Drivers of international collaboration in research

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Final report

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EUROPEAN COMMISSION

Drivers of International collaboration in research

Final Report

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Executive Summary

In international cooperation in science, technology and innovation (STI), countries do not only seek partner countries solely on the basis of STI characteristics. There is a wide range of rationales why countries and their science communities enter into cross-border STI cooperation. This study seeks to understand what (policy) considerations are made when establishing and implementing STI linkages with other countries. The report reviews the various drivers behind international STI co-operation and explores the interactions between these drivers. Evidently, the science and technology community has a strong influence on the direction and contents of cross-border STI partnerships. However, a wider set of policy objectives influence today's patterns of STI-collaborations between EU Member States and between the EU Member States and non-EU countries or 'Third Countries'.

At present one can witness a growing policy attention for STI collaboration and in particular the adoption by the European Commission of a "Strategic European Framework for International Science and Technology Cooperation"[1] in 2008 and the establishment by the Council of the European Union of a new European "Strategic Forum for International S&T Cooperation" (SFIC) mandated to drive forward the European partnership for international S&T cooperation[2].

The growing attention for international STI co-operation policies can be explained by a number of external developments that have triggered the policy debate in recent years:

- The emergence of the BRIC (Brazil, Russia, India, China) countries and particularly China as a country with a large research and technological development capacity that is becoming recognised for meeting high international quality standards
- The increased political debate and urgency of global challenges such as climate change, health issues and sustainable energy resources
- The globalisation of R&D, which is not a new phenomenon, but it is becoming more visible particularly in industrial research and also in the world wide mobility of researchers
- Particularly in Europe, general demographic developments and the decreasing share of graduates in science and engineering have made the shortage of research talent very urgent; STI collaboration can be used to attract talent from partner countries
- The increased policy debates and ambitions in Europe to provide more critical mass and international profile to research excellence, in which partnering with the best plays a big role. The discussion on the European Research Area and the position Europe should play in the global arena has also spurred more discussion on the topic.

When analysing the rationales behind international research collaboration policies, one can distinguish on the one hand the 'narrow STI cooperation paradigm' and the 'broad research cooperation paradigm' (Chapter 4). While every categorisation is a

[1] COM(2008)588 Communication from the Commission to the Council and the European Parliament, "A Strategic Framework for International Science AND Technology Cooperation".
[2] Conclusions of the Council of the European Union, Competitiveness Council meeting , 2 December 2008.

simplification of reality, it can be observed in policy practice that these paradigms exist alongside each other and their degree of overlap and interaction varies considerably from country to country.

In the **narrow STI cooperation paradigm**, the drivers are mainly to improve the quality, scope and critical mass in science and research by linking national (financial and human) resources and knowledge with resources and knowledge in other countries. The drivers originate from within the science community and are translated in science and research policy instruments. It can have a two-directional aim: to obtain access to state-of-the-art knowledge abroad as well as to attract state-of-the-art knowledge or people to the 'home' country. From the view of the research community, joint research activities are conducted for scientific problem solving. In less R&D developed countries an important 'intrinsic' driver is to build up national STI capabilities through international cooperation.

In the **broad STI cooperation paradigm** other non-science policy objectives interact with the 'intrinsic' science oriented objectives and STI cooperation becomes a means to reach other policy ends. What we have found in the literature and selected country studies is that alongside the 'intrinsic research policy' drivers the four main drivers behind STI cooperation are:

- Improving national competitiveness
- Supporting less developed countries by developing STI capabilities
- Tackling global societal challenges
- Creating good and stable diplomatic relationships (and indirectly ensuring international security)

The narrow 'intrinsic STI paradigm' forms the core of international research collaboration, motivated by the aim to achieve research excellence, to attract scarce human resources for research and also to build STI capabilities through people and institutions. External triggers such as the globalisation of R&D, the urgency of certain global challenges, the emergence of new players on the global research market and the lively policy debate about the place of Europe as the 'most excellent place to do research in the world' have stirred the interest for more strategic thinking on the role of STI collaboration within and outside Europe.

The external triggers have increased the weight of some drivers from the 'broad paradigm': the globalisation of (industrial) R&D has put competitiveness policy goals higher on the agenda. The urgency of certain global challenges has opened the discussion for more global research programmes and facilities on these topics. Other drivers such as diplomacy and historical cultural ties between countries and development aid have for a long time influenced the geographical direction and thematic focus of 'third country' collaboration and still form a stable influence in the background.

The country review revealed a wide set of (national and international) actors involved in launching and implementing initiatives for research collaboration. Cross-cutting coordination at the national (or trans-national) level, between the involved policy domains and between different levels of the research policy community – with the aim to align instruments, to select target countries or, thematic themes – is still an exception although many countries are working towards a more strategic framework. For those issues that need an urgent global approach, few strategic fora exist that can help to launch a dialogue in order to set priorities and define joint actions.

Given that the development of international STI collaboration is becoming a key dimension in the strategic considerations of governments, funding agencies, research organisations and individual researchers, and given the move towards a broad paradigm, one might expect to find evidence of elaborated strategic intelligence and indicator systems to support and inform strategies and activities. Whilst some data collection and analysis is undertaken, it still appears that – beyond a small set of well

established basic indicators such as co-publications, co-inventions or participation in the EU framework programmes – the use of indicators to support systematic and holistic policy making by national governments remains limited.

The study team proposes a strategy cycle approach conceptualising indicator needs in support of policy and strategy at four major 'stages', which correspond to key policy-making activities (Chapter 5). The first stage refers to indicators to assess the *status quo* in international collaboration activities. The second stage is about setting targets and making policy choices. The third stage needs indicators to understand the international 'opportunity environment'. And finally the fourth stage is about monitoring and evaluating international collaboration policies. On the basis of our country survey and literature review the report (Chapter 6) summarises how countries *use* indicators and metrics to develop and assess internationalisation policies. The sophistication and use of policy evidence, strategic intelligence and indicators varies considerably across countries. The general finding remains: indicator use to underpin internationalisation policies shows room for improvement. Policy makers across the world are increasingly aware of that and are in the process of developing better approaches. The study team provides proposals for a set of indicators and which policy actors should conduct actions to improve the data collection, design and use of this basic set of indicators (Chapter 7).

To support and validate the study an international conference was organised in October 2008, with many stakeholders from the STI policy community (see Background Report 4). The **main messages** that came from the conference were:

- International S&T collaboration could be made more effective and efficient through greater programme co-ordination between countries (and with international organisations and foundations) and through pooling of effort;
- International science and technology co-operation is both a policy goal and an instrument to support other policy goals (such as development, competitiveness, health and diplomacy). STI collaboration could become a more powerful policy tool if strategic policy frameworks were better developed to align diverse policy objectives;
- Few countries have developed a good impact assessment and measurement system to evaluate whether international collaboration policies have desired effects. Furthermore, there are still large gaps in the data provision that could support these assessments.

In summary the study has shown that a number of trends are emerging regarding international research collaboration and the use of policy evidence on behalf of this:

1. The policy attention for international research collaboration is growing rapidly in all countries. Globalisation (of markets and R&D), fast emerging large economies (India, China) and the opening up of their STI systems, the urgency of global challenges, scarcity of human resources in research are external factors that have spurred this growing attention to the subject;
2. In terms of policy drivers we have established a 'narrow paradigm' (stemming from the dynamics of science and research) and a 'broader paradigm' (stemming from additional policy objectives that use STI collaboration as a mechanism to achieve supplementary goals). The diverse sets of drivers interact with each other, even if they are not 'co-ordinated' in a formal sense by the policy domains and actors behind those drivers and particularly when international STI collaboration is not a purely bottom-up process run by the research performing actors themselves;
3. International STI collaboration policies and programmes that combine various policy drivers (e.g. research excellence with a diplomatic choice for the geography, scope and scale of research with improving competitiveness in specific thematic areas) usually have very fuzzy goals and the envisaged outcomes and impacts are

not well defined. In such cases, setting up a coherent set of indicators to define its success on all fronts becomes difficult;

4. While policy makers and research funders apply many assumptions regarding how international STI collaboration has an effect on various policy goals, these are rarely specified or operationalised in the implementation of the instruments in place. Particularly in the 'broad paradigm' the causal relationships between the desired effect and the contribution of international STI collaboration programmes cannot be established;

5. Given the multitude of actors involved in implementing STI collaboration, the variety of drivers, the different starting position of countries and the parallel use of bottom-up and more top-down strategies, it is not likely that EU Member States can easily develop a coherent evaluation and indicator framework. Nevertheless a starting set consisting of a 'bottom-line' framework and a set of key indicators starting from the 'narrow' paradigm would be a necessary first step.

1. Introduction

Policies to support international collaboration in research have a long history and many initiatives, programmes, collaboration agreements have been put in place. Globalisation has intensified the need to develop these policies more strategically and to make them more effective. The experience of, and factors affecting, the level of international research collaboration of major funding countries and of funding recipients prove to be very diverse. This report written jointly by the Technopolis Group and the Manchester Institute of Innovation Research (The University of Manchester), is a synthesis of a research project conducted on behalf of the European Commission DG Research. The project included two major blocks: the organisation of a conference on the topic of international research collaboration and a study on the same topic. This report mainly builds on the study conducted by both teams, but also includes input from an international conference held within the context of this project.[3]

2. The aim and focus of this study

The ERA Green Paper (EC 2007) stressed the importance of opening to the world: "The challenge is to make sure that international research cooperation contributes effectively to stability, security and prosperity in the world". It poses the question how the European Commission and EU Member States can work together to define priorities for international science, technology and innovation (STI) cooperation with the other dimensions of external relations.

The adoption by the European Commission of a "Strategic European Framework for International Science and Technology Cooperation" in 2008 provided a number of underlying principles to guide the development of European research cooperation with the rest of the world. The Communication also provided a stimulus for the Council to establish a new European "Strategic Forum for International S&T Cooperation" (SFIC) mandated to drive forward the European partnership for international S&T cooperation.

Our team, commissioned by the European Commission, DG Research, was tasked to conduct a study on the factors which influence international research co-operation policy and hence the scale, conduct and development of international research cooperation.

The study consists of a literature review, the analysis of STI cooperation policies in 10 EU-countries[4] and 10 non-EU countries[5] and thirdly the identification and development of a set of indicators to measure the progress and success of international STI cooperation policy. The information on the 20 countries was collected through desk research mainly and some telephone interviews with policy makers responsible for STI collaboration. Alongside this study, the team organised an international conference on the topic, which took place in Brussels on 13-14 October 2008. The results of the conference are also included in the findings of this synthesis report. A

[3] Conference on Drivers of International Collaboration in Research, held on 13 & 14 October, Brussels.

[4] Estonia, Finland, France, Germany, Ireland, Poland, the Netherlands, Spain, Sweden and the United Kingdom

[5] Australia, Brazil, Canada, China, India, Japan, Mexico, Russia, South-Africa and the United States.

more detailed account of the conference can be found in a separate report (Background Report 4). The **main messages** that came from the conference were:

More effective and efficient STI collaborations through greater programme co-ordination between countries

- International S&T collaboration could be made more effective and efficient through greater programme co-ordination between countries (and with international organisations and foundations) and through pooling of effort;
- International science and technology co-operation is both a policy goal and an instrument to support other policy goals (such as development, competitiveness, health and diplomacy). STI collaboration could become a more powerful policy tool if strategic policy frameworks were better developed to align diverse policy objectives;
- Few countries have developed a good impact assessment and measurement system to evaluate whether international collaboration policies have desired effects. Furthermore, there are still large gaps in the data provision that could support these assessments.

Factors which influence international research co-operation

The first task of the study was an identification and assessment of the importance of factors, which influence international research co-operation policy and how this influences the development of EU international STI co-operation programmes and policies. Focus was placed on building an understanding of the global international STI cooperation environment, covering issues such as how countries and regions are selected for cooperation at research policy level, what actors are involved in launching STI co-operations and whether this forms part of a wider STI internationalisation strategy. Thus the study looks at STI cooperation policy, and in particular the set of decisions and actions that affect the size, scope and contents of STI co-operation programmes between countries. The focus of this study is not on inter-European cooperation but on cooperation between EU-countries with non-EU countries, and cooperation between non-EU countries. From a European perspective this is referred to as 'Third Country' cooperation. The background on STI collaboration is discussed in chapter 3 and the factors and drivers influencing policies in chapter 4.

Identification of appropriate practical indicators

The second task of the study was the identification of appropriate practical indicators, which have been or could be used to assess success of international research co-operation; and, how these are/could be used in policy decision making. The rationale for this is that policy-making needs to take account of its goals and achievements, must be aware of the points of departure and should be explicit about the direction in which it wants to influence the research community. Whilst there are a whole range of indicators to measure the international activities of firms and individual researchers, little is known about the use of indicators and analysis of the internationalisation of policies and programmes and its effects. The review of countries suggest that most policymakers are still in the process of defining good measures for success of international STI cooperation and the indicators that could be used for measuring them. The second part of this report, chapters 5 and 6, will therefore be devoted to a conceptualisation of indicators to support international S&T policy making about the internationalisation of STI and a discussion of trends and obvious gaps. The basis for these considerations is a literature review and a review of the 20 countries. This screening explores trends and gaps in the usage of indicators as a basis for subsequent analysis and to make recommendations about how to improve the use of indicators in the future.

3. Background on STI collaboration

3.1 The global context of internationalisation of R&D[6]

Whilst science has always aspired to universalism, the growing internationalisation of research is perhaps most visible in the growth of a global science system of English language, international journals indexed in the Thomson-ISI Science Citation Index (SCI). Even within this globalised international science literature, scientific collaboration as measured by co-publication by authors from two or more countries is on the increase, and bibliometric data also suggest that such papers have, on average, a higher citation impact – though some commentators have expressed doubts as to whether these higher citation rates can be conclusively interpreted as an indicator of intrinsic quality (Glanzel, Debackere, Meyer, 2006, van Raan 1997). A number of patterns are visible that have policy implications. First, the more basic the field of research, the more likely there will be international collaboration. Second, researchers in smaller countries are more likely to turn to international collaboration than those in larger ones. Finally, patterns of scientific collaboration remain influenced by socio-economic and cultural ties: with collaborations often following language or historical links.

Internationalisation of research is perhaps most visible in the growth of a global science system

In the same way, co-patenting analysis suggests that the internationalisation of the ownership of technology (cases in which co-inventors are from two or more countries or where the owner and inventor of a patent are located in different countries) is increasing, though again with significant country differences in the extent of internationalisation. For instance, the UK scores relatively high on the internationalisation of technology on such measures whilst Japan exhibits relatively little. In general it appears that, much as for science, smaller countries (e.g. countries like the Netherlands or Denmark) exhibit proportionately more internationalisation of technology, on average, than do larger ones (e.g. Germany or France).

Publication and patenting analysis aside, most of the evidence concerning internationalisation of science and technology focuses on flows of funding and investment, on the one hand, and on human capital – researchers – on the other. In these areas indicators are much less developed and although much data is available the interpretation of data often collected for very different reasons remains difficult. Studies point to a growth in the international exploitation of high technology throughout the last 10 years over and above that in international trade more generally. There is evidence of clear differentials in the shares of industrial R&D invested across borders, in the relative importance of foreign affiliates in a country and the extent of cross-border co-operation in innovation.

