to new forms of global S&T collaboration.

4. Four conditions for effective coordination of international S&T policies

Against the background of major trends, some basic conceptual understanding and some recent illustrations of novel forms of international coordination are in order. The following section conceptualises international coordination more in depth and formulates four key challenges for effective and efficient coordination activity.

4.1. Clarity about S&T collaboration goals underlying the rationales for policy coordination

Any policy coordination within Europe aiming at cooperating with actors outside Europe needs to start with defining the motivations of both those who coordinate and those who are supported in their collaborations. The final addressees of coordination policies traditionally have been individual researchers. However, collaboration is increasingly important for research organizations who progressively design internationalization strategies themselves. Similarly, the nature and aims of collaboration in S&T change as soon as companies are involved. Market considerations and economic competition come into play, and coordination of S&T policies is connected to trade and industrial policies. This is especially true – but not exclusively so – when dealing with emerging economies, as those economies are often new partners with less well institutionalized governance structures and less clearly defined framework conditions.

One can summarize the most important motivations for international collaboration of researchers, institutes or firms as follows, whereby, if not otherwise indicated, the motives are relevant for firms and public research alike:¹¹

- Access to complementary and specialised expertise in scientific teams beyond national borders, or put more broadly, gaining access to trans-national knowledge networks;
- Access to scientific talent and high skilled workers
- Access to, or sharing the cost of, major facilities;
- Access to unique environments (e.g. geological phenomena) or populations (for example genetic or disease profiles);
- Achieving critical mass through cost sharing or combination of datasets;

¹¹ This list draws on very similar findings from various sources: AD Little (2005), Boekholt et al. (2009), Wagner and Leydesdorff (2005); Edler et al. (2007), Georghiou (1998).

- Collaboration as element of mobility strategies in science, providing the basis for the development of scientific capabilities and experience more broadly (in the receiving environment and for the mobile researcher herself);
- Additional research markets (contract research organizations, firms as R&D service providers);
- Preparing the ground for innovative activities and markets abroad, linking to complementary skills and resources (global value chain integration, firms mainly) or adjusting to local requirements (firms)
- Benefiting from cost advantages elsewhere (firms, mainly standardised activities of R&D, but increasingly also in specific scientific areas in which low cost countries are highly competitive – e.g. nanotechnology in China, software development in India etc.)
- Re-transfer of knowledge to be used at the home location, spill in of international knowledge into national innovation systems

Beyond those science-, technology-, and market-driven motivations there are political and societal drivers who are more and more coming to the fore. International collaboration addresses trans-border or global problems, and recent empirical work has shown that those broad motivations are becoming increasingly important (Boekholt et al. 2009). This, of course, has implications for the national and international actor arenas, as a whole set of ministries have started to formulate the need for and goals of international S&T collaboration (see below).

This richness and breadth of motivations thus leads to complexity when it comes to cost-benefit calculations of governments for certain collaborative activities. The weighing of motivations and the context conditions against which the internal coordination takes place varies considerably. Countries differ in the composition of scientific and economic actors and in the relative strengths and weaknesses of the innovation system. What might seem an obvious driving force for one country when it comes to engage in coordination might be marginal for another. The challenges and opportunities of S&T collaboration and accordingly the most appropriate mode of coordination normally differ between countries. Often these differences are not fully transparent and actors are not sufficiently aware of them. International policy coordination in order to follow those drivers of international collaboration activities must start with a clear definition of the objects and motivations for coordination. The recent survey by the CREST working group on 'Internationalization of R&D' (CREST Working Group 2007) has clearly shown how different aspirations and modes of internationalization policies of countries are.

Finally, one aspect most often overlooked when it comes to institutionalized coordination is the peculiarity of each issue area – and those peculiarities have severe consequences for the need for and benefit from (international) collaboration. It makes a difference to collaborate internationally in the fields of chemistry (scientific field), ageing (social issue) or 'China' (location). As current work in the EU network of excellence PRIME¹² shows, different scientific fields – or search regimes (Bonaccorsi 2008) – have different needs for international collaboration and hence also different needs for a coordination of those policies that enable international cooperation. It is

¹² www.prime-noe.org.

evident that the scientific area and thus the nature of knowledge creation plays a significant role, with different scientific fields having different needs to share infrastructure, pooling data and methodological skills (Adams et al. 2007; Wagner 2006; Kuhlmann et al. 2008; European Commission 2008).¹³

It becomes even more complex if international collaboration is organized around certain issues (obesity, ageing, water etc.), as there are a range of different scientific disciplines to be coordinated. Those, in turn, may have developed very different levels of international collaboration already, and very different agencies with different traditions of international engagement might be involved. All this has to be taken into account when coordinating the overall set of those disciplines. As the PRIME project has shown (Kuhlmann et al. 2008)¹⁴, the scientific discipline chemistry would not require a thick, very broad international collaboration and coordination approach, whereas the fast growing, dynamic area of catalysis within chemistry has a high need for international coordination to enable collaboration and even integration.

