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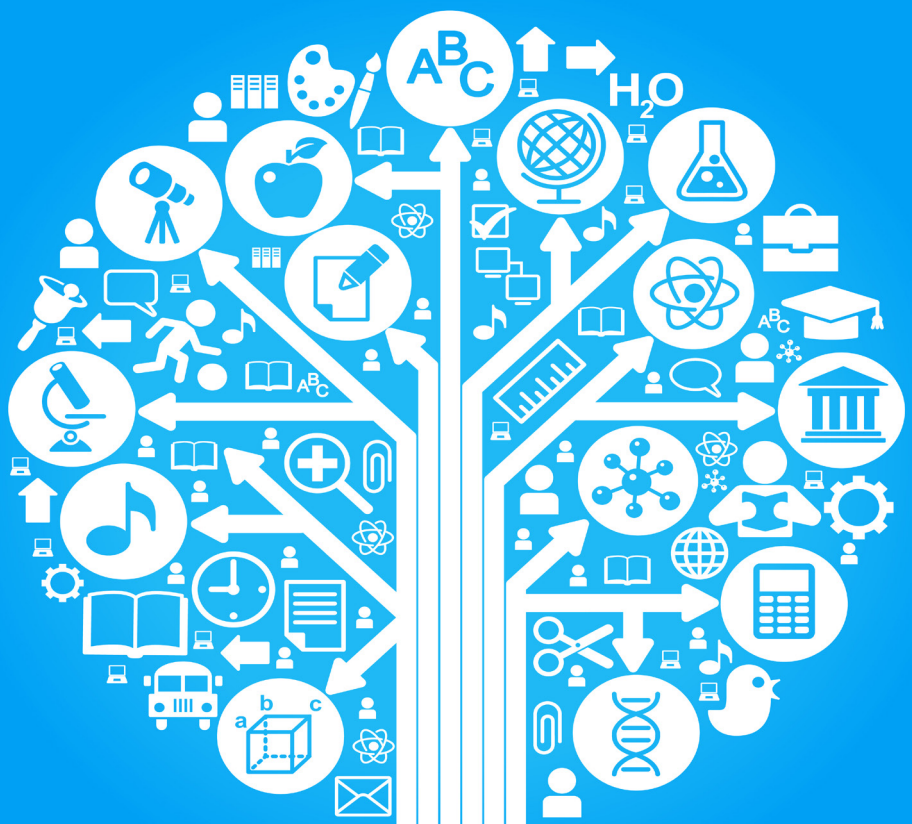
International Cooperation in Science, Technology and Innovation: Strategies for a Changing World

Report of the Expert Group established to support the further development of an EU international STI cooperation strategy



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Report of the Expert Group established to support the further development of an EU international STI cooperation strategy

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List of abbreviations

AC	Countries Associated to the EU Framework Programmes
CIS	Community Innovation Survey
CNRS	National Centre for Scientific Research, France
CREST	European Union Scientific and Technical Research Committee (since 26 May 2010 renamed into
ERAC	European Research Area Committee)
DG R&I	Directorate General Research and Innovation
EC	European Commission
EEN	Enterprise Europe Network
EFTA	European Free Trade Association
EG	Expert Group
EIRMA	European Industrial Research Management Association
ERA	European Research Area
ERAC	European Research Area Committee
EU	European Union
EUA	European University Association
EUI	European University Institute
FDI	Foreign Direct Investments
FP	Framework Programmes
FP7	Framework Programme 7
G20	The Group of Twenty. "The Group of Twenty Finance Ministers and Central Bank Governors (also known as the G-20, G20, and Group of Twenty) is a group of finance ministers and central bank governors from 20 major economies: 19 countries plus the European Union, which is represented by the President of the European Council and by the European Central Bank.[3] The G-20 heads of government or heads of state have also periodically conferred at summits since their initial meeting in 2008. Collectively, the G-20 economies account for more than 80 percent of the gross world product (GWP),[4] 80 percent of world trade (including EU intra-trade), and two-thirds of the world population.[3] They furthermore account for 84.1 percent and 82.2 percent of the world's economic growth by nominal GDP and GDP (PPP) respectively from the years 2010 to 2016, according to the International Monetary Fund (IMF)."1
G8	The Group of Eight. "The Group of Eight (G8) is a forum for the governments of eight of the world's largest economies. … The forum originated with a 1975 summit hosted by France that brought together representatives of six

[1] http://en.wikipedia.org/wiki/G-20_major_economies

	governments: France, Germany, Italy, Japan, the United Kingdom, and the United States, thus leading to the name Group of Six or G6. The summit became known as the Group of Seven or G7 the following year with the addition of Canada. In 1997, Russia was added to group which then became known as the G8.[1] The European Union is represented within the G8 but cannot host or chair summits.[2]”2
GDP	Gross Domestic Product
GPN	Global Production Networks
GVCs	Global Value Chains
H2020	Horizon 2020
HBA	Home-base Augmenting
ICT	Information and Communication Technologies
IISER	Integrated Information System on European Researchers
INCO	International Cooperation
IP	Intellectual Property
IPR	Intellectual Property Rights
IRSES	International Research Staff Exchange Scheme
IT	Information Technologies
JP	Joint Programming
JPIs	Joint Programming Initiatives
JRC IPTS	Joint Research Centre, Institute for Prospective Technological Studies
KET	Key Enabling Technologies
MNEs	Multinational Enterprises
MS	Member States
OECD	Organisation for Economic Cooperation and Development
PROs	Public Research Organisations
PROTON	ProTon Europe, the European Knowledge Transfer Association, created in 2003 by the European Commission and self supporting since 2007
R&D	Research and Development
RI	Research Infrastructures
RTD	Research and Technology Development
RTDI	Research, Technology Development and Innovation
S&T	Science and Technology
SFIC	Strategic Forum for International S&T Cooperation
SMEs	Small and Medium-sized Enterprises
SRA	Strategic Research Agendas
STI	Science, Technology and Innovation
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
WB	World Bank

[2] http://en.wikipedia.org/wiki/G8#cite_note-0

Executive summary

Changes in the international landscape require urgent policy action

Over the past few decades the international landscape has changed in ways that seem both dramatic and contradictory. New players have emerged, notably emerging economies such as China, Brazil, India, and South Africa. Smaller economies like Vietnam are to a greater degree imitating the Chinese strategy of placing science, technology and innovation (STI) at the centre of the economic development strategies, and raw materials based economies like Australia are increasingly STI-driven. Although Europe, Japan and North America still dominate aggregate STI investment globally, their shares are declining, and the international landscape is increasingly multi-polar.

The current economic and budgetary crisis in many European countries are increasingly resulting in a stagnation or even reduction of public spending on research, innovation and education in Europe at the same time as it undermines Europe's ability to attract global talent and corporate STI investments. As a result, the EU as a region risks falling behind. Europe is still attractive as an STI location due to its developed markets, advanced demand and high science and technology capacity but there is increasing global competition for attracting foreign R&D and talent. Overall, the changing global landscape both creates opportunities and increases the need for strengthening internationalization, e.g. due to increasing R&D costs and skills shortages, the emergence of new markets and persistent European and global challenges. The rapid increase in research and innovation resources outside Europe combined with Europe's relatively weak linkages to emerging research and innovation hubs in Latin America, Asia and Africa (and the Middle East), and the benefits offered by international cooperation in science and technology, underline the urgent need for strategic policy action.

A more strategic EU as a global player in STI

The changing global landscape warrants a strategic European framework to tackle international developments in a coherent and proactive fashion. This should involve the Member States and Associated Countries in well-functioning partnerships with an efficient division of labour to generate high impact against clearly stated objectives. It should also involve key stakeholders to optimize the efficient pooling and allocation of resources and to ensure that initiatives are relevant and anchored. Such a framework requires moving to a genuinely European-level strategy based on the needs and goals of the EU as a whole to strengthen Europe's attractiveness and competitiveness in research and innovation. Whereas the recent strategy for international STI cooperation gave much attention to cooperation, a new strategy should be based on collaboration and integration.

In their current forms, EU STI policies already have international dimensions, e.g. in thematic programmes of the Framework Programme, but they are fragmented, driven by diverse and sometimes conflicting objectives and lack of strategy, strategic intelligence and effective instruments.

A strategic approach to internationalization and international cooperation should increase coherence, define actions big enough to make a difference and have clear impacts at EU level and beyond. They should direct EU resources towards initiatives that Member States cannot initiate or effectively conduct alone. The European Commission and its resources, such as the Framework Programme (FP), occupy a unique position, which should be used to shape cooperation with other parts of the world, using Horizon 2020 as its instrument. The EU should take on a more ambitious global role in STI and become a stronger and more coherent international actor. A clear EU strategy will benefit European Member States, citizens and companies and help the EU to more effectively tackle global challenges.

Perhaps most importantly, an effective strategy must combine 3 levels of measures, namely initiatives for international cooperation that target strategically relevant areas or actors, measures aimed at promoting the general opening of European projects and programmes to international participation – for example through mobility-promoting activities – and strengthening conducive framework and regulatory measures in order to reduce transaction costs for international cooperation. An effective strategy, crucially, also requires a more effective coordination of measures across relevant Directorate-Generals within the Commission and between the Commission, Member States and stakeholders.

The strategy should focus on global challenges and thematic priorities

Thematic priorities can be defined bottom up by research and innovation performers or top down with the aim of addressing politically defined objectives. In reality, priority-setting is typically a mix of both and a key message from the EG is the need to allow for both bottom up and top down. A strategic focus should be developed through a structured top-down process, but without stifling interesting bottom up initiatives, in order to set priorities that are legitimate and effective in allocating resources to clear goals. A successful process should involve the research and innovation community and other stakeholders.

Thematic and geographic priority setting for the international collaboration strategy should be based on an assessment of where

- cooperation can increase the world's ability to tackle global challenges
- complementary scientific and innovative strengths lie outside the EU
- there are important gaps in European competences
- cooperation can increase access to global markets and infrastructures

Priorities for international cooperation should focus on actions that can gather large enough resources and funding to attract interest from industry and high-capacity scientific groups. Global challenges should therefore guide priorities in building large-scale, effective, multilateral cooperation platforms. The EU should build on lessons from actions such as the European and Developing Countries Clinical Trials Partnership (between 14 MS, Switzerland and Norway and Sub-Saharan countries), and the Human Frontier Science Programme (EU in cooperation with 13 countries around the world). The EU could use existing co-operations such as G8 or G20 to enable this.

Research and innovation infrastructure is an important building block for international cooperation. The EU should give priority to ensuring mutual access, mutual benefits and co-funding for research and innovation infrastructure needed to tackle global challenges. The strategy should also recognize the importance of European research infrastructures for European attractiveness in order to bring talent and investment to Europe.

The needed strategy should be based on thematic foci or global challenges, it should tackle different parts of the world in different ways, and be selective about Europe's choice of preferred partners.

Addressing industry and innovation

Firms go international to access markets that may be faster growing or more dynamic than mature European ones, search for skilled labour, participate in increasingly international value chains, de-locate production, source knowledge and access raw materials, to name a few reasons. These drivers generate sector- and firm-specific patterns of international cooperation. In many cases, internationalising firms are moving beyond being 'multinational' in the sense of retaining strong ties to a 'home' country and becoming more 'transnational' with production, R&D and ownership spread across multiple countries. For many multinational companies it is necessary to have both research and production outside Europe in order to keep and expand activities in Europe. In many cases research activities outside Europe can also be directly used in Europe.

A strategic approach to international cooperation that includes a focus on industry and innovation needs to balance two aims: strengthening international R&D cooperation; and promoting framework conditions that underpin a global 'level playing-field' in innovation.

Strengthening R&D cooperation involves ensuring that Europe is attractive as a region for lead markets, pilots and demonstration, infrastructure for testing and technology verification, and that Europe take a lead in technology platforms and standardisation through cooperation with stakeholders, all with a view to reduce uncertainty for industrial innovation. These aims in turn require that Europe stimulates mobility of researchers and students and access to talent and research.

Ensuring a level playing field means that

- The EU should lead projects aiming to set global standards and norms. This represents an opportunity to take the initiative and have a decisive influence on market opportunities
- The EU should lead key projects addressing some of the grand challenges, where a global effort is beneficial for everyone. This is especially useful in 'horizontal' issues where IPR is not a major concern
- More broadly, EU international projects should have clear and transparent IPR and exploitation rights. The EU should work towards more harmonised international rules and practices in relation to IPR
- The EU should ensure coherence with traditional trade and industry policy aspects such as reduction of trade barriers and encouraging entry under fair conditions

- The EU should develop a strong European voice to influence other international actors on regulatory matters

Exploit variable geometry: Internal and external partnerships

A key element of any strategy is positioning. In the present context this means positioning European actors relative to other competitors/partners globally. The European Commission refers to this as geographical differentiation to help target actions with partners. The Framework Programmes, including the proposed Horizon 2020, have developed groups of countries to aid this targeting, including also principles for funding foreign partners (like industrialised and emerging countries, neighbourhood and enlargement countries and developing countries). In addition, there are contractual differentiations between countries: There are, for example, 20 science and technology cooperation (S&T) agreements in operation in 2011, and 14 association agreements to the Framework Programme.

The EG has the following recommendations:

- The overarching perspective should be that international cooperation is integrated into and across EU STI activities, in particular the coming H2020. The guiding principle for priority setting should be horizontal and thematic rather than geographic, building on the priorities of H2020. The strategy should help enhance the international dimension of ERA through mutually reinforcing the benefits that ERA and international cooperation may generate.
- There is no great need to let the international cooperation be guided by an a priori geographical differentiation. The FP/H2020 has general opening as its basic principle for international cooperation, and this principle does not differentiate between groups of countries. The only exception concerns funding, where in specific cases participants from 3rd countries may be funded by the FP. Such differentiation should be reduced to a funding rule. The Commission should give priority to developing a mechanism that allows stakeholders from any country to participate in programmes or consortia, provided that they add value to the consortia. The overall principle should be to allow and encourage "the best and brightest" to participate in projects, regardless of their geographic location. International cooperation should be clearly driven by thematic considerations, but implemented by geographical ones. In addition, a stronger encouragement and support in the various themes in the Framework Programme is required to increase the level of participation from non-European countries.
- Contractual relations should be used more explicitly to gain a strategic grip on international cooperation. S&T and association agreements to the Framework Programmes define two important groups for EU/MS, the former a potential vehicle to develop targeted actions with key partners including in multilateral structures, the latter an arrangement for full participation in and co-funding of the FP. The EG suggests a third modality: Focused or limited association agreements that allow 3rd countries, individually or collectively, to connect to European initiatives. Such agreements should be linked to ambitious, targeted actions of a multiannual nature to

allow strategic partnerships with a more reciprocal funding and mutual benefits, but bearing in mind that stakeholders (e.g. industrial firms) themselves do not consider such reciprocity as important to their actions. Such agreements may also be used to allow partners from 3rd countries to participate in smaller schemes and project consortia and hence support co-funding internationally.

- A strategy for international cooperation should include an element of bottom up selection. With this the EG means that bilateral programmes and initiatives that Members States or the Commission have with 3rd countries, and that are assessed to be successful or "good practice" should take the role as "lead initiatives" around which other MS actions may be associated through mechanisms of mutual opening of programmes, to establish clusters of cooperation based on variable geometry etc. This means that concerted actions with significant synergies may develop without a top down, a priori strategy (e.g. by the Commission). But the strategy should then include platforms and agreed principles through which such clustering may effectively take place.
- Horizontal actions coordinated by the Commission must be undertaken multilaterally to establish common institutional settings to create a level playing field with global partners. The Commission should take the lead and, with the MS/AC, create global platforms for STI cooperation in areas that need a global, concerted effort to ensure critical mass and impact.
- The Commission should cooperate with the MS to reignite the Strategic Forum for International STI Cooperation (SFIC) as a truly high-level and more effective strategic body for collaboration among MS/AC and the European Commission, with the aim to achieve an integrated, collaborative approach going beyond cooperation and exchange of information and experiences.

Ensure policy is evidence based

Information and data analysis are indispensable to support the definition and implementation of the strategy and the design of schemes and concrete action. Systematic data collection and analysis must specifically support priority setting – as any strategic effort must make choices – and the choice of partner countries and regions for each of the priority areas. It thus underpins negotiations within the European research area (ERA) including the Framework Programme, and with potential external partners and by doing so helps to create effective partnerships. It will also develop a new focus on supporting international innovative activities.

Four basic functions are relevant for jointly collecting data and producing indicators.

- Understanding the status quo in terms of the EU's STI profile and STI internationalisation activities: this helps to define the needs as starting points for the strategy (competencies, gaps, needs as seen by various actors within the EU)
- Formulating targets, benchmarks to reach: this helps to define goals, to communicate the purpose of international activities and to measure achievements later on (link to thematic priorities of H2020)

- Understand global bottlenecks (e.g. access to markets and infrastructure, legal obstacles to cooperation etc.) and opportunities (STI profiles, "hot spots" abroad in light of a rapidly changing global landscape): this helps to link the thematic priorities defined to concrete choices in terms of scientific and technological fields and in terms of partner countries/regions (country follows priority) and it enables effective negotiations with partners
- Monitoring activities (at policy and actor level) and measuring the impact of international activities on the overall goals of STI policy and strategy

Information sharing should be focused, based on the need to minimise duplication and transaction costs for those involved and avoid costs related to generic, non-purpose information sharing. The Commission has an important role to play in providing systems and guidelines. There should be five activities.

- Making national/Commission information on bilateral programmes and related actions of international cooperation easily available, including evaluations and assessments, on public web sites
- Producing regular reports by science counsellors in countries outside Europe about their STI policies, programmes and capacities
- Creating common platforms for information sharing, i.e. include information generation and sharing as integrated parts in the strategic research agendas
- Sharing forward-looking information such as trends, market developments and other strategic intelligence developed at national level
- Exchanging experiences and good practice in governance of international cooperation at national level.

Key recommendations

The main message coming from the Expert Group is that the EU urgently needs a collaborative and integrated strategy for international cooperation in STI. With this in mind several recommendations are launched:

1. The strategy should focus on promoting European attractiveness as an international research and innovation hub and partner in order to strengthen European competitiveness and prosperity
2. Theme- and problem-oriented prioritization is needed rather than geographic; Grand Challenges as a clear prioritization tool should be mainstreamed also in the international dimension. Prioritization of international collaboration should follow closely the priorities of the EU's core research and innovation programmes, while the geographical approach should be the core of an implementation strategy
3. Make the Horizon 2020 truly open and attractive to the best and brightest in the world allowing European actors to work with the best brains wherever they are
4. The international perspective needs to be more fully integrated into 'regular' programmes at EU level

5. Variable geometry should be exploited to the full, with flexible arrangements (within EU and with countries outside EU) including multilateral platforms for strategic cooperation. Variable geometry initiatives should also build on lead initiatives by individual Member States that expand their successful bilateral activities to several European partners
6. A strong focus on firms and innovation is needed. This has not been properly addressed before and it requires a new/different approach; there are fundamental differences in drivers of international cooperation between academia and industry and between research and innovation
7. Reinforce efforts to strengthen framework conditions for and removal of barriers to international cooperation
8. Design targeted initiatives for strengthening cooperation in selected (prioritized) areas: these can be multilateral, bilateral, and unilateral. The key criteria should be achieving benefits for European stakeholders, effectively address global, grand challenges, and support the Union's external policies
9. All initiatives must be based on more evidence- or analysis-based decision-making, including forward looking analysis to inform decision making about likely trends and future changes and systematic exchange of experiences.

Introduction

Background

In the past decades, The European Union has made great strides in developing a European research community. The successive Framework Programmes for RTD have been a key contributing factor in this development, proving incentives and mechanisms for cross-border cooperation in STI. In addition, several programmes and other initiatives have broadened the scope of European cooperation, such as ERA-NETs, European Technology Platforms and Joint Technology Initiatives. The next Framework Programme called Horizon 2020, signal an even greater effort to leverage STI for European economic and social development in the overall policy context of the Europe 2020 strategy.[3]

With the development of the European Research Area since 2000 a clearer focus on the need for more synergy and effectiveness in European STI efforts has developed. One consequence of this realization was the so-called ERA-initiatives aimed at speeding up the European STI integration with concrete measures. Against the backdrop of the rapidly changing global landscape, the international dimension has received more attention and resulted, among other things, in a Strategic Forum for International STI cooperation (SFIC) aimed at improving coordination among and between the Member States and the Commission in cooperation activities with countries and regions outside Europe. This partnership was launched in 2008.