Evidence focuses on flows of funding and investment, on the one hand, and on human capital – researchers – on the other

Similarly, whilst there is comparatively little systematic collection of consistent data about national researcher stocks and flows on either a Europe-wide or indeed a global basis, a range of ad-hoc studies suggest that the international mobility of researchers is increasing, and some patterns and dynamics can be observed. Not surprisingly, studies suggest that the US is the most popular destination for graduates seeking career opportunities abroad due to better salary conditions, prospect of swift career advancement and access to top-of-the-range facilities. Within the EU, the UK is a popular destination for inwardly mobile researchers. As with co-publication patterns, linguistic and cultural proximity appear to be major influences on the choice of country of migration – as do the presence or absence of dedicated schemes and the enforcement of favourable immigration policies. Whilst potentially significant barriers

[6] A full literature review with precise citations is available as Background Report 1 of this Final Report

to researcher mobility remain (such as national research funding system rigidities and problems around transferability of pensions), it seems that many barriers to international mobility have been lowered significantly in recent years (an alternative interpretation might be that 'attracting' or 'repelling' factors at the source or destination locations have increased). Despite increased discussion of the possible benefits to all parties of 'brain circulation', analysts and policy-makers alike remain concerned about the possible problematic consequences of outflows of researchers for smaller economies that cannot guarantee top-of-the-range salaries and research facilities.

3.2 Main developments in STI collaboration policies from a European perspective

Much recent policy attention has been paid to the role of international collaboration in STI as driven by trade, foreign investment, global influence, the flow of research and innovation talent, etc. At the same time, collaboration is increasingly seen as a contribution towards or even an essential underpinning of, for instance, education, diplomatic and development policy.

Spread of big science models in last four decades

Some aspects of STI related policy have long been international. The last four decades have seen the emergence and growth in importance of major international collaborative research facilities, and organisations in the context of the spread of big science models from their origins in astronomy and particle physics. Europe, supported partly by the general drive towards economic and political integration, has often been the locus for collaborations of this kind in both basic and more applied fields, with the most famous examples being CERN and the European Space Agency. A second pillar of international collaboration has been set up and developed through the European RTD Framework Programme which has developed as one of the most important drivers of the internationalisation of the research communities of many EU member states.

A third phase of international collaboration in Europe has emerged in recent years, as national research funding agencies (in Europe often with the encouragement and support of the EU) are increasingly coordinating efforts and even collaborating on joint programmes. In parallel, research performing institutions at the national level (and especially Higher Education Institutions) are increasingly including internationalisation as part of their formal strategies. The entire scale and scope of those developments cannot yet be assessed, and interestingly, they are not yet accompanied by a more general opening up of national research funding programmes. Still, it appears that the policy landscape in STI is changing, with the nation state becoming relatively less important as the prime locus of policy and strategy with the advent of diverse and multi-faceted funding arrangements and organisational strategies.

Highly skilled worker mobility on the agenda since the 1990s

Big science apart, the internationalisation of the STI community has become a major issue for national research and innovation policies. In the 1990s, the issue of economic consequences of researcher and highly skilled worker mobility came back on the policy agenda. For many years, the major perspective for international mobility of scientists and highly skilled workers had been the so-called 'brain drain' discussion. Although prominent in debates about smaller or less-developed countries, the term 'brain drain' originated in fears dating back to the 1960s over the loss of UK researchers to the US system, and countries like the UK have intensified their efforts to attract back or retain elite researchers. The European Commission has estimated that in order to meet its 3% objective, a further 600,000 to 700,000 researchers will be needed, increasing the current level of researchers from 6 per 1000 labour force to 8 per 1000. A more flexible and transparent European labour market for researchers is now viewed as highly desirable for research, innovation and growth in general and for improving employment and working conditions for researchers in particular. This policy approach is underpinned by the assumption that geographical mobility tends to lead to productive combination(s) of localised knowledge, efficient intellectual exchange to

foster international research collaboration and dissemination of good practice and research excellence. The focus on raising the mobility of researchers has to be seen against the fact that researcher mobility is largely a temporary phenomenon, with most doctoral and post-doctoral researchers later returning to their home countries bringing with them valuable knowledge, experience and contacts. European countries have intensified efforts to govern brain circulation to reap such benefits. However, if a European research system is truly emerging then a number of potentially serious deficiencies have been identified by scholars, including: relatively poor employment conditions including precarious employment; narrow career prospects; and mobility opportunities hampered by structural, institutional and national boundaries. The Kok Report (EC, 2004a), in reviewing progress in accordance with the Lisbon agenda, particularly stressed the need for Europe to rapidly improve its attractiveness to researchers by reducing administrative obstacles to mobility in the areas of social security entitlements, fast-track work permit and visa procedures and recognition of qualifications. A great deal of recent EC effort has been focused on how to remedy these deficiencies and make a career in research more attractive to the best researchers, to incentivise researchers to stay in Europe whilst also attracting the best researchers in the global marketplace to come to Europe. Despite these efforts mobility measures have not proceeded as fast as expected, partly because of limited Community competences in policy areas such as social security, and partly due to a lack of political willingness within Member States to accept Community measures for specific categories of workers.

Europe to rapidly improve its attractiveness to researchers

European countries increasingly have a high-level internationalisation strategy in place, sometimes as part of a general globalisation strategy. Others are in the process of defining such a strategy. Despite this enormous interest in strategy building, many of these strategies do not appear to be direct drivers of policy action at present, and strategy development and implementation remains more of a promise than a reality in most of the countries surveyed in this study. The policy drivers highlighted by these internationalisation strategies are broadly similar from country to country. In general, the most important drivers as documented in the literature are: strengthening (domestic) research excellence through access to existing excellence and facilities abroad, to increase the attractiveness of domestic systems to overseas researchers (inward mobility), preparing the ground for domestic innovations to be marketed abroad, and to contribute to the solution of global challenges. However, countries are also at least in principle aware of the risks of engaging in international activities, such as those around IPR issues, 'brain drains' or the outward relocation of key companies to other countries.

More high-level internationalisation strategies in place in EU countries

There is some evidence that governments are less actively pursuing outward technology links for domestic firms than they are attempting to attract inward investment and mobility. Policy makers continue to struggle to find a balance between the promotion of beneficial internationalisation and firmly embedding both domestic and inwardly mobile companies and research organisations within the national research and innovation system. Only limited data is available about the 'openness' of nationally funded research and technology development programmes to overseas partners. That data which does exist suggests that the share of the budgets that are spent on international activities within national programmes is still low even where they are open in principle. There is some evidence that universities and research institutes may be more ready and willing to internationalise than are companies, suggesting that universities and institutes could play an important role in linking different national research and innovation systems.

3.3 Consequences for STI collaboration policies

A broad array of drivers for internationalisation act upon individual researchers, research performing organisations and policy-makers, and the scope of drivers appears to have broadened and certainly has shifted in recent years. For the individual researcher, international cooperation and mobility is becoming almost a condition

An increasing interest in monitoring and measuring STI cooperation

sine qua non when it comes to academic career and impact. Internationalisation of firms is also on the rise, with a shift to knowledge seeking globally and combined with efficiency considerations (costs). Although science has always been highly international, scientific institutions and funding institutions have been latecomers when it comes to internationalisation. However, strategies are being developed now at all levels, even if funding organisations in particular still struggle with their design and implementation, and with determining the right level and modes of international involvement. Finally, national policy-makers are at the beginning of a journey towards more conscious and comprehensive internationalisation strategies that link bilateral, European multi-lateral, European and global approaches and are driven by a broad range of motivations. There is an increasing interest in monitoring and measuring these developments and thus underpinning the strategic actions taken by individual and institutional actors within the country.

The coverage of the set indicators remains unsatisfactory. A list of indicator deficiencies can be detected:

- The international activities of individuals
- The sectoral and technological patterns of industrial cooperation
- Cooperation in innovation more broadly
- The embeddedness of foreign actors within their host system
- The extent to which international collaboration is pushed and financed through global challenge organisations
- The scope of internationalisation of national policy and programmes

Determining the impacts of internationalisation activities presents a significant challenge

Above all, there are no indicators to measure the effects and impacts of international collaborations of all kinds. Activity and output indicators often exist, and are often key in mapping internationalisation of researchers, institutions and firms. At the policy and funding level data is patchier and at all levels, even in cases where evaluation and monitoring collects information on international activities, there is no focus on the impacts of such activities, whether positive or negative. Determining the impacts of internationalisation activities presents a significant challenge to evaluation and strategic intelligence more generally and here policy makers will have to work closely with analysts to determine innovative new approaches which can tackle this gap. Without better evidence in this regard, better data on activity levels will be of limited use. A crucial problem in this regard is the difficulty in distinguishing between drivers of internationalisation which can be considered to be 'internal' to the scientific enterprise and 'external' pressures[7].

[7] Fuller (2000), discussing the ever-growing capital-intensity and 'materially interested' nature of modern science, discounts the idea that these trends are the result of a 'natural' internal trajectory of modern science, arguing rather that such developments are constructed over time and then reinterpreted as inevitable by a number of 'intermediation' processes which obscure the choices thus made.

4. Mapping the Drivers for International Research Collaboration Policies

4.1 Introduction

Despite the long history of autonomous cross-border co-operation between scientists and researchers, a wide array of policies to enhance co-operation between research actors is also in place. In fact, the policy activity in this area is growing in terms of visibility, geographical scope and probably also the budgetary size as established in the previous chapter. This chapter gives an overview of the drivers behind STI collaboration policies. The main questions addressed are:

- What policy considerations and goals are behind international research collaboration?
- What factors shape the geographical and thematic focus of international research collaboration
- On what grounds are countries and regions are selected for cooperation at research policy level?
- What actors are involved in launching STI co-operations?
- In how far are these policies part of a wider STI internationalisation strategy?
- What has triggered the recent emergence of this policy topic?

Thus the focus of the study is on *policies* to support international research collaboration, rather than the collaboration between individual researchers or research organisations. We define international STI collaboration policies as any explicit action by government officials (regulation, programmes, official agreements and memorandum of understanding, financial investments, etc.) that has the aim to influence the intensity, content and direction of collaboration between research performers in the public and private sectors across borders. As mentioned above, in this study intra-European collaboration is not the focus of attention, although it is discussed as the wider context in which international research collaboration is shaped for the countries under review.

Focus of the study is on *policies* to support international research collaboration

The study suggests that due to changing global trends, these non-science policy objectives are moving more to the foreground and provide the research policy community with both opportunities and challenges. Important triggers for the increase of activity in international research collaboration in recent years are:

Important triggers for the increase of activity in international research collaboration

- The emergence of the BRIC countries and particularly China as a country with a large research and technological development capacity that is becoming recognised for meeting high international quality standards
- The increased political debate and urgency of global challenges such as climate change, health issues and sustainable energy resources
- The globalisation of R&D, which is not a new phenomenon, but which is becoming more visible particularly in industrial research and in the world wide mobility of researchers
- Particularly in Europe, the general demographic developments and the decreasing share of graduates in science and engineering have made the shortage of research talent very urgent; STI collaboration can be used to attract talent from partner countries

- The increased policy debates and ambitions in Europe to provide more critical mass and international profile to research excellence, in which partnering with the best plays a major role. The discussion on the European Research Area and the position Europe should play in the global arena have also spurred more discussion on the topic.

The EU has played an important role in mobilising the discussion

The European Commission itself with its manifold recent studies, expert groups (e.g. EU Expert group 2008) and trans-national policy working groups (e.g. the CREST group on internationalisation of STI) has played an important role in mobilising the discussion. Similarly, the OECD has put together indicators (mainly for industrial R&D and mobility) for many years and organised a trans-national discourse of policy makers and analysts which has raised awareness about both the increasing level and changing nature of international STI collaboration. Exactly how individual countries have reacted to the challenges and opportunities is still very diverse, policy learning does not automatically mean policy convergence. Our present study does not analyse the basic triggers and the way policy makers have learned, but it takes stock of the resulting policy drivers and the evidence base underpinning policy. On this basis it suggests a simple framework for evidence based international STI policy making (see Chapters 5 and 6). Thus, it is itself a contribution for improved policy learning and development in Europe.

By analysing the rationales behind international research collaboration policies one can distinguish on the one hand the 'narrow STI cooperation paradigm' and the 'broad research cooperation paradigm'. While every categorisation is a simplification of reality, it can be observed in policy practice that these paradigms exist alongside each other and their degree of overlap and interaction varies considerably from country to country.

Narrow and broad STI cooperation paradigms

In the **narrow STI cooperation paradigm** (see paragraph 4.3) the drivers are mainly to improve the quality, scope and critical mass in science and research by linking national (financial and human) resources and knowledge with resources and knowledge in other countries. The drivers originate from within the science community and are translated in science and research policy instruments. This can have a two-directional aim: to obtain access to state-of-the-art knowledge abroad as well to attract state-of-the-art knowledge or people to the 'home' country. From the view of the research community, joint research activities are conducted for scientific problem solving. In less R&D developed countries an important 'intrinsic' driver is to build up national STI capabilities through cooperation.

In the **broad STI cooperation paradigm** (see paragraph 4.4) other non-science policy objectives interact with the 'intrinsic' science oriented objectives and STI cooperation becomes a means to reach other policy ends. What we have found in the literature and selected country studies is that alongside the 'intrinsic research policy' drivers the four main drivers behind STI cooperation are:

- Improving national competitiveness
- Supporting less developed countries by developing STI capabilities
- Tackling global societal challenges
- Creating good and stable diplomatic relationships (and indirectly ensuring international security)

The different drivers are not mutually exclusive, nor do they operate in isolation

Figure 1 gives an overview of the main policy domains, which share a number of drivers to establish international STI co-operations and have a variety of objectives and goals. The different drivers are not mutually exclusive, nor do they operate in isolation. The geographic direction of intrinsic science objectives is influenced by diplomatic goals: for instance, we often see that science relations were set up as a first step in diplomatic relations or as a result of longstanding diplomatic ties (e.g. post-colonial relationships). The degree to which these domains are integrated is largely a matter of governance: for instance, coordination between science ministries and

ministries responsible for foreign affairs is in most cases not very strong, although countries such as France and the UK do have a tradition of coordinating these policy domains.

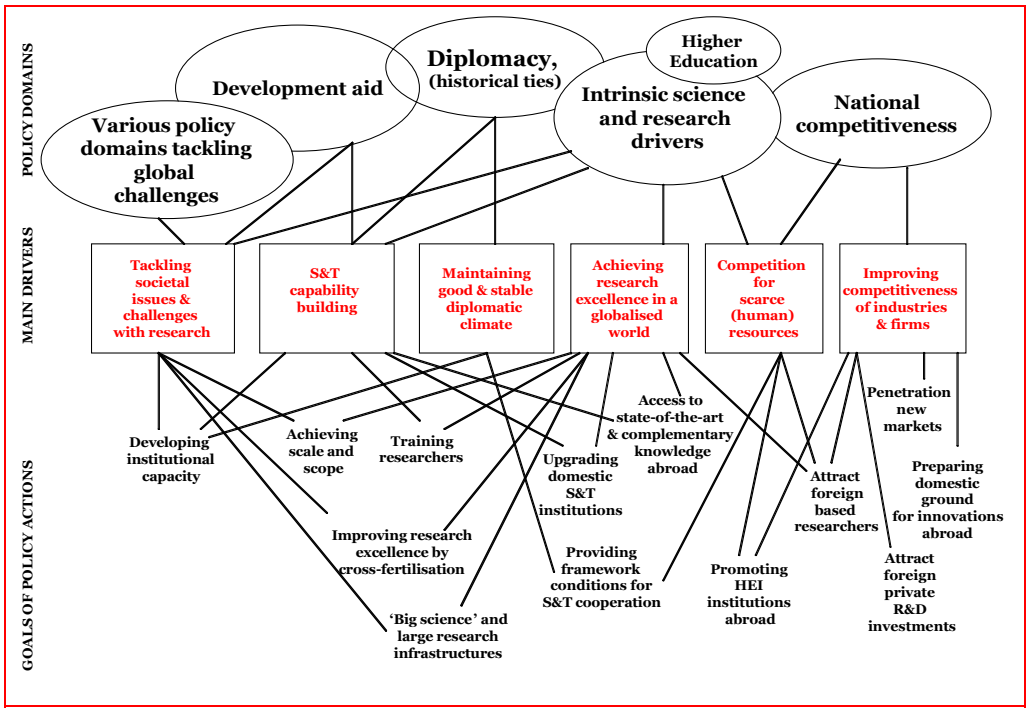
The emergence of competitiveness as an important driver is becoming more intertwined with science policy drivers as excellent science is increasingly seen as a magnet for international business investment. However, none of the countries under review have a set of STI collaboration policies that are solely matched to their industrial strengths.

