Roadmap for bilateral research cooperation

The Research Council of Norway


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Research cooperation with **China**

The Research Council has drawn up roadmaps for cooperation with eight priority countries outside of the EU/EEU: Brazil, Canada, China, India, Japan, Russia, South Africa and the US.

The roadmaps contain background information about the research policy and the research and innovation systems in the priority countries, Norway's cooperation with these countries, and an assessment of areas of and opportunities for cooperation. The roadmaps are intended to provide a basis for setting priorities and encourage more targeted cooperation with the selected countries.

The roadmaps are a follow-up of the white paper on research, Meld. St. 18 (2012–2013) *Long-term perspectives – knowledge provides opportunity*, which identifies these eight priority countries.

The roadmaps for international cooperation were approved by the Executive Board of the Research Council on 28 September 2014. More information about the Research Council's international cooperation is available at www.forskningsradet.no/internasjonalt

1. Key figures and summary of conclusions

KEY FIGURES		
Population in 2012	Inhabitants (mill.)	1 350.7
Gross Domestic Product (GDP) per capita in 2012	USD (thousands)	6.2
Growth in Gross Domestic Product (GDP) in 2012	Per cent	7.8

R&D EXPENDITURES		
R&D expenditures as a percentage of GDP in 2009	Per cent	1.84
Change in R&D expenditures 2002–2011	Per cent	425.6

INTERNATIONAL COOPERATION		
Grant proposals submitted to FP7, total	Number	1 398
Joint grant proposals with Norway submitted to FP7	Number	166
Projects awarded funding in FP7, total	Number	245
Joint projects with Norway awarded funding in FP7	Number	37
Success rate for China in FP7	Per cent	17.5
Success rate of joint grant proposals with Norway in FP7	Per cent	22.3

TRADE AND INDUSTRY		
Import of goods and services as a percentage of GDP	Per cent	27
Norwegian goods exports to China in 2012	NOK mill.	13 901
Norwegian goods imports from China in 2012	NOK mill.	46 944
Norwegian direct capital investments in China in 2011	NOK mill.	2 772
Position on Global Innovation Index 2014		35

In a relatively short time, China has emerged as a major actor in the research sector, and will soon surpass the US as the world's largest producer of scientific papers. Chinese research is becoming steadily more international and quality is climbing. At the same, it is clear that Chinese researchers collaborate less with researchers in Norway than in the EU States and the US.

China's significance will continue to grow in the future. The Research Council of Norway therefore recommends expanding and strengthening R&D cooperation with China. Measures should be targeted towards areas that are of strategic importance for China and that address global challenges to society. The Research Council also recommends focusing on building better relations with Chinese actors and boosting competency in dealing with issues relating to intellectual property rights (IPR).

The following thematic areas have been identified as promising for productive cooperation with China:

- Climate, the environment and environmental technology
- Energy
- Aquaculture
- Agriculture
- Polar research
- Social sciences and the humanities

Norway's greatest business interests vis-à-vis China are in the seafood, maritime, offshore, renewable energy and environmental technology industries.

Existing national funding instruments for Sino-Norwegian cooperation are:

- The bilateral Norwegian Programme for Research Cooperation with China (CHINOR);
- The UTFORSK Partnership Programme for strengthening links between higher education and research in international collaboration;
  Funding for long-term institutional cooperation on research (INTPART);
- The EU Framework Programme for Research and Innovation, Horizon 2020, is also an arena for cooperation between Norway and China.