The policy context of Horizon 2020 pays increasing attention to the need for economic growth, competitiveness and innovation. This is manifested by the Flagship initiative "Innovation Union" which is driven by an imperative to integrate a better strategy for innovation in the overall STI efforts in Europe. Further, the changing global STI landscape and a greater focus on global challenges that require significant and concerted inputs from research and innovation reinforced the importance of finding new and better ways for international cooperation in STI as well as reaping the benefits from this cooperation.

Against this backdrop, the Commission set up an Expert Group on international science, technology and innovation cooperation to provide advice for the further development of international cooperation policy and the international dimension of ERA. The EG was launched in parallel with the preparation of two important policy initiatives from the Commission: A Communication on the ERA Framework and a Communication on a European Strategy for international cooperation in STI to be published in the early summer and early fall respectively. Hence, the mandate included giving input to these two Communications as a 1st phase of the EG's work[4].

Two workshops were arranged during the course of the EG's work. First, a stakeholder workshop for the ERA Framework was conducted by the Commission on the 13th March to which two of the EGs members were invited. In this workshop the international dimension of

[3] COM(2010)2020 – Europe 2020 A strategy for smart, sustainable and inclusive growth.
[4] See annex 1 for the mandate for the Expert Group.

ERA was discussed as part of the process of preparing the Communication on the ERA Framework. Second, a dedicated workshop for the industry and innovation dimension of the EG's work was arranged on the 17th April, with several industrial representatives present. This workshop provided useful contributions to the group's work.

Since the SMEs were not presented at the industry workshop, and the EG considered the SME input important to the group's work, semi-structured interviews were carried as a complementary activity out with 10 SMEs from the ICT industry in Germany, and 14 SMEs from different industries in Bulgaria. The findings are reflected in the report and summarized in annex 5.

Understanding international STI cooperation

A strategy for international cooperation relates to the broader process of internationalization of STI which the EG defines on two levels:

1) Generation of knowledge and innovation:
   - All international cooperation and coordination, inward and outward investment, inward and outward transfer of knowledge including inward and outward mobility, international use and cost sharing of data and infrastructure;
   - by public and private researchers, public organisations, civil society, and private firms;

2) Policy, frameworks and funding to support 1) above which involves activities and measures such as cooperation, coordination, integration of policy and funding bodies (including foundations) in various forms (between and across levels), regulatory issues, removing barriers to internationalization.

International cooperation as such can be understood as all cooperative relationships between STI performers in non-equity relationships. Hence, international cooperation is primarily driven by "bottom up" priorities of individual researchers, research organisations or R&I performing enterprises: *STI cooperation includes informal and formal agreements that involve exchanges of knowledge on a systematic basis between R&D actors that are organisationally separate.* A strategy for international cooperation for the EU will hence include public policy priorities, actions and resources aimed at influencing international cooperation in accordance with given objectives. The EU may enter into cooperative agreements, typically bilateral STI agreements, which define the incentives and constraints for the cooperation of R&D performers. National governments may also enter into programme cooperation through for example Joint Programming in the ERA-case, or joint bilateral programmes and calls for proposals.

It is useful to bear in mind the fact that policies and frameworks are often negotiated results of cooperative processes between governmental actors or other public bodies. In addition, frameworks for STI cooperation in this manner constitute a certain level of coordination

among Member States and associated countries and between these and the European Commission that stretch from no coordination (competition) through information exchange and other measures to integrated strategy as fully coordinated actions:

- Integration: joint strategic approach/programme
- Collaboration: Pooled programmes with merged management
- Cooperation: Distributed but linked programmes, shared access, strategic divergence/specialization
- Co-ordination: Information exchange on distributed programmes
- Competition: Overlapping programmes in competition

When assessing the options for the Commission and the Member States in promoting a strategy for international cooperation, this context of public policy will be duly considered. It will be a red thread throughout this report that there is a need to strive for moving upwards on this scale to achieve a more collaborative and integrated strategy for international cooperation.

The international dimension of ERA

The renewal of an EU strategy for international STI cooperation will take place in the context of the emerging European Research Area. ERA was initiated in 2000, but redefined and re-launched in 2007-2008 through five ERA initiatives, one of which was the external or international dimension of ERA. Following the publication of the Commission Communication "A Strategic Framework for International Science and Technology Cooperation" in 2008, the European Strategic Forum for International S&T cooperation (SFIC) was created with an overall aim to increase the coherence of the international S&T activities of the MS and the EU. The SFIC is seen as a partnership where the Commission is one of 28 partners, and where associated countries to the FP7 are observers. SFIC received the following mandate by the Council:

> "To facilitate the further development, implementation and monitoring of the international dimension of ERA by the sharing of information and consultation between the partners (Member States and the Commission) with a view to identifying common priorities which could lead to coordinated or joint activities, and coordinating activities and positions vis-à-vis third countries and within international fora".[5]

There are several critical aspects of ERA that the EG would like to stress are key to an EU strategy for international STI cooperation, bearing in mind the broad objectives of ERAs external dimension:

- Strengthen the excellence and attractiveness of EU research and innovation;
- Underpin EU economic and industrial competitiveness;

[5] Council Conclusions 16763/08.

- Enable EU and MS to tackle global challenges;
- Support external policies

This section in the report highlights these aspects of the ERA as the major context for an international strategy for international cooperation in STI.

Integrate the external dimension of ERA

The external dimension of ERA is important for its success. The speed of globalisation and internationalisation of STI, as well as the importance of enhancing Europe as a region of attractiveness to conduct STI underpins the urgency and importance for ERA's external dimension. Therefore, ERA's external dimension cannot be an add-on, but should be integrated as a horizontal priority across ERA.

The coming EU Framework Programme H2020 to be launched in 2014, will likely have general opening as a basic principle. The EG wants to address two key issues in this context. First, the H2020 should be a facilitator and driver in ERA's external dimension, providing momentum, direction and synergy, including appropriate links with ERA activities through the "Grand Challenges" block of H2020. Second, the bilateral activities of MS should be brought into the external dimension of ERA through frameworks for mutual opening and joint programmes with 3rd countries/partners, also linked to grand challenges.

A balance between cooperation and competition in a strategic framework

The external dimension of ERA should be operationalized in a strategic framework that takes EU level interests and synergies as a starting point. The framework should clarify in which cases a joint or common strategy is warranted vis-á-vis looser forms of coordination such as policy harmonization, consultation and information exchange. The EG sees the balance of cooperation with competition among European partners as a key consideration. An ERA strategic framework should ensure that those objectives and activities that require EU level actions are in fact included, while MS or regional level objectives and activities are left to MS/AC. These are competitive arenas that are key to the functioning of ERA, and underpin the dynamism that MS/AC can bring to a concerted effort for cooperation with 3rd countries or other global settings. Joint or coordinated action should be given priority in areas where national contributions are too small to have impact or where critical mass on EU level is needed, whereas competition and competitive arenas should be retained and stimulated between research and innovation performers.

The external dimension of ERA will need to address how it can support and enhance the competitiveness and improve opportunities for European industry and business in general. For industry, appropriate framework conditions are more important than public cooperation programmes in S&T. Cooperation with 3rd countries are key to establish platforms for technological solutions, standards and market access. These issues will be thoroughly discussed in the later section on industry and innovation.

Internal and external dimension of ERA: Towards a symbiosis

The ERA was originally launched with the aim to develop an internal market of research and development in Europe, taking into account the fact that the Member States provided by far most of the resources and other inputs for research. The ERA development has delivered a plethora of new, experimental instruments with variable geometries, which have been widely taken up by policy makers and funders, and it has introduced a range of new governance mechanisms to establish better coordination between MS and the EU. This has overcome the traditional two-level structure of funding in Europe (MS vs. FP) and led to more appropriate and efficient funding and support mechanisms. However, the position of the Expert Group is that there is a great urgency in moving from a strategy of coordination of disparate activities to a more collaborative and integrated approach, thus making international cooperation truly strategic.

However, ERA is not quite yet the strong, open internal knowledge market with clear governance structures it is intended to become. In addition, it has yet to establish a logical and well-coordinated link between the external and the internal dimension. The opinion of the EG is that there is a great need to develop ERA further as a European knowledge market in order to achieve an external dimension with significant impact, both in terms of its effective functioning and in terms of its attractiveness and competitiveness in the global production of knowledge and innovation. The Strategic Forum for International STI Cooperation (SFIC) has a great potential to be a driver of such a symbiotic development. However, SFIC has not yet lived up to that potential.

The external dimension of ERA has two key dimensions: On one hand it cannot be successful and effective unless ERA itself constitutes a viable and attractive entity for research and development. Hence, it builds on the efficiency and effectiveness of ERA. On the other hand, an effective external dimension of ERA will be highly beneficial for the further development and completion of ERA, e.g. through providing effective channels for scientific and technological talent that Europe needs to develop its overall competitiveness. An EU strategy should therefore give considerable attention to convey this mutual relationship, and bring out the importance of the external dimension for ERA as well as the need for a more mature ERA to better reach impact and attraction globally.

Drivers of globalization of STI

R&D and science and technology more generally are some among many areas from culture to markets that are becoming global. This reduces the influence of individual countries or blocs such as the EU on developments both at home and abroad but also generates important benefits through specialisation, trade and competition. The data show that R&D and science and technology is still strongly focused on the ‘Triad’ countries overall. However, this pattern is weakening fast, as especially the large emerging economies’ role in global science, technology and production continues to increase. Given that changes in the location of R&D, cooperation patterns and human capital production all have long lead times, EU research and

innovation policy needs to anticipate a future where knowledge production and use – industry as in science – is increasingly multipolar and globally networked.

Internationalisation of R&D: characterizing the phenomenon

The internationalisation of Science, Technology and Innovation materializes through a wide variety of complex **processes,** ranging from:

- *The internationalisation of Science and Technology Development* at public or private research institutes or universities: through the international mobility of S&T students and researchers; the international collaboration among S&T researchers (as witnessed by joint publications or joint projects)
- *The internationalisation of Technology Development and Innovation* by firms who develop R&D activities internationally, simultaneously home and abroad. The R&D done at home uses inputs from abroad, through the recruiting of foreign S&T employees; building on existing knowledge located abroad. The R&D done abroad enables use of locally available S&T human resources sourcing of locally available know-how. Even if R&D is concentrated in the home country and uses only home country resources, firms are exploiting their innovations on world markets, through licensing their technologies abroad or selling their innovations on foreign markets
- *International collaboration in S&T,* where partners (firms and research institutes) from more than one country jointly research and develop technological know-how and innovations

The STI internationalisation processes thus include *on the input side* the international mobility of human capital (S&T employees and researchers) as well as the international mobility of physical and financial capital with R&D facilities and funds controlled from abroad. *On the output side,* the internationalisation process includes the international mobility of knowledge and technology and the international production and sale of new products and services.[6]

Drivers and barriers for the internationalisation of Science

The on-going globalization and internationalization of STI is affected by a number of drivers and barriers. These are different for industry and innovation compared with general science. Several factors drive the increasing globalisation of science:

- The globalisation of the world economy drives firms to increasingly access scientific sources outside their local boundaries.
- Students and researchers are increasingly mobile. As a consequence, scientific institutions and firms are ever more competing for talent in a global labour market.

[6] Please see annex 3 for a broader discussion, and Veugelers (2010) Bruegel Policy Contribution and the references cited therein.

- The ICT and the Internet revolution have reduced the cost of international communication and boosted international exchange in science. These trends are amplified by the growth in transport systems and reductions in real transport costs of the last few decades.
- ICT and internet have also fostered new ways of gathering knowledge, leading to innovative international knowledge transfer models in the fields of fundamental research. Examples such as the Milky Way Project or the Artigo Project build up databases with tremendous scientific gain.[7]
- The research agenda is increasingly being made up of issues that have a global dimension, such as climate change, energy, safety, pandemics.
- Policy makers are increasingly focusing attention on international S&T cooperation and funding programmes to stimulate internationalisation of higher education and research. This includes many governments from emerging economies, who have come to view Science and Technology (S&T) as integral to economic growth and development. To that end, they have taken steps to develop their S&T infrastructures and expand their higher education systems. This has brought a great expansion of the world's S&T activities and a shift toward developing Asia, where most of the rapid growth has occurred.
- Costs of and access to infrastructure lead to stronger incentives to cooperate and share resources across boundaries.
- Increased specialisation of knowledge production globally makes excellence being located more diversely and makes it vital to seek advanced knowledge where it is.
- Scientific knowledge is produced with greater "speed" and impact, creating incentives to avoid duplication.

Nevertheless, also within science there are still forces counterbalancing the globalisation, such as the resilience of the national dimension in education, science and technology policy and public funding, proximity effects in the exchanges of tacit knowledge requiring face-to-face interactions; cultural and language barriers, and the inertia of personal and institutional networks (Kaiser, et al. 2011).

Drivers for the growing internationalization of R&D and innovations by firms

A number of changes in the competitive, international and technological environment have driven the increased R&D internationalization of multinational firms and the increasing importance of asset-seeking foreign R&D.

- Technological and scientific expertise has become more widely distributed in the world.
- In addition, in countries such as China, rapid increases in R&D are combined with rapid growth in markets and income, making it much more attractive for foreign investors for in particular adaptive R&D.

[7] See the websites of the projects: http://www.milkywayproject.org/ and http://www.artigo.org/about.html.

- Developing economies with strong governments increasingly require local R&D activity as a quid pro quo for allowing foreign participation in local markets (a practice ranging from the earlier requirement for oil concessionaires to do or fund R&D in Norway to the demands of China for a local R&D component in aircraft production consortia)
- Many nations have improved their infrastructure and business climate for foreign firms to conduct R&D.
- Based on international treaties like the TRIPS agreement, patent right systems have significantly improved in some countries, primarily less-developed countries that historically had weak patent systems, like China and India[8]. Nevertheless, the risk of patent infringement is still high in the international level, especially in the IT business (Kaiser 2010).
- Developments in the codification and standardization of R&D processes have increased the possibilities to segment R&D activities over different locations.
- Advances in information and communication technologies have further facilitated the management of globally distributed research and development activities.
- More generally, the emergence of global supply chains and increased specialisation lead to a wider distribution of R&D activity. Companies must move new products from development to market at an even more rapid pace. Consequently, firms build R&D networks that allow them to access geographically distributed technical and scientific expertise at lower costs.
- Products such as aircraft and large pieces of infrastructure increasingly have the properties of 'large technical systems', necessitating multi-national and multi-company cooperation. Airbus is an obvious example, as are the consortia that build aircraft engines. In the automotive industry there has been a long process of having first- and second-tier suppliers themselves design sub-systems and components, so that the vehicle assembler acts as a systems integrator rather than designing all the parts of the vehicle
- More generally, while the idea of 'open innovation' is much hyped, it does reflect not only the realities just described but also the growing proportion of business R&D done extramurally in contract research organisations, the higher education and research institute sectors, and R&D partnerships among companies
- User-driven innovation also relies on more use of external collaborators – as in the well-known role of airline cabin staff in the development of the 777 interior by Boeing
- Driven by the needs and opportunities in emerging markets, 'frugal' innovation is changing the way engineering and production are done in some cases. Tata's small, low-cost car (a sort of 'Volkswagen' for India) is one of the best-known examples.

[8] New patent regulations are also considered as barriers for international business. See Kaiser et al 2011, p. 19-20.

Priority setting: Defining objectives and understanding roles

Prioritize for themes and challenges

Key objectives for international cooperation in STI

Priority setting lies at the heart of any strategic approach to international STI cooperation. The overarching objectives for international cooperation of the Union will be the reference point for priority setting:

- Strengthening the Union's excellence and attractiveness in research and innovation as well as its economic and industrial competitiveness;
- Tackling global societal challenges;
- Supporting the Union's external policies.

While priority setting normally is seen as a process taking place in a given institution e.g. through providing criteria and rules for allocation of funds, the EU level priority setting is different. Not only can the Commission itself be seen as a multi-actor institution in which priority setting needs to take place through negotiations, the Commission also needs to add two levels of negotiations to achieve sustainable priorities for STI: First this concerns the MS (and AS), in particular through the SFIC partnership, and second, it concerns third countries as external partners in cooperative efforts.

This complex negotiation process can then be classified according to drivers such as user needs, institutional or political concerns, but more importantly in this context is the differentiation between scientific vs. social or broader political, economic and societal goals, and include thematic and/or structural priorities (OECD 2012). With the above overarching objectives in mind, priority setting as the EG sees it, needs to be understood as negotiating processes including many stakeholders at various levels that delivers outcomes with significant added value to the aggregate STI efforts. Priority setting concerns allocating resources (sometimes with partners) towards certain goals formulated as targets related to the stated objectives to influence actions of research performers. For the EG, this implies that the priority setting should be thematic/mission/challenge oriented, rather than geographical which has been the preferred approach for e.g. SFIC up until now.

Current practice in priority setting

The EU's activities in international cooperation in STI have been channelled through the research Framework Programmes. The current situation has several key characteristics:

- International cooperation is mainstreamed across all thematic areas in FP7, with each thematic programme responsible for priorities being set.

- The general opening principle applies to any research performing entity in the world, implying that priority setting follows the priorities laid down in the calls from the thematic programmes.
- Cooperation with third countries is based on a differentiation across key partner groups, in H2020 the proposal is now in three groups: Industrialised and emerging economies, EU enlargement and neighbourhood countries and EFTA, and developing countries.
- Targeted actions and joint calls vis a vis third countries and regions on specific topics have grown to enhance the strategic impact of international cooperation.
- The INCO activity in the FP7 Capacities programme has supported policy dialogues and coordination of international cooperation among the MS and AC.

Four principles are currently being developed for H2020 on the basis of FP7:[9]

- Openness: This is operationalized through the principle of general opening of the Framework Programme, implying that anyone can participate in projects in this programme, when complying with universal eligibility criteria (but with restrictions on funding for participants from industrialised or high GDP countries);
- Effectiveness through enhanced scale and scope, as well as foreseen joint programming with Member States, raising the issue of partnerships and opportunities and obstacles in promoting such partnerships;
- Partnerships with 3rd country(ies) to reach win-win situations through common interests and mutual benefits;
- Synergies with other internal/external policies and programmes.

The criteria for success in this respect have mostly been measured in terms of share of international participations in the FP, in FP7 this is currently 6-7%. This is often seen as too low, however without a proper benchmark by which to qualify which level is too low or satisfactory. Further, there is little by way of assessing impacts of international cooperation, this is normally understood as necessary and useful. The EG agrees with this general view, seeing ERA and international cooperation in a symbiotic relationship in which ERA benefits hugely from global influences and effective international cooperation is highly dependent on an effective ERA.

The main message, crudely speaking, is that although there are strategic elements of the international cooperation activities, they are still rudimentary, and much is left to partially bottom-up priorities facilitated through the principle of general opening, combined with an inbuilt drive towards geographical prioritization. The EU has a large number of S&T agreements signed ad hoc (20 today), there is a great number of small coordinated calls for proposals with foreign partners, with generally low levels of scale, scope and probably impact.

[9] Presentation to the Expert Group by the Commission 27 April 2012.

The current situation seems to reveal at least four main problems that need to be rectified in a new strategic approach, bearing in mind that international cooperation policy will need to be formulated to achieve goals of science, industry and foreign policy as well as goals related to global challenges:

a) The key issue of competitiveness is not properly addressed. This means that in practice the priorities in international cooperation are too weakly linked to the objective of strengthening the competitiveness of European industry, and innovation is not sufficiently integrated in the priorities. International cooperation remains mostly a public to public cooperative relationship. The need for a new focus on industry and innovation is addressed later in this chapter.
b) There is too little focus on the needs of the scientific community and how it can exploit international cooperation to enhance excellence of the European system. Rather, international cooperation follows an implicit priority of extending globally to as many countries as possible for some (marginal) participation in the FP. The implication is to give more priority to cooperation with countries with STI strengths.
c) The fundamental principle of general opening of the FP seems to forego strategic orientation. Much of the FPs resources (funding and DG R&I personnel) is focused on managing this broad, all-covering interface, which hence also indirectly seems to reduce the opportunities for effective, targeted partnerships with Member States.
d) Too little flexibility in the allocation of funds for strategic, targeted opportunities reduces the potential impact of international cooperation.

Negotiating priorities

The Strategic Forum for International S&T Cooperation (SFIC) represents an EU level partnership mandated to enhance the overall strategic dimension of priority setting. Its main approach has been to select pilot countries as geographical priorities and then developed cooperative research and innovation agendas. In the case of India, this started with a more incidental focus on water related research which was later expanded to comprise a broad cooperative agenda. In the case of China, a strategic approach was launched from the beginning, building up a strategic learning process, with the intermediary result of a set of recommendations for priorities via a vis China that were transmitted to the Commission and the Council in line with SFICs role as an advisory body.

