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Priorities, strengths and comparative advantage in Norwegian research, viewed in relation to the cooperation with South Africa

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Preface

This report is commissioned by the Research Council of Norway and the Norwegian Agency for Development Cooperation – NORAD (a directorate under the Norwegian Ministry of Foreign Affairs Research).

We were asked to write a paper about "Priorities, strengths and comparative advantages of Norwegian research, viewed in relation to the cooperation with South Africa".

In the report we describe the Norwegian R & D system, compare the scientific publication profiles of both countries, map the priority areas of the research cooperation agreement, look into co-authorship between both countries and analyse research areas that do not fall under the current priority areas.

The paper was presented at a joint workshop of the South Africa-Norway Programme on research co-operation. The South Africa-Norway Programme on research co-operation started in 2001 and is still going on.

Oslo, 21st of September 2005

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Director
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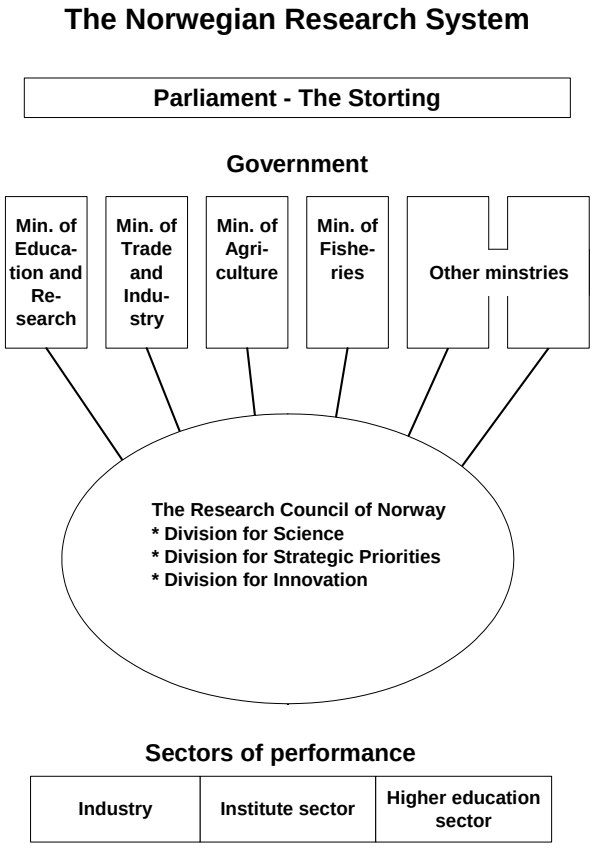
This paper deals with three issues: First it describes the Norwegian R&D system and discusses general trends and key issues in Norwegian research policy. Second, it compares comparative advantages of Norwegian research with comparative advantages of research activities in South Africa. Third, the paper ascertains research areas that do not fall under the current eight priority areas in the South Africa-Norway Cooperation Programme, and discusses this on the background of national priorities and the comparative advantages of Norwegian research.

1. The Norwegian research system and the current research policy

The basis for the current Norwegian research policy is a White Paper produced in 1999, outlining aims and measures for the following years. The Norwegian Government is now preparing a new White Paper, which will be presented before Easter 2005. In this document the present Government's research policy goals and strategy for the years to come will be outlined. Important themes in the new white paper will be international research co-operation, research based innovation, and the quality of research.

1.1 Description of the Norwegian Research system

Three levels can be identified in the overall Norwegian research system – the political level, the strategic level, and the performing level.



The political level
The Norwegian Government and the Parliament – the *Storting* – determine the overall aims and the policy for research. The various ministries of the Government are responsible for promoting and financing research in their respective areas. However, the Ministry of Education and Research has an overall responsibility for developing and implementing the Norwegian research policy and for co-ordinating research policy across the sectors. The Ministry also finances Norwegian universities and university colleges, in which about one quarter of all Norwegian R&D[1] activities is performed.

The strategic level
The Research Council of Norway (RCN) has a key function at this level, which is an intermediate level linking the political level and research performing entities. Important functions at this intermediate level are strategic research planning and allocation of resources for R&D. It also acts as a government adviser in science policy questions, identifying present and future needs for knowledge and research. Norway has – unlike most other countries – only one research council. The council covers all aspects of R&D, and funds basic research, applied research, as well as industrial research. About one third of all Norway's public sector research is channelled through the Research Council. In the reorganisation of the Council that took place in 2003, following an international evaluation 10 years after the merger in 1993 of all previous research councils into the one RCN, a stronger "customer orientation" towards the basic research community and industry may be detected.