4.2. Clarity about the objectives of and the responsibilities for coordination

An obvious – but operationally complex – prerequisite for international coordination is a clear understanding of 'what' in fact is to be coordinated and 'who' is responsible for this object of coordination. First – and as just seen in the previous section – the institutional actors that engage in international coordination are very heterogeneous. Coordination requires a thorough understanding of the capabilities, needs, framework conditions, embedded rationales and reference frameworks of each of the participants of the coordination activities. The institutional settings for S&T policies are very different (along a whole range of categories such as 'agencification', mix of programmes vs. institutional funding, importance of collaborative approaches and so on), and thus the requirements for the different modes of coordination. For example, if coordination is about programmes, one needs to understand not only the concrete design or the explicit goals of the programmes, but the underlying rationales and knowledge about who the owners and managers of the programme are. The governance of the various programmes or initiatives that should be coordinated and the roles of the various actors within this governance need to be clarified. The coordination of different traditions and structures regarding governance modes poses additional challenges for 'learning' as the major prerequisite of successful coordination.

Moreover, the positioning of the programmes in the institutional and systemic contexts 'at home' need to be made explicit. This also involves the relative importance and leverage of the programmes as regards the programme addressees in the various countries, who not only differ in terms of scientific and economic ambitions, but also in terms of their need and inclination to engage in international collaboration. This, of course, leads to very different cost-benefit considerations for the various national actors who engage in the policy coordination in the first place.

¹³ Although, as Wagner (2006) rightly states, we still do not know enough to link the properties of a science field to international collaboration patterns, the evidence is not yet consistent and a range of non-area specific variables interfere.

¹⁴ See for an illustration www.prime-noe.org/Local/prime/dir/General%20Presentation/News/Bonn_Case_Chemistry.pdf.

4.3. Understanding the coordination challenge within member states

International S&T policy coordination first of all calls for internal, domestic coordination. As studies have shown, the need to 'speak with one voice' and to engage in European activities often triggers challenges of domestic coordination. National coordination and European/international coordination are interdependent and co-evolutionary, but without a clear dominance of one over the other. Derlien (1991), Metcalfe (1994) and Peters (1998) have extensively discussed the need for internal coordination and the various forms this can take in order to arrive at a strategic actor capacity and an internal clarity that is needed for international policy coordination. For international S&T coordination this is especially interesting. The option to coordinate internationally can open up new ways to coordinate hitherto unconnected or uncoordinated national attempts as international coordination means that those involved have to be transparent and explicit with their activities and goals and thus create the momentum and pre-conditions for internal synergies.

However, given the heterogeneity of actors in national administrations that deal with R&D funding, there is no single voice when it comes to coordinating national policies. This often leads to strong groups lobbying for specific coordination, instead of systematic strategic development. Further, there is very little internal intelligence on internationalization needs across the various stakeholders and fields, which again makes coordination of related policies highly problematic. The internal challenges when it comes to defining priorities and ways of action – as a prerequisite for sound coordination with other countries – are exceptionally complex for international activities. This has become apparent in a recent exercise for the Irish government¹⁵, in which for the first time in Ireland systematic attempts have been undertaken to set up a process across the government to define priorities for international activities. This also includes the set up of a discursive process in order to obtain more transparency about ongoing international activities, future aspirations and the relative contribution of international activities to the overall research goals. This kind of cross government coordination mechanisms would in fact be an absolute necessity when it comes to decide in which areas and with which partners to coordinate international activities. When looking at the various coordination mechanisms at EU level, we find an interesting process of defining strategies in an ex-post manner, which emerges from a lack of internal coordination. The extensive growth of bottom up coordination through ERA-Nets and ETPs has been driven by individual agencies and departments rather than by an all-government approach within individual countries. Only after a few years of uncontrolled – or un-coordinated – growth of such coordination activities EU countries start to bring those coordination activities under some strategic umbrella. The separation of responsibilities for European and international policies in many countries hinders coordinating international policies with European ones, or at least it poses additional challenges of internal coordination within a country.