The priority setting process can briefly be described as complex negotiation processes:

- The thematically based priority setting takes place in the context of the thematic committees in the FP7, and expands to include other services in the research “family” of FP7, as well as beyond to DGs or policy areas at EU level that research and international cooperation are supposed to serve;
- The INCO programme committee is in line with the above as negotiating platform.
- SFIC as a strategic forum serves as a base for negotiating among the partnership, including the Commission. The priority has been towards geographical selection. An inherent imperative has been the coordination of national, bilateral activities vis a vis

third countries, while these have also been cast in nationally grounded priority setting processes.

- Regular negotiation takes place with key international partner countries of the FP7 in the context of various agreements such as international cooperation agreements where priority setting is normally on the agenda.
- The need to link priorities from "bottom up" (the research performing community) with "top down" (from the policy making community) is typically underdeveloped. Better mechanisms for stakeholder involvement and communication of priorities are among key elements to develop this link into a viable negotiation and exchange system. An example may be that research actors define international partnerships and then can apply and negotiate for support in a competitive allocation process.

From this simplified picture one can deduce that a coherent international cooperation strategy is hardly feasible. The transaction costs involved are high and the sum of compromises great. To better achieve a strategic approach for international cooperation in STI, it might be necessary to reduce the scope and scale of the negotiation system, taking into account the following levels of priority-based rationales for international cooperation:

1) National priorities limited to available national resources and capacities: No international cooperation;
2) Regional, neighbour (e.g. defined through the European Neighbourhood Policy) based focus on cooperation based on priorities that can be met with such limited cooperation;
3) Bilateral cooperation based on priorities linked to specific objectives in the national policy making system, such as market growth in China or aid in developing countries;
4) European cooperation in areas of greater European concern and where the issues at stake warrant pooling of resources at this level;
5) Global or multilateral cooperation to meet global or large scale challenges with matched resources.

A general approach to priority setting that will enhance strategic direction, create momentum and synergies and reduce transaction and negotiation costs would be to exploit the Framework Programme's (soon H2020) weight and position to leverage multilateral cooperation with thematically oriented priorities towards challenges while ensuring the attractiveness of ERA for investment in R&D and innovation. Key principles should be

- impact and value added
- effective internal and external variable geometry
- synergy and incentives
- thematic targeting towards global challenges
- framework conditions for industrial involvement for innovation
- mutual benefit

The Emergenc(y)e of Global Challenges in international STI Cooperation

With increasing material welfare, rising levels of consumption, based on accelerating globalising exchange relations, also global challenges multiply and gain importance rather than being solved in the short-term. Examples for global challenges are manifold, such as security and sustainability of energy and food supply, the threat of (re-)emerging infections diseases, climate change and the loss of biodiversity, chaotic mass migration phenomena, or the complexity of global financial systems moving out of the control of democratic legitimisation and regulation. What makes many global challenges even more difficult to trace is that they are interlinked across regions and disciplines. In addition, effects of global challenges are unequally distributed and are sometimes impacting those later who bear the larger part of responsibility for their generation or acceleration.

Science, technology and innovation (STI) can play a central role in understanding the interaction of the relevant environmental, technological and social factors of global challenges, in assessing risks and the possible unintended negative consequences of strategies, and – of course – in developing solutions (Stamm, Figueroa and Scordato 2012). The organisation of STI today, which is pre-dominantly embedded in national and sometimes local frameworks, rationales and policies, has to be scaled up in its international dimension and broadened in scope. The international cooperation strategy of the EU should include policies, actions and instruments to help STI create impacts on global challenges at an international scale.

Global challenges do not stop at national borders but affect a wide range of actors, calling for increased cross-border and international cooperation to address them and for building STI capacity at both national and international levels. Usually single governments cannot ensure effective solutions and policy makers have clear legitimisation disincentives to spend available R&D funding on multilateral undertakings. To lower individual risks for national decision makers and programme implementers internationally co-ordinated action and collaboration are required based on a clear political will (OECD 2012).

Strong European engagement in the international STI arena will not only benefit the protection of public goods which naturally also benefit European citizens (e.g. the problem of over-fishing), but also the European economy through the boosting of environmentally friendly technologies, products, processes and services on world markets and green job development. However, “frugal innovation” that provide innovative goods and services at low cost to address global challenges that affect the poor (OECD 2011) can also be voiced. If adequate answers to global challenges are to be found, scientific input is also required from countries with limited availability of research infrastructures, human resources and financial means to support STI throughout the innovation cycle from agenda setting to the deployment of new solutions (Stamm, Figueroa and Scordato 2012). Thus, international STI cooperation also has to consider research for development (by applying recognised standards of excellence and relevance) and STI capacity building in developing countries. While hands-on S&T capacity building should be increasingly considered in, and financed through, European

and Member States official development assistance programmes (to create necessary absorption capacities), strategic agenda setting and STI policy support (especially oriented towards global challenges and frugal innovation), as well as excellence based research for development should become an integral part of the EU's international STI policy and embedded in international oriented Horizon2020 activities.

It must be made clear that the use of STI for addressing global challenges cannot be reduced to a simple "technology fix". Any strategy for using STI to address global challenges must also address potential unintended negative effects, since many of today's global challenges are partly effects of the use of new technologies and innovations. This calls for an integration of ecological and social sciences and technology assessment approaches in technology development projects and for an enlightened STI policy dialogue with international partners.

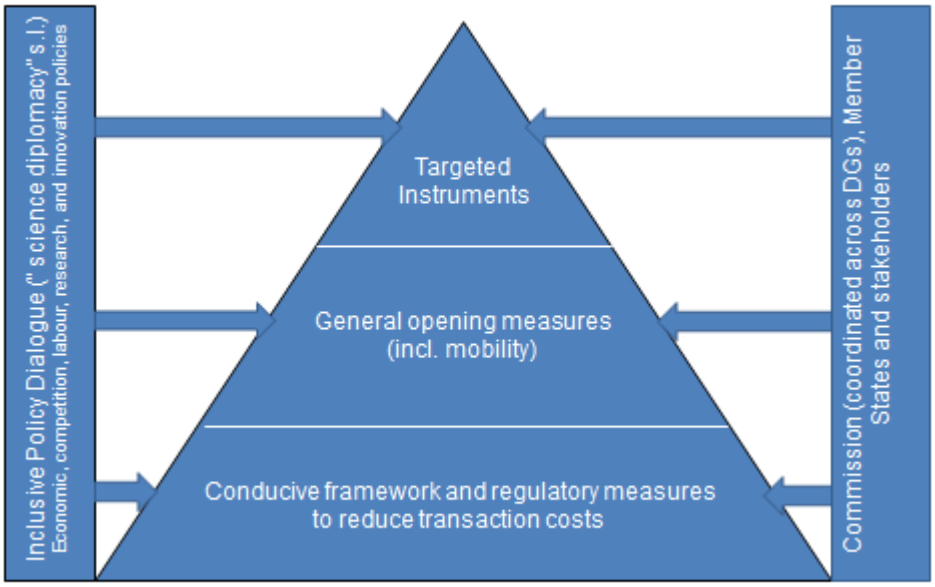
Prioritizing with instruments

Policy levels and instruments

As shown in Fig. 1 basically three aggregate levels of intervention to support STI internationalisation can be differentiated. The most basic level concerns a comprehensive framework to forward techno-globalisation and international STI cooperation in general. It is rooted in international alignments and agreements as well as regulatory measures aiming to create comparable and fair conditions for international exchanges and transactions in the field of science, technology and innovation. Examples are frameworks for technological standards, common IPR and their enforcement, anti-plagiarism regulations, reciprocal access conditions (e.g. for public procurement) etc. If once settled, these measures contribute to a reduction of transaction costs (e.g. search costs, legal costs, communication costs, adaptation costs etc.). The addressed policy levels are manifold including competition policy, labour market policy, and economic policy. They go beyond the sphere of narrow R&D policy and can be subsumed under science diplomacy in the broad sense. Today's science diplomacy, however, is in many regards not ready to oversee the complexity and shape inclusive frameworks for international STI cooperation. A close cooperation with and across other policy fields is required.

The second level to foster international STI cooperation emphasises general opening measures. These include the participation and possibly funding of foreign researchers (and/or research organisations and/or companies) in national programmes, the portability of grants across borders (in- and outward), facilitation of mobility of researchers and students and especially also the opening of labour markets for foreign researchers. The latter also has to take into account adequate models concerning the attribution of social security payments and guarantees (e.g. contribution to pension system). Evidently, different policy areas are addressed on this level too. The overall aim of this aggregate level is to facilitate and mainstream quasi-automatic bottom-up cooperation of researchers across borders.

Fig. 1: Intervention levels for international STI cooperation



Targeted STI internationalisation interventions, finally, constitute the third level for international STI cooperation. They are often based on bilateral and multilateral agreements and often executed via joint or coordinated calls for proposals addressing more or less narrowly defined S&T fields. Such targeted interventions are not necessarily the 'summit' of international cooperation suggesting that they are only implemented if the "lower" two aggregate levels of international STI cooperation are fulfilled or are not adequate to fulfil overarching objectives: targeted interventions may be deployed because the two other levels are not working properly. In this sense, targeted interventions can be developed as pockets for enabling international STI cooperation (where otherwise it would not work 'automatically') AND as experiments to test whether or not more far-reaching steps for international STI cooperation can subsequently be approached (scale-up and/or roll-out). Moreover, it is important to complement the rationale and routines of bottom-up cooperation by other rationales stemming from other "arenas", which would otherwise not be adequately (e.g. early enough) addressed. Examples for mission-oriented interventions from other "arenas" are for instance the initiation of international research cooperation to address global challenges or to establish first-mover advantages with countries or regions with whom – due to political, economic or cultural reasons – bottom-up STI cooperation has been traditionally less developed.

The EG considers all three intervention levels as important for further EU engagement. Particularly it recommends to DG Research and Innovation

- a closer interaction and cooperation with other DGs to improve the framework conditions for international STI cooperation and to promote more strongly the

intrinsic objectives of science and research as well as international academic values at different multilateral policy fora;

- a retention of the general opening up approach of FP7 in H2020;
- an extension of targeted international STI cooperation measures based on matching funds, reciprocity and variable geometry with major economically potent cooperation partner countries;
- a close division of labour with the EU's External Action Service and development aid actions to unilaterally further support S&T capacity development and excellence-based research for development to address global and regional challenges.

Table 1 sums up some of the arguments described above by attaching to each of the three aggregate intervention levels of international STI cooperation, which are basically identified in fig. 1, the major driving rationale (the why?), the major operational instruments for their implementation (the how?) and the actors responsible for their realisation (the who?). In addition, table 1 highlights in the bottom-row the role of international STI policy (i.e. science diplomacy), which influences all other levels of international STI cooperation. Also at this generic horizontal level, the main rationales, common available instruments and main responsible actors are shown. The EU as global player has to be in the position to make offers to all regions of this planet and to provide – at least – policy dialogue fora (by including the Member States on variable geometry) and to stimulate good practice exchange and learning exercises by employing a variety of methods.

A major rationale of international STI policy cooperation is to conduct and support priority setting towards joint objectives. Fig. 2 shows the different arenas, where priority setting towards international STI cooperation is currently taken place in the EU. It shows a complex picture. The following arenas influencing priority-setting can be distinguished:

- intelligence measures to support priority setting (e.g. benchmarking);
- stakeholder consultation and buy-in;
- priority setting stipulated by overarching European STI policy (e.g. priorities of H2020);
- priority-setting negotiated within bilateral S&T agreements (of the EC but also of single Member States with a number of third countries), which are often implemented by matching fund based instruments such as joint or coordinated calls;
- priority-setting across several Member States exercised by SFIC (the Strategic Forum for International S&T Cooperation);
- a number of policy support projects which facilitate international policy dialogue and which lead to priority-setting in certain problem areas;
- a number of multilateral funding initiatives and projects, which – although sometimes geographical by initial orientation – focus on certain thematic priorities when it comes to specific research funding agreements respectively calls for proposals.

Tab. 1: Levels of international RTDI cooperation differentiated by main rationales, instruments and responsible actors

Levels	Why? Main S&T objective	How? Main instruments	Who? Responsibilities
Targeted intl. R&D collaboration	• Cooperation to address global challenges • Addressing other joint thematic priorities (win-win) • Regional priority rationales (e.g. Neighbourhood policy, R4Development)	• Joint calls • Co-ordinated calls • ERA-NETs, JPIs, Twinning) • Joint centers (virtual or physical)	• EC • Ministries • Research councils • Innovation agencies • Regions
'open' intl. R&D collaboration	• Increasing research quality and fostering excellence • 'technology for market' research cooperation • Gaining resources (know-how, brains, funding, students, technologies ...)	• Opening up national funding programmes to intl. participation ('general opening') • General funding intl research cooperation (e.g. top-up funding for additional costs) • Promoting mobility	• EC • Ministries (not only STI) • Research councils • Universities • Research institutes
General measures to reduce transaction costs	• Promote globalisation • Fostering market access and penetration • Strengthening attractiveness for investment and human capital	• Demonstrators, test sites • Standard-setting • Simplification • IPR protection • Consortia building support • Business advisory services (e.g. IPR helpdesk in China) • Removing mobility barriers	• EC • Ministries (not only STI) • Research councils • Trade and investment promotion agencies • Innovation and enterprise development agencies • Patenting offices
International S&T-Policy Cooperation *(across the other categories mentioned above)*	• *Support science diplomacy (broad extension)* • *Support priority setting towards joint objectives* • *Preparing and supporting joint activities (e.g. cost and risk reduction concerning large scale RI; joint funding; joint evaluation)* • *Support STI policy learning*	• *Policy dialogue fora* • *Good practice exchange and learning exercises* • *Intl. S&T policy mix peer reviews & benchmarkings* • *Joint "intelligence" events* • *Policy support projects*	• *EC* • *Ministries (not only STI)* • *Research councils and innovation agencies* • *STI policy support organisations* • *Development agencies*

Fig. 2: Measures and instruments for priority setting in international cooperation

Fig. 3: A Dynamic policy framework

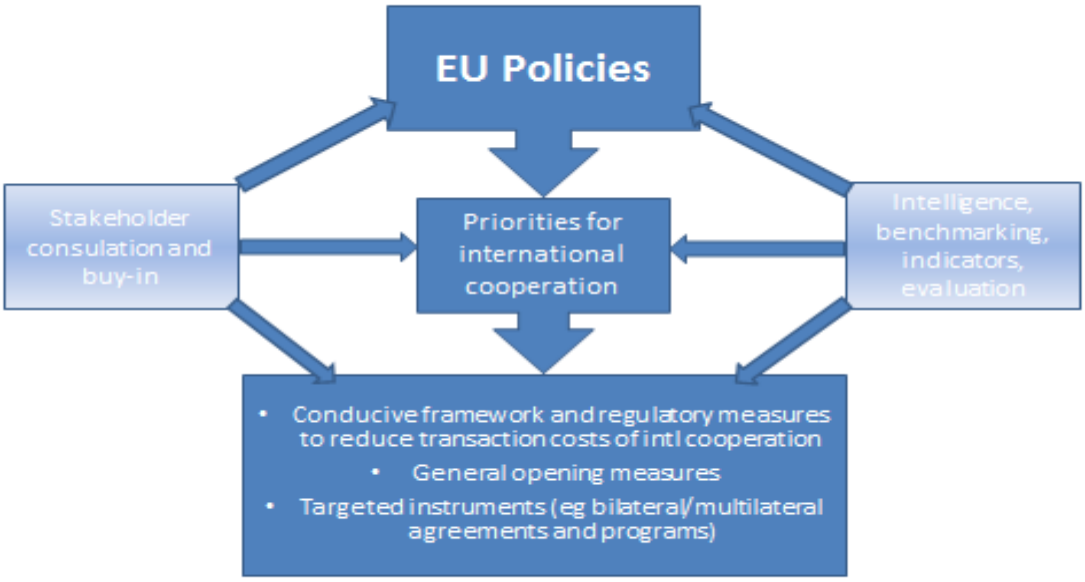


Fig. 3 illustrates a more dynamic view in which the measures and instruments are interconnected, and priorities are linked clearly to EU policies and objectives. Key support activities such as bottom-up stakeholders' consulation and buy-in as well as intelligence

based on indicators and information are necessary conditions for a well-functioning policy and strategy framework.

In order to capitalise synergies between the different approaches and to avoid redundancies and contradictions, the EG recommends

- to maintain and advance a high level of evidence-based policy making;
    - by requesting and supporting strategic intelligence activities in its policy-support projects;
    - by establishing a comprehensive and user-friendly knowledge-management system which can be accessed by all European STI stakeholders ;
    - by promoting the development and use of relevant STI internationalisation indicators which grasp the objectives of STI internationalisation policy; and,
    - by promoting standardised approaches of data recording across its Member States.
- to increase together with the Member States the level of stakeholder consultation and buy-in across all thematic areas;
- to strongly support the priority-setting stipulated by H2020 as well as relevant international commitments;
- to increase the binding character, reciprocity, transparency and operational value of its bilateral S&T agreements;
- to foster the cooperation with SFIC by providing to SFIC adequate resources and by including SFIC in the consultation for preparing calls for policy support projects;
- to strengthen policy support projects through better priority-based guidance by concurrently maintaining a certain degree of freedom to test new cooperation approaches and to respond to urgent needs of international cooperation partners (especially those with whom the EC does not have a bilateral S&T agreement);
- to further fund the coordination of international ERA-NETs according to the priorities of H2020 and to co-fund research under ERA-NET PLUS by promoting the application of harmonised participation and funding rules (simplification).

Principles and criteria for priority setting

The above discussion leads to a revised set of principles with criteria that should create concrete guidance for priority setting through operational implications, bearing in mind the three overarching objectives referred to earlier:

1) Thematically driven priorities: The strategic approach is best served through a thematic rather than geographic priority setting. Addressing global challenges or emerging scientific or technological areas through cooperation in STI should lead to negotiating structures of internal and external variable geometry of partner countries for implementation, in the case of global challenges preferably through multilateral platforms.
2) Adding value to excellence and competitiveness: International cooperation should give clear benefits to scientific excellence and overall competitiveness in Europe,

and lead to a significantly more attractive Europe for both STI and investments. The implication is that international cooperation, guided by thematic priorities, should concentrate on countries and regions with clear excellence, such as US and other industrialised countries, pockets of excellence in countries that are otherwise not broadly excellent, countries and regions with market growth to ensure synergies with the strategic interests of the business community, and sectors and countries with high levels of frugal innovation.

3) General opening: This is the basic, strategic principle of the Frameworks Programmes, and the EG supports this as the key vehicle by which European research performers can cooperate with those partners globally that they see beneficial and necessary for their research.
4) Flexibility: A key principle of a new strategy needs to be the ability to allocate significant resources to emerging opportunities, e.g. larger targeted actions.
5) A knowledge based policy: A more focused strategy along the principles above needs to be built on a solid knowledge and evidence base. Intelligence and analytical efforts need to underpin the priority setting process more than is the case today. This concerns not least forward-looking intelligence to improve the effectiveness of the priority setting process.
6) Improved coordination with (i) other EU policies and programmes (Development and Cooperation, Regional Policy), (ii) international organizations (such as UN and WB) and (iii) international research agencies.
7) Research infrastructures need to be an integral part of the EU Strategy for International Cooperation in STI. RI need to be in the focus of the future negotiations and agreements on international STI collaboration.

Strengthening policies for industry and innovation[10]

The need to differentiate between research performers

In improving the competitiveness and level of scientific excellence of the EU STI community, it is important to distinguish between three primary sets of actors – firms, non-profit research organisations (PROs) and universities. Each of these three actors have different sets of motives, priorities and objectives when engaging in STI cooperation, and therefore require an explicitly nuanced approach to priority setting and instruments.

Universities, for instance, tend to engage in more 'science' based activities (see figure 4), and are often engaged in a broader range of disciplines and technologies than PROs which tend to be focused on specific subject areas. PROs may often be dedicated to specific industries, and while they may engage in basic research (depending upon the maturity of the dominant

[10] Former work by expert groups on international cooperation in STI has not covered industry and innovation in any comprehensive way. Hence, this report seeks to give a dedicated treatment to this, not least due to the increasing weight given to innovation in European STI policy.

technological paradigm within their sector[11]), their activities have a substantially greater applied research component than universities. While large firms may engage in basic research, the majority of such firms, and almost all SMEs, tend to engage in applied research and development activities.

Universities and PROs, by and large, are also much more location-bound than firms, with very limited opportunities for internationalisation of R&D activities, except through collaboration. As such, STI cooperation between PROs and universities in different countries is a well-established activity, with reasonably well-established protocols governing this activity and its output. Since – by and large – universities and a good proportion of PROs are state-subsidised or state-controlled as part of national public goods, these international STI collaborations are influenced by bilateral and multilateral inter-governmental agreements, unlike most STI collaborations by firms.