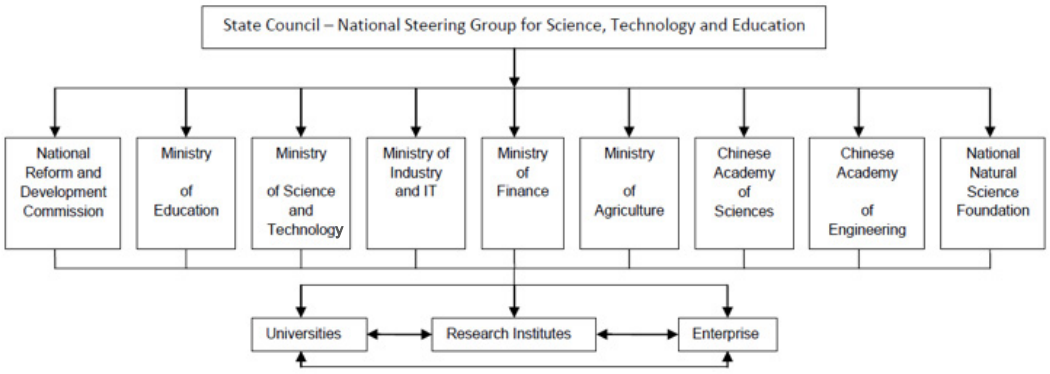
2. Brief description of China's research policy and research and innovation system

China has a centralised research and innovation system that is overseen by the national authorities. China's 12th Five-Year Plan identifies research and innovation, together with increased domestic consumption, as key instruments for promoting continued economic growth and sustainable development. The plan also prioritises international cooperation.

The responsibility for research and innovation policy lies directly under the *State Council*, in the *National Steering Group for Science, Technology and Education* (see Figure 1). The steering group is comprised of representatives of ministries and research institutions, and its activities are coordinated by the *Ministry of Science and Technology.*

Currently, China's research system consists of roughly 2 500 national universities and university colleges, 100 research institutes affiliated with the *Chinese Academy of Sciences* (CAS), and a number of other research institutes affiliated with other academies and sectoral ministries, for a total of 2.3 million researcher full-time equivalents (FTEs). China has significantly revised funding schemes, launched competitive arenas, and established a range of research parks and incubators in large and medium-sized cities. Most major international corporations have established development activities in China.

FIGURE 1: RESEARCH AND INNOVATION SYSTEM



Chinese authorities with responsibility for research and innovation.

Medium-sized European companies have also established a presence or invested in China in recent years.

China has experienced major growth in research budgets in recent decades that has been greater than the general economic growth. The national research budgets have tripled in size since 2005. The budget of the *National Natural Science Foundation of China* has tripled since 2006, while CAS's budget has increased by 150 per cent since 2007. This increase in funding has been directed towards priority areas and has resulted in a larger number of students, particularly in undergraduate education. In 2010, 50 000 students completed their doctoral degree at a Chinese university, and there were 7 000 foreign doctoral students in China.

Investment in R&D has led to an increase in the number of publications in international peer-review journals as well as in the number of patents. In 2012, China was ranked second in the world in terms of output of scientific papers. Analyses of these scientific papers show that Chinese research is strongest in mathematics, engineering disciplines, chemistry and agriculture research, as well as in several humanities and social science disciplines. The quality of Chinese research varies greatly, but several of the large universities and research institutes have a top international standing.

In addition to national research policy and funding, there is also extensive research activity and funding in China's large provinces. Provincial-level science and technology commissions administer a significant amount of funding for research, technology development and innovation activities. Jiangsu and Zhejiang are the provinces with the largest number of R&D-performing companies. Jiangsu Province, Beijing Municipality, Shanghai Municipality and Guangdong Province receive the largest amount of R&D funding from regional authorities; each received over NOK 60 billion in 2009.

National research-funding institutions in China

Ministry of Science and Technology (MOST) operates in part as a research council and in part as a ministry. MOST provides funding to larger-scale projects in national priority areas, such as larger-scale infrastructure and other wide-ranging measures that are closely linked to national political objectives. It is primarily oriented towards the natural sciences and technology.