Development aid research collaboration has a strong synergy with tackling global issues such as fighting infectious diseases and mitigating the effects of climate change. The geographical direction of STI collaborations in the field of development aid are mostly influenced by international diplomatic and cultural ties.

In line with the key triggers described above, the trend that can be observed is that enhancing competitiveness and addressing global issues through international research co-operation are moving to the foreground, while fostering diplomatic relations with STI collaboration has created a strong historical basis and nowadays can influence the creation of new STI collaborations.

Enhancing competitiveness and addressing global issues through international research co-operation are moving to the foreground

Figure 1 Policy Domains, Drivers and Goals



The lower part of Figure 1 portrays the types of goals in international research collaboration. It shows that particular policy actions can serve more than one driver. For instance actions to attract foreign-based researchers can contribute to improving research excellence in the host country and can help to alleviate the shortage of researchers in academia and in industry, both of which are beneficial in terms of increased competitiveness.

The following paragraphs discuss each of these drivers and the policy domains and goals behind them in more detail. The following Figure 2 shows the overview of drivers that are made explicit in the countries under review (described in more detail in Background Reports 3 and 4). The overview shows that 'achieving excellence in a global world' (the 'narrow' R&D paradigm) is still the core driver for STI cooperation.

Figure 2 Overview of main drivers influencing national agenda's, made explicit in policy strategies in 20 reviewed countries

Country	Tackling global societal issues & challenges	STI capability building		Maintaining good and stable diplomatic climate	Achieving research excellence in a globalised world	Competition for scarce resources	Improving competitiveness
		Development aid	Domestic				
Estonia			XX		X		XX
Finland					XX		X
France		XX		X	XX		
Germany	X	X	X		XX	XX	XX
Ireland			X		XX		X
Poland			X	X	X		X
Spain		XX			XX		
Sweden	X		X		XX		XX
Netherlands		X			X	XX	X
United Kingdom	X	X		XX	XX		XX
Australia	X				XX		X
Brazil			XX		XX		
Canada	X				XX		XX
China		X	X		XX		XX
India			XX		XX		
Japan	X	X		X	XX		
Mexico			XX	XX	X		
Russia	X		XX		X		X
South-Africa		X	XX	X	XX		XX
United States	XX	X			XX	X	

0 = not existing or explicit x = driver xx = very strong driver

4.2 Factors that shape the geographical and thematic focus and intensity of international STI collaboration

4.2.1 The role of actors in shaping STI collaboration

There is no single policy actor defining STI cooperation policies and strategies in the countries under review

In practice, in all countries under review there is no single policy actor defining STI cooperation policies and strategies. In fact, in most countries there is a cumulative set of actions by multiple actors that shape the STI community. Thus policy on research collaboration is mostly a collection of individual measures taken by different actors, rather than a well structured 'policy mix'.

Even in countries with an overarching STI internationalisation strategy such as the UK and Germany, the policies and strategies are an amalgamation of actions by many

actors. In addition several larger countries (Australia, Brazil, Canada, Germany, Mexico, the USA) have regional or state governments involved in STI collaboration.

We can distinguish a number of 'typical' actors that shape international STI collaboration policy[8]:

- National governments (in only a few cases setting the context for an overarching STI internationalisation strategy)
- Ministries directly responsible for research (and/or) innovation policy: in all countries, Ministries are key actors for launching policies. Most countries have divided the research and innovation functions while in some, such as the UK, this is more integrated
- Public organisations tasked with funding of research (e.g. Research Councils, Academies of Science, etc.) and technologies (innovation agencies)
- Ministries responsible for a particular policy domain that apply international STI collaboration as one of the instruments to achieve their policy missions. These could be in the domain of Agriculture, Energy, Environment, Foreign Affairs, Development Aid and Health
- Multilateral research organisations (ESA, EUREKA, ITER, HFSP, etc.)
- Not-for profit and Charity Organisations that have a mission to support research
- Associations of research institutes and individual research organisations such as universities, contract research centres
- Embassies and foreign representative organisations that mainly provide 'strategic intelligence' on specific countries.

As might be expected, the review of countries shows that in all cases ministries/ departments responsible for research and/or innovation policy are the most important actors that shape international STI collaboration *policy*. The funders (Research Councils, Academies of Science) are also quite active and have their own strategies and programmes. However, one can see a recurring pattern of other types of ministries launching and maintaining STI collaborations. For instance, in the domain of health (together with Foreign Affairs) active collaborations are in place in the area of research on specific diseases that particularly affect developing countries (e.g. malaria). In the domain of agriculture specific research collaborations are set up on research on agricultural issues specifically for lesser developed countries with severe challenges (climate, drought, etc.). Here the interaction with the development aid driver is evident.

Ministries and departments responsible for research and/or innovation policy are the most important actors that shape international STI collaboration policy

While STI collaboration was for decades something that the science community conducted in a mode of 'self-organisation' (with the exception of the big science initiatives which needed a good coordination of public financial resources and development aid which needed financial incentives and focused programming), particularly with the emergence of the drivers on competitiveness and global challenges, policy involvement became more necessary to 'steer' researchers towards specific themes or countries.

The advanced STI countries are mostly 'in search of excellence' and aim to attract human resources for STI. In these countries, the top research performers themselves are typically well connected internationally and need little additional incentives to publish in international journals. The emerging EU countries (only two cases in our sample) are mainly aiming to build up the capacity and quality of their own STI system, given that their researchers have not long been exposed to the international

[8] The goal of the study was not to create a comprehensive review of all the actors involved in each of the countries.

STI community. The rationale is that more STI collaboration will give domestic researchers more access to the best in the world and will provide them with incentives to work (publish) more internationally. The countries in development (Brazil, Mexico, China, India and South-Africa) also aim to give their national researchers more incentives to access state-of-the-art knowledge and to build up networks with international research groups. Thus there is a strong training of researchers element involved. Both China and India have evolved from being receiving countries to a position where STI collaboration is based on joint investment and reciprocity.

Only three countries from our review, Germany, Finland and the UK, have an overarching STI collaboration strategy within a wider 'R&D internationalisation strategy'. This does not imply a top down policy strategy that all other actors have to follow. It provides the country with a broader vision of what it aims to achieve and defines the framework conditions that need to be put in place. It also does not mean that coordination does not take place in the other countries. In Canada, for instance, the Department of Foreign Affairs and International Trade has a coordination role and conducts dialogues with other departments. Many countries have a highly decentralised system with many actors playing an independent role.

The study could not detect clear patterns of mechanisms to involve the research performers (research organisations and individual scientists) in the decision making process. In contrast to multi-lateral science programmes, bilateral agreements are typically made mostly for political and diplomatic reasons, not directly related to the priorities of the research community, unless they are with the most advanced countries in the world. In thematically oriented programmes (focusing on a discipline, a specific research field, disease group etc.) the science and user communities are more directly involved. While the science and research community are engaged in the general policy debates on international STI collaboration, they hardly operate as a strong driving force for more policy actions and more structured R&D co-operation. They are users of international research programmes if they are set up, but rarely form a strong lobby force demanding more policy action. The exception is in the 'big science' and research infrastructure areas.

There is no clear pattern which drivers define the geographic direction of the STI co-operations

There is no clear pattern in which drivers define the geographic direction of the STI co-operations. As mentioned above, none of the countries studied have a coherent and coordinated strategy to establish international STI co-operations. Even those with a coordinated policy strategy deal with a legacy of co-operations from previous decades and multiple actors. While in the 'narrow' paradigm the focus is on establishing cooperation with countries with world-class R&D (mainly USA, Europe, to a lesser degree Japan) the competitiveness drivers have shifted the attention to those countries with expanding markets without necessarily world-class research (particularly the BRICs). Nevertheless in a majority of countries under review, the geographical choices in formal STI agreements are made in an ad-hoc fashion.

There is a differentiation between the advanced R&D and already internationally positioned countries (Finland, France, Germany, Ireland, Sweden, The Netherlands, United Kingdom, Australia, Canada, Japan and the United States) and those that are in the process becoming more internationally connected (Spain, India, China) or which have significant catching up to do in terms of building or reforming their STI capacity (Estonia, Poland, Brazil, Mexico, Russia and South Africa). The latter group sees STI collaboration as a way to improve the domestic STI institutions and capacities. They suffer from brain drain rather than brain gain and building STI capacities is a way to attract (back) or retain researchers to the system and to open up the research system to international standards regarding publications and scientific quality. For the first group, the most common driver is to connect domestic researchers with the best in the world, regardless of location. For Spain, India and China, which have large domestic STI capacities the main aim is to add an international focus to what is very much a domestic research 'market'.

The global STI scene has changed

One factor that has had a strong influence in the last five years is the fact the changing nature of the global STI scene: emerging countries such as India, China and Singapore

have large (human) resources dedicated to STI and their research organisations are becoming global actors. Whereas for the last two decades these countries were considered mainly as a source of scarce researchers to attract to the leading STI countries, today their domestic research capabilities are of such scope and quality that they are considered as interesting partner countries. The upcoming position, particularly of China, has triggered much attention for intensifying and co-ordinating the co-operation agreements with this country (Horvat and Lundin, 2008, Arnold *et al.*, 2008). These new perspectives have changed the drivers for developing STI cooperation policies, partly with regard to their nature and content, partly with regard to their geographical focus. Almost all countries under review now aim to establish cooperation with China. Apart from China, the BRICS countries have an interest to establish co-operations with each other as the threshold for cooperation (the differences between R&D competencies) is lower, compared to establishing relations with the most advanced countries.

The upcoming position of particularly China has triggered a large attention of the international community

4.3 The 'Narrow Paradigm': drivers for international STI collaboration in STI policy

In the narrow paradigm international science and research collaboration is linked to drivers 'intrinsic' to the science dynamics. Envisaged effects are:

- Contribution to the quality of science (through cross-fertilization, competition, combining complementary knowledge, access to world class researchers, facilities and groups)
- Solving specific scientific problems that need the input from various international teams
- Increase of the scope of research (combining complementary knowledge, pooling funding and human resources, sharing risks, increasing computational power)
- Better access to scarce human resources for research
- Increase of (international) productivity and visibility of research
- Contribution to building institutional capacity in research organisations

The literature review has elaborated on the international origins of the science process. This does not need further explanation.

Most countries adopt a bottom-up approach: individual researchers and research organisations (universities and other institutes) have the freedom and own responsibility to form international STI partnerships or to attract foreign researchers. In this case research policies can facilitate this bottom-up collaboration through funding schemes, by setting the formal framework conditions (e.g. bilateral collaboration agreements). Many Australian, European and US universities have international offices, mainly focused on attracting foreign students, but increasingly so to promote their research qualities and strengths internationally (Boekholt et al., 2008, Edler et al, 2007).

Within the narrow paradigm most countries adopt a bottom-up approach: the research performers define the themes and partners

Alongside the bottom-up approach, governments steer the bottom-up collaboration between research performers by:

- Defining thematic research funding programmes for bilateral or multi-lateral cooperation. These are either defined by scientific disciplines (e.g. mathematics), by technology domain (often one that fits the strength or strategic goals of both collaborating countries) or related to a societal challenges (e.g. medical research for a certain disease)
- The choice of bilateral partners that are not necessarily the most advanced STI countries, but targeted for reasons concerned to trade, history and cultural ties (shared language, colonial history, shared political system), diplomacy or

development, thus adding additional rationales stemming from the broad paradigm (see below).

- In terms of thematic areas assigned for collaboration there are a limited number of areas that countries seem to follow: nano-technology, bio-technology (& life sciences), research related to climate change, physics (through big science projects) and ICT. Other thematic areas targeted in STI collaboration were oceanography, energy and, as stated earlier, disease related medical research.

In summary, the narrow paradigm is still forms the core of STI collaboration activity. The main rationales are to enhance science and research by stimulating cross-fertilisation, enlarging the scale and scope of research activities, improving the capabilities of researchers (training) and institutions, getting access to state-of-the-art knowledge and attracting human resources for STI.

4.4 The Broad Paradigm: Drivers from policy areas outside the STI domain

4.4.1 Competitiveness and innovation as drivers for STI collaboration with third countries

Improving national competitiveness is becoming a major driver for many countries

It seems that while improving national competitiveness is becoming a major driver for many countries, in this policy domain the objectives and goals of international STI cooperation are operationalised in a very broad manner. A distinction could be made between outward oriented strategies (providing access to national actors to expertise abroad) and inward oriented strategies (attracting business and investment to own country) linked to competitiveness. There is little evidence-based policy research or benchmarking that has formed the basis for these policy rationales. A trigger for this driver, alongside the opportunity aspect, is the fear that nationally based R&D industries will re-locate part of their research activities to more attractive (high quality, lower cost) regions in the world. The review found the following assumptions on the improvements to competitiveness that would stem from STI collaboration:

- If strong clusters or certain technology domains build up international STI relationships they will get access to the best science and technology and build up business relationships with interesting companies in similar clusters/ domains abroad. This type of objective often leads to a thematic approach to international STI relationships (e.g. Sweden)
- Providing national businesses with relevant information and contacts in interesting countries would improve their market access (often the rationale behind science and technology attachés, foreign investment offices located in interesting countries). The boundary between international STI collaboration and Trade and Export support is very thin. Nevertheless, only a few countries (United Kingdom, Finland, Canada) have a coordinated policy approach in these domains.
- Improving collaboration with strong STI countries could enhance R&D related foreign direct investment (for instance, a strong rationale in the United Kingdom and an upcoming goal in the Netherlands).

The envisaged impact is indirect: improving the attractiveness of the national science and technology system will benefit the performance of national industries and attract foreign direct investment in R&D

- Most of the envisaged impact is indirect: improving the attractiveness of the national science and technology system will support the performance of national industries and attract foreign direct investment in R&D. In fact, the review found very few programmes and measures that are directly related to building STI collaborations for the purpose of innovation or direct commercial gain. One example is the International Science and Technology Partnerships Program that promotes bilateral research between Canada and India or China for projects that mainly have the potential for commercialisation. Interviews suggest that European programmes such as Eureka and the Framework Programmes are better geared to

research more directly related to competitiveness, rather than existing collaboration programmes with 'third countries'.

The objectives and targets linked to this driver are rarely defined in measurable and quantifiable terms. South Africa has set the target that foreign funding of R&D remains at least 15% of total R&D expenditure, but such a quantifiable target is an exception in the countries reviewed. Examples were found of thematic collaboration programmes, which have been evaluated on the basis of mostly qualitative assessments. However, given the methodological difficulties of attributing effects on (improved) competitiveness to STI collaboration programmes, it will be difficult to identify good indicators for this driver.

Thus, in this driver domain the diversity between individual countries is connected to their economic specialisation patterns, their strong clusters and the dominant private sector actors. Even within broad thematic areas such as life sciences and ICT, the specific interests will vary enormously.

4.4.2 Global issues

Global societal challenges require multi-lateral approaches on a global scale due to the nature and magnitude of the issues. Obvious examples are climate change, energy production (e.g. ITER), biodiversity and health issues such as HIV/Aids. These types of drivers have led to large multi-lateral programmes and research facilities. Again this driver is not new as some longstanding 'big science' initiatives also aim at tackling societal issues. In the area of health not only government policy and public research funders are initiators, but also international organisations (UN), Foundations and Charities such as the Wellcome Trust, and the Gates Foundation.