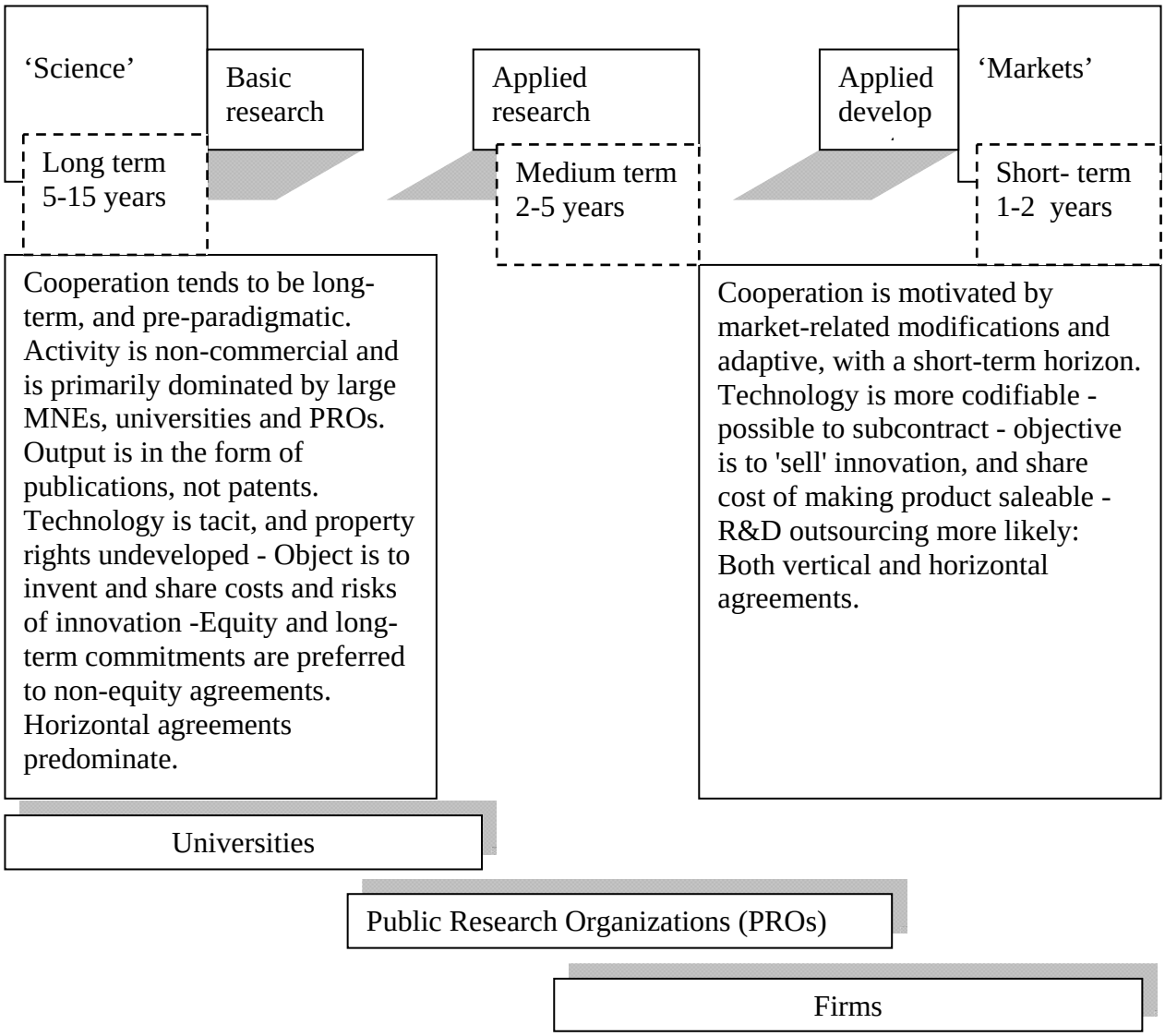
More importantly, there are long-established formal and informal institutions (rules) that determine the way in which inter-university STI collaboration is undertaken, with or without bilateral or multilateral agreements. Universities differ from PROs and firms also because of the longer-term horizon of their research, and as such, agreements, property rights and their scientific output can be negotiated with greater deliberation.

Universities and PROs are location-bound and form the 'core' of national innovation systems. Since they provide crucial inputs to PROs and firms (scientific knowledge and specialised human resources) that cannot be acquired from a distance, firms that require these inputs must seek to locate close to them, creating important knowledge clusters. This is especially important in new and emerging sectors, because knowledge transfer in tacit areas requires physical proximity (Criscuolo and Verspagen 2008).

However, whether firm, PRO or university, leadership in one scientific or technological sub-discipline/area does not imply leadership in other related fields. Although there may be several actors at or close to the frontier, leadership is rarely static amongst the peer group. Hence, universities, firms and PROs do not regard STI cooperation as a sign of weakness. Cooperation is a necessary means to keep abreast of their relative leadership within the peer group, as much as it is to develop work jointly (Narula and Santangelo 2009). That the peer group is widely distributed across several countries requires such cooperation also to be international (Narula 2003). This is one of the reasons why "clustering" has become a strategic instrument for R&D&I. Clusters themselves are a means for international cooperation as they are often represented by cluster management organizations which focus on strengthening the international reach of the cluster and connecting it with clusters in other parts of the world.

[11] For example, a PRO focused on the wood and pulp sector will engage in very limited basic research, compared with a PRO dedicated to the biotechnology industry.

Fig. 4 Long and medium term priorities (and possible instruments



R&D cooperation is not an alternative to in-house R&D, but complementary to it[12]. R&D cooperation (which includes outsourcing) does not replace the need for firms and PROs to undertake internal R&D activities, but it enhances it. This is because: 1) there are cognitive limits to the resources available to any given firm or PRO; 2) the costs of acquiring a world-class expertise in all the different knowledge bases needed in multi-technology products is prohibitive; 3) Even where resources are not an issue, it is simply impossible to be at the frontier in every technological area, and finally 4) firms focus on their core competencies and immediate attached areas while solutions offer require more, i.e. suppliers' innovations.. Leadership **at the frontier** of specific technological areas of firms and PROs shifts rapidly, particularly in new and emerging sectors (but less so in more mature industries).

[12] Ibid.

Universities and PROs often are a source of breakthrough science and innovation. The role of universities and PROs in collaborative research is well described in the Responsible Partnering Handbook developed by EIRMA, PROTON and EUA. The Responsible Partnering framework provides ten, experience-based lessons to support successful collaborative research. These lessons or guidelines can be summarized as follows:

- foster strong institutions
- align interests of collaborating partners
- treat collaboration strategically
- organize for lasting collaborations
- provide the right professional skills
- establish a clear intent for the collaborative work
- use standard practices and communicate regularly
- achieve effective management of intellectual property
- provide relevant training
- view innovation as a trans-disciplinary activity

Over the last ten years, those ten principles have become the cornerstone of collaborative frameworks deployed across Europe by universities and PRO's alike. They serve as a useful basis for a policy to support the development of strategic alliences between research performing institutions outside Europe. The Commission should ensure greater awareness of these guidelines.

MS and the EU have been relatively successful in promoting STI cooperation between universities and PROs. However, the success of R&D cooperation between firms is hard to judge a priori. Despite large investments to promote intra-EU R&D cooperation, in new technologies, firms continue to show a preference to engage in alliances with US and Japanese firms rather than EU firms (Narula 1999). In other words firms will not always benefit from cooperation activities sanctioned or supported by EU instruments, and indeed, they may have a higher risk factor than promoting intra-EU collaboration. However, international R&D cooperation is not an alternative to intra-EU cooperation. It is an essential complement to it, and has been for the last 25 years. Research has shown that EU-subsidised R&D cooperation leads to an increase in non-EU cooperative activity.

Horizontal and vertical dimensions

It is important to distinguish between horizontal R&D cooperation and vertical R&D cooperation. Each has different primary motivations:

Horizontal cooperation takes place among enterprises operating in the same industry, engaged in roughly the same kinds and types of value adding activity. The opportunities for economies of scale and scope are here maximized, but also provide the possibilities for conflict and leakage of intellectual property from one partner to the other. The cooperation between two biotechnology enterprises or between a human biotechnology enterprise and a pharmaceutical manufacturer would be considered a horizontal alliance. These are strategic

in nature, and in general occur between large firms and organisations that are leaders in their field. They are commonly used to establish standards, and may often be seen by regulators as anticompetitive, as they involve some degree of collusion. They are also commonly preferred in research (rather than development).

Vertical cooperation occurs among enterprises operating in related industries *along the same value chain*, where one partner produces inputs for the other. The latter may be a larger enterprise assembling or sub-assembling products from parts and components acquired from different suppliers, including SMEs. It may also be a small systems integrator close to markets and obtaining equipment from larger suppliers. Vertical collaborations are less problematic, as the partners possess complementary but not competing capabilities and opportunities. Their primary (but not the only) motivation is towards reducing costs.

Vertical alliances are especially important within global production networks and global value chains, and are especially common for development (as opposed to research). Both types of STI cooperation depend upon having complementary assets with which to barter.

International R&D strategies of MNEs

In the current process of globalization, the role of MNEs needs to be well understood. As is more thoroughly discussed in a dedicated paper for the EG[13] some crude facts emerge as guides to policy:

a) The main conclusion of early work was that the world's largest R&D spending firms tend to locate a vast proportion of their innovative activities at home, close to the location of their headquarters
b) However, the increasing levels of knowledge creation of EU firms from foreign locations may result in a 'hollowing out' of national R&D. This is regarded as indicative of a weakening of the national innovation system and an erosion of technological competitiveness.
c) The quantitative growth in international R&D has been accompanied by a qualitative restructuring of international R&D towards networks of corporate-wide centres of excellence where MNEs are moving away from a 'centralised hub' to a multi-hub 'integrated network'.
d) There are three distinguishing features of the drive towards increasing internationalization of R&D and technology creation:
    a. The first is the increasing level of green-field investments undertaken by large R&D spending companies;
    b. The second is the fact that such investments are now undertaken in an increasing number of countries, including fast developing economies such as India and China;
    c. The third feature highlighted is that such investments often go beyond local adaptation of nationally produced technology.

[13] See Vandana Ujjual: *Advances in the understanding of the International R&D Strategies of MNEs.* Unpublished paper, SPRU, Brighton, UK.

e) International outreach of R&D is one of the key strategic decisions that almost every large R&D spending firm has to make and increasingly such firms are implementing corporate-wide strategies for achieving this at the business unit and functional level.

An industry view on policy support

During the work of the EG, a dedicated workshop with representatives from industry and European Technology Platforms was conducted (please see a summary in annex 4)[14]. The main conclusions coming out of this workshop point to key policy implications:

a) The companies were keen to emphasise that the first thing to do in support of the internationalisation of EU industry and the ERA is to continue to operate a strong (but of course administratively simplified) Framework Programme. One aspect of investing in STI in Europe is to attract FDI and to continue to make it attractive for EU-based firms to remain in place.
b) Reciprocity in access to programmes was seen as important. There is lack of a clear distinction between policy to support development in poor countries and STI cooperation with developed ones. In the second case, the EU should only support cooperation with countries that allow EU organisations to participate in their programmes on a similar basis. The EU should devote efforts to persuading others to open their programmes as this would make international cooperation easier.
c) International cooperation plays an important role in converging efforts, reducing risk and setting standards. This is valuable and needs support well beyond Europe.
d) Researcher mobility schemes operating beyond Europe should be strengthened.
e) Investment by the EU not only in R&D but also in pilots and demonstrations is necessary. They have benefits both for technological development and for standardisation.
f) The EU should lead projects aiming to set global standards and norms. This is an opportunity to take the initiative and have a decisive influence on the shape of such standards.
g) The EU could also take the lead in projects addressing some of the grand challenges, where a global effort is beneficial for everyone. This is especially useful in 'horizontal' issues where IPR is not a major concern. More broadly, EU international projects should have clear and transparent IPR and exploitation rights. The EU should work towards more harmonised international rules and practices in relation to IPR.
h) The EU efforts towards innovative procurement should be mirrored in international activities – encouraging others to open their innovative procurement programmes also to EU firms.
i) The EU should pay attention to traditional trade and industry policy aspects such as reduction of trade barriers and encouraging entry.

The global context makes good and transparent framework conditions important. In fact, with the increasing globalization, a global "STI commons" should be supported by rules,

[14] To cover SMEs a small survey was conducted, see annex 5.

regulations and values that make up a level playing field. The EG therefore also supports the recommendations coming from recent work on knowledge transfer identifying obstacles and bottlenecks for international cooperation (Kaiser et al 2011).

Reducing transaction costs for SMEs

Various views hold that there are high barriers to participation in e.g. the European FP due inter alia to high transaction costs for potential partners from developing countries (similar to the challenges faced by EU SMEs) in terms of application, information gathering, reporting etc; the need to rely on national level support from their home countries, which may have different priorities and national champions/objectives they wish to prioritise. Given that R&D time frames operate on a relatively small window – especially development activities closer to the market, and in fast-moving sectors – such delays can make the purpose of the collaboration redundant. Transaction costs include:

1. Costs of identifying and establishing membership of innovation network/GPN (Global Production Networks)/cluster
    a. Identifying specific new opportunities for collaboration.
    b. Negotiation costs within the alliance (legal issues, etc).
    c. IPR issues require well-defined consortia agreements regarding commercialization.
    d. Identifying and acquiring membership of the innovation network.
2. Costs associated with applying for EC /MS resources
    a. Preparation of applications.
    b. Participation costs/project management costs.
    c. the reporting, monitoring and evaluation processes required for each project by each contributing donor.

SMEs cannot afford to spend resources on long-term research projects, because short-term imperatives mean that resources simply are not there to invest in these areas. Resources (time, money) to address short-term goals reduce the ability to draw on resources for long-term goals. Specific instruments may be:

1. Developing a structure that allows for the independence from research programmes (*i.e.* largely "bottom-up"). One option is the establishment of specialised PROs which will act as Centres for knowledge transfers built around communities of practice. These centres will build strong partnerships with industry, national laboratories, and international centres of excellence. Another well-established option is regional, thematic-based clusters. Here, complementary offerings of geographically close SMEs allow for better positioning at non-EU GVCs (Global Value Chains). Clusters complement the supply chain capabilities of MNEs and allow for more strength of the SMEs themselves.
2. Establishing 'brokering' organisations by industries. Identify the relevant knowledge producers and knowledge users and bring them together in a comprehensive and communication-rich network. Epistemic communities – researchers who share a similar approach or a similar position on an issue and maintain contact with each

other across their various locations and fields - create new channels for information and discussing new perspectives. This is a role that is perfectly designed for industry-specific PROs.

3. Absorb transaction costs which make partnering with non-EU partners costly.

Specific recommendations:

The additional survey on SMEs conducted as part of the EGs work (see annex 5) highlighted several recommendations in line with the above principle discussion:

- SMEs need mediation for finding non-EU partners. This mediation should be sector-specific, facilitating the communication between potential partners, the exchange of know-how, as well as the access to information. This could be achieved through improving the services of Enterprise Europe Network by making the way of contacting companies more efficient and by improving the match-making services of the Network for identifying relevant partners for international STI collaboration (pre-screening). Improved, qualified assistance for project applicants, e.g. at EEN nodes, should be available. Another possible option is networking of networks - collaboration with other non-European networks similar to EEN. The initial focus should be on mapping such networks outside Europe, their coverage and mandate and identifying opportunities for collaboration. Some examples are the networks supported by the World Bank, and the regional networks of UNIDO.
- Building pilot infrastructures in non-European markets in order to better understand their specific requirements. Some efforts on the EU level should be focused on collecting appropriate information and statistics about the different industries and the different markets.
- Information about the respective non-European international cooperation programmes should be available.
- Reduction of red tape when applying for STI cooperation with partners from foreign countries would be beneficial. Overhead for funded international cooperation is even higher than for EU cooperation, so that the cost-benefit-relationship often is not in favour of a proposal/participation. This should be considered in the funding schemes of the EC for SMEs. Current bureaucracy is too complex, especially for SMEs. The barrier to understand the requirements and the processes are too high to interest more SMEs in participating in international STI. Therefore, either the bureaucracy for SMEs is reduced and simplified, or the provided support at the proposal phase for SMEs is improved to accelerate interest in the international EC programmes.
- A promising approach to supporting international STI partnerships would lie in supporting/establishing global Networks of Excellence in several technological fields where the most important players in this field come together and build trust.

Towards a strategic approach

A strategic approach to international cooperation that includes a focus on industry and innovation needs to be based on a balance between two considerations:

- How to support and strengthen international cooperation through R&D related resources on firm- or cluster level:
    - Ensure that Europe becomes attractive as a region for lead markets, pilots and demonstration, infrastructures for testing and technology verification, and that Europe take a lead in technology platforms and standardisation through cooperation with stakeholders, all with a view to reduce uncertainty for industrial innovation.
    - Stimulate mobility of researchers and students and access to talent and research.
    - Ensure that the business support presence of EU and MS in 3rd countries is coherent to provide relevant and professional innovation support to European firms;
    - A stronger coordination of national actions at EU level; Joint priority setting and pooling of resources; public authorities to provide a clear response to industry initiatives (e.g. Strategic Research Agendas) and easy access for SMEs to international R& I.
    - An EU strategy should avoid a too strong pre-selection of countries for international cooperation. Industry typically differentiates between their partners on strategic research vs. development and engages in different countries accordingly. An EU strategy needs to be flexible to accommodate this varied approach to international investments and cooperation in R&D.

- How to develop and implement framework conditions globally that ensure level playing fields:
    - The EU should lead projects aiming to set global standards and norms. This is an opportunity to take the initiative and have a decisive influence on the shape of such standards. The EU could also take the lead in projects addressing some of the grand challenges, where a global effort is beneficial for everyone. This is especially useful in 'horizontal' issues where IPR is not a major concern. More broadly, EU international projects should have clear and transparent IPR and exploitation rights. The EU should work towards more harmonised international rules and practices in relation to IPR.
    - The EU should pay attention to traditional trade and industry policy aspects such as reduction of trade barriers and encouraging entry.
    - Ensure common rules in areas such as IPR, procurement and access to 3rd countries' procurement programmes, licensing.
    - Creating a strong European voice to influence strong international actors on regulatory matters.
    - Help create strong international incentives to innovation like performance regulation of products and technologies.

The output of the science system is both in the form of publications and patents, although publications prevail in quantity. Over the last two decades though, universities and PROs have developed the competencies and instruments to deal with this dual output simultaneously. This has led to the development of IPR practices that are well developed and articulated, even at the early stages of scientific discovery and publication. Even as technology is under development, the Technology Transfer Offices that have emerged at universities and PROs know very well how to deal with IP at the discovery frontier. This emerging practice should be further developed in line with the guidelines for IP management produced by the Knowledge Transfer Working Group of ERAC[15] which specifically concern research cooperation agreements with partners beyond Europe. The EG strongly supports these guidelines as a key component in a EU level strategy for international cooperation.

[15] European Research Area Guidelines on Intellectual Property (IP) Management in International Research Collaboration Agreements between European and Non-European Partners. Knowledge Transfer Working Group of ERAC, June 2012.

Exploit variable geometry

Objectives for STI internationalisation policies

Basically two different sets of R&D internationalisation objectives can be distinguished: an *intrinsic one*, which put goals into the centre of public S&T policy that directly aim to substantiate S&T (e.g. through enabling R&D cooperation among the best researchers globally or to find joint solutions for large-scale R&D infrastructures which cannot be financed by a country on its own); and an *extrinsic one*, which rather focuses on goals that are meant to support other policies (e.g. facilitation of access to foreign markets through standard-settings or research for development to assist technical development cooperation).