Chinese Academy of Sciences (CAS) is both a research-performing institution and a scientific academy. CAS is oriented towards the natural sciences and technology, and encompasses over 100 research institutes, a handful of universities and several national infrastructures (Key Labs and State Key Labs). Altogether, the CAS institutions employ some 40 000 researchers. In 2013, CAS surpassed the University of Tokyo as Asia's leading producer of articles published in the scientific journal *Nature*. Several CAS institutions have established cooperation with Norwegian institutions, and the Research Council issued a joint call with CAS on environmental and climate research in 2010.

Chinese Academy of Social Sciences (CASS) is both a research-performing institution and a scientific academy. CASS is now made up of 31 research institutes and 45 research centers, and cooperates with several Norwegian research institutions. CASS is often referred to as a think tank, and plays a special role as an advisor to the authorities on social and welfare policy reforms. The Research Council collaborates with CASS and hopes to issue a joint call on welfare research.

National Natural Science Foundation of China (NSFC) is a research council based on a Western model, primarily the US National Science Foundation (NSF) and the German Research Foundation (DFG), and adapted to Chinese conditions. NSFC uses independent peer-review procedures and provides funding for research activities at both universities and institutes. NSFC is oriented towards the natural sciences and technology. It was evaluated by an international expert

committee in 2011, which pointed out some areas for improvement and recommended that the foundation fund a smaller number of larger-scale projects rather than a large number of small-scale projects.

The four above-mentioned institutions all receive allocations directly over the national budget. In other words, MOST does not govern CAS, NSFC or CASS. MOST and NSFC fund research by organising competitions and awarding funding. CAS and CASS may also seek funding in these competitions, along with other institutes, research centres and universities. As both CAS and CASS are also scientific academies, membership of and honours bestowed by the academies are prestigious in China and define a scientist's reputation and, to some degree, his or her opportunities to obtain research funding.

Polar research is primarily administered and financed by the *State Ocean Administration*, which owns the *Polar Research Institute of China* (PRIC). An increasing amount of polar research is being carried out at the universities.

National plans of importance for innovation and research in China

There are two important national planning processes of relevance for research policy: the economic five-year plans and the *Medium- and Long-term Plan for Science and Technology Development*. These incorporate slower economic growth (seven per cent annually) than we have seen in the last ten-year period. The Chinese authorities are planning to invest significantly in modernising industry and building important social institutions to further develop the social welfare system. Research and innovation are the most important drivers for sustaining economic growth named in the *Twelfth Five-Year Plan*, which was presented in 2011.

The realisation of the five-year plan will require extensive political and institutional reforms. China is seeking to base its economy on more sustainable development, more high-tech exports and increased domestic consumption. Ensuring a secure, stable energy supply with significantly lower CO2 emissions is a key point. Continued substantial growth in research and education is planned. The target is a gross domestic expenditure on research and development (GERD) of 2.2 per cent of GDP by 2015 (up from 1.7 per cent in 2010).

The plans emphasise that the entire research and education system must be upgraded and modernised, among other things because China will need greater scientific capacity in a number of fields. The importance of international cooperation for enhancing quality in the R&D system in general and for developing the country's innovation system in particular is stressed.

China's plan for science and technology (S&T) development (for the 2006–2020 period) lists a number of thematic priorities.

Many of the highest-priority topics are in alignment with Norway's priorities.

China's S&T plan also places priority on the three *technology areas of ICT, nanotechnology and biotechnology*, which also harmonises well with Norway's priorities.

FIGURE 2: THEMATIC PRIORITY AREAS IN CHINA'S SCIENCE AND TECHNOLOGY (S&T) PLAN

CHINESE NATIONAL MEDIUM AND LONG-TERM S&T DEVELOPMENT PLAN OUTLINE (2006–2020)
Thematic priorities
1. Energy
2. Water and mineral resources
3. Environment
4. Agriculture
5. Manufacturing
6. Transportation
7. Information industry and modern service industry
8. Population and health
9. Urbanisation and city development
10. Public security
11. National defence