4.4. Definition of functions and modes of coordination

¹⁵ Conducted by a consortium of Manchester Institute of Innovation Research and Matrix, Dublin/Belfast 2007/2008 on behalf of FORFAS (Edler et al. 2008).

Clearly, in order to best translate coordination and collaboration motives into concrete coordination action, policy-makers need to consider the different modes of coordination. To understand modes of coordination, we can turn to political science literature, even if political science has focused mainly on intra-governmental, inter-departmental coordination (Peters 2005; Painters 1981). Recently, this has been elaborated for domestic knowledge policies by Braun (2008) and applied to country cases by Edler and Kuhlmann (2008), Griessen and Braun (2008) and Pelkonen et al. (2008). Earlier, Metcalfe (1994) had elaborated on coordination for international governance. However, he has done so in terms of intra-government coordination in order to engage in EU policies rather than inter-government coordination itself. Lately, a European expert group on the Lisbon Strategy (European Commission 2009) has discussed the various modes and benefits of coordination of S&T policies within Europe – albeit not especially related to international S&T collaboration.

For coordination within countries, Painter (1981) distinguishes five objectives:

- (1) reduction of duplication,
 - (2) reduction of policy inconsistency (across government),
 - (3) reduction of bureaucratic and political conflict
- as well as
- (4) increase of coherence and priorities and
 - (5) design of a comprehensive all-government approach (reduction of policy fragmentation).

These five objectives may fit the need for cross-government coordination to enter international coordination. However, it is important to understand they largely do not apply for the inter-national (inter-ministerial or inter-agency) coordination itself. There is little need for an 'all-government approach' (5), for an increased coherence and priority ordering among different national governments (4), and even for a reduction of inconsistencies (2) as the interests and needs of the governments involved might remain quite diverse and coordination functions therefore much more limited and multi-faceted. Those ambitions would only come in the focus of coordination if it is intended to lead into integration into a new, coherent whole. This, in turn, would only apply if the EU or some sub-group of countries would claim to act on behalf of all member states or the members of that particular group when it comes to all aspects of international S&T collaboration. This, however, is far beyond the current policy reality. Even the ambitious 'Art. 169'-initiatives largely integrate parts of national policy programmes into a new programme, but they do not create an entire new whole with distinct strategic actor qualities.

Only within the integrated parts would coherence in terms of goals and instruments be expected. Given the diverse interests and context condition within the EU, it may be even detrimental for the very purpose of the coordination – as it would force member states into a uniform, single approach when it comes to international S&T collaboration. Equally, the fourth objective, the reduction of conflict between administrations has an entirely different meaning when it comes to international coordination of S&T.

Conflicts between administrations of different countries when it comes to international S&T collaboration are rather unlikely. However, if it occurs it might be an expression of competition for access to resources, talent, expertise or complementary funds in other countries. This can be overcome through strategies to create win-win situations when

joining forces to gain better access and offer better exchange with international partners altogether.

Finally, the fifth goal, avoiding duplication (e.g. in setting up collaboration structures, in performing research in similar areas etc.) may be a reasonable policy goal in international S&T policy coordination. Duplication may in fact often increase variety, and is thus a means for improved performance through competition and enhanced selection scenario for the best approaches. At least, duplication can offer alternative routes to knowledge production with different potential outcomes.

Thus, to systematically reduce duplication of international collaboration efforts may be counterproductive. However, competition of approaches is only meaningful if the S&T community can actually choose and if the national approaches for S&T collaboration are open for participation from other countries. If they are not, duplication does not mean competition but inefficiency. In addition, to reduce duplication certainly is an issue for international policy coordination when it comes to build up common structures and networks or even harmonized programmes to fund joint work in commonly agreed research areas.

In short, it is the efficiency and effectiveness argument rather than the coherence argument that is relevant for international S&T policy coordination. Actors coordinate to achieve their own goals better and more efficiently. Currently they do not do it to claim a coherent approach across all EU countries (or a substantive sub-set of countries) or all scientific domains. Coherence would be a goal of policy integration.

A second, related issue is the mode and thickness of coordination. The thickness of coordination has been systematized along various scales. While those scales have been designed for intra-government coordination, they can help us to understand the nature of inter-organizational coordination in policy-making and hence also guide the analysis of international policy coordination.