In 2008 the CREST[16] working group on internationalisation identified among the European Union Member States the following objectives that drive R&D internationalisation from an S&T policy perspective[17]:

- quality acceleration and excellence
- market and competition
- resource acquisition
- cost optimisation
- global or regional development
- science diplomacy

Different rationales are guiding these objectives: the rationale behind the *quality acceleration and excellence objective* is primarily an intrinsic one that assumes that international R&D cooperation improves the domestic science base, leading to faster and improved scientific progress as well as enhanced scientific productivity and is also supportive for the professional advancement of the involved researchers (e.g. through joint publications in acknowledged international journals). Behind this assumption stands the idea that only the 'best' (institutions and/or researchers) succeed also in international competitive procedures[18]. The rationale behind the extrinsic *market and competition objective* is to support the market entry of domestically produced technologies/innovations abroad as well as to support the access to and a quick uptake of technologies produced abroad within the domestic economy. Here absorption capacities and the availability of efficient spill-over mechanisms are of importance. The rationale behind the *resource acquisition objective* overlaps partly with the two major objectives mentioned before. The access to information, knowledge, technology and expertise as well as to singular equipment/facilities and materials are in the focus. But

[16] CREST (since 26 May 2010 renamed into ERAC: European Research Area Committee) is a strategic policy advisory body whose function is to assist the European Commission and the Council of the European Union in performing the tasks incumbent on these institutions in the sphere of research and technological development.
[17] These were confirmed by Boekholt et al. (2009), who included in their comparative study also policy examples from non-EU countries.
[18] This assumption can, however, be challenged. A deliberation on this is provided by Schuch (2011).

resource acquisition is not limited to different codified and tacit dimensions of technology transfer but extends to brain gain, gaining of solvent students (for universities) and increasingly also gaining research funds from abroad or from multilateral or international sources. The *cost optimisation objective* from a public S&T policy focus does not primarily mean to use cost arbitrages (e.g. lower wages in a foreign country) as this might be a rational argument of the corporate sector, but rather focuses on cost sharing approaches to create critical mass in a certain science arena, e.g. to establish large scale research infrastructures and it also includes the rationale of risk sharing. The assumption behind the *global or regional development objective* is that many risks have no frontiers (e.g. infectious diseases or climate change) or cannot be solved without international cooperation and solidarity (e.g. Millennium Development Goals) and, thus, have to be tackled through international R&D collaboration (e.g. research for development). Also the *science diplomacy objective* often refers to global challenges and to development cooperation agendas. Fundamentally, it has two main rationales: firstly to support through R&D cooperation other external policy dimensions in terms of science for diplomacy (e.g. non-proliferation of mass destruction weapons through keeping former weapon researchers busy with civilian R&D projects) and, secondly, to promote the own science base abroad in support of other objectives already mentioned above (e.g. to attract 'brains' or to promote a general quality trademark like "made in ….").

EC-Member States Coordination for international STI cooperation

As regards the European level, the former CREST working group made a comprehensive attempt to analyse public S&T policies of 21 European countries[19] towards R&D internationalisation by placing R&D and innovation policy in an actor's role (Sonnenburg et al. 2008). This study clearly revealed that in most countries, which participated in this working group, the traditional roles of S&T policy for R&D internationalisation, which can be described as either 'enabling' or 'preventing' have been gradually challenged. The enabling function comprises the development of stimulating incentives or support programmes such as cross-border R&D programmes and/or the openness of national programmes and projects (Edler et al. 2002), while the preventing function primarily concerns the protection of intellectual property at international scale. Above all, however, the main task of public S&T policy towards internationalisation of R&D traditionally was (and still is) to keep the own house clean, i.e. to be an attractive place for conducting R&D and, thus, for attracting R&D inflows from abroad too (Verbeek and Shapira 2009).

Examples for a more pro-active understanding are the introduction of incentives to attract inward corporate and institutional R&D, to participate in cross-border research programmes (often triggered by EC activities), to invest in joint R&D labs abroad, to support the mobility of researchers and to intensify the coordination of R&D internationalisation policies among EU Member States and countries associated to the EU RTD Framework Programme towards

[19] Austria, Belgium, Czech Republic, Denmark, Germany, Greece, Finland, France, Ireland, Island, The Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom.

third countries, typically with the support of and in division of labour with the European Commission. In 2008 SFIC, the Strategy Forum for International S&T Cooperation, which has been recommended by the CREST Working Group, was established with a remit to develop high-level co-ordination.

The basic rationale for pronounced coordination and collaboration efforts is the insight, that scattered national STI undertakings will in many cases not deliver effective solutions in a reasonably short time, while international co-operation can lead to the bundling of financial and intellectual resources, thus exploiting economies of scale and scope (e.g. Henderson and Cockburn 1996). In this sense, international cooperation is more and not less necessary in times of tight public budgets. However, there are signals that international STI cooperation activities at Member States level have been frozen or even reduced due to the necessity to consolidate public budgets. An evidence-based assessment of the scope and scale of Member States international STI activities is limited by the lack of data available in a standardised manner on how much public money is allocated for international STI endeavours at national level. Estimations vary within the lower one digit percent range.

In order to respond to the variety of legitimate R&D internationalisation objectives and the global challenges mentioned above, the process of coordination, which brings different elements of the international oriented STI system into a more "harmonious" and/or efficient relationship, must be accelerated and transformed into collaborative actions, where joint work is carried out to achieve common goals, to pool expertise and resources. In addition, integration efforts should be taken on the strategic agenda, which would imply a shift of competencies in order to combine activities or structures so that they form a new whole (see Edler 2010). Examples of this could be a centralised implementation agency for international ERA-NETs or an integrated approach for the establishment of INCO-houses in third countries.

In order to foster international R&D cooperation between the EU, its Member States and countries associated to HORIZON 2020 with international partner countries for the sake of mutual benefit and progress, the partnership between the EU and the Member States must be further promoted

- by cutting back existing information asymmetries
- by developing joint activities with critical mass based on variable geometry
- and by promoting a stronger perception of Europe as a whole at the international level, not just as a sum of single components but with value added.

It should be noted, that the promotion of partnership is not meant to replace individual efforts (by the EC nor by the Member States), but to establish activities with European value added and traceable impact to attain the basic objectives mentioned above.

Recommendations for promoting partnerships

The EG recommends starting the external policy dialogue and its follow-ups based on the priorities and challenges identified. Country choices will result from such deliberations, but should not be the starting-point.

In order to promote an enhanced partnership between the EU and Member States to address challenges and thematic priorities, the focus is on the following actor levels and core functions:

1) SFIC – function: policy coordination
2) MS/EC plus 3rd country partner regions - function: policy dialogue and collaborative structural/thematic pilot activities
3) EC/MS plus 3rd countries with S&T agreement – function: collaborative roadmap implementation
4) MS/EC plus 3rd countries – function: joint international research funding
5) R&D organisations – function: generic support for addressing global challenges
6) MS/EC – function: establishing European Lead Initiatives
7) EC/MS

1) Support the **internal** RTDI internationalisation **policy coordination** among the MS and EC and at the same time unburden **SFIC** in its core tasks concerning priority setting and harmonising framework conditions for joint international STI efforts, through
    a) enhanced secretarial support,
    b) an upgraded dedicated budget for expert workshops, promotion activities and accompanying research (e.g. regarding S&T internationalisation indicators)
    c) development of a user-friendly knowledge management system with web2.0 features.

    At the governance level, SFIC should ensure a truly high-level representation. Moreover, the governance structure should be further developed into a reflective and responsive "learning system" tailored to the needs of the specific targeted collaborations, allowing active and responsive adaptation. In such an enhanced governance system also implementation agencies and analytical 'intelligence providers' have to find their role and place for operative exchange and collaboration. SFIC must continue to establish and maintain linkages between national, regional and international levels to help to avoid duplication and create transparency among stakeholders.

2) Support the **external** STI internationalisation **policy dialogue** between the MS plus EC (internal variable geometry) and the rest of the world (through external variable geometry) with the aim to develop and **implement a number of coordinated pilot activities**
    a) through regional platforms
    b) which reach out to different fields of policy (including economic and development policy; innovation etc.) and to the targeted research communities

c) with a strong jointly accessible and usable analytical back-up function building on already existing knowledge (see section on indicators)
d) with an ambition to establish coordinated pilot activities, which could be of structural or thematic nature (e.g. thematic working groups to coordinate STI efforts; promotion of European research capacities)
e) by including third partner countries case-by-case (variable geometry)
f) with a strong focus on global challenges
g) financed by the European Commission.

As regards the external policy dialogue support, benefits for MS should be better worked out and procedures should be developed to better respond to the needs of the participants. The policy dialogue should involve policy makers and policy-delivery systems (not necessarily as partners but as participants in various activities), analytical intelligence providers and multiplicators from the EU, the Member States and the international partner countries. Outreach activities to other stakeholders, measures to put STI into practice and support for capacity building for STI at a strategic level (e.g. through joint S&T policy mix peer reviews), both at the side of EU MS and associated countries and third partner countries, should be a priority at several stages of such projects. Capacity building should be an element of joint efforts to address global challenges.

In this context, the increasing attention by the EU to address regions as a level (to better engage groups of countries in dialogues and cooperation) deserves a comment. In line with a key argument in this Report, priorities should be based on challenges and themes, while partner countries are seen as channels for implementation. The EG does not see regions as channels for implementation in this sense, but rather as potential mechanisms for dialogue to address framework conditions and include STI in wider political and diplomacy concerns. Approaching multiple countries for cooperation within a given priority should give rise to (external) variable geometries with those that share those priorities.

3) Support the **implementation of the results of the external** S&T internationalisation **policy dialogue** between the EC plus MS (variable geometry) and **partner countries with whom the EC has a S&T agreement** with the aim to **implement the jointly developed roadmaps**
   a) in bilateral settings
   b) which facilitate a stronger participation of excellent researchers in HORIZON 2020 projects AND the participation of excellent researchers from the EU in national programmes of the partner countries through different instruments (thematic workshops, procedural advisory services, promotion activities etc.)
   c) in principle across all HORIZON 2020 priorities (but in practice limited by the thematic or structural priorities agreed and stipulated by the S&T agreement under scrutiny)

d) with operational and intellectual support for implementing structural and thematic activities which have been jointly agreed by the EC and the third partner country within their mutually agreed roadmaps
e) promoting European research in the partner country and vice-versa
f) financed jointly by the European Commission and the partner country with S&T agreement.

4) Support the **coordination of research funding** between the MS plus EC (variable geometry) and selected third partner countries through
   a) International co-funding or matching-funding activities (e.g. based on ERA-NETs, JP and twinning instruments)
   b) thematically addressing – but not necessarily limited to –global challenges
   c) a leverage effect in terms of European value added and critical mass generation
   d) mutually agreed professional research programming, funding and evaluation standards
   e) financing as a joint effort between the EC (coordination), the participating Member States and countries associated (research funding), as well as the participating international partner countries (research funding);
   f) eventually offering a financial top-up of the EC to research funding (e.g. ERA-NET PLUS) provided that the HORIZON 2020 rules for participation and financial regulations are – at least to a high extent – applied (see separate box below).

   Funding and spending mechanisms should contain contingency provisions and means of ensuring funding for multi-annual research projects. Provisions for accompanying measures (such as summer schools, thematic conferences, short-term mobility schemes to S&T infrastructures), which also include partners with less financial commitments, should be encouraged. Knowledge sharing and IP provisions should be adapted to each phase of the collaboration cycle.

5) Support a few global strategic partnerships based on **programmatic research coordination and capacity building** between excellent **R&D organisations** from the EU and third partner countries
   a) through enhanced ERA-WIDE projects including elements of IRSES (sub-programme of the Marie Curie in FP7)
   b) with thematic or generic enabling functions for addressing global challenges (e.g. foresight on global challenges, social innovation for global challenges, financial system's observatory etc.)
   c) through a high leverage effect in terms of intra- and extra-European networking/outreach
   d) especially with partner countries with whom the EC has a S&T agreement and with developing countries, where it is crucial to strengthen the institutional and personnel capacities

e) funded by the EC (except with high-income partner countries, where a joint funding regime should be applied).

Outreach from the research community to other stakeholders should be a priority at several stages of any such project. Knowledge development and capacity building should be an element of joint efforts to address global challenges.

Excursus: international ERA-NETs

Enhance the performance of international ERA-NETs

Verbeek and Shapira (2009) consider the integration of foreign actors into (collaborative) R&D programmes as a channel to absorb excellence through cooperation. Since cooperation is based on voluntarily participation, a strong win-win-assumption prevails.

With the support of the EC, groupings of Member States started to build - on basis of variable geometries - international ERA-NETs as of FP6 to launch calls for proposals. Despite some shortcomings, this approach proved to be promising and should be continued. It is, however, recommended to invest more efforts and resources, both by the EC, the Member States and 3rd partner countries, to make this activity more sustainable and attractive and less prone to ad-hocery.

Thus, the expert group suggests

- to continue with the instrument of international ERA-NETs under HORIZON 2020, but to grant a minimum duration of 5 years by requesting the established international ERA-NET consortia to launch regular calls for inclusion of new partners before the conception of new calls for proposals;
- to set as a principle that – by referring to the subsidiarity principle - the coordination costs of international ERA-NETs should be financed by the EC (eventually co-financed by some [post-]industrial third partner countries as regards flanking measures such as brokerage events etc.) and that the costs for projects funded under call for proposals launched by the international ERA-NETs should be borne in essence by the participating countries;
- if, however, the partners of international ERA-NETs agree to adhere the HORIZON 2020 rules for participation and financial regulations, the EC should top-up the call budgets with 50% (if there is a strong alignment) respectively 20% (if there is a lighter alignment) (ERA-NET PLUS mechanism). Alignment criteria should be defined by the EC.

6) Support **internationally oriented European Lead Initiatives** in thematic areas
   a) through scaling up existing research activities through enhanced coordination
   b) based upon best practice of certain Member States identified by SFIC
   c) enhanced through mutual opening-up of research funding programmes of other Member States based on variable geometry
   d) including the establishment of a platform and of clustering activities

e) with strong overseas promotion under the label of a European Lead Initiative
f) financed jointly by the MS and the EC

7) Establishment of **feasibility studies and pilot activities** to initiate several other unilateral and/or (pilot) joint activities with Member States such as
   a) European Weeks of Science, Technology and Innovation
   b) Technology scouting activities
   c) Foreign liaison offices
   d) International IPR consultancy
   e) Joint labs
   f) Negotiated access conditions to foreign research infrastructures
   g) Diaspora activities
   h) European Summer Schools
   i) Funded by the EC and participating Member States (variable geometry).

8) Besides the points 1-7 mentioned above, which are specifically addressing the policy dialogue and its substantiation and targeting, the entire H2020 funding portfolio should be used too to stimulate international RTDI cooperation between researchers from academia and industry. However, international RTDI cooperation in the thematic directions/lines of H2020 should be designed, explained and implemented in a more strategic manner and less ad hoc, scattered and under-critical than in FP7, enabling more sustainable and substantial RTDI results.

The need for an evidence- and analysis-based strategy

Promoting indicators and information

The EG sees information and data as a key resource to design and support defined elements and objectives in a strategy. Hence information and data, and its sharing, is not an end in itself, but a means to an end. For the design and implementation of an EU internationalisation strategy as outlined above, systematic data and analysis must specifically support (1) priority setting – as any strategic effort must make choices – and (2) the choice of partner countries and regions for each of the priority areas (countries follow priorities, not the other way round). It thus (3) underpins negotiations within ERA (between MS and the Commission) and with potential external partners and by doing so helps to create effective partnerships. It will also develop a new focus on (4) supporting international innovative activities. This section discusses the need and concepts for capturing data and information and for sharing it, with the ends to support internationalisation of STI at EU level.

The nature and origin of relevant data and information is heterogeneous. Information is either mainly based on standardised data linked to clearly defined indicators or it is more qualitative and idiosyncratic[20]. Underlying data can either be collected centrally or it can be collected de-centrally. Finally, data and information can either be shared and provided for all or it can be done for specific, idiosyncratic purposes with limited value in sharing. The table below summarises the different situations and highlights the basic principles for data collection and information sharing.

Indicators

The basic rationale

Indicators must support the three stated and agreed overall objectives of an EU internationalisation strategy for STI: strengthen STI competitiveness, tackle global challenges and support external policies. Against this background, and in line with the main message of our report, the starting point for all development and use of indicators must be the need for indicator support for a *European level* STI internationalisation strategy. The starting

[20] A short principle clarification as to what we mean by information, data and indicators: Information is needed to make decisions. Information is based on *data* and *indicators* and *interpretation.* Data are values of defined variables, quantitative or qualitative. In itself, data has no meaning, it must be interpreted, it is the raw material for indicators and information. Indicators are measures that refer to a clearly defined and measureable parameter and signify a specific phenomenon beyond the parameter that is measured. Indicators are necessary to qualify and quantify a certain phenomenon, most often one indicator is not enough to do so, and indicators need to be interpreted with care (e.g. co-publication as one indicator for the level of cooperation, and it means different things in different scientific areas or geographical regions). *Information* is data that is contextualised, with data brought into relations and interpreted following certain interpretative frames, information carries meaning. Indicators support the translation of simple data into information, but in itself are not enough. It is information that is the basis for action (Dasgupta and David 1992, 9), not data or indicator itself.

questions thus ought to be: what kind of indicator and data does a European approach to international STI need? Indicator development is therefore not mainly about aggregating data obtained at Member State level. Rather, the need at EU level determines what we need to collect data for. The data collection itself can – and should – of course be done in a way that realises synergies with Member State activities and vice versa and it should avoid duplication of work. Thus, EU level indicator development will have to take stock of what is being done at national level and mechanisms should be in place that allow a sharing of data and information (see section below) and allowing for a basic level of comparability. Further, the indicator system must be lean; following the principle that only those data are collected that are really needed for decision making.

Table 2: Matrix for information collection and sharing

	Standardised, indicator based	Idiosyncratic, policy practice, contextual
Central collection and provision	Commission, Eurostat to collect data for a set of agreed indicators through central instruments (and where appropriate in cooperation with OECD)	Commission collects "soft" information and commissions studies where it is needed specific to its own strategies. Information and analysis open to all MS
De-central collection	MS collect data through national agencies and offices, and for an agreed set of indicators send data to a EU organisation to provide standardised data (can be done through SFIC and SFIC data subgroup).	MS collect soft information and share those parts where there is common agreement that sharing is in the overall EU interest (done through SFIC).

The discussion of indicators and processing needs to answer three key questions:

1) What do we need indicators for at European level (functions), and which indicators are best suited to fulfil those selected functions (functional fit)[21]?
2) Who should define the indicators and collect the data? Who uses the indicators (actors)?
3) How are data collected, processed and shared (process)? What is needed on a regular and permanent basis, what capacities are needed for ad hoc initiatives?

Which indicators are needed? Functions and levels of indicators

Indicators are important tools for decision making in STI policy and STI strategy of research organisations and firms. There is a whole range of related but distinct functions of indicators.

Four basic functions must be differentiated:

[21] This will have to include questions regarding the limitations of indicators.

1) Understanding the status quo in terms of the EU's STI profile and STI internationalisation activities: this helps to define the needs as starting point for the strategy (own competencies, gaps, needs as seen by various actors within EU)

2) Formulating targets, benchmarks to reach: this helps to define goals, to communicate the purpose of international activities and to measure achievements later on (link to thematic priorities of H2020). The targets must follow from the overall goals of the internationalisation strategies (in terms of societal challenges and bottlenecks to be addressed and opportunities to be captured).
3) Understand global bottlenecks (e.g. access to markets and infrastructure, legal obstacles to cooperation etc.) and opportunities (STI profiles, "hot spots" abroad in light of rapidly changing global landscape): this helps to link the thematic priorities defined to concrete choices in terms of in terms of scientific and technological fields and in terms of partner countries/regions (country follows priority) and it enables effective negotiations with partners.

4) Monitoring development and measuring the impact of international activities and related public support on the
    a. overall goals of the EU STI policy strategy (in terms of STI competitiveness, contribution to tackle grand challenges and external policy support) and
    b. the stakeholders involved.

The following figure is a graphical representation of those four functions of indicators for STI internationalisation.

For strategic development, all four functions are important. However, an indicator system for the future development of EU strategies in STI internationalisation should focus on the bottlenecks within the status quo analysis, on opportunity structures to capture untapped areas for researchers and firms and, finally, the measurement of effects in order to monitor the support given and re-adjust the strategy as needed.