3. China's strengths and weaknesses in research and innovation, and the country's international standing

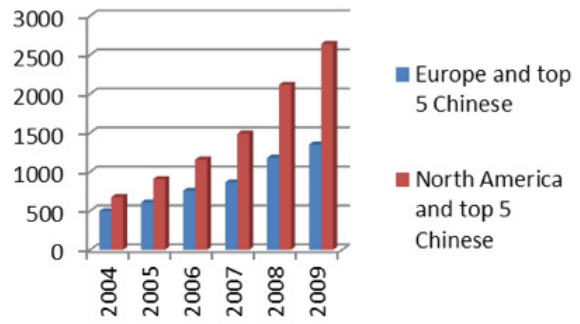
International standing and cooperation

China's research system is undergoing rapid change, with a trend towards increased research activity, enhanced quality and increased international cooperation. Against this background, the bibliometric study conducted by Science-Metrix for the Research Council (2014) defines China as a key scientific partner with which Norway should expand future collaboration.

In the near future China is expected to replace the US as the country with the highest scientific output in terms of the number of publications. Although the scientific impact of Chinese researchers is still lower than the world average in most areas, it is on the rise.

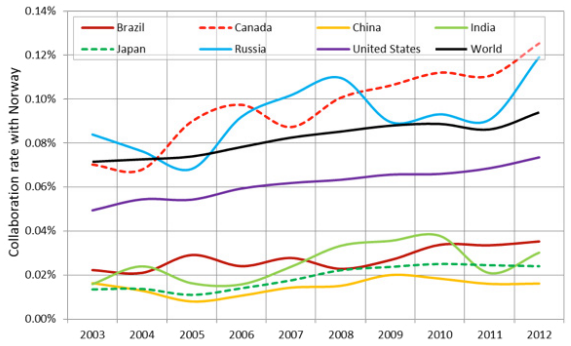
The bibliometric study shows that China is among the countries with the lowest international collaboration rate. The share of scientific papers published with an international co-author has remained at just under five per cent during the past ten years. This trend also applies to co-authorship between Chinese and Norwegian researchers; China's collaboration rate with Norway is low compared with that of other countries, with a gradual increase since 2005 (see Figure 4). The bibliometric study notes that China shows a certain

FIGURE 3: TOP FIVE CHINESE RESEARCH INSTITUTIONS' CO-PUBLICATION WITH EUROPE AND NORTH AMERICA (NO. OF PUBLICATIONS)



(Source: Schwaag Serger, Vinnova, 2011)

FIGURE 4: COLLABORATION RATE WITH NORWAY AS A SHARE OF THE COUNTRY'S TOTAL OUTPUT IN SCOPUS



(Source: Bibliometric study, Science-Metrix, 2014)

affinity for Norway, with more co-publishing than expected given the size and publication patterns of the two countries.

It is important to point out that China's scientific output is so large that in absolute numbers China's number of co-publications with other countries is among the highest in the world. China's collaboration with North America is increasing more than its collaboration with Europe (Figure 3).

China has some of its highest output in the theme *Nanotechnology & New Materials*. Measured by the number of publications per year, China has already surpassed the US in this field. China is also one of the countries with the highest specialisation index scores in this theme as well as a relatively high impact score. *Information & Communication Technologies* and *Energy* are also themes of interest, in which China has a high output and a high level of specialisation as well. *Environmental Technology* is another theme in which China performs fairly well on all indicators and which is of interest to Norway.

Strengths and weaknesses

Quality: Chinese research is strongest in natural science and technology disciplines, and particularly strong in applied mathematics. Chinese research groups also rank above the world average in inorganic chemistry, nuclear science, engineering science and agriculture. Quality varies from research institution to research institution, with a few large, leading universities of top international standard.

Common thematic priorities: Norway and China share a number of priority areas and interests. In terms of technology, both countries prioritise ICT, nanotechnology and biotechnology. Further, energy, the environment, agriculture and health top the research agendas in both countries. Moreover, China is the world's largest aquaculture nation, and Norway and China may have a common interest in collaborating on developing this industry. Last but not least, the countries have shared interests in marine and polar research, areas in which Norway has a leading research policy role and where cooperation between the two countries may be further strengthened.