The performing level
In the national research system of Norway the performing level is usually considered to consist of three sectors: the industrial sector, the institute sector, and the higher education sector. In total, the R&D expenditures in all the three sectors taken together amounted to 27.3 billion NOK in 2003. This corresponds to about EUR 3.4 billion. Less than 50 per cent of the R&D activities were funded by industry, slightly above 40 per cent by public sources, and 10 percent by other sources or from abroad. Altogether were about 50.000 persons involved in R&D in Norway in 2003. The number of R&D full-time equivalents amounted to about 30.000, of which 20.000 were performed by higher educated personnel (scientists and researchers).

The industrial sector. About half of all Norwegian R&D expenditure is allocated to industrial research. The Norwegian industrial structure is still characterised by industries whose activities are based on raw materials such as petroleum and gas production, and where relatively small resources compared to productivity are traditionally spent on R&D. There is a broad political agreement that the Government shall support and encourage increased research investment in Norwegian industry.

The institute sector. A characteristic feature of the Norwegian research system is the great number of research institutions *outside* the higher education system. Slightly below one fourth of the total Norwegian R&D expenditure in 2003 was spent in this sector. In international statistical terms the institute sector covers units from the Government and Private Non-Profit sectors, as well as non-profit institutions performing R&D within the Business Enterprise sector.

[1] Research and Development

The higher education sector. More than one fourth of all Norwegian R&D takes place in the higher education sector, mainly within the universities and the specialised university institutions. In some fields, like the humanities, almost all research takes place at the universities. R&D within higher education is mainly funded over the institution's ordinary budgets, but the Norwegian Research Council awards supplementary funding for equipment as well as for specific programmes. In recent years, contract research has become more important for the institutions in higher education. Universities and the specialised university institutions have a particular responsibility for basic research and for the training of new researchers, while the state university colleges carry out predominantly applied research linked to their regions or professional education.

Since 2002 Norwegian universities and university colleges have undergone a reform process to improve quality in higher education and research, and to meet Norway's obligation to achieve the aims of the Bologna Process. This *"Quality Reform"* covers both public (state) and private institution of higher education.

1.2 Current research policy – key issues

"Goal for growth". A prime objective according to the 1999 White Paper and the dominant issue of all subsequent budget proposals from the Norwegian Government has been to bring the total Norwegian R&D efforts up to the average level of the OECD by 2005. This goal is far from being fulfilled. The latest statistics available shows that the ratio R&D expenditure/gross domestic product (GDP) in Norway is 1.75 per cent, as compared to 2.26 per cent in the OECD. There has been an increase in the governmental appropriations for R&D during the last few years – in 2005 the growth came to a halt, however – but there has been no substantial increase in the R&D funding from industry. A high growth in Norwegian GDP has kept the R&D expenditure/GDP ratio at a level not substantially above that in 2000, despite increases in (public) R&D expenditure.

However, the objective will probably not be abandoned altogether. The Research Council of Norway recommends that the objective should be realized by 2010. The chairman of the RCN even recommends compliance with the 3 per cent aim proposed by the European Union for its member states. The new White Paper is expected to propose a new formulation of the goal for growth in Norwegian R&D expenditure.

An important new source of R&D funding, The Norwegian Fund for Research and Innovation, was established in 1999 with capital from the Norwegian Petroleum Fund. The fund contained NOK 31.8 bill. NOK by July 2003. The proceeds from the Fund reached in 2005 close to 2 bill NOK, nearly 15 per cent of total government appropriations for research that year. As the proceeds from this fund has during the last 3-4 years been a major source of discretionary funds for research, policies for the expenditure of these funds have in large part shaped general research policy in Norway. It was initially envisaged that the proceeds should in their entirety be distributed by the Research Council, whose overall budget has had a considerable increase due to this new funding scheme. However, since 2003 at least a third of the proceeds have been used to increase the institutional funding of research at universities and colleges, partly to finance the aforementioned Quality Reform from 2003 on. Both parts of the proceeds from the fund have to a very large extent been used to support long-term basic research generally, which has lead to an increase in the funding of sophisticated research equipment and positions for graduate students in all fields of research.