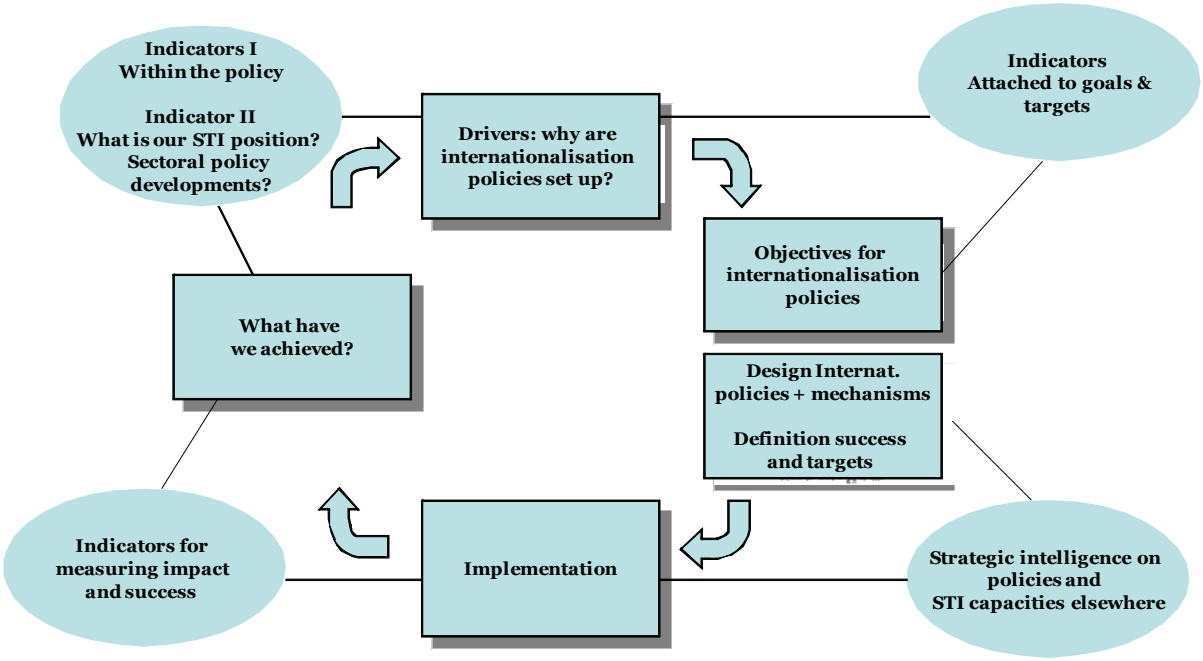
The indicators we suggest in this report should focus on the usefulness for the support of EU level policy strategy. However, in order to do so, indicators must also be able to capture international opportunities, activities and internationalisation effects for different actor groups and at various levels: individual scientists (cooperation, mobility, recognition), research organisations and firms (cooperation, re-location, transfer), systems (EU level, country level). The latter also includes indicators on *policy making itself* (framework conditions, support mechanisms and funding opportunities etc.).

In consequence of this multi-function, multi actor framework, there is a number of potential indicators that could support the strategy process within the framework outlined is endless. We recommend

- to limit a European system of indicators to the minimum required to define priorities, design activities, negotiate with partners and measure success;

- to build up the indicator system gradually, starting with those that are indispensible for decision making at EU level and which are readily available (quick wins);
- to have a stronger focus on innovation related indicators than we had in the past - in line with a stronger emphasis on innovation and internationalisation of firms' STI activities.

Figure 5: Uses of indicator in policy making



Source: Edler/Flanagan 2011; Boekholt et al 2009

One final clarification is needed: For many indicators it would be desirable to have both the intra- and extra-European dimension to understand the relative importance of non-EU vs. intra-EU activities. While we believe that it is crucial to understand the level of cross border and trans-national activities *within* Europe (as is done in the emerging ERA indicator framework), an EU strategy for internationalisation must focus in addition on the extra-EU dimension and be linked in with the ERA indicator framework.

Key indicators for a European internationalisation strategy[22]

In this section we list selected indicators along the various actor groups and levels which the group thinks are of vital importance for a mid- and long-term STI internationalisation strategy. For each set of indicators we will indicate the priority in order to signal where the EG thinks action should start.

Individual Scientists

[22] The compilation of indicators draws on Edler/Flanagan 2009 and 2011 and Schuch 2011

Scientific collaboration: (priority *medium*, lots of data available already, but important to understand status quo of international activities)

- Co-Publication and co-inventions (applications, granted) of EU and non EU partners authors (absolute numbers, relative shares, differentiated for knowledge areas, analysis of partner countries).[23]
- Citations of extra-EU collaborations (vs. intra-EU or non-collaborative papers), development over time

Financing: (priority low) Publications from projects funded by non EU funding sources[24]

The data for those indicators should be compiled and analysed on a regular basis through in-house capacities (DG Research or JRC IPTS) or outsourced to a regular data provider.

Mobility: (priority high as competition or talent is a major challenge)

Indicators should capture mobility (intended for limited duration) and migration (in principle open by nature) of public and private researchers. Given the importance of the availability of talent in the decades to come, there should be a focus on PhD and early stage career researchers, inward, outward. Data should enable country and field specific analysis. Indicators on mobility should build on the work done in the EU funded project IISER (Integrated Information System on European Researchers[25]). The IISER indicator set covers researcher stocks (general and early stage), research careers and researcher mobility (intra-EU, into and out of the EU).

As the instruments are in place at EU level for most of the data, data for those indicators should be compiled and analysed in a European wide database, building upon existing activities.

Research Organisation *(medium priority)*

Data for research organisation (PRO and Universities) is very scattered and non-systematic across Europe. Every ambition must take this into account. We thus recommend *starting* with a simple list of key indicators to understand dynamics and effects of international activities and relations of organisations. [26]

- Share of projects with non EU partners
- Share of project and licencing income coming from non EU sources
- Number, location and size/importance of labs in non-EU countries
- Share of employed research staff coming from non EU countries

[23] An analysis of numbers and trends should be accompanied by a selected analysis of patent values, i.e. linked to licensing income.

[24] Can be analysed via Web of Science, as this data is available now on a regular basis.

[25] More information on this project can be found at: http://ipts.jrc.ec.europa.eu/activities/research-and-innovation/iiser.cfm

[26] This list does not contain as yet so called strategic "positioning indicators" (Lepori et al. 2008, Barré 2006) which indicate the position of organisations within their system and vis-à-vis other organisations (such as the existence of internationalisation strategies etc.).

- Qualitative assessment of trends through leading research managers (countries, importance of industry as partners)

There is no reliable reporting system across Europe in place to compile this data. The data for those indicators could be compiled through a *simple* electronic annual monitoring survey with organisations across Europe; it could also be linked to existing endeavours to measure research activities of organisations.

Firms and innovation activities (medium to high priority as innovation internationalisation is a new focus)

While international R&D of firms has been a hot topic in academic research, and while a few countries have a very elaborate annual reporting system on industrial R&D (such as Germany), uniform and pan-European indicators for activities and opportunities of firms are scarce. Therefore, the indicators we suggest here are moderate to start with, but this report suggests building up more thorough indicators and data for innovation activities. Those are important to understand weaknesses and strength of European as a location and European based firms as innovation actors and to see developments over time.

We build on the assumption that a new, specialised pan-European survey system for firms is not practicable. However, next to existing databases (e.g. patents, foreign investments (statistical offices)) the regular CIS survey should be expanded to include some of the variables below.

- Bottleneck and need survey mobilising existing channels (at national level, see below) (we suggest to give this line of analysis highest priority)
- Share of business R&D (share of R&D expenditure) performed by non EU MNEs (national statistical offices) within European countries
- Share of affiliates under foreign (non-European) control in the business sector (national statistical offices) within European Member States
- Share of R&D of affiliates outside Europe as percentage of expenditure in Europe (CIS)
- Share of R&D workers of European based companies located outside EU (CIS), compared to the share of overall staff located outside Europe.
- Number of R&D labs of European companies outside Europe (locations), (CIS)
- Geographical origin of external source for innovation: differentiation for EU and non EU sources (CIS)
- Number / share of technological collaborations with non EU partners (alliances and project specific, firms and public organisations a partners) (CIS)
- Share of patents with co-inventor from non EU countries (country and technology area analysis) (regular monitoring, EU, service provider)
- International licensing income (share from non EU income) and technological balance of payment

- International acquisition of firms in technology intensive areas

The indicators so far are traditional indicators that capture important dimensions of internationalisation. One caveat of this list is that they do not reflect the breadth of innovation activities, and they do represent innovation activities differently for different sectors. As the international *innovation* dimension is becoming more important, we suggest to explore and develop new types of indicators. This exploration should receive high priority as it promises to add value to understanding new trends and relevant dimensions of innovation internationalisation. Examples of those indicators to be developed are:

- De facto standards, an indication of technological leadership, determining the production and diffusion of innovation. Those de facto standards are hard to capture systematically, analytical work could be done by the EU to establish processes to capture the development of de facto standards.
- Level of involvement and leadership in standardisation bodies, such as number of chairs in standardisation bodies coming from different countries.[27] This measure indicates leadership and involvement at international scale.

Existing caveats for innovation measurement: We need to stress that this report focuses on key STI indicators. The discussion here does not encompass two important dimensions that, for a holistic development of an STI internationalisation strategy, should be considered in the future (medium priority):

- the scope and relative strength of *production* and *value added* in different areas. An overall strategy that also focuses on innovation must take production and competitiveness indicators into account. We suggest to link indicator work to the valuable work on key enabling technologies (KET)[28], i.e. to link patent and publications analysis with analysis of market share of certain innovative products or technologies – depending on strategic interests.
- the *demand* conditions for innovation, i.e. the readiness of markets to trigger and absorb innovations. The more favourable demand for innovation is in an area, the more likely it is that innovation generation and spill over innovations (complementary services and products) will also happen in this area. Especially in ICT and internet based products and services forefront demand and co-development of innovations are closely linked. Thus, data on market entry and diffusion patterns should be made available to understand geographical differences in diffusion and understand where the test markets for innovations are in different areas. This is crucial for any international activity that is market oriented.

Funding, policy and framework conditions within EU and in selected comparator countries / regions

[27] The group is grateful to Prof. Knut Blind, Berlin, for this suggestion.
[28] See http://ec.europa.eu/enterprise/sectors/ict/key_technologies/kets_high_level_group_en.htm

The development of a strategy at EU level must be built on a sound knowledge of existing funding patterns and policy driven initiatives, at national and EU level. This analysis is not solely indicators based, but as for indicators, the following are suggested:

Funding (medium priority):

- Share of public R&D programme and Research Council spent on non EU partners, if possible for fields (indicator *need*: a systematic overview does not yet exist)
- Funding income for firms and research organisations from non EU sources (if possible for sectors and fields)
- Share of and opportunities in funding programmes open to non EU participation, including all instruments set up at EU level (JPI, ERA-NET calls etc.)

A European status quo analysis of scientific and technological strengths and a European aggregation of the data captured for the dimensions above should be enabled by these kinds of indicators (where data comes from national sources) (high priority)

Hot spot analysis of non EU countries (high priority): Understanding of opportunities and threats for a European STI strategic should include a system of scientific and technological field specific analysis of hot spots outside the EU to help to identify excellent individuals and organisations / firms as well as a system to understand the public spending patterns for those selected areas (in order to detect future strengths and future cooperation possibilities). This hot spot analysis should get high priority, but, as stated above, must focus on those areas that have been identified as priorities for international activities rather than start with country priorities.

Information and data sharing

Basic principles

The sharing of information and data follows out of the needs at EU level. Ideally, the mechanisms developed will also help Member States in their internationalisation activities, information sharing will thus be a two way street, but the focus is: how can partners share information in a way that makes EU level policy more effective and efficient and in doing so also supports MS activities?

Data and information can be shared that has been collected centrally or that is distributed. The latter concerns information and data that are generated and collected in a dispersed fashion without a central coordination, but that may, for aggregate benefits at European level, be shared. It is obvious that there will be much more information available on national level, at Commission level, among R&D organisations etc, than should or could be shared among principle policy makers at European level. Hence, a key principle for information sharing will be that it should be *purpose led*.

Data gathering and sharing for the indicators suggested

In terms of data for the indicators the following principles are suggested:

- a collaboration of DG Commission services (DG Research, JRC IPTS), EUROSTAT (through adjusting regular reporting by national offices, through support of patent and publication analysis) and Member States activities that are reported through appropriate channels such as SFIC (see above, section on EC – MS coordination).
- An adjustment of analytical tools to the pressing need of improved internationalisation (such as enlargement and adaptation of the CIS survey)

The European Commission should have the main responsibility

- to build up capacity for bottleneck and opportunity analysis in areas where there is a broader need (not specific for individual firms) (high priority)
- to capture international activities across all EU (co-)funded instruments and
- to influence EU level and financed instruments to better capture international activities (eg. CIS) (high priority)
- to actively support and coordinate data capture of Member States for EU purposes (high priority)
- to set up a regular EU level specific publication and patent analysis (medium priority)

Co-ordination of Member States activities cannot be a command and control fashion. Rather we strongly recommend that *SFIC* is mandated with establishing an indicator and *data sub-group* that is linked to the key data gathering units in the various Member States and establishes a flow of data. As the indicator needs as outlined in this report are limited to basic requirements, for most of the indicators data already should exist and updated on a regular basis.

SFIC and the Commission should also *collaborate* to develop joint guidelines and standards for "positioning indicators", e.g. indicators that capture the strategic and operational activities and relative position of organisations in the global STI system.[29]

As regards the data collection process for those indicators, there are two basic ways forward:

1) use and enlarge existing survey (CIS and S&T[Frascati]-surveys)
2) make a separate standardised inquiry (which has – next to some disadvantages – also one basic advantage: S&T policy makers and also agencies can be directly addressed, which is not the case in the CIS and S&T-surveys; agencies and ministries can provide data about international participation in national programmes; intergovernmental S&T programmes; share of national funding going abroad etc.)

We also need to stress that a European approach needs to rest on two pillars: a standing list of indicators for which regular data should be compiled, and the possibility to perform ad hoc studies to underpin a specific technological or country related strategy. Relevant capacity, in-house or through contracts with external service providers, should be at the disposal of the EU Commission DG Research and Innovation.

[29] In Boekholt et al (2009) http://ec.europa.eu/research/iscp/pdf/drivers_sti.pdf there is a long table (p. 43 to 46) with ideas regarding division of labour.

Information sharing to support the "policy cycle" in STI collaboration

Principles

Next to the indicators discussed above, there is a need for sharing more qualitative, policy related information to support the "policy-cycle" of specific STI collaborations. Of course, while the indicators captured above will support this cycle model, we focus on contextualised and policy related information here to illustrate the need for *additional* information and principles for information sharing along a simplified cycle model, in this context seen as:[30]

- Agenda and priority setting
- Partnering
- Implementation
- Evaluation and monitoring

Sharing distributed information among European partners will support partnerships and priority setting, as well as activities that are launched by partners in each case. Such information is widespread among partners, and it should be based on the need to contain transaction costs for those involved and avoid costs related to generic, non-purpose information sharing. As with indicators, information sharing needs to be lean and built on a need to know basis to avoid information overload and overloading partners to a degree that undermines the key motivations for information sharing in the first place, priority setting and partnering.

Agenda and priority setting

This concerns the early stage of a given activity where the "net" needs to be cast more broadly. Information that have a bearing on setting strategic agendas and thence priorities should contain the quality of being able to help discriminate between strategic options and differentiate between scenarios of costs and benefits of these options. Information sharing in this context will include:

- Information related to global challenges, e.g. climate change, energy balances and consumption, food security and health issues. The information should contain STI-related items to ensure that it is international cooperation in STI to help meet these challenges that are generated and shared. Partners in EU-level STI cooperation should make relevant national or otherwise distributed information available on their respective web-sites.
- Science Counsellors (or equivalent) in priority countries should share their respective information on strategic issues, perceptions and analysis of a given country's STI agenda, key challenges that warrant STI policies and strategies. Science Counsellors should also engage in cooperation to achieve concerted reporting to their principles, including the Commission.

[30] See e.g. «Innovation Governance», OECD 2005, Paris.

- Information on national priorities or initiatives for international cooperation that may benefit from a broader European cooperation to achieve stated objectives.
- Sharing forward-looking information such as trends, market developments, strategic intelligence developed at national level.
- Sharing information among sectorial ministries/DGs where international cooperation in STI may contribute to their respective objectives.

Partnering

Partnering involves both the generation of European partners, often in a variable geometry, as well as potential foreign partners in a multilateral setting or external variable geometry. Information sharing follows the needs arising from the processes of deciding on joint actions after priority setting has been achieved (this is to be seen in conjunction with the recommendations given in the section above on recommendations on partnerships):

- Information on current programmes and initiatives in the relevant areas (thematic/geographic) with a view to produce a map of existing efforts and help define what specific value could be added from joining efforts (this relates to the need for global country policy and financing analyses outlined above).
- More in-depth information (including evaluation reports) on best/good practice cooperative programmes that may serve as "lead initiatives" on which to expand cooperation through e.g. mutual opening of bilateral programmes.
- Detailed information by potential partner(s), including on programme management, procedures, preferred options for cooperation.
- Sharing information on potential modalities for cooperation, including novel multilateral platforms.

Implementation, evaluation and monitoring

The implementation phase of cooperative actions will be different from the two preceding it. First, this phase has similarities to the indicator section above in that there is at this point a need for generating information from a joint basis, albeit in this case on a programme level. Further, the information sharing logic will be reversed, so that information generated from the joint programme implementation should be redistributed to national counterparts or other actors or stakeholders involved.

- A key tool in implementation of joint actions will be strategic research agendas (SRA). These include the rationale, objectives and contents of the action in question. Hence, it provides key steering information for those involved, and should also be distributed to actors and stakeholders related to the specific action.
- For each significant action a set of dedicated indicators should be developed to be used in monitoring and managing the programme/action with information accessible for involved actors.

- Ex ante and ex post evaluations should be carried out and distributed to all involved as well as a broader community of identified stakeholders.
- Foresight studies and other information on future developments in key STI fields and countries/regions should be made easily available.

Modalities and practices of information sharing

The complexity of international cooperation, not least among MS with different traditions, vested interests, strategic objectives and STI systems, makes it crucial that the Commission takes a visible lead in defining a policy for information sharing. The fragmentation and disparities make a key actor highly necessary, one that can provide momentum and synergies as a gravitation point in the cooperative landscape. The Commission with its Framework Programme (H2020) as a key resource is the only partner in Europe who can do that.

A strategy for international cooperation in STI should differentiate between active and passive modalities depending on purpose. It goes without saying that a great bulk of data and information to be shared will be made available on web-sites among stakeholders and participants/partners. Such information should be produced according to common guidelines to ease accessibility and use. Further, there will be "living documents" such as strategic research agendas that are regularly revised and updated. A more active approach will be dedicated workshops to share information and lessons during the build-up of a strategic action that helps stimulating a common information and knowledge base. This includes the Strategic Forum for International STI Cooperation (SFIC), which, supported by a data sub-group, serves as the most important forum where such information can be presented, priorities defined, and partners selected.

Conclusions and key policy recommendations

Pulling all elements of the present analysis together, it is clear that Europe finds itself at a crossroads: Fundamental changes in the global research and innovation landscape are taking place. The increasingly pressing global challenges urgently require a strategic and forward looking response at EU level. Hence, the overall recommendation is to develop

1) A strategy with a focus on strengthening European attractiveness as international research and innovation hub and partner in order to strengthen European competitiveness and prosperity

Europe needs to get at the forefront of international collaboration in STI by making it the place to be for international researchers and non-EU MNEs. Secondly, the EU must provide their stakeholders an infrastructure to expand to other regions into the world and help universities, SMEs in particular to reach out to those markets in selected themes addressing the grand challenges of the next decades.

Only few countries have so far developed an integrated policy strategy. In the US and the UK the overarching, strategic orientation of policy is to support world-class excellence in science with the aim of generating attractiveness for R&D activities by MNEs. The emergence of China on the global S&T scene is backed by elements of an integrated policy strategy, albeit with strong elements of a planned economy context.

Currently there is a dominance of geographical prioritization through picking countries. This has been especially evident in SFIC. This should change:

2) Theme- and problem-oriented prioritization is needed rather than geographic; Grand Challenges as a clear prioritization tool to be mainstreamed also in the international dimension. Prioritization of international collaboration should follow closely the priorities of the EU's core research and innovation programmes, while the geographical approach should be the core of an implementation strategy.

This also implies that

3) The international perspective needs to be more fully integrated into 'regular' programmes at EU level

All EU programmes (old and new instruments) should be required to have an international dimension, e.g. through benchmarking and monitoring, identification of relevant partners – and competitors– outside Europe and activities for strengthening cooperation with non-EU partners and/or activities aimed at increasing proximity to relevant markets and users outside Europe. This requires the ability of evaluators and evaluation criteria to valuate and evaluate international partners and collaborations; criteria should be based on complementarities and critical assets for R&D projects.

The EU Framework Programmes are seen as the key vehicle to foster effective international cooperation:

4) Make the Horizon 2020 truly open and attractive to the best and brightest in the world allowing European actors to work with the best brains wherever they are.

International cooperation in STI is impeded by numerous bottlenecks:

5) Strengthen framework conditions for and removal of barriers to international cooperation.

This concerns in particular issues like mobility, standards, IPR, opening national research programmes, simplification of Framework Programme, increasing the competitiveness of European universities, realizing the ERA as a prerequisite to an effective international dimension.