Innovation: The authorities in China are very concerned with making a successful transition from production of inexpensive copies to innovation and production of quality products. This has been a priority in the most recent medium- and long-term plans for research in China. Although many Norwegian business actors have established a presence in China, they are only involved in research and development to a very limited extent.

Regulations: Norwegian actors in China must familiarise themselves with rules and regulations, authorities and competitors. Companies that are dependent on licences or other approvals may suddenly find their licences being rescinded. Norwegian research institutions have selected another model, establishing cooperation with leading Chinese universities and research institutes.

IPR: Another challenging area for Norwegian actors seeking increased cooperation with China involves *intellectual property rights* (IPR). Competency in and strategies for IPR and commercialisation cooperation are vital. The EU has issued a special guide on how to address IPR issues when collaborating with Chinese actors.

4. Existing cooperation with China

Research cooperation between China and Norway exists in a number of areas. It has primarily emerged from and is driven by contact between individual researchers in the two countries and is funded by the Research Council of Norway, the EU Seventh Framework Programme for Research and Technological

Development (FP7), and the EU Framework Programme for Research and Innovation (Horizon 2020).

In addition to the most heavily funded areas of environmental, climate and welfare research, Chinese and Norwegian researchers collaborate in the areas of polar research, architecture, design, drama, Nordic language and culture, ICT, biotechnology, nanotechnology, construction, energy, maritime research, agriculture, aquaculture, marine research, Chinese language and culture, human rights, minorities research, legal research, medicine, health services, rehabilitation, mathematics and upper atmosphere/space research.

In the years ahead it will be important to establish links between the Norwegian centre schemes – Norwegian Centres of Excellence (SFF), Centres for Research-based Innovation (SFI) and Centres for Environment-friendly Energy Research (FME) – and leading Chinese R&D institutions.

Bilateral cooperation
Activities in the areas of climate, climate technology, environmental and welfare research receive the most funding from the Research Council via the Norwegian Programme for Research Cooperation with China (CHINOR), which is funded by the Ministry of Foreign Affairs. Climate research projects also incorporate components of energy and polar research.

The Norwegian Centre for International Cooperation in Education (SIU) awards project funding to Norwegian higher education institutions seeking to cooperate with institutions in China. According to the SIU country report for China, there were more than 1 000 Chinese students in Norway and just over 300 Norwegian students in China in 2011.

The Research Council administers a mobility programme with the *China Scholarship Council*, which sends 10 scholarship recipients from Norway to China and 10 from China to Norway each year.

Multilateral cooperation
China has participated extensively under FP7 (245 projects), and Chinese participants have had their project costs partially covered by the EU. The success rate for Chinese applicants under FP7 was 17.5 per cent, somewhat lower than the success rate of joint grant proposals with Norway of 22.3 per cent. Chinese institutions will not have their project costs covered under Horizon 2020, and must finance their own project participation. This may result in decreasing interest in submitting grant proposals, so funding from China will be critical. The Science & Technology Section at the EU Delegation in Beijing is implementing a range of measures to counteract this development, including joint calls with MOST, CAS, NSFC and CASS that will have earmarked funding for projects with Chinese partners.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5. Grounds for considering cooperating with China

Norwegian research policy is targeted towards five strategic objectives in which research will be used to:
- Meet global challenges in the areas of the environment, climate change, oceans, food safety and energy in particular;
- Achieve good *health,* reduced social inequalities in health, and high-quality health and care services;
- Support research-based *welfare policy* and professional practice in the welfare services;
- Promote a knowledge-based industrial sector in all regions of the country;
- Encourage industrial development in areas relating to *food*, the *marine sector*, the *maritime sector, tourism, energy*, the *environment, biotechnology, ICT* and *new materials/nano-technology.*

The Research Council of Norway's Strategy for International Cooperation 2010–2020 identifies five main objectives for increasing international cooperation:
- Help to address global challenges to society;
- Enhance the quality and capacity of Norwegian research
- Boost the competitiveness of Norwegian trade and industry;
- Secure Norway access to international knowledge production;
- Promote Norway as a leading research and innovation nation in selected research areas.