Global societal challenges require multi-lateral approaches on a global scale due to the nature and magnitude of the issues.

During the conference on Drivers of International Collaboration in Research (Brussels, October 2008) the Global Biodiversity Information Facility (GBIF) was presented as an example where a pressing global issue (biodiversity under threat and deteriorating due to climate change) enabled the launch of a multilateral research organisation. The OECD Megascience Forum identified a need for global data to be involved in order to address the issues. From the very start of the initiative in 2002, countries from all over the world were involved in setting this up. Another example presented at the conference was the International Energy Agency set up in 1973, which now also includes a global range of countries that use cost and task sharing models to tackle collaborative energy research and technology.

Particularly for the large and highly developed STI countries, various global issues are drivers to engage in collaborative research on a global scale. The rationales found in the country reviews were as follows:

- Global issues are too large to tackle by one country alone, thus increasing scope and scale by working together and by creating large research infrastructures enhances the potential impact of this research
- As the issues are global, involving less developed countries with few financial means to engage in research and technology is essential for its success (and for tackling the impacts on those particular countries)

Germany and Canada have explicitly defined the policy ambition to take a role as initiator and leader in specific global challenges. There are however no clear mechanisms nor overarching international policy fora where the choice for specific issues or their joint approach can be defined. The United Nations Intergovernmental Panel on Climate Change is one clear example of a body that has put the topic high on the political agenda and indirectly in terms of international collaboration in related research. However, not all global challenges have such a Forum behind them, not even on the European level.

There are no overarching international policy forums, where the choice for specific global issues or their joint approach can be defined.

As the assumed impact on global issues is indirect and represents only a small intervention in the entire context of this global issue, the country reviews found very

few instances where evaluations were done and indicators used that could establish the causal relationship between the research programmes and the global issue at stake.

4.4.3 Research Collaboration for Development Policy

There has been a long-standing tradition for STI collaboration between developed and less developed countries with the rationale that the advancement of science and technology in developing countries is an essential element of their overall sustainable development.

Today STI is often an integral component of development policy

Today, STI is often an integral component of development policy driven from the idea of STI capacity and competence building in less developed countries. The UN Millennium Goals do not explicitly mention capacity building in science, research and development, but some of the goals – particularly those related to health and sustainable development - need an underpinning from science and technology which could be conducted in developed and/or developing countries. Recently, the G8 Science and Technology Ministers' meeting highlighted that building science and technology capacity in developing countries, in particular Africa, was an area that needed the collective support of the G8 countries.[9] The meeting welcomed the sharing of best practice in cooperation between developed and developing countries.

The drivers are different for the partner countries, depending on the R&D position of each of the involved countries. Whereas advanced countries and international organisations have mostly humanitarian and diplomatic reasons to help build research capacity in less developed countries, those lesser developed countries in our review sample see the building up of their own research capacities as a means to improve economic development and alleviate poverty. Many of the priority themes in developing countries have some overlap with the issues that are typically global: energy and water supply, conserving biodiversity, infectious diseases. The choice of topics is strongly related to the funding organisation in the developed countries, which often have a historical background in agriculture and land development, infrastructure or health related topics.

Our country reviews revealed that in most countries the STI collaboration strategies with developing countries are mostly defined separately from main stream STI policy making.

Traditionally, agricultural research has been a domain for international STI cooperation between developed and less developed countries. Therefore, this is not a new area in STI cooperation, but the STI element seems to have become more important recently. However, we have found little evidence of strong policy coordination between the core STI policy domain and development policy.

4.4.4 Other types of policy domains that affect international STI collaboration

Other types of drivers that have been explored in the study include diplomacy, higher education policy and security & defence policy:

Today diplomacy mostly influences the development of relations with neighbouring regions, although past foreign policy relations have created a strong basis for today's STI collaborations

- Diplomacy and foreign relations as a driver can be found basically in two forms. This driver now mostly influences the development of relations with neighbouring regions, i.e. those countries that wish to establish good diplomatic ties with countries within their own global region (e.g. South-Africa in the southern part of Africa, Japan in the Asian region, EU with the Mediterranean countries). Secondly, where former colonial ties shape a diplomatic interest towards specific countries or regions (e.g. the UK and Commonwealth countries, Spain with Latin-

[9] The G8 Science and Technology Minister's Meeting, Chair's summary, Okinawa, June 15th 2008.

America and France with African countries) and former political relations have an influence on the choice of partners (e.g. Poland and former countries in the USSR); Foreign relations and diplomacy have provided a strong basis of STI relations particularly between countries and regions that have a colonial history with each other. We have found very few examples where existing STI agreements were explicitly terminated.

- Higher Education policy: international STI agreements are used to promote Higher Education institutions (HEI) abroad mostly to attract graduates or to facilitate the location of foreign offices or arms of national HEI institutions. Examples of countries where STI cooperation policy focuses on the internationalising of Higher Education Institutions are The Netherlands (enabling HEI organisations to expand abroad) and Estonia (alleviating the brain drain and human resource shortages);
- Security and defence policy: the study found little evidence where this formed an explicit driver for the establishment of STI co-operations.

4.5 Policy instruments used for international STI collaboration

International collaboration in research is supported through many policy instruments, most with a long history. This section provides a broad picture of the mechanisms in use in the countries under review. The main findings are that:

- The EU countries under review focus mainly on EU- Framework programmes and the large European multi-lateral organisations. The interest for these programmes lies mainly in achieving research excellence, accessing knowledge and competence developed elsewhere and in improving competitiveness of certain industries and firms;
- For new EU Member States, bilateral collaboration agreements are still an important additional measure to facilitate cooperation of their domestic researchers in order to access complementary expertise, improve capabilities in national institutions and create another funding source for research (for instance Poland, Slovenia); for older EU Member States, bilateral agreements within Europe have lost much of their significance (mostly due to the many EU networks) but are still in active use for collaboration with Third Countries.
- For activities outside the FP and the large EU multilateral organisations, bilateral agreements are the most common types of interventions by far, although not necessarily the type of instrument that attracts the most research funding. Often the agreement functions as an umbrella, which hosts a multitude of collaboration modes: grant and fellowship programmes, exchange programmes, joint research programmes, etc. Information on the amount and type of bilateral agreements is far from transparent (Simmonds, 2001), let alone the funding which is attached to them. Whereas interviewees have stated that bilateral collaborations are also beneficial to define common framework conditions (e.g. IPR) very little information is in the public domain on how this is settled in practice.
- The 'narrow paradigm' has the broadest set of policy measures at its disposal:
  - Bilateral and multilateral agreements (while signed at national level these often facilitate collaboration at institutional level) as umbrella for various collaboration modes
  - Joint research programmes (often thematic)
  - Joint funding of research infrastructures

Bilateral agreements are the most common types of interventions, although not necessarily the type of instrument that attracts most research funding

  - Exchange programmes, grant and fellowship programmes
  - More recently: opening up of national research programmes (e.g. Australia)
  - Joint funding of physical research centres in a particular location
  - Joint Strategic Fora and agenda setting committees
- As stated above, measures to address directly the competitiveness driver are less 'discrete' and the few examples found include;
  - Information and brokerage services abroad (e.g. Finnish TEKES offices, Science and Technology Attachés, collaboration with Trade Agencies)
  - Specific collaboration programmes aimed at creating market opportunities for innovation and/or commercialisation of domestic technologies in a particular country, mostly with one of the emerging economies (India, China)
  - Opening up of national programmes to attract STI investment/ collaboration of foreign public or private research organisations.

The interviews suggest that joint programming and ERA-NET type collaborations are still in their infancy. However, in an internal EC survey conducted in 2006, 20% of the responding ERA-Nets indicated to have at least one non-European partner in the ERA-Nets and almost 50% of the ERA-Nets would welcome a global dimension of their network, especially if there were sound coordination across Europe as a preparatory step (Wittke 2008). The activities of four ERA-Nets (Co-Reach on Europe-China relations, ERA-ARD (Agricultural Research for Development), EULANEST (Europe-Latin American Network) and the SEE-Network (West Balkan region) indicate that new forms of joint action with partner regions are being developed; these are joint actions that link to the Framework Programme and are flexible in terms of participation.

4.6 Summary: Interacting drivers

External triggers have stirred the interest for more strategic thinking on the role of STI collaboration within and outside Europe

This chapter has described the set of policy domains, drivers and targets that interact in shaping STI collaboration policies. The narrow 'intrinsic STI paradigm' forms the core of international research collaboration, motivated by the aim to achieve research excellence, to attract scarce human resources for research and also to build STI capabilities through people and institutions. External triggers, such as the globalisation of R&D, the urgency of certain global challenges, the emergence of new players on the global research market and the lively policy debate about the place of Europe as the 'most excellent place to do research in the world' have stimulated interest for more strategic thinking on the role of STI collaboration within and outside Europe.

These external triggers have increased the weight of some drivers from the 'broad paradigm': the globalisation of (industrial) R&D has put competitiveness policy goals higher on the agenda. The urgency of certain global challenges opened the discussion for more global research programmes and facilities on these topics. Other drivers, such as diplomacy and historical cultural ties between countries and development aid have for a long time influenced the geographical direction and thematic focus of 'third country' collaboration and still form a stable influence in the background.

The review revealed a wide set of (national and international) actors involved in launching and implementing initiatives for research collaboration. Cross-cutting coordination at the national (or trans-national) level, between the involved policy domains and between different levels of the research policy community – with the aim

of aligning instruments, selecting target countries or themes, etc. – is still an exception although many countries are working towards a more strategic framework. For those issues that need an urgent global approach, few strategic fora exist that can help to launch a dialogue in order to set priorities and define joint actions.

5. Strategic Intelligence to support evidence based policymaking

5.1 Introduction

The previous two chapters have discussed the background and drivers for international STI collaboration. This section will now turn to a discussion of indicators to support policy making for international STI collaboration, followed by a chapter on the actual use of indicators. The discussion of indicators takes a policy strategy cycle approach. This draws partly on the literature (deductive), partly on our country observations (inductive). It lays the conceptual foundations for an indicator system on international collaboration in STI, while the following chapter summarises how those indicators are actually used in the countries examined and gives some illustrations. Building on these foundations, a framework for indicator development and use across Europe is suggested (Chapter 7).

In general the use of indicators for internationalisation policies remains limited

Given that the development of international STI collaboration is becoming a key dimension in the strategic considerations of governments, funding agencies, research organisations and individual researchers, and given the move towards a broad paradigm, one might expect to find evidence of elaborated strategic intelligence and indicator systems to support and inform strategies and activities. Whilst some data collection and analysis is undertaken, it still appears that – beyond a small set of well established basic indicators such as co-publications, co-inventions or participation in the EU Framework Programme – the use of indicators to support systematic and holistic policy making by national governments remains limited.

The shortcomings of existing indicator systems to measure internationalisation dynamics – and potentials – have become obvious. As the OECD Handbook on measuring globalisation conceded in the chapter on research and technology:

> *"Not included in the present version of this chapter are other important forms of internationalisation of technology, such as government R&D, international filing of patents, strategic technology alliances between firms, co-operation agreements between public institutions and also the migration of highly skilled individuals. Such forms of internationalisation of technology, some of which have gained in importance over the past twenty years, still require extensive methodological work and could be incorporated in a subsequent revision of the Handbook" (OECD 2005, p. 138)*

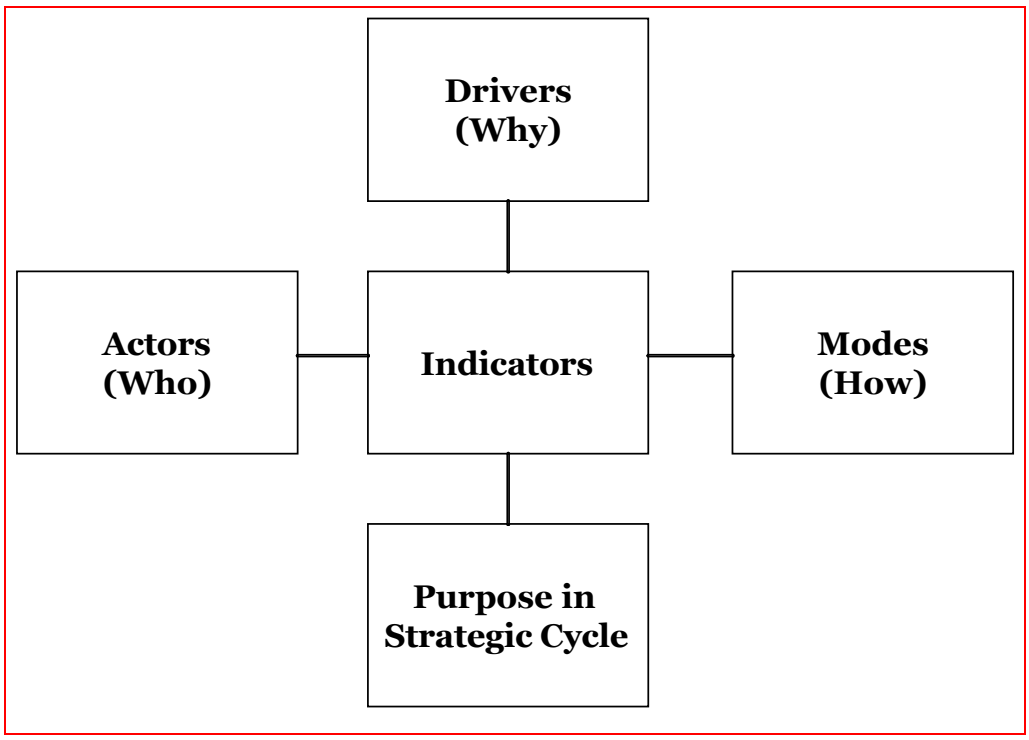
This list of omissions within the OECD document is far from complete. Policies try to support and influence the activities of private and public actors in complex systems, and to do so it is necessary to know the scale and scope of internationalisation in many different dimensions. Moreover, internationalisation is driven through the strategies of very different kinds of actors, and government policy is therefore only one driving variable. To better capture international opportunities, activities and dynamics and subsequent effects a much more rigorous approach to using indicators is needed. Chapter 6 will show that there are numerous attempts in this direction, but that policy makers and strategists in non-governmental institutions still struggle with defining the indicators and metrics needed and with filling them with data. The following sections will propose a consistent model to develop and use indicators and give some concrete suggestions so as to advise policy makers across Europe in their attempts to base their efforts more systematically on evidence.

5.2 Evidence and indicator needs in the strategic policy cycle

There are four key dimensions of indicator use

In the context of policies to encourage STI internationalisation indicators can in principle be conceptualised along a number of dimensions: the modes (how), the drivers (why), the actors engaged in or targeted by (or who could potentially be engaged in or targeted by) internationalisation activities/policies (who) is or potentially could be engaged in internationalisation) and the various functions indicators are used for within the strategic policy cycle (when).