Extending the well established dichotomy of the German political scientist Fritz Scharpf who distinguishes between positive and negative coordination, Peters (2006, taken up also by Braun 2008) develops a five level scale of coordination. He distinguishes between

- 1) no coordination;
- 2) negative coordination (mutual information of units who are not independent from each other, but no common policy formulation, coordination as adaptation to minimise costs out of actions of others);
- 3) positive coordination (involves pro-active cooperation in order to achieve certain goals better);
- 4) alignment of goals, which means that not the process or the instrument are harmonized, but the aim that is to be achieved. This mode is most promising if the systemic features of countries and their specific contexts are too different for joint action or adaptation of frameworks;
- 5) common development of visions, goals and strategies.

The broader rationale for and the thickness of coordination is often entirely unclear, ill-defined or even – more or less – contested. To take but one example, a European Expert Group on the Lisbon Strategy has analyzed the Open Method of Coordination (OMC), which can be defined as a set of fora for inter-organizational discourse across Europe, whereby various topics around S&T governance have been discussed with different country groupings involved in each of the groups (European Commission 2009). This is

important in the context of this chapter as the OMC is international (intra-European). It brings together actors from European countries with a mission to establish or prepare coordination. To analyze the nature and effects of the coordination, the Expert Group has used the approach of Braun and Peters and concluded that the trans-border, inter-organizational coordination within the OMC does not show many signs of real coordination along those scale categories. Most of the international inter-organizational coordination groups of the OMC focused on learning from each other (undoubtedly one major objective of the OMC) and only some of the participants in a limited number of those coordination groups aspired to positive coordination or even alignments of goals and common visions and strategies. None of the 18 groups of the four cycles of the OMC has reported positive coordination or even thicker forms of coordination. However, it appears that the OMC has – through the intensive learning that has taken place in some of the groups – paved the way for further common activities which become institutionalized – as the new Strategic Forum for International S&T Cooperation – and as such might lead to further joint activities beyond learning. There has, however, been an interesting diversity of views of OMC participants as to what coordination actually is, and a vast majority appears to have interpreted mutual learning as the actual objective of coordination and thus favoured a mode of knowledge exchange and common reviews over an approach of defining common ground for strategies. Learning might – as the expert group has recommended – be designed to speed up the process of adapting to the shared goals and to check for possibilities for joint action. However, in itself it is not coordination in one of the four ways described above, not even negative coordination.

For the ERA-Net examples above, the picture appears to be very different. Here, it seems there are first signs of positive coordination, as many of those ERA-Nets strive for synergies in their own national approaches through joint action. But it also appears that alignment of goals or even the development of joint strategic visions and programmes is still the exception.

5. Conclusions – elements of a logic model of coordination

Any policy coordination is complex. Conceptual and empirical analysis has shown that coordination of policy to foster international S&T collaboration is by and large rather poor even *domestically*. This chapter has argued that *international* coordination of *national* policies for *international S&T collaboration* meets an additional set of challenges that need to be tackled systematically. The conceptual considerations presented in this chapter can lay the basis for an analysis of current coordination activities. They can, however, also be utilised to design systematic coordination schemes for *policies* geared towards international collaboration as they provide the major elements of strategic approach for such an international coordination approach as they would have to be applied in their logical sequence¹⁶.

The starting point of a *strategic coordination process* is the *definition of goals* for international S&T collaboration and an analysis of the status quo of this collaboration. Already this definition of goals necessitates transparency and a co-ordination domestically in order to understand how different ministries and agencies perceive opportunities through international collaboration and policy coordination. In a second

¹⁶ This part is inspired by an internationalization concept developed in Edler, J. et al. (2008). It serves as a first illustration of a potential process development.

step, the *opportunities* of international S&T collaboration have to be *explicitly defined*, based on the overall national S&T priorities – across the various ministries involved – and based on the motivations and aspirations of the S&T community to collaborate. This opportunity definition needs to take account the heterogeneity and specific needs of the research fields. On that basis concrete potential target countries and focus areas for S&T collaboration can be identified. All this definition process may utilise broad strategic intelligence, such as bibliometric and technometric analyses for the profiling of countries and identification of strongholds. But most importantly it must involve a strategic discourse among policy-makers, research managers and scientists *domestically*. In such an ideal-type process, the international co-ordination is not at the beginning, but a consequence of systematic search and definition processes. Obviously, very often coordination activities develop very differently, they emerge from discussion fora, from initiatives of foreign partners, out of policy instruments such as ERA-Net which start with coordination at European level and only subsequently ask for the linkages to domestic contexts and arena. However, the ideal-type process stylised here serves to highlight the importance of internal, national administrative co-ordination and discourse with the scientific community if co-ordination.