Cooperation with China is of relevance in relation to the following objectives:

Help to address global challenges to society
The course taken by China in certain areas will play a critical role in global developments relating to the climate, energy distribution and food. If research cooperation with Norway can influence policy development in China in these areas in some way, this cooperation may in turn have an impact on global challenges in areas of major significance, such as international climate negotiations.

Enhance the quality and capacity of Norwegian research
China is the world's second-largest research nation, and cooperates most extensively with the US, Japan, Canada, Australia and Korea. Cooperation is particularly close with institutions on the western coast of the US (California) and Canada (British Columbia).

Quality-wise, China is strongest in *mathematics, agriculture, engineering disciplines* and *inorganic chemistry*. The country is now focusing most on *biotechnology, nanotechnology and new materials, ICT* and *industrial production*, all of which are rooted in the traditionally strong research environments. Cooperation between dynamic research groups in China and Norway will enhance the quality of research in both countries.

Secure Norway access to international knowledge production
Gaining access to knowledge production in China is not easy. It is important to establish mutual trust in the introductory phase in order to harvest the fruits of subsequent research cooperation.

A long-term perspective, institutional frameworks, mobility and education cooperation are elements that strengthen relations and build trust between actors. In areas where long-term cooperation has already been established, this cooperation should be maintained and bolstered in order to secure access to Chinese research.

China is building research infrastructure at a rapid pace, often in the form of *Key Labs* or *State Key Labs* run by CAS institutes or universities. The EU seeks to create closer ties between the *European Strategy Forum on Research Infrastructures* (ESFRI) and the Chinese infrastructure system, and has begun to map the infrastructures that already have European partners. Norway can assess whether bilateral cooperation on infrastructure or infrastructure cooperation via ESFRI is most expedient. Several Norwegian research groups have expressed interest in gaining access to Chinese infrastructure, particularly for DNA sequencing, but also for space and polar research as China already has one ice-breaking research vessel and another is under construction.

Boost the competitiveness of Norwegian trade and industry
There are currently 114 high-tech parks in China, which account for 10 per cent of GDP. These high-tech parks are now in a phase in which they are seeking more international contact. Innovation Norway has established an *Innovation House* in Shanghai, which is affiliated with a *Knowledge and Innovation Community high-tech park* located in the same district as two of China's most prestigious universities: Fudan University and Tongji University.

Using research cooperation with China as a door-opener for boosting the competitiveness of Norwegian trade and industry involves two types of cooperation: cooperation on developing new products or services and cooperation to gain a better understanding of China by learning about structures, preferences, actors, business and leadership culture, and rules and regulations. Such knowledge is essential to marketing a product or service successfully in one of the world's largest, most competitive markets.

In China, service production accounted for 43 per cent of GDP in 2012, a much lower figure than in the West. Although services make up a relatively small share of the Chinese economy, the market for knowledge-based services is growing. DNV GL, Nemko, Lloyd's Register Consulting – Energy (formerly Scandpower) and Statoil currently provide knowledge services in China, along with a number of Norwegian IT companies. Wikborg Rein and DNB have established offices in Shanghai. The SINTEF Group, Norwegian Geotechnical Institute (NGI), Norwegian Institute for Agricultural and Environmental Research (Bioforsk), Norwegian Institute for Air Research (NILU) and Norwegian Institute for Water Research (NIVA) currently deliver research-based knowledge services in China, particularly to local authorities.

China is the world's largest aquaculture nation, and aquaculture is a priority area for Norway.