Figure 3 The four dimensions of indicator use



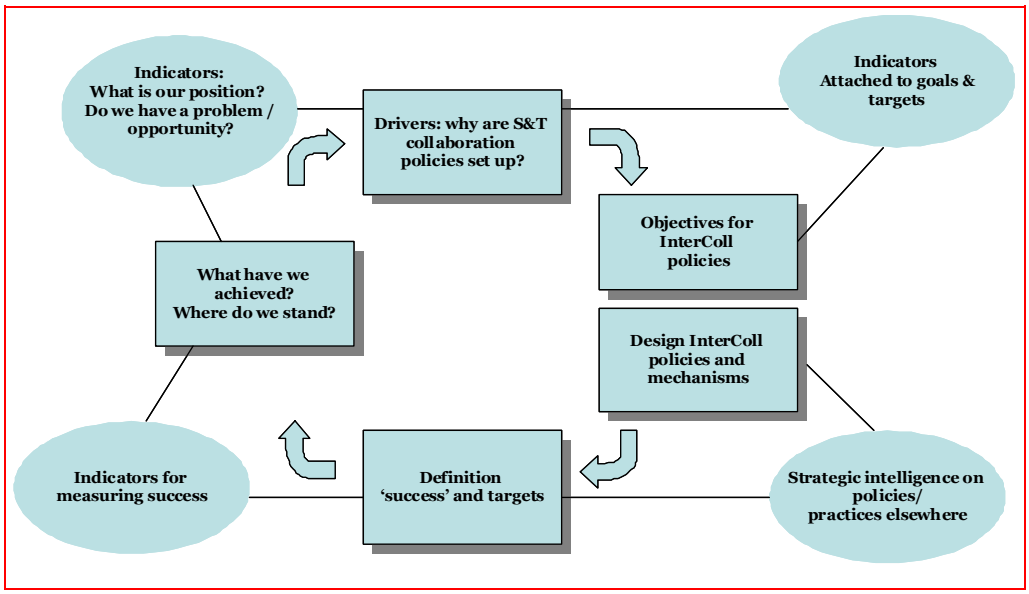
In the preceding chapters and in the literature review, actors, drivers and modes have been discussed at length. The target community of internationalisation policies in STI is vast, and with the rise of the broad paradigm it has become vaster still. Indicators must be capable of capturing the relevant activities of public research organisations, firms, funding organisations, and ministries and other public agencies responsible for STI or for international STI aspects in their respective remits. Chapter 4 has dealt intensively with the drivers. The modes of international STI collaboration are numerous, ranging from mobility[10] (at individual, institute and firm level) and physical cooperation to virtual cooperation, cross-border contract research, participation in international research organisations and, finally, to various levels of coordination and joint programming. It is important to keep this multi-dimensional space in mind when discussing a conceptualisation of indicators for STI collaboration polices (for more details on modes see the literature review).

[10] We can define mobility as one important form of international collaboration, where an agent physically crosses borders in order to be part of the external research arena, interacting more or less formally with actors abroad. In our literature review we have dealt with this dimension intensively.

Indicators are needed along the whole strategic policy cycle

What have yet to be discussed are the various possible kinds of indicator needs in this area. Thus, the indicator discussion focuses on those indicators that are – or should be – used by policy makers and other public bodies. The role of indicators in policy-making is different at different stages of the policy making process. Consequently, a **strategy policy cycle approach** is proposed, conceptualising indicator needs in support of policy and strategy at four major 'stages', which correspond to major policy-making activities. While such a cycle is a simplified idealised understanding of policy making, it helps us to conceptualise indicator requirements in a comprehensive fashion. Indicator needs throughout the policy (strategy) cycle are illustrated in Figure 4.

Figure 4 Indicator needs in a strategic policy cycle framework



5.2.1 Stage 1: Where do we stand? Indicators of the status quo

The starting point is a status quo analysis regarding...

The starting point for policies and strategies for international activity should ideally be a status quo analysis: what is our position in the global STI system vis-à-vis other regions and countries, and who is doing what? Such an analysis would have three related but distinct pillars:

.... the STI strengths and weaknesses of the innovation system...

Analysis of the STI *strengths and weaknesses of an 'innovation system'* (at whichever level it is defined) or an institution, in order to define the starting point for international activities (i.e. relative scientific and technological advantages as defined through scientometric or bibliometric specialisation patterns, excellence patterns, innovation indices, etc.). This is often done on the basis that strengths can be a powerful attractor to potential overseas partners, whilst weaknesses may benefit from increased co-operation with those overseas researchers close to the leading-edge in that field and also from the inward mobility of leading researchers into the domestic system.

... and the scope and scale of internationalisation of the STI community.

Analysis of the *existing scope and scale of international activities* of a country in STI and related policy and strategy. The translation of drivers for internationalisation policies into specific objectives and concrete actions (see below) requires an analysis of how internationalised the national 'system' already is (in terms of actors, structures and actions (policy measures)). At this level indicators are defined based on **actors**. The literature review within this study gives an extensive overview of indicators to assess the internationalisation of the STI community and of policy itself.

Scope and scale of internationalisation of the STI community (individuals, research organisations, firms, funding organisations). First, indicators need to be able to characterise the scale and scope of the *various modes* of *international activity*, such as international collaboration, international mobility, relocation of R&D activities, monitoring of activities elsewhere and absorbing knowledge from elsewhere, joint ventures or international cooperation agreements with overseas partners. Second, indicators should be in place to capture internationalisation for different kinds of actors, individual researchers as well as *institutions and firms* (whilst taking care to consider the variation expected in such patterns between sectors, field or technologies).

Indicators most often used are international co-publications

In terms of empirical analysis on the internationalisation at the level of individual researchers, the majority of work has been to capture the absolute and relative levels of international collaboration. The indicators most often used here are co-publications of authors from two different locations ("basic" research) and co-patenting (application oriented). The analysis conducted comprises the absolute numbers, the share of international co-publications out of all publications and out of all co-publications. In addition to the number and share of co-publications a further indicator for the scope of internationalisation is the analysis of the (average) number and geographical spread of different countries that collaborate (see also Mattison et al. 2008). Thus, co-publication analysis tells us about the relative importance of international collaborations that lead to tangible outputs (publications) and the nature of these collaborations in terms of countries and disciplines (see, for example, Glänzel 2001, Glänzel /DeLange 2002, Schmoch/Schubert 2008, Mattison et al. 2008, Edler et al. 2007). In terms of application oriented research, co-patent analysis has been used to characterise the growth of international cooperation and patterns of partnerships (Guellec/Pottelsbergehe 2001).

The second most important field of work has been done on mobility. Here a number of relevant indicators have been constructed within the IISER (Integrated Information System on European Researchers) project of the European Union DG JRC-IPTS. The IISER indicator set covers researcher stocks, research careers and researcher mobility (intra-EU, into and out of the EU). Many of the researcher mobility indicators specified remain unfilled by any data though a major new empirical study funded by DG Research aims to fill some of these gaps. The indicators specified include the circulation of doctoral researchers within the EU (i.e. inflows, outflows and netflows); outflows to the US (e.g. country of origin of non-US citizen holders of US doctorates; function of non-US researchers in US universities; fields of specialization of non-US researchers in US universities); and inflows of non-EU researchers into the EU (country of origin of non-EU doctoral candidates in EU universities; ratio of third country to non-EU doctoral candidates; etc). It can be noted that the mobility indicators used to date are focused on doctoral researchers with much less data available about other categories of researcher, reflecting the long-standing frustration that 'researcher' is not a unitary statistical category[11].

Positioning indicators can help to understand the situations of organisations

Beyond individuals: Lepori et al. (2008) and Barré (2006) have convincingly argued that in order to understand the properties of a national 'system' it is important to understand the *relative position* of the various organisations that constitute the system (firms, research organisations, funding organisations, ministries), their behaviour vis-à-vis other actors in the system, their linkages and broader cooperation patterns and their activity portfolios in general. Moreover, the constitution of institutions, their compositions and governance structures need to be understood for a

[11] New data is being collected via a series of surveys to be undertaken by a consortium led by IDEA-Consult with NIFU-STEP and the University of Manchester as part of the European Commission's Partnership for Researchers initiative. For information on the original IIESR study please see: http://ipts.jrc.ec.europa.eu/activities/research-and-innovation/iiser.cfm

robust characterisation of the role those institutions play. Indicators that locate institutions in their systems in terms of their relative position, their specific function and their activity patterns have been labelled *positioning indicators* (Barré 2006). Examples for those would be share of co-operations in all project work, share of overseas members of staff etc.[12] This area is also still rather under-developed, with relatively few convincing indicators proposed and still less good data available.

There is a whole range of indicators to map the status quo: an example of universities

A systematic and well-established set of indicators to measure the state of international activities and the effectiveness of those activities in the strategies of *research and funding organisations* does not yet exist. However, for *research organisations* at least, various studies have looked at the forms and indicators of international research activities (Edler 2007, Universities UK 2008, Noir sur Blanc 1999). For the sake of illustration, major positioning indicators for international research activities of universities used in those studies are[13]:

- Existence of an internationalisation strategy or plan, with targets, priority areas and priority countries
- Existence of dedicated budgets and / or a central internationalisation unit to support international research activities (seed money)
- Existence of an internationalisation unit to support internally
- Number of international agreements at University /organisation level
- Share of research projects with an element of international cooperation and/or using shared facilities, development over time
- Number of international partnership or cooperation agreements at institutional level (may or may not be linked to education agreements)
- Share of income for international funding sources
- Share of staff from abroad, share of domestic staff spending research time abroad
- Overall budgets spent on international activities and received from international sources.

It is important to recognise that many of these positioning indicators point to a general strategic orientation towards international activity, rather than directly to levels of activity or impacts thereof. In that sense they are highly complementary to the more output-oriented indicators already discussed. However, those positioning indicators do not yet cover the benefits and effects of internationalisation on organisations.

The already existing policies and framework conditions need to be understood in terms of their international dimension

Funding organisations individually collect much data on the international dimension of their activities, such as overseas participants in their programmes, recipients of funds, international mobility within their programmes, international conferences funded, etc. Many of the organisations have produced overviews in the various ERA-Nets in order to prepare for coordinated action.

Policy measures/instruments for international collaboration: to understand the internationalisation of STI and the role of policy – and eventually to design

12 The Third European Report on STI Indicators (EU COM 2003) in fact contains a range of those indicators that characterise organisations (e.g. Universities) within the European Science System.

13 Many of those indicators are included in the on-going study on ERA-Indicators, which has been used in this report as a checklist for the breadth of indicators to be used ('Monitoring progress towards the ERA" This Specific Contract for the ERAWATCH Network, under the Framework Service Contract Nr -150176-2005-F1SC—BE' , aims at better understanding and monitoring of progress towards the European Research Area. The report is forthcoming (2009), personal communication with P. Cunningham and Claire Nauwelaers.

internationalisation policies and strategies – one needs to have a clear picture of already existing supporting structures and instruments for international activities, both at the national and international level. Possible indicators would cover the following dimensions:

- The 'openness' of national programmes (role of overseas actors in national programmes, e.g. entry rules, share of overseas participants, share of budgets received)
- The number and activity level of international STI agreements and other joint activities (e.g. bilateral agreements, dedicated budgets (reciprocal or not), number of projects, number of partners, etc.)
- Participation in European schemes (FP, but also including strategic governance schemes such as ERANET and Technology Platforms), participation patterns in trans-national programmes (e.g. HFSP) and participation and activity patterns in International/Intergovernmental Research Organisations.
- The governance structures that relate to the measures, i.e. organisational indicators showing how those structures are oriented towards the international dimension. Here potential indicators are the existence of specialised units for internationalisation, an explicit internationalisation strategy and processes to implement it, the relative position of the internationalisation target in the target functions of institutions, existence of related incentive structures. [14]

5.2.2 Stage 2: Setting targets, making choices

The conditions for target setting are to understand the status quo and to have evidence on overall benefits of international activities

A second purpose of indicators is to support the *definition of explicit targets* for policy and strategy at all levels. Ideally, targets are set on the basis of a sound analysis of the *status quo* and a clear understanding as to the contribution of "more" international activities to the overall STI strategy of ministries or other organisations.

Quantitative and qualitative targets are needed both in the 'narrow' and 'broader' collaboration paradigm. Most internationalisation activities are set out to increase or improve internationalisation. Due to the lack of sound evidence as to the overall effect of international activities for STI profiles and performance of countries, those maximising strategies assume implicitly that more and better international activity will lead to greater impacts.

The obvious challenge for the countries screened within this study is to define a desirable scale and scope of activities that will yield the best cost-benefit ratio. This is especially challenging as to the definition of targets (let alone measuring the associated benefits, see below) within the *broad* paradigm, i.e. when it comes to drivers from other policy areas, problem solving, diplomacy, etc. The superimposition of multiple policy objectives and contexts means conflicting targets. Thus, those conflicts need to be brought in line and targets need different levels of priorities. The role of a clear analytical basis and strong indicators then becomes even more crucial.

5.2.3 Stage 3: Indicators to understand the international 'opportunity environment'

No matter what the drivers for internationalisation of STI may be, a good level of knowledge regarding (potential) partners is essential. In most cases – one exception being the GSIF indicators in the UK (see UK report) – there are no systematic indicator systems in place for the identification of international partners. Top-down

[14] Of course the very existence of data collection and analysis (whether *ad hoc* or systematic) on internationalisation activities is an *indicator* of strategic orientation, as would be the presence of active evaluation of internationalisation measures and evidence of learning from those evaluations (policy impact on successor programmes).

Systematic monitoring and analysis to understand the opportunities for international collaboration is asked for

prioritisation is done according to broad political criteria whilst bottom-up research collaboration is largely driven by the personal knowledge and personal networks of the STI community. While basic research rationales continue to be important in shaping internationalisation, bottom-up collaboration will always need to be supported by policy and therefore targeting systems would need to respond to the 'demand' signals of the domestic research community. However, a more systematic approach could also

- Help to identify the comparative profiles of strengths (specialisation) for the definition of scientific or technological 'hot spots' (technometrics, bibliometrics, peer reviews) or complementary capabilities and skills
- Analyse existing cooperation patterns
- Detect complementary policy structures and institutional partners (indicators for openness of programmes, strategic intelligence and reporting systems to get a picture on accessibility and mutual interest, etc.)
- Identify – as relevant – where STI collaboration could be linked to market opportunities abroad, both for public research and for firms (indicators to be used would be timing and speed of innovation diffusion in certain areas, existence of demanding users eager to collaborate with those at the research forefront, etc.)

Clearly, the opportunity patterns and the activities to define them are different for different STI areas and for different countries. There also remains the challenge of how to combine this targeting intelligence with bottom-up demands from the research and innovation communities themselves, and how to design appropriate instruments to take advantage of international opportunities.

5.2.4 Stage 4: Monitoring and evaluating

Evidence of the benefits of international STI activities is scattered and not systematic enough …

This leads us to the fourth major purpose of indicators, the monitoring of developments and the evaluation of specific measures to support international activity. On a first level, indicators would have to monitor how internationalisation of the system develops. There is a need to employ indicators that capture the *development of international engagement* of the STI community in all the different modes of internationalisation and the changes of governance and organisation positions, ideally in a cyclical approach using indicators for the initial *status quo* analysis. However, because internationalisation is only an end to other goals, monitoring would also have to *assess how international activity contributes to 'better" science and technological development, to competitiveness and to the societal and political goals associated with international STI activities*. Thus, further indicators may need to be developed in order to support such monitoring.

… except for the citation impact of international science co-operation measures

As illustrated in the literature review that accompanies this report, the area in which the *effects* or impact of international activities are best covered is in the monitoring of scientific co-operations. The literature offers well established impact analyses of scientific output, mainly through citation analysis, citation counts (comparison between international and national publications) or co-citation analysis. The common trend for almost two decades has been that, generally, international co-authored papers are more highly cited than single authored papers or publications based on national co-authorships (Glänzel et al. 2006, Narin *et al.*, 1991; Lewison and Cunningham 1991; van Raan, 1997; Roberts, 2006, see the literature review for more detail). In terms of international cooperation at the applied end of the research spectrum, effect measures include contracting income measures, success rates (and funding scale) in international collaborative programmes, comparisons of performance development between sectors with different scale of international cooperation, or micro effects on company R&D effectiveness and efficiency or innovation performance. As regards international mobility, effects are measured through economic analyses of brain drain or brain gain (systems level), through CV or citation analysis.