Once – ideally – purpose and targets for international S&T collaboration are identified, the *international coordination arena* needs to be understood, the activities, rationales and interests of other policy actors which seek to support international S&T collaboration in one way or the other and which have similar policy needs. This involves mapping global policy and funding activities, capabilities and opportunities, and to link them with existing international policy instruments and activities and involvement in international organisations. A search and definition process at international level then would have to define (1) the *concrete purpose* of the coordination, situated between pure policy learning on the one hand and efforts to integrate programmes (or parts of programmes) on the other hand as well as (2) the mode and thickness of the coordination . The target must fit the mode and the thickness of coordination. The definition must be explicit and formulate the added value, the benefits and the pitfalls of coordination – and, most importantly, be shared by the international partners. Based on the preceding domestic discourse, backing of key stakeholders and involvement in subsequent policy action on international level is to be ensured.

Once action is agreed, structures and processes set up, the developments need to be monitored and the added value of international collaboration and the change of opportunities and behaviours of the S&T community need to be measured. This includes a constant assessment not only of the benefit (efficiency, effectiveness), but also of the opportunity costs, i.e. the costs of non-coordination, as well as a clear understanding of an *exit strategies*. Explicit cost-benefit considerations and potential exit strategies are not hampering increased and improved co-ordination. To the contrary, they help to avoid international co-ordination to be regarded as a good thing per se, which then is easily ill-defined and develops path-dependencies that may lead to meaningless discourse fora detached form national policy goals and needs of the scientific community and unable to *adopt* modes and targets of co-ordination to the transformation of international scientific collaborations.

References

- AD Little (2005), *Internationalisation of R&D in the UK - A review of evidence*, Cambridge: AD Little.
- Adams, John, Karen Gurney and Stuart Marshall (2007), *Patterns of international collaboration for the UK and leading partners* (available at: <http://image.guardian.co.uk/sys-files/Education/documents/2007/07/13/OSICollaborationSummaryRepo.pdf>).
- Aho, Esko, Jozef Cornu, Luke Georghiou and Antoni Subira (2006). *Creating an Innovative Europe*, Report of the Independent Expert Group on R&D and Innovation appointed following the Hampton Court Summit, Brussels.
- Boekholt Patries, Paul Cunningham, Jakob Edler and Kieron Flanagan (2009), *Drivers of international collaboration in research*, Study for the European Commission, DG Research, Amsterdam, Brussels, Manchester: European Commission.
- Bonaccorsi, Andrea (2008), 'Search Regimes and the Industrial Dynamics of Science', *Minerva*, **3** (46), 285-315.
- Braun, Dietmar (ed) (2008), 'The Governance of Knowledge Policy', Special Issue of *Science and Public Policy*, **35** (3).
- Braun, Dietmar (2008), 'Organising the political coordination of knowledge and innovation policies', *Science and Public Policy*, **35** (3), 227-239.
- CREST Working Group (2007), *Internationalisation of R&D – Facing the Challenge of Globalisation: Approaches to a Proactive International Policy in S&T, ANALYTICAL REPORT. Policy Approaches towards S&T Co-operation with Third Countries*, Brussels.
- Derlien, Hand-Ulrich (1991), 'Horizontal and Vertical Coordination of German EC-Policy', *Hallinnon Tutkimus*, 3-10.
- Edler, Jakob, Patries Boekholt, Oliver Donard and Terry Wilkinson (2008), *Review of the ERA-NET 'iMERA' and ERA-NET Plus 'iMERA+' in view of the intention to prepare an Article 169 initiative*, Report of an Expert Group to the European Commission, Brussels.
- Edler, Jakob (ed) (2007), *Internationalisierung der deutschen Forschungs- und Wissenschaftslandschaft (Internationalisation of the German Research and Science Landscape)*, Karlsruhe/Stuttgart: ISI.
- Edler, Jakob, Kieron Flanagan, Ian McMorris, Deborah Cox, Lynn Gaynor, Andrea Mina and Paul Cunningham (2008), *Ireland's International Engagement in Science, Technology and Innovation, Technology and Innovation*, Dublin/Manchester: Forfas.

Edler, Jakob and Stefan Kuhlmann (2008), 'Co-ordination within fragmentation. Governance in knowledge policy in the German federal system', *Science and Public Policy*, **35** (3), 265-276.

European Commission (2007), *Third Status Report on European Technology Platforms*, Brussels: European Commission.