6. Current priorities for Norway's activities vis-à-vis China

The Research Council's activities vis-à-vis China are carried out within a framework of priorities:

- The white paper on research, *Meld. St. 18 (2012–2013) Long-term perspectives – knowledge provides opportunity,* specifies China as one of Norway's priority countries for cooperation.
- The *Government's China Strategy* (2007) describes research as a means of achieving several of the strategy's aims, but increased research cooperation is not defined as a separate aim.
- *The Research Council of Norway's Strategy for International Cooperation 2010–2020.*
- *Bilateral country-to-country agreement* (Agreement of Cooperation (AoC) between the Chinese Ministry of Science and Technology and the Norwegian Ministry of Education and Research) under which climate, polar, environmental and welfare research are thematic priorities.
- The *work programme for the CHINOR programme:* co-funding of projects in the areas of climate, climate technology, environmental and welfare research.

7. Follow-up and implications

Introduction
China's importance will grow in the coming years, so measures to expand and enhance research cooperation between Norway and China are recommended.

The Research Council considers it vital to establish good relations as well as to target research cooperation towards thematic areas presumed to be of strategic importance for China. These are key factors for successfully strengthening research cooperation given the current political climate.

The above-mentioned bibliometric study (Science-Metrix 2014) shows that China is a country to be reckoned with and a rapidly evolving research nation. The study also shows that the collaboration rate between Norway and China is generally low (in 2012, 0.02 per cent of China's publications were co-authored with Norway, compared with 0.16 per cent for the EU-28), which may be grounds in itself for Norway to consider China as an important partner in all of the above-mentioned research areas.

The bibliometric study names China as a particularly relevant partner for Norway in *Environmental Technology* and *Nanotechnology & New Materials.* China is also considered an attractive partner for Norway in *Arctic & Antarctic Research, Health & Care, Food Sciences, Information & Communication Technologies*, and *Energy,* as the country scores high on a number of indicators in these themes.

Relevant areas for research cooperation

Climate, the environment and environmental technology are thematic priority areas under the Research Council's CHINOR programme, which runs until 2017. Both internal and external actors support further research efforts in the following thematic areas: the climate system; impacts of and adaptation to climate change; soil, air and water pollution; international climate and environment negotiations; emission reduction instruments and other mitigation measures. Input from external research institutes point to challenges related to urban development in China and a high level of air pollution. Norwegian researchers should contribute where they can in these areas in order to help to deal with Chinese and global challenges.

Energy is an area of interest, as China's rapid growth is accompanied by a growing demand for energy. This demand must be viewed in the context of the country's heavy dependence on fossil energy sources, particularly coal. Investment in environment-friendly energy and related research efforts is therefore of global importance. China is rapidly increasing production of intermittent renewable energy, which will create major challenges related to balancing and energy storage. These may be relevant topics for research cooperation with China. Other topics include: offshore wind power, solar cells, hydropower, environment-friendly renewable energy development, and carbon capture and storage (CCS). Norway possesses extensive expertise in CCS, which is an important cross-sectoral topic.

Aquaculture is a highly relevant area, as both China and Norway are major marine and aquaculture nations. Both countries are also interested in management and development of the fisheries, aquaculture and seafood industries. Norwegian aquaculture and fisheries research is world-leading and makes a vital contribution to international knowledge development. In dialogue with the Ministry of Trade, Industry and Fisheries, the Research Council has articulated a clear desire to establish research cooperation in this area. Multitrophic aquaculture and algae cultivation are also interesting topics for research cooperation.

Agriculture is a high-priority area for China, which is home to 22 per cent of the world's population but only has seven per cent of the world's land area at its disposal. The increase in food production in China in the past 35 years as come at a high price, causing environmental damage and health problems among farmers and consumers. Norway possesses extensive knowledge about the environment and sustainability. The Norwegian University of Life Sciences (NMBU) identifies food production, along with secure access to food, as relevant topics for cooperation with China. Other topics include food safety, sustainable agriculture and the bioeconomy.