6) Design targeted initiatives for strengthening cooperation in selected (prioritized) areas: these can be multilateral, bilateral, and unilateral. The key criteria should be achieving benefits for European stakeholders.

The EU should become a stronger international actor in international science and technology fora and in taking the initiative in international science, technology and innovation collaborations through such targeted initiatives.

7) A strong focus on firms and innovation is needed. This has not been properly addressed before and it requires a new/different approach; there are fundamental differences in drivers of international cooperation between academia and industry and between research and innovation. Actions should e.g. be taken along several lines:

   - Make Europe the global lead market for innovations to be deployed. Provide the leading Research and Innovation infrastructures for pilots and early adopters.
   - Leverage Europe's diversity in language and jurisdiction to allow for true international products and solutions to be developed that can easily be sold globally.
   - Domestic clusters of S&T excellence are an important attractor for innovative companies, R&D institutes and R&D workers from abroad. A strong and vibrant academic and industrial research base, efficient protection of intellectual property rights and a well-trained workforce are major determinants for MNE investment in R&D, but will also promote the growth of domestic enterprises. Hence, such policy measures should be aimed simultaneously at creating favourable conditions for domestic and foreign-owned domiciled enterprises.
   - In order to benefit from the internationalisation of R&D, economies should optimize their absorptive capacity and networking with multinational firms. Among the factors that improve absorptive capacity, two stand out, viz. a high

educational level of the local labour force and a well-developed technological capacity of domestic firms.

- Stimulating the development of excellence in local Science & Technology capacities and providing an innovation friendly environment is key to any policy towards R&D internationalisation.

Many countries have not fully recognised the implications of the current internationalisation of STI. In part this is because the full implications are not yet clear, and this is certainly an area in which further research and analysis is required. The increasing mobility of financial resources for STI is accompanied by the increasing mobility of highly skilled scientists and engineers. This has implications not only for education policies, but also for a wide range of policy arenas – tax policies, regulatory frameworks and standards setting, among others. Although many of the instruments needed are already in place in most national and supra national policy levels, they need to be mobilized better to fit into a coherent, systemic policy approach to face the challenges of internationalisation of R&D.

An ambitious strategy for international cooperation will need to leverage the resources and initiatives in the Member States. The Commission should contribute to making the Strategic Forum for International S&T Cooperation (SFIC) a truly high-level and effective body with a capability to engage strategically in this policy field.

8) Variable geometry should be exploited to the full, with flexible arrangements (within EU and with countries outside EU) including multilateral platforms for strategic cooperation. Variable geometry initiatives should also build on lead initiatives by individual Member States that expands their successful bilateral programmes or activities to several European partners.

A credible and effective strategy on international cooperation needs to build on reliable information made available to key prioritization processes. There is a need for more structured information resources:

9) All initiatives must be based on more evidence- or analysis-based decision-making, including forward looking analysis to inform decision making about likely trends and future changes and systematic exchange of experiences.

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Annex 1: Mandate of the Expert Group (extract)

MANDATE OF THE EXPERT GROUP

3.1 Phase I: Support to the development of ERA Framework and Commission Communication on international STI cooperation

Phase I: The Expert Group on international STI cooperation will help to provide support to the development of the external dimension of the ERA Framework, ensuring coherence with the external dimension of the future Horizon 2020 European research and innovation programme. The expert group will equally contribute to the further development of a more strategic EU international STI cooperation policy and to the forthcoming Commission Communication on this issue.

The provision of advice and other inputs on international STI cooperation in support of the conception of these 2 policy documents will constitute the first phase of the work of the Expert Group. Provision of such advice will cover support to both the drafting of policy documents and any subsequent discussion with the Member States (represented in the Council Research Working Group) and European Parliament, as required.

3.2 Phase II: Support to the implementation of EU international STI cooperation policy

Phase II: In the second phase of the work of the Expert Group, members will carry out a comprehensive analysis of the key issues affecting the development of coherent and effective STI cooperation with other regions of the world. A non-exhaustive list of key issues is provided in section 3.3 below.

Starting from a review of the main drivers (including increased globalization of science, technology and innovation activities; emergence of new STI powers, need for global STI cooperation to address key societal challenges which require a large-scale effort; and, need to access knowledge globally to remain competitive) and the objective of engaging more actively and strategically in international cooperation, work should focus on providing a clear, substantiated narrative for each of the issues. This should include the nature and extent of the problem, the research actors (public and private) concerned, as well as the impact of the problem for researchers, institutions, and Member States.

In addition to problem analysis, the group should also identify examples of good practice where a particular issue has been successfully addressed by one or more countries or institutions. Evidence should be provided for a wide range of Member States, be it at institutional, national or international level. Cross-country comparisons should be presented, where appropriate.

Work should take account of existing study reports (including internal Commission study reports and those of the SFIC), the preparatory analysis already undertaken within DG Research and Innovation (including the ongoing work to establish a more strategic approach for EU STI cooperation with third countries) as well as the issues addressed in the 2011 public consultation on ERA.

On the basis of the problem analysis and taking account of the policy objectives, the group should develop recommendations for EU policy action, which could be of a binding nature or in the form of recommendations or guidelines. The group should explain clearly how they would contribute to enhancing the coherence and efficiency of EU international STI cooperation with other regions of the world.

Where appropriate, the group should then assess the effectiveness of policy options, including their potential impact, before putting forward recommendations. Where the preferred option entails EU action, evidence should be provided justifying the grounds for such action. In doing so the group should address precisely the respective roles of the EU and Member States including complementarities and synergies.

3.3 Issues and Questions to be addressed in Phase II of the work of the Expert Group

The expert group will be free to develop considerations which they feel are important for international STI cooperation in the context of the European Research Area but should cover:

3.3.1 Sharing of information between MS and between MS and the EU on international cooperation strategies, plans and actions, development of common information system on international STI cooperation policy development, challenges and approaches for cooperation with key partner countries.

Consideration should include:

- the type of information which should be shared and its availability and how to address concerns about the sensitive or restricted nature of such information;
- how such information should be provided including the assessment of the need/appropriateness of introducing legally binding obligations on MS and/or the sufficiency of voluntary guidelines, etc.
- developing a coordinated approach to monitoring and analysing STI policy development; strengths and weaknesses of STI capacities; and, opportunities which offer mutual benefit in 3rd countries (including making the best use of available resources), the role of networking and coordination of science counsellors (EU & MS); involving big research organisations (e.g. Fraunhofer; Max Planck, CNRS) and other potential information sources.

3.3.2 Promoting greater partnership between EU and MS on international cooperation strategies, plans and actions.

Consideration should include:

- defining the objectives, principles and modalities of a common EU–MS strategic approach and priorities to underpin EU-MS coordination and joint EU-MS international actions;
- assessment of the costs (political, economic, financial and scientific) associated with not increasing European policy coherence in international STI cooperation;
- the possibility of strengthening the role of SFIC as a platform for developing and implementing a common EU-MS strategic approach;
- balancing cooperation and competition objectives between EU Member States in relation to 3rd countries;
- opportunities and benefits of a coordinated approach to framework conditions for international STI including with respect to removing market barriers, action to facilitate standardisation and action to promote access to public procurement.

3.3.3. Developing a common approach to priority determination for international STI cooperation.

Consideration should include:

- methodological approach (i.e. principles and criteria for developing common priorities in international STI cooperation, including criteria for thematic and geographical targeting;
- developing a common approach to criteria to differentiate between potential strategic partners, or groups of countries, when developing strategic bilateral partnerships and the promotion of cooperation at regional level (i.e. what do we want to achieve and by what means of action?);
- balancing cooperation and competition objectives vis-à-vis 3rd countries in international STI cooperation; and,
- the need to adopt different approaches to cooperation for activities which are closer to the market or are innovation related.

3.3.4 Developing the support to and involvement of industry in EU international STI cooperation policy

Consideration should include:

- assessment of the availability of information concerning industrial investment in international STI cooperation (including international scoreboards);
- understanding the drivers for industrial international STI cooperation;
- the factors determining industry's choice of location of their R&D investments as compared to the factors leading industry to enter into cooperative R&D relationships with entities in third countries;
- comparison of the pattern of industrial investment in international STI cooperation with that of the EU and MS public sector;

- development of principles and objectives for promoting European industry interest in involvement in public/private international cooperation initiatives;
- assessment of the desirability, potential mechanisms and effective incentives to promote industrial involvement in EU-MS joint initiatives for international STI cooperation;

This action should involve consultation with industrial groupings and individual companies, possibly through the organisation (by the Commission Services) of a specific consultation event focused on selected technology platforms.

3.3.5 Additional topics

The Expert Group Chairperson will also be free to propose additional or alternative topics for the group to study/provide advice on subject to the agreement of the Commission representative(s).

Annex 2: Dimensions of strategic priority setting

<table>
<tr><th></th><th>Short-term
1-2 years</th><th>Medium
term
2-5 years</th><th>Long-term
5-15 years</th></tr>
<tr><td>Emerging fields/global challenges
(mix of top-down and bottom-up)
Primary research in emergence of new fields and/or paradigm shifts in existing fields and significant impact on the frontiers of STI, and in education.

Global challenges are primarily research intensive in nature. STI to address global challenges is largely embedded in international research efforts, which are mainly driven by nation states.</td><td></td><td colspan="2">• Focus on basic research
• Capacity building and infrastructure
• Investments in multi-user research facilities

• Primary participants:
S&T organisations universities, PROs

• Outputs: publications, patents

• No geographic limitations

Challenge driven research is less attractive for firms, especially where the intention is to generate public goods. Key actors from the private sector will only invest resources and take risks of project failure if they can expect a reasonable return in the case of success. On the other hand, swift diffusion of new products and processes is crucial to have a significant impact on global challenges. Diffusion may be hampered if prices for innovations are too high and there are no funding mechanisms to make them broadly available.

Leadership in these sectors is yet to be determined, because it is still nascent, and limited to long term basic-research.</td></tr>
<tr><td>Infrastructural challenges

Capacity building and retention (primarily top-down)</td><td colspan="3">Focus is on reducing brain-drain from Europe, of scientists, engineers and entrepreneurs by making available opportunities and conditions for researchers and scientists and entrepreneurs to return to EU after training abroad

Retention of non-EU citizens with advanced degrees from European institutions
ERA and MS policies to be supplemented by EU policies</td></tr>
<tr><td>Horizontal actions (primarily top-down)</td><td colspan="3">EU to work with counterpart funding agencies in other countries to lower barriers to collaboration for scientists, engineers, and students, and encourage jointly funded, and multilateral projects, and address IPR issues</td></tr>
</table>

KETs (key enabling technologies) **Primarily bottom-up)** Where the themes reflect existing research competencies and capacities and maintaining or catching-up competiveness in crucial, specific technological areas, there should be a much stronger bottom-up approach, because of short life cycles means that time-to-market is important. The priority should be the technological competences of the partners, as judged by the EU partners, rather than geographical or national level issues.	**Focus on development and product/processes that are close-to-market** Interaction between customer-suppliers on development and market-adaptation innovation project	**Focus is on applied research** Establishment of EU based Centres for knowledge transfers built around communities of practice. These centres build strong partnerships with industry, national laboratories, and international centres of Excellence Objective is to promote complex interactions between researchers and users. The more sustained and intense the interaction between researchers and users, the more likely the research results will be used. Secondary objective is SME-driven: SMEs cannot afford to spend resources on long-term research projects, because short-term imperatives mean that resources simply are not there to invest in these areas. Resources (time, money, and so on) to address short-term goals reduce the ability to draw on resources for long-term goals. Focus is on global production networks and global value chains, where joint innovation activity is core to longer-term participation in GPN or GVC Focus is on 1. EU SMEs acting as suppliers to non-EU GPNs 2. Non-EU suppliers to EU-centred GPNs and GVCs Objective is to reduce transaction costs	
Generic technology and interdisciplinary standard-setting **Primarily bottom-up)**	**Establishment of voluntary standard-setting**, driven by firms - focus is on Customer-supplier networks:Internal (GPN, MNE, or keiretsu) standards Also extends to helping EU firms meet standards set by non-EU firms.	Pre-competitive voluntary standards setting in nascent sectors	

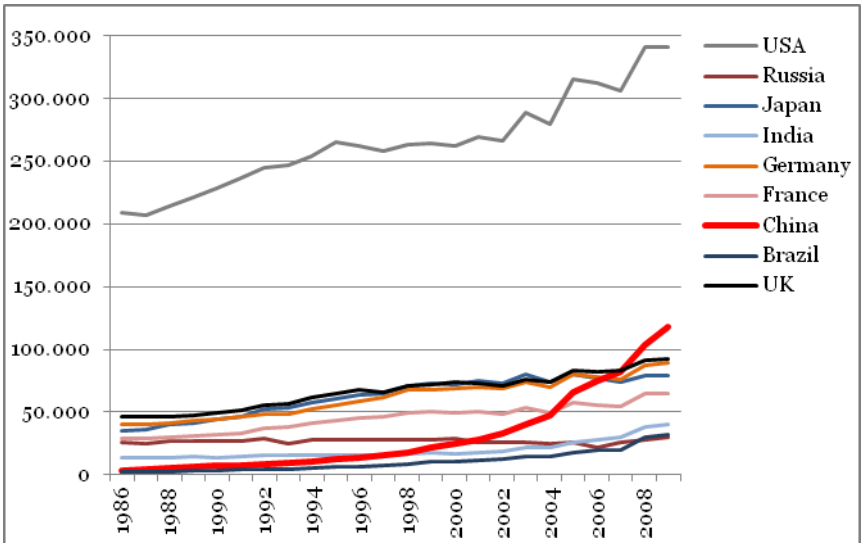
Annex 3: Trends, Drivers and Impact from Internationalisation of STI[31]

Trends in the Internationalisation of Science

The US and the EU have for decades led the world in production of scientific knowledge in both quantity and quality terms. However, in quantity terms, both the US and the EU, and other developed nations have started to lose ground to Asia, particularly China. China has doubled its output since 2004 and now publishes more than any other country apart from the US. Publication frequency has also risen in other emerging nations such as Brazil, South Korea and Turkey.

China's growth is particularly impressive in targeted disciplines, notably engineering, chemistry and physics. China is focusing its knowledge base building up in key technologies such as material sciences. China and other Asian countries are for now only very modestly making inroads into the top quality segments. However, in specific fields, engineering being the prime example, the top segment is also contested. China and other Asian countries are already having a significant impact on this discipline, and the gap between China/Asia and the EU/US is closing fast. Tsinghua and Beijing Universities are the chief targets to become world's top universities. Both are already listed among the top 200 in the Shanghai Ranking of Research Universities.

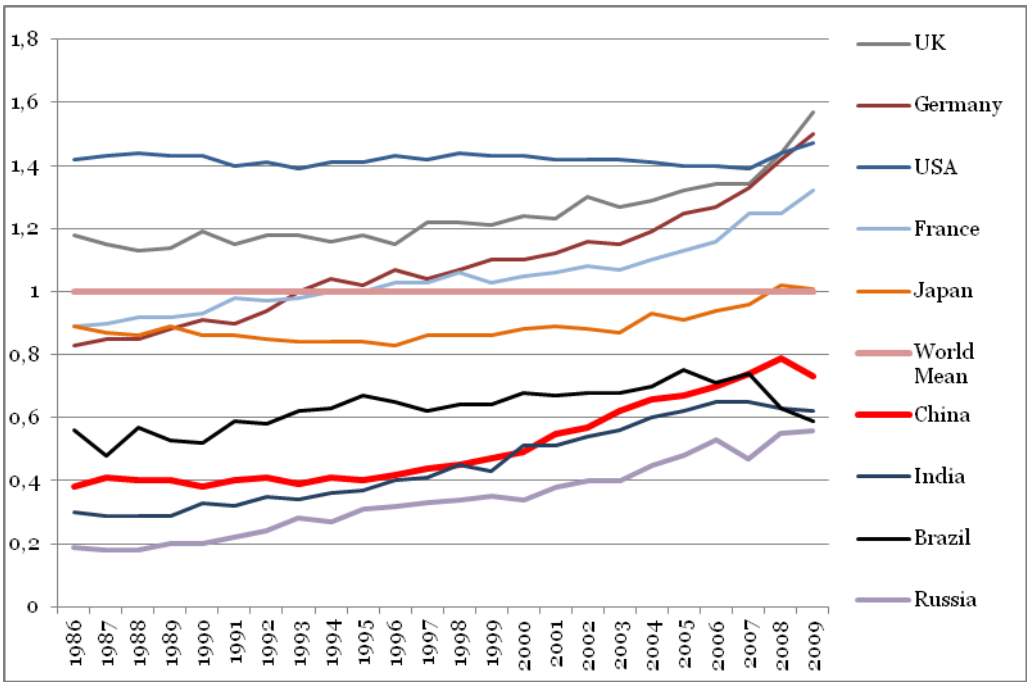
Figure 1 Publications in the Web of Science, 1986-2009



Source: Thomson Reuters Web of Science; cited from evaluation of NSFC

[31] By Reinhilde Veugelers, see also Veugelers (2010) Bruegel Policy Contribution and the references cited therein.

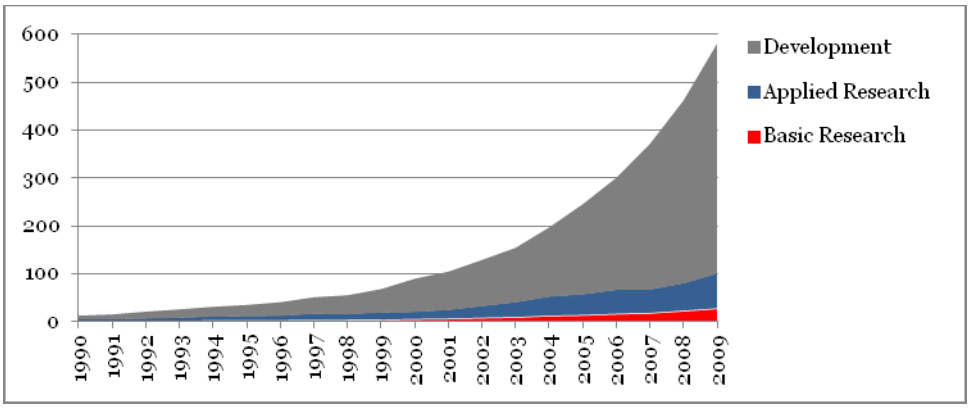
Figure 2 Relative Impacts of National Publication Relative to the World, 1986-2009



Source: Thomson Reuters Web of Science

The rise in the scientific output of Asia and particularly China, correlates with substantial investments by these countries in building up their scientific and technological capacities. South Korean R&D spending has increased steeply, and China's R&D/GDP ratio has more than doubled in the last decade.

Figure 3 Growth of Research and Development (GERD) in China, 1990-2009



Source: China Statistical Yearbook on Science and Technology (1992-2010), National Bureau of Statistics and Ministry of Science and Technology

China has more than doubled its research workforce. It now has as about as many researchers in its workforce as the EU and US: about 1.4 million. US universities import much of their scientific talent from abroad, particularly from Asia, and are therefore particularly worried about continuing to be able to fill their laboratories with imported brains. This concern,

however, is not so far justified by the data. On the contrary, the evidence shows that the international mobility of scientific talent is increasing. China's share of PhD degrees awarded by US institutions to foreigners continues to grow, being almost one third of all 'foreign' PhDs in the US in 2007.

The imperfect evidence available for Europe shows that the PhD student populations of EU countries have fewer foreigners compared to the US, and the origins of foreign PhD students are different, with a less strong Asian presence and geographic, cultural and political links being more important. Does the increasing rise of non-traditional science countries manifest itself in changing patterns of international scientific collaboration? A first important observation is an overall increase in international scientific collaborations. Nevertheless, there is a marked inertia in the choices of partners. International co-operation networks are sticky and only gradually change. They are heavily correlated with human capital flows, geographic proximity and sensitive to policy-support.

Intra-EU collaboration has substantially increased over time, suggesting progress has been made in building the integrated European Research Area (ERA). But this has happened at the cost of diversion from extra-EU collaboration. The emerging scientific powerhouses, particularly China, are still relatively under-represented as partners for the West. China's collaboration is mostly with other Asian economies. Its collaboration with the US has increased over time on par with the growth of its own scientific power. The EU's collaboration with China remains at a far lower level than it could be, considering the growth of China's scientific power.

Impact from Internationalisation of Science

In the open US science model, foreign born are a critical source of the US S&E workforce. Not only do they contribute disproportionately to U.S. top science, there is also evidence that foreigners are increasingly responsible for US patents and US technology and engineering start-ups. They are also important sources to establish international networks for recruitment, collaboration, and ideas development. Foreign talent is thus vital for US science and innovation capacity. This is why the US fears the power of its S&T machine will diminish if the pool of mobile foreign talent entering the US dries up. There is no clear evidence so far to justify this fear. For the moment, the rise of Asia's own capacity to produce S&E degrees does not seem to disconnect the US from the pool of potential Asian candidates to recruit from, on the contrary.