Four thematic priority areas. In addition, a part of these funds has been the major source of appropriations for the four thematic priority areas that were designated by the White Paper from 1999, namely: marine research, medicine and health research, information and communication technology (ICT), and energy/environment. Except for the funding by the Research Council of research projects within these priority areas it seems, however, difficult to establish to what extent these priorities have actually received an increase of funding. Since 1999 at least three additional thematic areas have *de facto* become large priority areas in Norwegian research: functional genomics (2002), nanotechnology/materials science (2003) and petroleum research (2005). The Research Fund has also provided the financial basis for the establishment of a new type of research units in Norwegian research, the establishment for a ten year period of 13 new Centres of Excellence within a wide range of research topics, from medieval studies to the physics of geological processes. These centres are an institutional innovation in Norwegian research policy to enhance the quality of basic research. Hence, they were selected on the basis of scientific quality alone. A new call is forthcoming for the establishment of additional centres from 2007.

Internationalisation. According to the Norwegian Government, internationalisation of research and international research cooperation are becoming increasingly important dimensions of Norwegian research policy. The most important arena for international research cooperation at present is the EU Framework Programmes for Research. Research cooperation with developing countries is promoted through the Norwegian Council for Higher Education's Programme for Development Research and Education (NUFU), which to a large degree is funded by the Norwegian Agency for Development Cooperation (NORAD). An essential part of the strategy to improve the quality of Norwegian research is to participate actively in international research organisations, programmes and institutions.

While participation in the EU's research framework programmes for research has become increasingly important, the research minister has warned however, not to play down the research co-operation with other regions, and taken initiatives to strengthen research collaborations with other geographical regions. In this context bilateral agreements are important instruments. Norway has also signed bilateral agreements on research cooperation with several countries. A new strategy for stimulating research collaboration with North-America has recently been published. China, Japan, Germany and France have been designated as the other priority areas for bilateral research collaboration.

A tax incentive to increase industrial investment in R&D. Compared to most other countries the R&D funding from industry is small in Norway. Norwegian firms are relatively small in terms of size and economical strength; many are traditional enterprises processing raw materials, see above. The R&D activities of these industries are generally lower than in modern high tech industries. Even if such industries have developed also in Norway, the relative impact of R&D intense enterprises is low.

The low level of the industrial investments in R&D in Norway has triggered certain measures from the Government. In 2002, a tax deduction scheme ("SkatteFUNN") was introduced to increase the R&D activities of private enterprises. The scheme is managed by the Research Council of Norway. The scheme has turned out to become very popular, and it is expected that the tax reduction scheme will have a favourable effect on the willingness of the enterprises to invest in research. The scheme will be evaluated in 2007.

Plan for a comprehensive innovation policy. During the 1990s Norwegian innovation policies became increasingly influenced by the so-called systemic approach to innovation. According to this view, technological advance and competence building are characteristic by interplay and mutual learning between different types of knowledge and actors, including firms, institutes, universities, sources of financing, relevant public agencies and more. According to this way of thinking, public authorities may encourage innovation by strenghtening industrial learning and by developing efficient networks for the distributing of knowledge and personnel.

The Government launched in 2000 a Plan for a Comprehensive Innovation Policy titled "From Idea to Value". An important aspect of the plan is to improve mechanisms for dialogue between administrative levels within the public sector, between the public and the business sector, and between the research and innovation communities. It is too early to assess the results of the government's initiative to frame a holistic, systematic innovation policy in Norway.

2. Research in Norway and South Africa

We will here present a bibliometric study of Norway's and South Africa's research activities, as scientific publication profiles can be used to investigate a country's research priorities, strengths and weaknesses in comparison to the rest of the world. In this part of the paper we will investigate and compare the publication profiles for Norway and South Africa. We shall analyse levels of activity and impact for the different research fields for both countries. We also intend to look into the selected priority areas and present a co-authorship analysis.

2.1 Norway's activity and impact profile for scientific publications

The analysis is based on the database National Science Indicators Standard Edition for 2003 from the Institute for Scientific Information (ISI). For the purpose of our analysis we used both activity and citation indicators from 1999 to 2003[2]. The activity is measured by a specialisation index: "This measure indicates whether a country has a relatively higher or lower share in world publications in a particular field of science than its overall share in world total publications" (Glänzel, 2000, p. 126). For measuring the impact of the different research fields we used a similar citation index (Sivertsen, and Aksnes, 2000b).