Polar research is an area in which Norway is a global leader and where China is keen to cooperate. China has a long history of polar, ship technology and climate change research. In the field of polar research, cooperation on climate and environmental issues is of key importance. China was granted observer status in the Arctic Council in May 2013. It is a polar research nation with research activities and research infrastructure in both the Arctic and the Antarctic. China is developing its Arctic research profile in response to the growing interest in the region.

Social sciences and the humanities: There is ongoing cooperation on social science research between Norwegian and Chinese researchers at the institutional level. Within the framework of the Research Council's CHINOR programme, potential topics for research cooperation include: migration, mobility and working life, e.g. in relation to social rights; social inequality and poverty in relation to rural-urban dimensions and the expected increase in population concentration in China; demographic development, the family and labour market; and private and public provision of services. It may also be of relevance to provide funding for research on institutional perspectives, welfare policy development at various levels, and the ideologies and values on which the two countries build.

Innovation, industrial development and commercialisation of R&D

Norway's major *business interests* in China are in the seafood, maritime, offshore, renewable energy and environmental technology industries.

-Maritime and offshore: China is now the world's largest shipbuilding nation. The country is also building more and more rigs and FPSOs for the oil and gas industry. Research and technology development for green shipping/LNG as fuel for vessels is important, also in terms of developing the northern and Arctic sea route to China. There is potential for increased cooperation on petroleum research in the future, in the area of enhanced oil recovery (EOR) and in geophysics, mathematics and natural science disciplines, among others.

-Renewable energy and environmental technology: In the energy sector, CCS research and technology development is crucial, given China's heavy dependence on coal as an energy source for many years to come. It is also important in relation to offshore development in the East and South China Sea. All research and technology development for offshore wind power, wave power and tidal power is of interest to the Norwegian business sector.

-Seafood: In light of China's position as the world's largest seafood nation, research and technology cooperation related to aquaculture and fish health is of interest.

In the years ahead it will be vital to create ties between Norwegian Centres of Expertise (NCE) or the forthcoming Global Centres of Expertise (GCE) and Chinese research and technology clusters. This is particularly important in the maritime, offshore (subsea technology/drilling technology), and energy sectors.

Instruments

National research funding

The CHINOR programme (2009–2017), with its focus on climate, the environment, climate technology and welfare, has already allocated its existing budget through various funding announcements. The continuation of the programme for a new period after 2017 is desired, as is an expansion of the scope of the programme to encompass more research topics.

Many Norwegian and Chinese institutions have already signed separate cooperation agreements. The Programme for International Partnerships for Excellent Education and Research (INTPART) may emerge as an instrument for consolidating existing agreements and generating new ones.

The Research Council and the Norwegian Centre for International Cooperation in Education (SIU) collaborate via the UTFORSK Partnership Programme on establishing links between new educational components and existing research cooperation in China, among other countries. A continuation of the programme after the pilot phase will enable these links to be extended. By facilitating contact between Norwegian-educated international students and Norwegian students educated internationally, the NorAlumni networking platform, which is a collaboration between the Research Council, Innovation Norway and SIU, can play a key role in building relations with China.

Multilateral instruments

Cooperation with the EU: China has participated extensively in FP7 and is expected to make use of Horizon 2020 as an arena for international cooperation with Europe in selected areas. A comparison of publication patterns in the above-mentioned bibliometric study with the results of FP7 calls shows a low level of collaboration between Norway and China in the themes Arctic & Antarctic Research, Health & Care, Information & Communication Technologies and Nanotechnology & New Materials, although it was higher in the themes Environmental Technology, Food Sciences and Energy. Thus there is clearly a need for stronger focus in Norway on China in all these areas under Horizon 2020.

China and Norway are both members of the Belmont Forum. In addition, both countries are active members of the *International Institute for Applied Systems Analysis* (IIASA), which should open up the opportunity for joint initiatives between the two countries' researchers through this institution.

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