A virtuous circle thus seems to emerge: the US's top position in science is based on its openness to the best foreign talents, who stay long enough to make a contribution to quality science, and this top position keeps on attracting the best foreign talent. The increasing globalization of science allows the US open model to benefit from a larger and better developed global pool to recruit from and interact with.

The EU science has not managed to establish such a virtuous open model. But the impact extends beyond science into the R&D and innovation patterns of the corporate sector. The

S&T rise of Asia has translated into Asia becoming an increasingly attractive location for multinational companies' research activities.

Internationalisation of R&D and innovations by firms

Since the second part of the nineties, R&D expenditure by foreign-controlled affiliates has grown faster than their turnover in the OECD area, illustrating that R&D is one of the most dynamic elements in the globalisation process of large multinationals (OECD 2009, DB 2010).

The sector with the most internationalized R&D is pharmaceuticals. The EU business sector is the most internationalised on R&D spending. Most of the EU outward R&D-FDI is destined for the US and vice versa. However, if the EU has long been the major host for US foreign research and vice versa, the emerging markets and most notably China, are currently attracting also an increasing share of overseas outlays by MNEs. Survey evidence on intentions for R&D investments confirms the increasing importance of emerging markets (UNCTAD 2005, EUI 2004, McKinsey (2006)).

With the share of R&D activities by MNEs located abroad on the rise, and with R&D expenditures from foreign controlled firms increasing much faster than those from firms under national control, foreign controlled R&D becomes an increasingly more important part of the R&D landscape in many recipient countries. This holds particularly for small countries, but not exclusively. For instance in the UK, it is thanks to R&D investment by foreign affiliates that overall business-sector R&D continues to grow.

International collaboration in R&D: a phenomenon on the rise?

A trend in the internationalisation of R&D is the rising number of cooperation agreements or alliances since the 1980's between partners residing in different countries (*e.g*. Hagedoorn and Schakenraad, 1990, 1993; Duysters and Hagedoorn, 1996). The increasing similarity of technologies across sectors and cross-fertilisation of technology between sectors, coupled with the increasing costs and risks associated with innovation, has led firms to consider international R&D alliances as a first-best option in many circumstances.

Through R&D cooperations and strategic alliances, leading international technological enterprises have created new solutions that allow for the rapid and flexible networking of institutionally or regionally scattered centres of competence. The formation of research joint ventures enables companies to pool resources and risk, exploit research synergies and reduce research duplication. It creates investment 'options' in emerging technology fields (Contractor and Lorange, 1988; Hagedoorn et al., 2000).

Companies are increasingly carrying out joint R&D projects with the best possible partners, who can be other firms or science partners. This search for best partners is done at a global scale. From a traditional transaction cost economics perspective (Williamson, 1996) one would expect that companies are somewhat hesitant to enter into R&D partnerships with foreign companies due to the lack of control over long-distance, lack of trust between

companies from different countries and the high asset specificity of R&D. However, as increased international competition has led many companies to follow a strategy of gradual internationalisation, one can assume that this experience gradually also opens the way to non-domestic R&D partnerships (Hagedoorn and Narula, 1996).

The evidence shows that since the 80s the number of newly established international strategic technology alliances has increased considerably (Hagendoorn 2001), in line with the general boost in technology alliance activities. In relative terms, one could expect that, in the context of the overall importance of internationalisation to companies and their partnerships, the *share* of international R&D partnerships in the total number of R&D partnerships should also have increased during the last four decades. However, the past forty years indicate a somewhat irregular and slightly downward trend in the share of international R&D partnerships.

Changing innovative strategies of transnational companies

Given the prominence of large technology intensive multinational firms in STI capacity building, it is important to understand the *changing motives of firms to source and exploit technology abroad* within the process of increasing globalisation of STI, as described in the previous section.

Historically, multinationals (essentially US multinationals) tended to keep R&D in their 'home' country. This meant they could manage the risks of innovation and de-bug new products and processes with the minimum of transaction costs (Vernon 1966) and (rather incidentally) it also limited the extent to which they could suffer knowledge 'leakage' in distant markets. They would then successively 'roll out' new products and processes to plants abroad, doing only R&D for local adaptation at a distance. Later writers call this 'home base exploiting': the idea being that the foreign R&D builds on the position of the home country.

While most R&D abroad was associated with market-related motives (integration with foreign production, responsiveness to local demand and regulations), the increase in foreign R&D activities that emerged from the early 90s, could not solely be explained by demand related motives. The new evidence gathered shows that MNEs are establishing foreign R&D facilities, driven increasingly more by supply related motives; in an attempt to tap into knowledge and technology sources in centres of scientific excellence located worldwide.

These decentralized R&D activities have been defined as "home-base augmenting" (HBA) (Kuemmerle, 1996) or "asset-seeking" R&D activity (Dunning and Narula, 1995), as opposed to the more traditional "home-base exploiting (HBE) or asset-exploiting strategies. This correlates with a shift towards MNE subsidiaries that are R&D active, not just in incremental, adaptive innovations, based on development activities, but also in drastic innovations, creating basic generic know-how, where the subsidiary is as active as headquarters in external linkages.

In this new perspective, supply related motives, related to the presence of scientific and technological skills, become more important as location factors. Location decisions for this

type of R&D facility are based not only on the technological infrastructure of the host country, but also on the presence of other firms and institutions, which may create externalities that investing firms could absorb. When the purpose of R&D is to try and gain access to localised knowledge, firms will establish centers in proximity to universities or national laboratories. When instead they are supporting manufacturing and marketing activities R&D sites they will be located near a lead market or in a cluster of competitors.

The cost of R&D labour has been much discussed as a reason for multinationals to 'offshore' R&D but it appears that in developing markets the price of R&D labour quickly rises towards world levels. Western firms report not only lower labour costs and the importance of the growth potential of Asian markets, but also, and equally important, the quality of R&D resources and the proximity to universities and institutes (Thursby and Thursby, 2006). The rise of Asia's indigenous scientific capacity is therefore increasingly turning into a factor of attractiveness for locating corporate R&D labs abroad.

Some types of R&D are more likely than others to be offshored – for example, clinical trials seem to respond to cost levels (and probably also to the laxity of regulatory protection for patients). But it seems that the 'leverage' of R&D over huge amounts of production is so high that companies can often afford not to worry much about its relative cost. This will change as emerging economies offer greater amounts of well-qualified and experienced R&D workers, so EU policy needs to be robust against this change. The rate of growth in the Chinese research base is an important signal here.

Impact of the growing internationalisation of R&D and innovations by firms

The previous sections have made the case that increasing cross-border flows of R&D are a major trend and feature of the world economy. In many economies significant shares of domestic R&D are performed by affiliates of foreign firms. Likewise, firms are performing increasing amounts of R&D outside their home base. An important emerging dimension of these trends is a change in extra Triad relations. R&D and innovation activity are moving to a number of rapidly developing economies. The transition is not just in the changing scale of the internationalisation of R&D and its destinations, but also in its drivers. In the past, firms undertaking FDI tended to keep their major technology-creation activities in or close to their home bases. Nowadays, firms are relocating R&D to benefit from knowledge capabilities that are distributed across countries, either in partner companies or in public sector knowledge infrastructures. How will all this impact countries?

The trend toward increasing internationalization of R&D and the growing role of technology sourcing motives for internationalizing R&D would predict more potential danger to the host economy from loss over domestic innovative capacity. But at the same time, it also creates more scope for potential benefits since more technology transfers to the host locations are likely to occur, first because the host locations being selected by a MNE in a technology sourcing strategy will have a stronger technology capability and thus are more likely to have the capacity to absorb international technology. In addition, they are interesting clusters for exchange of know-how in quid-pro-quo networking arrangements. However, if strong

competitors are located in these local clusters, MNEs will be more concerned to protect their core know-how to safeguard their competitive position.

When multinational firms are technology leaders and affiliates are located in countries with an insufficiently developed intellectual property rights protection regime, maintaining control over core technologies is a key issue, discouraging firms from localizing R&D abroad or inciting MNEs to prevent know-how leakage to the local environment. Foreign R&D labs are restricted in their technology activities, as the parent maintains control over key complementary technologies. Multinational firms adapt the type of activities located abroad in response to intellectual property rights concerns, with knowledge intensive and higher value added activities reserved for countries with stronger IPR regimes.

In general, it is fair to conclude that the results of technology transfers to host economies are not strong and robust, partly if there is poor absorptive capacity and a weak technological position of the host economy and in weak appropriation regimes, where the MNE will protect its core knowledge from spilling over. Compared to intra-industry spillovers, the potential for vertical (inter-industry) spillovers is much larger, as multinational firms will be more willing to upgrade and transfer knowledge to their local suppliers and customers in the value chain.

Countries that are net sources of foreign R&D investment are worried that the internationalisation of R&D may substitute for R&D undertaken at home. A consequence of outward R&D-FDI could be the reduction of knowledge intensive activities in the home country if MNEs decide to relocate advanced production stages from home to countries with a higher-skilled labour supply or with a better knowledge infrastructure. Furthermore the home country as a whole may lose control over a key technology and with it a strategic position in the international market. R&D capacities above a certain size are powerful in generating externalities in the form of thickening markets for innovation that will benefit the whole system. Delocalisation therefore deprives the home country of these externalities (Foray (2006)).

But at the same time, foreign R&D activities of MNEs may provide access to foreign technologies and they can therefore represent a channel for transferring knowledge back to the home country. The knowledge accumulated abroad AND transferred within the multinational organization from the subsidiary back to the parent, may leak outside the MNE's boundaries to other home country firms and institutions. Most of these spillover channels work better if the MNEs involved are locally embedded in their home market, and if home country firms have the necessary absorptive capacity. Empirical evidence for the UK shows that positive effects are much more likely to be found when the R&D-FDI is motivated by technology sourcing.

Annex 4: INCO Expert Group Industry Workshop, Brussels 17 April 2012: Summary of Issues Raised

This note summarises inputs from representatives of industry and European Technology Platforms at a meeting with some members of the Expert Group at DG-Research. It does not represent a comprehensive record of what was presented and discussed but includes some interpretation and is intended to capture the major issues of relevance to the work of the Expert Group. The companies represented were in biotechnology, aerospace, engineering and electronics, power generation and transmission, telecommunications services, forests and paper, construction and water. Most of the attendees were from large organisations; additional account should be taken of the perspectives of internationalising SMEs.

The Business Environment

The companies represented all work in global industries. The location of major demand has shifted from the Triad to the 'emerging' economies in many cases – both for capital equipment (power stations, planes) and for some consumer goods and services (mobile telephony). This implies a radical shift in how we think about industry and policy in Europe. For example, the major aircraft market in the world is now Asia, not the USA or Europe.

There is a strong need for companies to operate internationally in order to anticipate market needs, create local value chains at an early stage to support future business and shape future supply chains, benefit from the global talent pool.

The state and other customers are powerful in such markets, so market access is partly negotiated. In some industries, there is a need to do local sourcing, production or R&D. In the process, some knowledge and advantage are lost to others. In engineering, 'co-makership' – where companies in the supply chain take growing responsibility for the design as well as the manufacture of sub-systems and components – continues to become more important. This means there is on the one hand greater interdependence of systems manufacturers with their suppliers in their 'home' countries; on the other hand greater dependence on suppliers in emerging markets. These relationships may start as 'shotgun weddings' but can become sources of competitive advantage by shifting parts of the supply chain from high- to lower-cost regions. At least in some industries, technology sourcing is becoming increasingly global.

This engineering pattern is, however, not universal. Some of the industries represented were more science-based and process-orientated, having less scope for sharing technology with others in the supply chain, as inputs tend to be raw materials rather than sub-systems.

Some face important problems of access to raw materials, such as wood biomass for the pulp and paper industry. This can affect the location of production. All will be affected by rising real energy prices and the costs associated with mitigating climate change. More broadly, all were exposed to the implications of the 'challenges' (climate, energy, ageing – of infrastructure as well as people, etc) both because these affect product and process innovation and because they shape markets (including labour markets).

While policy discussions focus on the BRICs, especially China, this is a less meaningful category to industry, which is interested in internationalisation with respect to whatever markets it serves. There are other markets – for example the rest of Latin America and increasingly Africa – that need to be taken into account.

A concern that appeared in some industries was that European development and construction times are very long compared with best practice in some newly industrialising countries.

Location of R&D

So far, the international pattern of R&D has not shifted very far from the Triad. China is important for some of the European companies, but at this time they tend to be doing fairly low-level development and localisation rather than cutting-edge product and process development there. China, whether formally or informally, has the muscle to force major foreign suppliers to do R&D locally, even if it is hard for it to control what **type** of R&D they do. So the location of R&D is partly driven by the need to do R&D in order to get market access.

It seems reasonable to expect that over time the R&D that foreign companies do in China will become more sophisticated. India is way behind China in terms of foreign companies doing local R&D while Brazil tends to be rather autarchic in R&D terms. But this will not always be the case. At varying rates in different industries, R&D by both local and international firms will increase not only in the BRICs but also in other locations such as South Africa, and potentially one or two other African locations. Policy will need to anticipate this change. Where necessary, it will be useful to build scientific links ahead of this happening.

Multinationals often do small amounts of 'monitoring' or 'scouting' R&D in demanding markets to understand potential demand as well as R&D that is physically near to excellent research organisations with which they see value in cooperating.

Research Cooperation

The Framework Programme is important for most of the companies present. However, it is slow moving and consensus based. It is not very effective at inducing disruptive change.

The companies are generally interested in cooperating with excellent research groups in their field. The criterion is primarily excellence rather than geography, so while in the short term that cooperation will be focused on the USA and Europe, over time it will stretch geographically out to the rest of the world. One science-based company was especially vigorous in seeking out ideas and technology worldwide. Often this resulted in licensing rather than a deep cooperation. It is based more on buying information than on establishing lasting relationships. Other co-operations are longer lasting.

Different cooperation partners were chosen for different reasons, which might be access to science, standardisation, access to technology, supplier development, technology testing or pilot development.

Access to IPR was in many cases a reason for cooperating but IPR could also be a reason **not** to co-operate, in particular where potential partners could not be trusted, where the terms of the cooperation would not let the firm adequately protect background knowledge from its partners or where there was a risk that a university would claim rights – a problem especially in the USA under the Bayh-Dole Act.

Firm size helped determine the kind of co-operations that were possible. While large firms could take a strategic and long-term view of benefits, smaller ones needed co-operation to produce results of more immediate, shorter-term relevance.

Research cooperation would become easier if there was greater researcher mobility to build personal linkages.

Policy Implications

The companies were keen to emphasise that the first thing to do in support of the internationalisation of EU industry and the ERA is to continue to operate a strong (but of course administratively simplified) Framework Programme. STI funds should primarily go to EU companies, rather than funding non-Europe-based firms to compete with the EU. One aspect of investing in STI in Europe is to attract FDI and to continue to make it attractive for EU-based firms to remain in place.

Reciprocity in access to programmes was seen as important. There is lack of a clear distinction between policy to support development in poor countries and STI cooperation with developed ones. In the second case, the EU should only support cooperation with countries that allow EU organisations to participate in their programmes on a similar basis. The EU should devote efforts to persuading others to open their programmes as this would make international cooperation easier.

International cooperation plays an important role in converging efforts, reducing risk and setting standards. This is valuable and needs support well beyond Europe.

Researcher mobility schemes operating beyond Europe should be strengthened.

In line with the KETs discussion, companies wanted to see investment by the EU not only in R&D but also in pilots and demonstrations. These have benefits both for technological development and for standardisation.

The EU should lead projects aiming to set global standards and norms. This is an opportunity to take the initiative and have a decisive influence on the shape of such standards. The EU could also take the lead in projects addressing some of the grand challenges, where a global effort is beneficial for everyone. This is especially useful in 'horizontal' issues where IPR is not a major concern. More broadly, EU international projects should have clear and transparent IPR and exploitation rights. The EU should work towards more harmonised international rules and practices in relation to IPR.

The EU efforts towards innovative procurement should be mirrored in international activities – encouraging others to open their innovative procurement programmes also to EU firms.

In addition, the EU should pay attention to traditional trade and industry policy aspects such as reduction of trade barriers and encouraging entry.

Annex 5: Outcomes of a survey on SMEs

SME Inputs on how Future EU Research and Innovation Policy should Support Global Cooperation in Industrial Research

Following the industry workshop (on 17 April 2012, in Brussels) the EG members agreed that the input on behalf of SMEs is important and an additional effort should be undertaken in this regard. Thus, 10 SMEs from the ICT sector from Germany and 14 SMEs from Bulgaria (half of them from the ICT sector and the other half from various industries) were interviewed via e-mail, on the phone and face-to-face. All interviewed companies have well-established international activities. These interviews were organised as a complementary activity to the INCO Expert Group Industry Workshop.

The SMEs were asked the following questions:

1. What are the trends and underlying drivers (both technological and commercial) which push industry to internationalise STI activities?
2. Which factors determining the STI strategy (cooperation, joint venture, investment, acquisition, etc.) and specific geographic targeting?
3. What is the relationship between private investment and public intervention and assistance?
4. How the EU and other public authorities could best support the international STI cooperation activities of companies and how it might be best focussed?

The empirical evidence from Bulgaria and Germany supports the general understanding related to SME internationalisation and innovation:

- The market is leading as a driving force for internationalisation of STI activities, while technological factors appear to be 'secondary'. The commercial drivers are the most important ones for companies to internationalise their activities - firms seek to fill in market niches and find new markets for new products. An important aspect of the internationalisation is the 'localisation' to the market and the local realities. In this regard several companies stress the importance of having local partners and consultancy expertise on-site.
- Location advantages resulting from being embed in clusters is of utmost important for SMEs to generate ideas, avail assistance and gather information on international partners. This suggests that the cluster location helps the SMEs to overcome their lack of experience and resources to some extent in facilitating strategic networking prospects.
- Access to funding is highly important. SMEs with funding are more able to engage in international STI cooperation. It basically confirms past literature which suggests that

SME are usually constricted due to the limited resources available to them to pursue such international collaborations.

- The size of the company is also seen as a factor for going international and for international STI collaboration. Larger companies are the ones working with foreign partners and developing innovations. The small ones need some mediation for finding non-EU partners. This mediation should be sector-specific, facilitating the communication between potential partners, the exchange of know-how, as well as the access to information.
- The convergence of different technologies is considered an important driver of internationalisation of STI activities of the companies. As various independently developed technologies begin to converge, the companies that produce them begin to work together to bring new and innovative products to the market.
- Public support is often the initial reason for establishing new contacts with international partners, which in the end can also lead to lasting partnerships, also in the sales domain.
- A lack of adequate public support hinders STI internationalisation due to high risks taken; thus initial public assistance could encourage further private investments. The current mechanisms of public intervention and assistance are too long-term and exhaustive for being a real help in tackling the STI challenges at hand.
- SMEs are mainly engaged in "innovation“ part of the STI collaboration, suggesting a more exploitative strategy and rather limited exploration strategy, which is the "Science“ and "Technology“ part of STI. The extent and intensity of the STI collaboration however can depend on the market that the SME is serving as well as business the the SME is involved in.
- Since the sample does not allow us to analyse the sector specific influences, we cannot show how certain technology-intensive SMEs find it more important to pursue Technology-led international cooperation. However, we can confirm that on the whole Science-led international cooperation, where SMEs are engaged in research consortia dealing with new technology, application etc. is mostly absent.
- The interviews seem to confirm the relevance of the opportunities created for SMEs as a result of finding the strategic partner for international cooperation. In certain cases, it is the academic partner for developing new technology, innovation etc, , while for others it is the R&D consortia and FP7 projects which create opportunities for funding, markets etc.
- The dynamic environment for enabling such sharing of information and opportunities regarding international partners is critical for SMEs. Proximity to such sources seems to facilitate this.

European Commission

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In support of the preparation of the Commission Communication “Enhancing and focussing EU international cooperation in research and innovation: A Strategic Approach”, a high level expert group was established under the Chairmanship of Dr Sylvia Schwaag Serger.

The Expert Group’s remit was to provide advice and recommendations, including on the international dimension of the European Research Area, to facilitate the development and implementation of a more strategic approach to international STI cooperation.

The Expert Group strongly supported a more strategic orientation and offered key policy recommendations on a broad range of issues including: prioritisation, supporting openness, strengthening framework conditions, encouraging industrial participation, exploiting “variable geometry”, the importance of evidence based policy and greater integration of international cooperation in European activities

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