A second, more concrete function is the evaluation of internationalisation *measures* and the evaluation of *international dimensions in national programmes*. The indicators here would have to help the assessment of concrete policy measures that are designed to foster international engagement and the cost-benefit ratio derived from them for individual researchers, institutions and the country as such. Here again, the development of specific indicators, is at its early stages, although good examples can be found (see below, chapter 7). This reflects the fact that, as seen in the accompanying country review (and the CREST Working Group Report 2007), countries are just beginning to systematically design and review their internationalisation strategies. Thus, the international dimension is not yet reflected in the broader literature on the evaluation of STI policy, and the international dimension of evaluation and measurement of success mainly comes in when countries assess relative performance (of policy measures) against other countries (Georghiou/ Larédo 2006, p. 35).

5.3 Additional challenges: linking the narrow and broad paradigms

Before reporting in the next chapter on the ways in which countries use indicators, reflection on the challenges of the use and design of indicators is needed when it comes to the broad paradigm of international STI collaboration. In principle, the conclusions and arguments of the previous chapter apply here equally, and a similar strategic policy cycle approach can be applied. However, there are two obvious complications:

The role of international STI in other policy domains is important, but needs more explicit analysis of the benefits …

First, within policy areas such as defence, foreign/diplomacy, health, energy, environment, etc., the relative roles of STI capacities and STI collaboration are less clearly defined, as are the responsibilities for supporting those activities through policy. Many countries (one of the notable exceptions is, of course, the USA) do not have mission or challenge oriented STI responsibilities, but specialised STI ministries which cover the various STI activities across domains. Thus, core activities in those policy areas are not linked to the respective STI activities, and therefore the *status quo*-analysis of capabilities as well as the knowledge on necessary adjustments and international agendas and actors is less clear. Knowledge is dispersed across domain based and STI policy actors. In principle – and simplified – the problem seems less severe in areas with domain based international organisations that also deal with international STI activities, such as the International Energy Agency. In those cases, the domain based policy makers are more likely to be engaged in international STI arenas and thus, could provide the linkages more easily.

… and coordination with STI indicator systems

Second, as stated above, there is a severe challenge of horizontal coordination in terms of policy and of strategic intelligence. Information needs and strategic intelligence opportunities are overlapping, but are still different. Different countries have different mechanisms to bring domain based and horizontal STI agendas together. There is a trade-off: in countries with a mission oriented strategy and structures (e.g. USA), it appears to be easier to coordinate for the sake of domain oriented policies and to bring the data and metrics together that are needed (as argued above). This, however, necessitates that the metrics, indicators and analyses on international activities are reported and coordination with the horizontal supporting policy is established. On the other hand, in countries in which STI responsibilities also for missions (or domains) is within the central STI ministries and funding agencies, there is a gap between STI indicators and overall domain policy goals.

Further, there is a need for coordination between domain based actors and STI policy actors on activities at the international level (e.g. domain based international organisations) so that the opportunities offered in international organisations are linked to STI strategies, and the related indicators, strategic intelligence and benchmarks are diffused in the system.

These two challenges of course have implications for the design and use of indicators throughout the strategic policy cycle. The most serious challenge lies in the definition of targets for international STI collaboration as often the specific contribution of STI and STI collaboration to the goals within domains is not clearly defined.

6. Indicators and metrics used to support policy and assess progress and impact of international STI collaboration policies

6.1 Introduction and major trends

As seen in the previous chapters, the purposes of indicators are manifold, both as regards the strategic policy cycle (different stages) and as regards the multitude of actors and their strategies. This chapter summarises how countries *use* indicators and metrics to develop and assess internationalisation policies. The basic questions here are: who uses indicators, for what purposes, and in which stages of the policy process? What can one learn from existing practices and – more importantly – what are the gaps for evidence based policy making for international STI collaboration? On this basis, chapter 7 points to opportunities for European learning, co-ordination and cooperation for the design and application of metrics and strategic intelligence.

The empirical part of our study focused on those actors primarily responsible for international cooperation within science and technology policy. This gives a thorough picture, even if – as regards the broad paradigm – our empirical country work could not screen all responsible ministries and agencies which might have important international activities.

The basic message from the country reports and the national interviews is that there is little *systematic design, use and adaptation of indicators* to grasp the *status quo* and benefit of international collaboration and to evaluate the effects of policy frameworks and policies. [15]

6.2 Stage 1: Where do we stand: Indicators to analyse the status quo of the country

Analysis of the STI strengths and weaknesses of an innovation system in general

To understand the needs for and opportunities of international STI collaboration, a country needs to know its own STI profile. In terms of indicators and strategic intelligence activities to analyse a country's STI position, most countries have some sort of regular reporting system in place that gives an overall profile of major STI indicators to position the country in terms of STI 'competitiveness'. Many countries integrate the EU Scoreboard and OECD data for that purpose, but most also have their own overall regular analyses and indicator systems in place to support their *national* STI strategies.

The use and sophistication to understand one's own STI systems varies considerably in the countries of the review

The level and sophistication of those country analyses is of course very diverse. Some countries, such as Germany, have annual or bi-annual reports on technological competitiveness, Canada is an international leader in the development of innovation indicators through Statistics Canada, and the UK and Nordic countries invest in sophisticated analyses of inputs and aspects of performance (e.g. on-going work on Policy Relevant Nordic Innovation Indicators financed by the Nordic Council). Others, especially some Southern and Central/Eastern EU countries have yet to

[15] The next section will provide more detail and examples. For individual countries we refer to the country reports. We order those considerations according to the different stages of the strategic policy cycle and the different purposes indicators have in those stages.

The lack of indicator use in some countries shows room for improvement for evidence based policy making

develop the same level of sophistication.[16] There is no level playing field across the EU when it comes to knowledge of one's starting point for international STI collaboration. The lack of analyses in *some* countries is not only an unfortunate gap in the use of indicators, but evidence of a poor indicator system altogether. This has to be kept in mind if European countries seek to engage in learning and coordination in terms of international collaboration activities and indicator underpinning in Europe.

Another issue is the question whether these types of indicator sets are used to specifically assess the need for more international collaboration in research. Mostly only those countries which make a high-level innovation system analysis with such data-sets will link the benchmark with overall R&D internationalisation issues.

Existing scope and scale of international activities of a country in STI

(a) Scope and scale of Internationalisation of the STI Community

There is no uniform or dominant approach for monitoring the international activities of the STI community. Several countries have intensified activities in order to understand the need for and opportunities of international activities and thus for support (e.g. Germany, Ireland, UK, Netherlands, Finland to some extent) as they have started to develop explicit internationalisation strategies (as indicated in CREST Working Group 2007). However, in general, interviewees in our countries conceded that policy making is not very advanced in understanding the international profile of the country and the subsequent needs for collaboration of the STI community.

Some countries have specialised institutions or have conducted one-off studies to understand the internationalisation of STI communities

Some countries have regular indicators systems in place to map internationalisation of the STI community very generally. For example, in France, the specialist public institute OST provides regular reports on STI activities and performance, both within France and globally. The institute also publishes indicators on international co-publication on a regular basis,[17] and issues specific, one-off studies on the co-publication profile of their research community. However, this practice is neither uniform across Europe nor is it widespread and systematic. Other countries commission *ad hoc* studies.

Another example is a one-off large scale study on the internationalisation of the German research landscape. This included data on *individual* mobility and cooperation patterns, hindrances, benefits and need for better framework conditions (Edler et al 2007) as well as data on *institutional* strategies and patterns. The Federal Ministry for Education and Research sought to underpin its strategy development process with empirical data on the individual and the institutional level (see also Matthes 2008, for more details see Edler et al. 2007 and Figure 5 below). It is, however, not clear if a regular indicator system on international activities will be established, and if so to what extent.

16 This has become overly clear in a recent Conference of the Czech Presidency on Innovation Policies in CEE countries, where all analysts agreed that the knowledge base to understand specific STI strengths and weaknesses needs further development (http://www.eu2009.cz/event/1/188/). The existing indicator systems are not sufficient to give a full picture of the specific profiles in those countries, not taking into account, for example, the level of imported R&D intensity in intermediate goods, which is part of internationalisation (inward technology trade) and contributes to the R&D and innovation capabilities.

17 http://www.obs-ost.fr/fileadmin/medias/tx_ostdocuments/Partie5Graph_01.pdf.

Beyond these examples of one-off studies[18] and few standing reporting systems (France), the use of data on the internationalisation of public research organisations or funding organisations for national policy making appears underdeveloped and the picture is very blurred. Funding organisations have their accounting systems and know how. Much of their budget is dedicated to inward or outward activity or international cooperation. Many of them have international linkages, joint programmes or reciprocity agreements. It is not clear how systematically this data is reported to STI ministries and used for the strategic policy process. For research organisations the picture is even more complicated. There is no reporting system on international agreements[19], no systematic and uniform reporting system about the share of overseas nationals working within the organisation[20] or mobility activities.

Therefore, little analysis to understand the effects of international activities within research organisation and at the institutional level is available. This is especially true when it comes to differentiation across different scientific fields. Whilst large organisations have their strategic units, internal reporting and clear formulation of international targets, a country wide or even internationally compatible indicator system is missing. We have found little evidence from our own empirical work that countries systematically assess the need and scope for cooperation when mapping the strengths of other countries and of their own community.

Two areas in which many countries use data more systematically are *industrial R&D* and – more recently – *mobility* of researchers. For both dimensions, our interviews indicate that countries here rely heavily on OECD and EUROSTAT data to benchmark their relative attractiveness and performance against peers. For many years, the OECD and various national survey systems have delivered aggregated data and analysis based on firm report data, patent data, FDI and trade data, and national policy makers have learned to use those datasets.[21] However, even here the policy makers feel they know too little about the ways in which international activity translates into STI spillovers to the domestic system, and about how SMEs, who are not generally engaged in FDI or international patenting, can best profit from internationalisation. Data for international activities and related benefits is scarce.

Mobility of researchers and industrial R&D data is gathered and used more systematically

b) Policy measures/instruments for international collaboration and c) governance structures

Many countries also lack a full picture of the internationalisation of their own *policy activities* and the impact these have (see below, stage 2 and 4). There is a general lack of knowledge about the internationalisation of policies, programmes and the research

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18 Two further recent examples are the UK and Ireland. The UK commissioned a study that was very sophisticated in covering partner countries and different scientific areas and in explaining profiles and linking those profiles to the overall scientific standing of partner countries (Adams et al 2007, Adams 2008), Ireland conducted - in the course of the strategy development process – a survey an all major research organisations and asked for their international collaboration patterns; a one-off study has been commissioned in the context of the strategy formulation process that asked for the motives and benefits of international activities of Universities (Technopolis, 2005).

19 Some national federations have databases which often are not up to date and do not report on activities within agreements

20 Except where required for legal reasons – e.g. equal opportunities monitoring or immigration enforcement.

21 Currently there is a study underway within the Framework Project RINDICATE (in which the team of MIoIR is involved), that tries to collect all data on international money flows for R&D, both private and public, and to develop some metrics that help policy-makers in Europe to understand the scale and scope of those flows and related activities and subsequent effects. Although it is far too early to judge, from the early stages of the project it seems that the ways in which countries collect data on flows is very different and short of what one would expect as basis for policy decisions.

There are improved efforts to understand the starting point for internationalisation activities amidst a generally low level of evidence gathering

base in many countries, and benefits are not explicit and programmes and agreements are often path-dependent or driven by factors external to STI considerations. This is not so much an issue of evaluation (see below), but about the *starting point* for strategic initiatives. A few countries (e.g. Germany, UK, Ireland, Finland) have conducted systematic empirical analyses to understand the scale and scope of internationalisation more broadly. Germany and Ireland that have included both the public research organisations and the policy support level. In Ireland, a systematic screening of all departments and agencies and of a large sample of research organisations and researchers has been conducted that enabled a characterisation of the importance of international activities and of policy support; Brazil is conducting similar approaches.

In Ireland, a broad survey not only of research organisations but also of *ministries* and *agencies* was conducted as a basis for a development of a new internationalisation strategy that is well integrated into the STI strategy more generally (FORFAS / ACSTI 2008, Breathnach 2008). In the German study mentioned above, the analysis of policy was on a higher, more strategic level, covering different ministries, but not getting to the detail of individual programmes and agencies. Both the Irish and the German activities, albeit very different in overall design, had a strong emphasis on understanding the internationalisation of their own polices (below) and linking it to the internationalisation of institutions in the country.

Organised discourse on international activities is a first step for improvement

The analysis in the UK, Ireland and Germany has fed into the strategy making process, delivering for the first time a set of quantitative and qualitative indicators to understand international involvement and gaps (*see box 1 for specific examples*). Recognising that simple quantitative indicators about international activities and supporting mechanism are not sufficient, these countries have developed *discourses* around those analyses to check quantitative indicators at country and institutional level. Another example is Estonia, where a peer review exercise of public research organisations tried to assess the international linkages and potentials of research organisations.

There are some more systematic approaches that go beyond discourse – although of course discursive processes can prove a very efficient tool for mobilising the relevant community. One holistic approach has been conducted in the UK through the Global Science and Innovation Forum (GSIF, see UK report). This sought to combine data provided by scientific attachés with data retrieved from reports of key funding and research organisations and a limited set of other studies. Data was acquired on four dimensions: international involvement (how engaged a specific country is in international programmes and fora); level of development; science; and innovation. The data sources for this 'indicator system' are existing data from international sources and from the various countries, combined with specific studies (e.g. bibliometric) and the positioning indicators of important institutions in those countries. Interestingly, the UK sought to acquire qualitative, positioning data in order to get complete profiles, strengths and interfaces for collaboration activities. However, the exercise ended up with a data gap on those dimension, and most of the data that was collected fell into the traditional category of input/output indicators of scientific activity. Nonetheless, this combination of existing data has helped to identify the potential for STI collaboration with other countries.

The general finding remains: indicator use to underpin internationalisation policies shows room for improvement – and policy makers are increasingly aware of that

The general picture, however, remains: our interviews confirm the CREST report finding that desirable metrics and databases are rarely available (CREST Working Group 2007). Thus, although there may often be an abundance of bilateral STI agreements between countries or programmes, and a need to reach out for international collaboration more widely, systematic country-specific analyses based on indicators such as bibliometrics and technometrics are very rarely used to inform decisions about engaging in, continuing or terminating such collaboration

frameworks. There is also a lack of data on funding and knowledge flows[22] between countries to understand existing linkages. Of course there exist a range of academic analyses on technological and scientific profiles, trade statistics and the like. However, programme owners and ministries often rely on bottom up, discursive approaches, in which the demand for collaboration with specific countries is defined by scientists and policy-makers on the basis of qualitative judgement and interest involved. Very often explicit indicators are not used at all, as STI agreements follow a whole range of motivations, and are often not triggered by STI considerations in the first place.

6.3 Stage 2: Setting targets

Targets for internationalisation policies are mostly general and qualitative

The usage of specific indicators is surprisingly limited when it comes to defining targets for international activities (and target countries, see 6.4 below). Targets are mostly general and qualitative and reflect the general desire to 'raise' or 'improve' international engagement and activities. This is not to say that each target would need quantification,[23] however it does seem that the lack of analytical depth in the first phase, the lack of positioning indicators and of knowledge on the exact position of countries and institutions, makes it harder to define specific goals. In other words there is a knock on-effect through under-specification.