European Commission (2008), *Opening to the World: International Cooperation in Science and Technology*, Report of the ERA Expert Group, Brussels: European Commission.

European Commission (2009), *The Open Method of Coordination in Research Policy: Assessment and Recommendations*. A Report from the Expert Group for the follow-up of the research aspects of the revised Lisbon strategy; Brussels.

Georghiou, Luke (1998), 'Global cooperation in research', *Research Policy*, **27** (1), 6-11.

Glänzel, Wolfgang (2001), 'National characteristics in international scientific co-authorship relations', *Scientometrics*, **51** (1), 69–115.

Glänzel, Wolfgang and Cornelius De Lange (2002), 'A Distributional Approach to Multinationality Measures of International Scientific Collaboration', *Scientometrics*, **54** (1), 75-89.

Glänzel, Wolfgang, Koenraad Debackere and Martin Meyer (2006), '*Triad*' or '*Tetrad*'? *On global changes in a dynamic world*, Paper presented at the SPRU 40th Anniversary Conference 'The future of science, technology and innovation policy: Linking research and practice', University of Sussex.

Griessen, Thomas and Dietmar Braun (2008), 'The political coordination of knowledge and innovation policies in Switzerland', *Science and Public Policy*, **35** (3), 277-288.

Katz, J.S. and B.R. Martin (1997), 'What is research collaboration?', *Research Policy*, **26** (1), 1-18.

Kuhlmann, Stefan, Peter van den Besselaar, Jakob Edler, Luisa Henriques, Philippe Larédo, Terttu Luukkonen, Barend van der Meulen, Maria Nedeva, Daniel Pardo, Emanuela Reale and Duncan Thomas (2008), *Configurative processes of knowledge, institutions and policy in Europe*, presentation from the PRIME ERA-Dynamics project, May 2008, Bonn (available at: <http://www.prime-noe.org/Local/prime/dir/Projects/ERA%20Dynamics/ERA%20Dyn%20presentation.pdf>).

Kveseth, Kari (2008), *Experiences from Bilateral and Multilateral Cooperation*, presentation at the Conference 'Drivers of International Collaboration in Research', organised by the European Commission, 13-14 October 2008, Brussels.

Mattison, Pauline, Patrice Laget, Anne Nilsson and Carl-Johan Sundberg (2008), 'Intra-EU vs. extra-EU scientific co-publication patterns in EU', *Scientometrics*, **75** (3), 555–574.

Metcalf, Les (1994), 'International Policy-Coordination and Public Management Reform', *International Review of Administrative Science*, **60** (2), 271-290.

Nedeva, Maria, Terttu Luukkonen and Remi Barré (2006), 'Understanding the dynamics of networks of excellence', *Science and Public Policy*, **33** (4), 239 – 252.
OECD (2007), *OECD STI Scoreboard*, Paris: OECD.

Painter, M. (1981), 'Central agencies and the coordination principle', *Australian Journal of Public Administration*, **60** (4), 265–280.

Pelkonen, Antti., Tuula Teräväinen and Suvi-Tuuli Waltari (2008), 'Assessing policy coordination capacity: higher education, science, and technology policies in Finland', *Science and Public Policy*, **35** (3), 241-252.

Peters, Guy (1998), 'Managing horizontal government: the politics of coordination', *Public Administration*, **76** (2), 295–311.

Peters, Guy (2005), *Concepts and theories of horizontal policy management*, X Congreso Internacional del CLAD sobre la Reforma del Estado y de la Administración Pública, 18-21 October 2005 Santiago, Chile.

Subramanyam, K (1983), 'Bibliometric studies of research collaboration: A review', *Journal of Information Science* **6** (1), 33-38.

Technopolis (2005), *Drivers, Barriers, Benefits and Government Support of UK International Engagement in Science and Innovation*, Report for the Global Science and Innovation Forum, UK.

Wagner, Carole (2006), 'Six case studies of international collaboration in science', *Scientometrics*, **62** (1), 3-26.

Wagner, Carole and Loet Leydesdorff (2007), *Globalisation in the network of science in 2005: The diffusion of international collaboration and the formation of a core group*, MIMEO (available at <http://users.fmg.uva.nl/lleydesdorff/cswagner07/globalisation.pdf>).

Wiener, Antje and Thomas Dietz (eds) (2004), *European integration theories*, Oxford: Oxford University Press.

Wittke, Wolfgang (2008), *ERA-Net Survey on joint research activities*, Brussels: European Commission.