Following research fields have been distinguished:

AGD	Agricultural Sciences
ASD	Space Science
BID	Biology & Biochemistry
CHD	Chemistry
CLD	Clinical Medicine
CSD	Computer Science
ECD	Economics & Business
EDD	Education
EGD	Engineering
EVD	Ecology/Environment
GED	Geosciences
IMD	Immunology

LAD	Law
MBD	Molecular Biology & Genetics
MCD	Microbiology
MSD	Materials Science
MTD	Mathematics
NED	Neurosciences & Behavior
OTD	Multdisciplinary
PHD	Physics
PLD	Plant & Animal Science
PMD	Pharmacology
PSD	Psychology/Psychiatry
SSD	Social Sciences, general

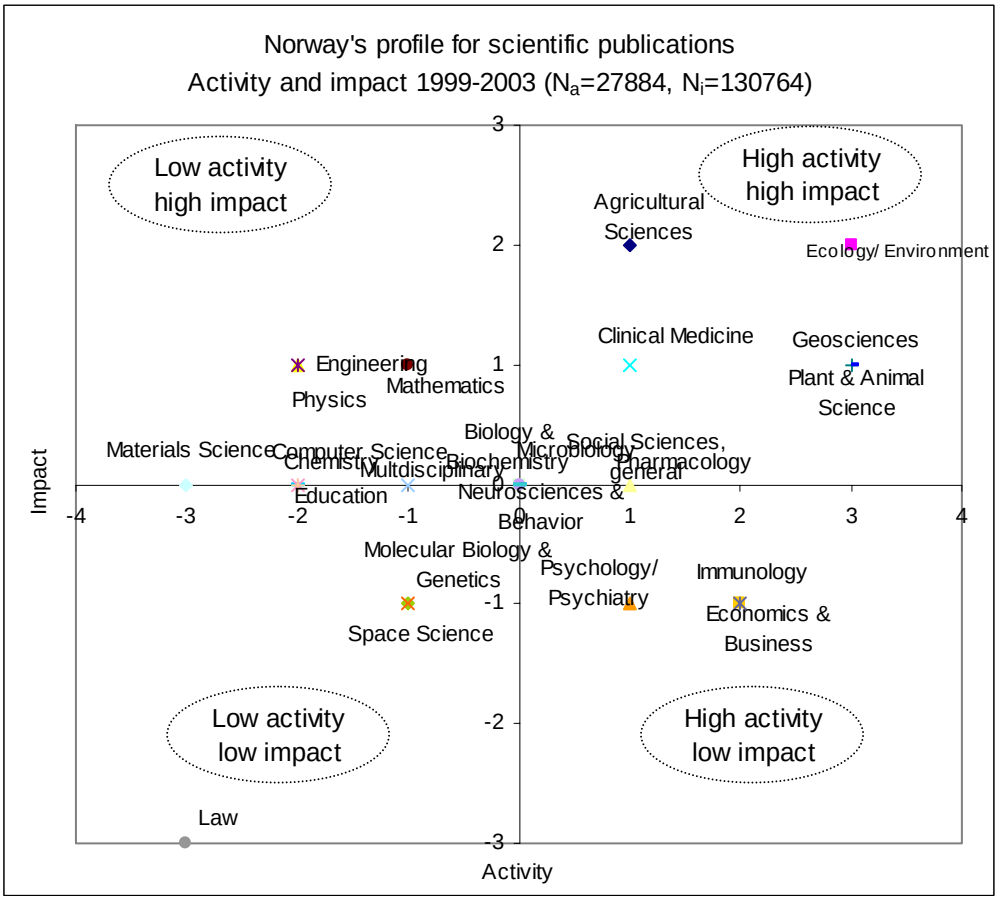
[2] The definition for the Activity Index is:

$$AI = \frac{the\_share\_of\_the\_given\_field\_in\_the\_publications\_of\_the\_country}{the\_share\_of\_the\_given\_field\_in\_the\_world\_total\_of\_publications}$$

The indicators were transformed in the following manner:

> 1,5	More than 50% over world average	+3
1,3-1,5	30-50% over world average	+2
1,1-1,3	10-30% over world average	+1
0,9-1,1	World average	0
0,7-0,9	10-30% below world average	-1
0,5-0,7	30-50% below world average	-2
< 0,5	More than 50% below world average	-3

By combining activity and impact index we can compare the position of the 24 different research fields in comparison to each other – both the level of activity and the level of international impact.[3] The results of the activity and citation index were transformed into standardised indicators. By plotting the indicators of the different fields in a diagram with a horizontal axe for the activity index and a vertical axe for the impact index (with a scale from -3 to +3 for both axes) we get an overview of the standing of Norwegian research.



Glänzel distinguished in an analysis based on publication data from 1987 and 1997 four patterns in national publication profiles (Glänzel, 2000, pg. 127):

1. the 'western model' with clinical medicine and biomedicine dominating
2. the model for former socialist countries and China with high activity level in chemistry and physics
3. the 'bio-environmental model' for developing countries with biology and earth and space sciences dominating
4. the 'Japanese model' with engineering and chemistry in the focus.