The linking of internationalisation targets to existing goals of broader STI strategies is limited and targets are set on the level of measures rather than on effects

Very few internationalisation policies or strategies have explicit internationalisation targets that are directly connected to their overall goals. As already noted, internationalisation is a means to an end, whereby the end can be competitiveness, contribution to global challenges, etc. However the targets that are defined tend to be focused on increasing internationalisation (more collaboration, more researcher mobility, etc) rather than on the contribution this delivers to the final goal. This is related to the problems of demonstrating cause-effect relationships in complex systems and, in contrast, the easier availability of intermediate activity indicators. However, an emphasis on activity measures can be problematic: take the example of researcher mobility, where 'more mobility' is generally regarded as a good thing (certainly intra-European mobility). The evidence (e.g. Idea Consult *et al* 2008) reminds us that there are both push and pull forces affecting the mobility of researchers – and that these have asymmetric consequences both for receiving and sending research institutions and for the professional and personal lives of individual researchers. Furthermore mobility is a dynamic process lived out through the life-course of the individual researcher and will have 'positive' and 'negative' knowledge, capacity and personal effects at different times and places. In particular what may be an inhibiting factor for the career development of a researcher in their domestic system (e.g. rigid careers structure, funding problems, etc) can also be a push factor for international mobility[24].

Interpreting our interviews with policy makers, there seems to be a lack of knowledge about which levels and kinds of international activities yield the best results for a certain overall goal, bearing in mind that 'the best' mix will likely vary from one field or sector to another, from one national 'system' to another, and will change over time as the dynamics of the research or innovation system and field or sector continue to evolve. To have targets for the scale, scope and nature of international activities assumes that the effects of those activities on other policy goals and the system as a whole are known. However there is little evidence of causality that can be generalised.

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22 See footnote 21 above.

23 One rare example of quantifications is the explicit goal in the German internationalisation strategy of 20% participation of overseas partners in the research programmes of the Federal Ministry of Education and Research.

24 It is quite possible to imagine that improvements in conditions in a number of national research systems in Europe would result in *less* researcher mobility.

One illustration of indicators across the board of different drivers and directly related to the catalogue of explicit targets can be derived from the German strategy document (see also Matthes 2008). These 'indicators' are not officially set by the BMBF, but target dimensions officially stated in the strategy which could be used as yardsticks in an evaluation. It is not yet decided if the strategy will be assessed along those 'indicators'.

Figure 5 Target indicators for strategic internationalisation – example from Germany[25]

Main Actor	Key objective	Indicator (derived from the document, not officially declared as target)
BMBF	Access to overseas excellence and experience, at home and abroad	Increase the share of overseas students in Germany above the current 15%
		Increase the current number of 8% overseas Professors in German Universities
		Increase in the number of German students having been abroad during their studies. Higher number of mobility student grants.
		Increase in the number of German researchers gaining experience and degrees abroad
		Increase in the number of international collaborations, with an explicit target of 20% participation of overseas companies in national programmes of the BMBF. Increase the share of SMEs that cooperate internationally.
		Increase the return rate for EU FP 7 above 20% and the success rate above 24%.
		Increase the number of international inter-institutional co-operations by research organisations/ Universities I strategically important countries
	International exploitation of innovation potentials	Increase the number of actors integrated in high-performing international in networks
		Increase participation of overseas actors in innovation networks (national competence networks)
		Improve the link to research in Germany with international standardization bodies
		Increase (and therefore measure) the effectiveness of marketing campaigns abroad
	Intensifying the cooperation with developing countries	Increase the number of engagements in science centres in developing countries – no maximising, but tailored effort to link to national interest
		Enlarge the scientist networks with developing countries (number of individuals in networks)
		Enlarge the access of scientists from developing countries to knowledge in Germany (open access), number of scientists accessing data)
	Contribute to solution of global challenges	Intensification of issue oriented dialogue (number of committees, fora, recommendations, implementations)

[25] These 'indicators' are not officially set indicators by the BMBF, but target dimensions officially stated in the strategy which could be used as yardsticks in an evaluation. It is not decided if the strategy will be assessed along those 'indicators'.

6.4 Stage 3: Indicators to understand the international 'opportunity environment'

It is important to understand the opportunity environment for international activities

Perhaps the weakest link in the policy strategy cycle is the use of indicators to support systematic attempts to understand the opportunity environment for international activities, to define target countries and thus to support the international activities of STI communities. The usual and most pragmatic way in such understanding is generated through scientific attachés in embassies, where they exist. The extent and capacity of such networks vary from country to country, with France and the UK being much more active than, e.g. Germany. Generally, attachés report about general developments and act as brokers into the local systems.

The lack of this systematic analysis is directly related to the fact that so many actors are involved in defining the direction and contents of collaborations, in addition to the long history of many collaborative ties. This complicates a 'fresh' look into the complete set of international research collaboration based on empirical strategic intelligence. While decisions for new collaborations are 'easily' made (e.g. all countries have stepped up their ties with China, both through bottom up and through strategic top down measures), decisions to streamline or stop existing collaborations are politically more difficult.

Criteria to judge collaboration partners exist…

In terms of systematic decision rules used for characterising other countries and support decisions on priorities, the CREST survey conducted 2007 (CREST Working Group 2007) identifies a range of dimensions which are very much in line with the drivers:

- Expected scientific benefits including improving quality and excellence
- Political reasons including solving societal problems and contributing to development goals
- Gaining access to (new) markets, competition and innovation aspects
- Human factors (immigration of knowledge workers, brain drain, brain gain and brain-circulation)
- Promotional activities for the national science system
- Geographical, historical, linguistic and cultural ties.

… and some countries have set in place related efforts more systematically

Some examples from countries illustrate some interesting practice. The UK has, in the process of the GSIF, linked reporting by attachés to a systematic *status quo* analysis on target countries, using existing quantitative data, based on international and overseas sources, using the available quantitative indicators on the STI systems and collaboration patterns, and analysing countries with a limited set of indicators: total number of scientific citations and share of scientific papers in most prestigious journals, number and development of patents, total and business R&D and development of student numbers. In this process it was acknowledged that that many indicators for 'influence and development' are not available.[26] These templates then were mapped against the strategic priorities as discussed within GSIF. This country monitoring was accompanied by an in-depth analysis of the profiles of partner countries which compared the relative importance of partner countries in co-publications and analysed the gap between the expected level of cooperation (indicated through the publication profiles of partner countries) with the expected and the actual cooperation activities (Adams et al 2008).

The French STI indicator and analysis institute OST produces regular reports on STI activities and performance, in France and globally. Those reports also contain the

[26] See the UK report produced within this study for more detail.

scientific profile not only of the advanced OECD countries but of emerging and developing countries, which puts the country in a good position to detect important developments early on (e.g. http://www.obs-ost.fr/fileadmin/medias/tx_ostdocuments/Partie5Graph_01.pdf).

The strategy discourse in Ireland included a discourse on specific, concrete international activities and the exchange about international cooperation and co-ordination options. This discourse was not so much based on indicators, but on anecdotal evidence and expertise of participants, as a means to further explore more concrete areas of action and define metrics to better assess future options.

Finally, one example for a reporting system on international research and education activities and related policy developments in around 40 countries is the German service "Kooperation international" run by the German Federal Ministry of Education and Research (http://www.kooperation-international.de/). This service does not provide regular analytical insights on scientific hot spots based on some quantitative indicators, but it points towards concrete cooperation potential (e.g. through international cooperation fairs) and provides current information about policy initiatives, institutional and organisational developments that have proved very valuable for the decision makers in policy, funding and research organisations.[27]

6.5 Stage 4: Monitoring and evaluating

There are two levels of impact: 1) effects of international STI activities and 2) effects of dedicated policies

When screening existing monitoring or evaluation activity related to internationalisation in our 20 countries, two levels need to be distinguished. The first level is the assessment of effects of international activities, the second is at the level of evaluating the effects of policy measures and framework conditions on STI collaboration patterns and their impact.

1) The effects of international STI activities

The strongest area of assessment activity is the impact analysis of scientific co-publication

STI collaboration is not an end in itself, it is done to enhance benefits of scientific and technological activities for those who cooperate and for the system as such. However, no country in our sample has a system in place by which the effects of international activities are measured systematically. Most policy-makers are aware of the impact analysis as regards scientific co-publication and they have plenty of anecdotal evidence for the benefits of all kinds of international activity. To our knowledge, while the scale and scope of international activities are increasingly covered in national indicator systems (albeit not on the level of research and funding institutions), the *effects* of international activities are not part of regular indicator systems at all.

The study for the German Federal Ministry of Education and Research mentioned above is an exemption. The following box gives a list of indicators that were used to measure the impact of international activities on institutions and on individuals in that study. Those indicators were felt to be useful by the BMBF and used for the internal and external communication. It is as yet unclear whether they will be taken up for the monitoring and assessment of the strategy. This was the first time that data on individual researchers, their mobility and cooperation patterns as well as data on the internationalisation activities of *research organisations and funding organisations* was brought together to inform the Ministry about strengths, dynamics and needs (see box below).

[27] This has been found in the interviews within the study on internationalisation of public research in Germany (Edler 2007).

Box 1: Indicators used to assess scale and impact of international activities (Germany)

- International collaboration of researchers, measured through co-publication and co-patenting analysis of firms and public researchers, differentiated by institutional backgrounds and thematic areas.
- International institutional cooperation, measured through numbers and development of inter-institutional agreements (Universities) and interview and survey questions regarding number of inter-institutional agreements
- International mobility, measured through survey questions about the mobility activities of overseas and German researchers differentiated for host countries and countries of origin and by the share of overseas scientists at German research organisations,
- Participation in international programmes, especially EU programmes
- Impact indicators – institutional level : a range of indicators that tried to measure how international activities of public science effected quality, speed, reputation gains, changes in cooperation patterns, ability to access complementary or specialised knowledge, changes in thematic scope, organisational changes in the organisation, efficiency gains.
- Impact indicators, individual level (impact of mobility): scientific career, cooperation with researchers, international teaching experience, and effects on publications, networking with overseas firms and career planning.
- Assessment of framework conditions and policy: Furthermore, an attempt was made to understand the meaning and impact of framework conditions and specific programmes. To do so, individual scientists and leaders of research organisations and universities were surveyed. They were given a set of assessments on the various supporting and hindering framework conditions and supporting programmes and answered in a Likert-scale. While this was no formal evaluation, it helped the ministry to get a feeling about the relative importance and impact of framework conditions and supporting instruments, especially as the analysis could differentiate between types of institutes and types and thematic areas of research (for details see German country report within this study and Edler et al. 2007).

2) Evaluating policies and programmes

Second, evaluations of the link to the overarching goal of programmes (e.g. contribution to foreign policy, solution to grand challenges, linkages to related national activities, etc.) are very limited. Often the success of internationalisation programmes is equated with improving the scale and/or scope of international activity itself. This might be justified if the goal of a programme is to improve international engagement radically and this is the final and overarching goal or if catching up through strong international engagement and build up of new structures is aimed at. However, even in those cases, the impact assessment of international collaboration programmes, such as the assessment of some STI agreements, is very often simply about the numbers and the forms of activities, rather than about structural changes, lasting networks, contribution to common agenda setting, spill-over effects to other activities, etc. One example in which the lasting effects of internationalisation programmes have been looked at is the evaluation of the British Council International Programme which analysed subsequent project activities in the Framework Programme (Georghiou / Cunningham 2002).

The success of internationalisation policies is measured by the increase in scale and scope of international activities, rather than by their effects on scientific and innovation performance

Interestingly, although the international dimension is horizontal to many STI strategies and programmes, there are also only very few attempts to understand the *effects of national research funding programmes* on the international collaboration activities and how those international activities contribute to programme goals. One of the few examples can be found in Finland, where a systematic analysis has been

conducted on agency level. Tekes conducted an evaluation of the dynamics and impacts of internationalisation policy instruments (Tekes, 2004). The evaluation determined the impacts and mechanisms of all Tekes's technology programmes in enhancing the internationalisation of research and development work, innovation and technology-based firms. The evaluation combined an international comparison, with programme specific impact assessment by means of survey and case studies. Although the evaluation is not conducted across all government activities, it retrieves insight in the processes of internationalisation that can be generalised for other public policy bodies. It for instance analysed how internationalisation takes place over the life cycle of a programme, revealing the process of path dependencies in the programmes and the effect on internationalisation of programmes.[28] The indicators used to characterise the international activities in the programmes were: share of projects with international partners in all project and share of funds used for international projects, differentiated for partner countries, overseas speakers in seminars and workshops, cooperation with international networks and programmes, exchange of researchers, participation (of programme officials) in international committees and standardisation bodies, international marketing activities of the programmes.

Further, studies on the national impact of the Framework Programmes have shown that there can be a trade-off between the wider availability of national research funding and the willingness of researchers to engage into international projects with more transaction costs (impact assessment FP5 Ireland and FP6 Sweden).

The mapping and monitoring activities have seldom kept up with the diversification of the policy drivers

However, in the 'broad paradigm', if international engagement is not the final goal but the means to other policy ends, the conceptual link to the final goal must be made visible and every attempt made to make the contribution of international activity to this end measurable. This is still extremely weak in most of the countries – and *an obvious area of improvement at all levels* (see below). While the policy drivers of internationalisation activity have diversified, the mapping and monitoring activities have seldom kept up.

A good example from Canada for the evaluation of domain based internationalisation policies

The case of the Canadian Institute of Health Research (Figure 6 below) is an example of an evaluation that takes into account a whole range of goal dimensions. The institute in fact is based on a mission oriented programme of activities, and as such the link between scientific excellence and direct impact on the societal goal (health) is more direct. The indicators range from simple numbers of international collaborators in the programme to proof of excellence and follow up funding (grants in the International Opportunity Program), indicators for governance adaptations (international peer reviewing, international Advisory Board members), impact on the next generation (training awards, returnees), integration into International Health Research Networks, both outward (grants in Global Health Research grants) and inward (overseas participants in national programme), knock on effects in terms of complementary programmes dedicated to specific societal challenges (agenda setting) and finally recognition as an international best practice programme. With such a multi-dimensional framework, the position of the programme can be more fully defined and changes over the years be monitored.

[28] A much less ambitious attempt in the same direction was done in Germany where the major R&D programmes of the BMBF were assessed through interviews and document analysis, not – however – developing and using uniform indicators (Edler 2007).

Figure 6 The use of indicators in the international activities of the Canadian Institutes of Health Research*

Key driver	Indicator
Research: Increased international collaboration by Canadian health researchers and institutions Increased Canadian involvement in international clinical trials. Continued or enhanced access for Canadian health researchers to leading-edge technology and thinking regarding health research	The number of CIHR grants that involve international collaborators.
	The number of grants made through the International Opportunities Program (IOP) seed funding.
	The dollar value of IOP grants secured as the result of projects.
	The number of Canadian health research publications with a non-Canadian co-author.
	The number of Canadians involved in non-Canadian peer review and international researchers involved in CIHR peer review.
	The number of international Institute Advisory Board members.
	The number of international clinical trials involving Canadians.
Talent: A Canadian health research community that is globally connected.	The number of training awards that involve a non-Canadian studying in Canada or Canadians studying in another country.
	The number of Strategic Initiative In Health Research projects that have an international component
	The number of Canadian researchers who have returned from training internationally.
Global Health: Recognition of Canada as a contributor to addressing significant global health challenges. Health researchers in low and middle-income countries collaborating with Canadian colleagues.	The number of grants and awards made by the Global Health Research Initiative.
	Existence of the Teasdale-Corti and the Grand Challenge Programs, the number of research linkages supported by them.
	The number of countries involved in the Canada-HOPE Program and the number of scholarships provided.
Safety and Security: Research contributions to mitigate emerging health threats to Canadians and bio-terrorism.	The existence of a research component in Canadian government strategies aimed at combating health threats and bio-terrorism.
	The existence and functioning of the Canadian Rapid Research Response Team.
Best Practices: Improved policies and systems for research management at CIHR. CIHR contribution to improving the policies and systems for research management in research organizations in other countries. International recognition of CIHR as a leading-edge health research organization.	The number of countries that have consulted CIHR regarding research management advances.
	The number of instances in which research management advances from other countries have been adopted by CIHR.

‘ Source: Canadian Country Report (Background Report 3)

In the previous two chapters (1) indicator needs for evidence based policy making regarding international collaboration in STI have been discussed applying a strategy cycle approach to cover various functions indicators should support and (2) the actual usage of indicators in the countries of our review has been analysed. All this conceptual and empirical discussion leads to a clear conclusion: there is a strong need for a more appropriate design and use of indicators and strategic intelligence more generally along all functions and across various policy goals associated with international collaboration. Policy seems to fall into the lamppost fallacy trap. Policy makers use those indicators they can readily find and design policy tools that allegedly improve the performance along those indicators.

7. Summary and main conclusions

7.1 Major findings: trends and challenges

This study has shown that a number of trends are emerging regarding international research collaboration and the use of policy evidence on behalf of this:

The policy attention for international research collaboration is growing due to external triggers

1. The policy attention for international research collaboration is growing rapidly in all countries. Globalisation (of markets and R&D), fast emerging large economies (India, China) and the opening up of their STI systems, the urgency of global challenges, scarcity of human resources in research are external factors that have spurred this growing attention to the subject;

The set of drivers for internationalisation policies in research is diversifying

2. In terms of policy drivers we have established a 'narrow paradigm' (stemming from the dynamics of science and research) and a 'broader paradigm' (stemming from additional policy objectives that use STI collaboration as a mechanism to achieve supplementary goals). The diverse sets of drivers interact with each other, even if they are not 'co-ordinated' in a formal sense by the policy domains and actors behind those drivers and particularly when international STI collaboration is not a purely bottom-up process run by the research performing actors themselves;

The envisaged outcomes and impacts are not well defined

3. International STI collaboration policies and programmes that combine various policy drivers (e.g. research excellence with a diplomatic choice for the geography, scope and scale of research with improving competitiveness in specific thematic areas) usually have very fuzzy goals and the envisaged outcomes and impacts are not well defined. In such cases, setting up a coherent set of indicators to define its success on all fronts becomes difficult;
4. While policy makers and research funders apply many assumptions regarding how international STI collaboration has an effect on various policy goals, these are rarely specified or operationalised in the implementation of the instruments in place. Particularly in the 'broad paradigm' the causal relationships between the desired effect and the contribution of international STI collaboration programmes cannot be established;
5. Given the multitude of actors involved in implementing STI collaboration, the variety of drivers, the different starting position of countries and the parallel use of bottom-up and more top-down strategies, it is not likely that EU Member States can easily develop a coherent evaluation and indicator framework. Nevertheless a starting set consisting of a 'bottom-line' framework and a set of key indicators starting from the 'narrow' paradigm would be a necessary first step.

The concluding paragraph and Table 3 provide such a first set of indicators.

7.2 Defining a framework to support decision making for and to measure progress and impact of STI collaboration – and proposal for a set of realistic indicators

The window of opportunity is good

Given that the (often very ambitious) international strategies developed by many European countries are currently only partly evidence-based, making recommendations is a challenge: our findings on how indicators are used for policy-making in international STI co-operation shows a rather poor picture – in most cases policy-making at best draws on evidence from *ad hoc* studies and policy imitation from other countries. The window of opportunity is good, as most countries are actively seeking a pragmatic and meaningful indicator system and as many policy-makers have realised the potential benefit of international collaboration both for their STI communities and for broader policy goals.

If Europe wishes to promote more intensive and more extensive international STI collaboration in the future, and to exploit those collaborations across many policy areas, a much more systematic evidence base will be required upon which national and EU level policy-makers can draw. The relative dearth of indicator use at the moment is not based on lack of interest – policy makers are well aware of their needs – but indicates a high level of uncertainty and the high costs of designing and using indicators. However, the cost–benefit ratio of using indicators more systematically could shift significantly: first, the benefits of international STI collaboration appear to broaden (broad paradigm, complex knowledge creation, increasing costs, increasing specialisation, increasing speed, etc.) and second, there is a huge potential in coordinating and pooling activities at the European level. We propose, therefore, that efforts should be made to work towards both a more systematic design and more concerted use of indicators.

Given the diversity of activities across Europe, a step-wise learning approach and simple coordination means across Europe are most promising

A fully fledged systematic design would have to differentiate amongst different modes, actors, drivers, and stages of activity. It is too complex a task to develop a concept from scratch that is able to capture all dimensions in an undertaking of this scale and in any case this would be premature without policy co-ordination. We believe the kind of co-ordination envisaged in the Strategic Forum for International S&T Co-operation should allow for a **step-wise learning and coordination approach**. Such a learning forum could, generally speaking,

- Start an exchange on indicator use and needs given the different organisational structures and strategic visions in the countries
- Support countries in the development and operationalisation of national level indicators by drawing upon experiences elsewhere and by exchanging good cases
- Set up a clearinghouse[29] for relevant indicator and analysis at the EU level (for instance this could be done through the ERAWATCH activity)
- Define areas in which countries could pool their data and the data finding activities whilst retaining a variable geometry
- Define areas for which a supranational (EU) or otherwise transnational approach of collecting and disseminating data is most beneficial for the European and the national activities [30]

[29] The data clearinghouse idea as such is not new, it has been revitalised in the European evaluation debate by Kuhlmann / Heinze (2004) and Edler / Kuhlmann 2006, the basic idea of a clearinghouse would be that data collecting institutions in the countries would report uniform indicators to a European collector for comparison, exchange, aggregation and learning, following uniform collection standards.

[30] The focus of indicators is on policy, and the study has asked for national perspectives and activities. It can be argued that this national perspective itself is a limitation as it traps us in an approach that takes the national level as starting and end point rather than relating

- Exploit existing variable geometry opportunities in terms of pooling countries with similar interests (for internationalisation of sectors or partnering with certain countries (as done with the ERA-NET Co-Reach or partly by INCO-Nets).

The following Table 3 summarises our recommendation in terms of concrete indicators. The **left column** in the following table gives a **concrete set of indicators that should be used for policy making at national level**. The boxes next to those indicators give an **indication as to how coordination at European level can support** this process. We are not intending to be narrowly prescriptive but nevertheless present the list of indicators on the basis of the various information sources and literature we have digested and the basis of good and promising practice.

transnational activities of actors and transnational STI dynamics to transnational problems and opportunities. However, national policy making still sets the scene for other institutional actors and strategies, and it is the level that still to a great degree defines how opportunities for those actors are opened (and how they can be seized). Our task has been to conceptualise indicators starting from the country perspective, and until we dare to think policy design more radically, more problem driven, this perspective may prevail.

Table 3 Needs and actions to improve the design and use of indicators for international STI collaboration

Key indicators to be used (in brackets: data sources)	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
Stage 1) *Status quo* of the country			
(1.1) Analysis of the STI strengths and weaknesses of an innovation system			
In principle, the whole existing array of RTDI (input, output) indicators[31] can be used to present the evidence of the status quo. To prepare for international STI and to be informed on the level of fields, the following indicators are a basic requirement. **GERD and BERD, R&D expenses differentiated for fields; number of researchers (for fields), research intensity (as needed for sectors)** **scientific profiles (bibliometric) and technological profiles (technometrics) (both relative quantity and excellence);** **co-operation intensity (scientific co-publications, number of industry-science co-operations (co-publications, funded projects), number of funded co-operations; technological alliances),** **innovativeness (CIS definition[32]) of sectors**	There is a high diversity of reporting systems and indicator use at general STI performance level. Countries would certainly have a range of reasons to provide their decision makers with strategic analysis and will tailor approaches to their needs. However, they should check how their own systems support the definition of weaknesses, strength and collaboration needs and opportunities, and they should check in how far those systems are set up to cover areas in the various domains of the broad paradigm.	(Re-)Establish centralised data on weaknesses and strengths of European science activities. Think about a 'Science Scoreboard' that differentiates between scientific areas and is able to detect hot spots. A specialised unit could build up the expertise needed to map the European science system and could deliver European wide and – on-demand – area, country or country-group specific analysis.	Learning: Discuss the existing strategic intelligence in the various countries and how it enables to understand strengths and weaknesses in those systems as a basis to define collaboration needs. Discuss the role of hard indicator vs. discursive and peer driven processes. Report about country activities and good practice in defining areas of need or opportunities for collaboration Discuss about the need or opportunity to set up area specific groups to synthesis data and define common collaboration needs – within and outside Europe

31 Here countries and the EU are well equipped, the latest key figure report of the EU (EU Com 2009) and the scoreboard work (http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=437&parentID=51#) provide those indicators that would in principle suffice to provide a swot analysis in terms of STI of countries (EU Com 2009)

32 Innovativeness could be defined – based on CIS - as share of companies with a certain percentage of turnover realised thorugh products and services introduced within the last 3 years. Effects of innovations would be the share of

Key indicators	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
(1.2) Existing scope and scale of internat. activities of a country in STI			
(1.2a) Scope/scale of internat. STI activities: individuals			
Co-publications and co-inventions (databases) **Project cooperation data (funding databases)** **Citation impact of (international) co-publications (databases)** **Share of researchers co-publishing internationally (databases)** **Co-operation partner analysis (funding and publication databases)** **Mobility indicators: number and share of professors/senior researchers, other researchers and research students going overseas and coming in (surveys, employee statistics)** **International networking: number of researchers involved in international networks and co-operations (survey data)**	Include international indicators into the routine national reporting system Design area specific tools as the country profile demands	Set up regular bibliometric and technometric analysis on co-publication patterns that allows for country specialisation Analyse, on a regular basis, cooperation patterns in FP with extra-European countries (along actor types countries and programme lines) Make full use of OECD database on Higher Education	Exchange about good practices in use of these indicators Make all those regularly used at international and national level available to others

Key indicators to be used (in brackets: data sources)	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
(1.2b) Scope/scale of internat. STI activities of organisations (Research, funding, firms)			
The indicators above (a1), but on institutional level (whereby the level at which data is collected within institutions is crucial, university level is misleading) **Budgets / units for internationalisation (surveys, national reporting systems)** **Share of overseas employees (surveys, national reporting systems)** **Number / nature of intl. agreements (administrative survey)** **Share of income from overseas sources (survey, national reporting system)** **R&D related FDI (and staff) in companies, number of labs abroad, / at home (existing OECD / EUROSTAT reporting system)** **Patents abroad / at home (database)** **Target country representation (survey)**	Exploit existing data on Universities Set up a simple survey system on institution and firm level taking into account national specificities or enlarge national surveys with key variables Monitor and co-ordinate with the HEI indicator developments of the CEIHE project under the Socrates Life Long Learning Programme	Add a set of questions / variables to the CIS survey Use OECD firm data Set up a data clearinghouse on research organisations and funding organisations with simple indicators, ideally mediated through central national actors, synthesised at European level for aggregation and comparison.	Define which indicators from those mentioned at the left should be collected at European level, which should be co-ordinated (following uniform standards) and which are too specific. Guideline: only collect few centrally, through simple on-line survey supported by national governments, using – where available – University federations and umbrella organisations of non-University research institutions. Support the work towards a data clearinghouse: definition of common standards for positioning indicators (stage 1.2 above)

Key indicators to be used (in brackets: data sources)	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
(1.2c) Policy measures/ instruments for international collaboration			
Specialised programmes: number of participants, number of joint activities, development over time (organisations themselves, in-house) **differentiated for target countries or groups (as defined in country strategies, e.g. neighbours, developing countries, leading countries etc., depending on target dimension)** **National programmes: Openness (share of overseas participants, share of budget going abroad), domain specific (administrative survey)** **Number and status (activities, budgets) of STI agreements (of ministries, universities, funding organisations) and live projects within them, drivers in those agreements (administrative survey)** **Participation in EU policy schemes, including ERANET and TP (administrative survey, IPTS database)** **Participation patterns in International Organisations and Infrastructures (central query at organisations)**	Survey all major national funding programmes as regards overseas participation and money flows, using – as far as possible – existing data. Install a simple, regular reporting system on both issues, taking advantage of existing University and non University institute federations and headquarters.	Provide regular data on the STI agreements and the international dimension of FP 6 Systematically report on international activities of EUREKA and COST. Provide a database on activities of and participation in international organisations that have a science, technology or innovation remit, link this data to relevant ERANETs and programme committees.	Check in all on-going ERA-Net activities for options to coordinate on strategic intelligence on international activities in those areas. Check for the possibility of a European clearinghouse to which a central actor at national level would send the data collected at national level. This allows for a cross area check of
(1.2d) Governance structures (policy)			
Existence of internationalisation strategies, budgets, units and strategic intelligence? (key policy organisations themselves) **Involvement in coordination schemes such as ERANET with international dimension (central ERA-Net database, on-going IPTS project)**	Set up a reflexive process to understand the function of	Covered through CREST Working Party already	Covered through CREST Working Party already

Key indicators	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
Stage 2) Setting targets			
Existence of explicit targets? Existence of explicit quantifiable targets? If so, at which level (scale and scope of international activity or indicators to measure the impact?) (in-house (ministries), administrative survey as needed) **In principle these are any combination of indicators above, depending on how explicit targets are set.**	Define targets explicitly along the national STI strategy and in ways that make them operationable, measureable both for general programmes and internationalisation programmes and activities.	Define targets explicitly along the FP work programme and in ways which make them operationable, measureable.	Reflect about the nature of the underlying challenge for the various targets, if this is a transnational challenge of equal importance to all, check for

Key indicators	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
Stage 3) The international 'opportunity environment'			
Scientific and technological profiles of countries (database, service providers) **Hot spot analysis on institute level (database, service providers, key researcher query)** **Demand and Market indicators (Diffusion patterns, purchasing power, regulations, public procurement) (Market research, World Economic Forum survey, industry survey (fedeations))** **Number and nature of existing collaboration (see above, FP data, co-publication data)** **Nature of funding opportunities and policy direction in potential partner countries (policy intelligence, scientific attachés, Erawatch(?))** **Involvement of those potential partners countries in international organisations (survey (reporting system of international organisation representatives)**	Targeted indicator search for specific scientific areas Activating overseas embassies to mobilise peer assessments	Set up reporting system (in-house, external) that provides a basic analysis of scientific and technological profiles around the globe, top support weaker member states and create a common basis for the definition of opportunities. Regular monitoring of International Organisations and their activities	Pool efforts in a variable geometry (in terms of attaches, in terms of indicator data, in terms of policy reporting systems) for areas that are not of EU wide interest but not to country specific.

Key indicators	Action on country level	Action on EU level	Issues for Co-ordination (SFIC)
Stage 4) Monitoring and evaluating			
Regular data on the various internationalisation indicators as listed above to monitor development (for those variables that are influenced by concrete interventions this monitoring would be part of an intervention evaluation) **This should include behavioural changes (attitudes and actions as regards international mobility and cooperation)** **For impact of those developments, one needs to select those RTDI performance indicators (output, economic effects) the change of which can (partly) be attributed to increased international activity (e.g. correlation between increased international co-publication and measures of scientific excellence (citation). This is contingent upon the individual measures taken and cannot be summarised in such a table, but must be designed to fit purpose,see Figure 5, the German example.**	General: Have a permanent intelligence structure to cover the indicators under 1 above in a regular pattern For specific internationalisation programmes or international organisations:	Issue specific studies to learn more about impacts of international activities on individuals Consequent evaluation of FP 6 international dimension, participation patterns, specific output and outcome	Exchange on existing evaluation schemes as regards national programmes (openness, impacts), participation in International Organisations Spread good practice in evaluation of participation in International Organisation (e.g. Austria, Switzerland, see Edler et al. 2007)

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Policies to support international collaboration in research have a long history and many initiatives, programmes, collaboration agreements have been put in place. Globalisation has intensified the need to develop these policies more strategically and to make them more effective. The experience of, and factors affecting, the level of international research collaboration of major funding countries and of funding recipients prove to be very diverse.

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