He identified for Norway a mixture of the western model and the bio-environmental model. The other three Scandinavian countries tend more to the western model. As a result of our analysis we can see that Norway is still quite strong in research fields related to the sustainable exploitation of its natural resources, but also in fields like clinical medicine, Social sciences, Pharmacology, Biology & biochemistry, Microbiology and Neurosciences and behaviour. Fields like chemistry, physics, material science and engineering have still a relatively low activity level, but they receive an impact which is at least around the world average level or higher. We can sort the 24 research fields in four groups:

1. High activity and high impact:
   Ecology / Environment, Geosciences, Plant and Animal Sciences, Agricultural Sciences, Clinical Medicine
   Some fields have high activity and an impact level around the world average: Social Sciences, Pharmacology
   Other fields have an activity level and an impact level which are both around the world average: Biology and Biochemistry, Microbiology, Neurosciences and Behaviour
2. High activity and low impact
   Immunology, Economics and Business, Psychology and Psychiatry
3. Low activity and high impact
   Engineering, Physics, Mathematics,
   Some fields have low activity level but an impact level around the world average: Multidisciplinary, Chemistry, Computer Science, Education, Material Science
4. Low activity and low impact
   Law, Space Science, Molecular Biology and Genetics.

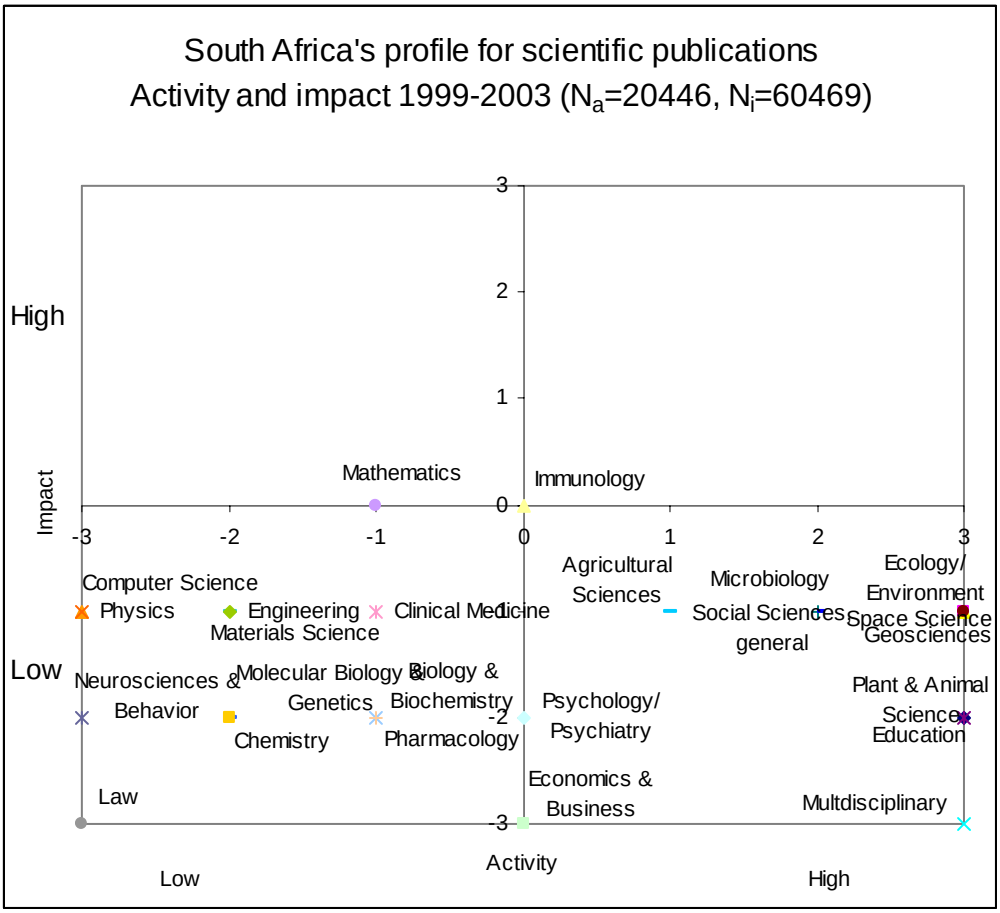
2.2 South Africa's activity and impact profile for scientific publications

We analysed the activity and impact level of research also for South Africa and plotted the results in a diagram.

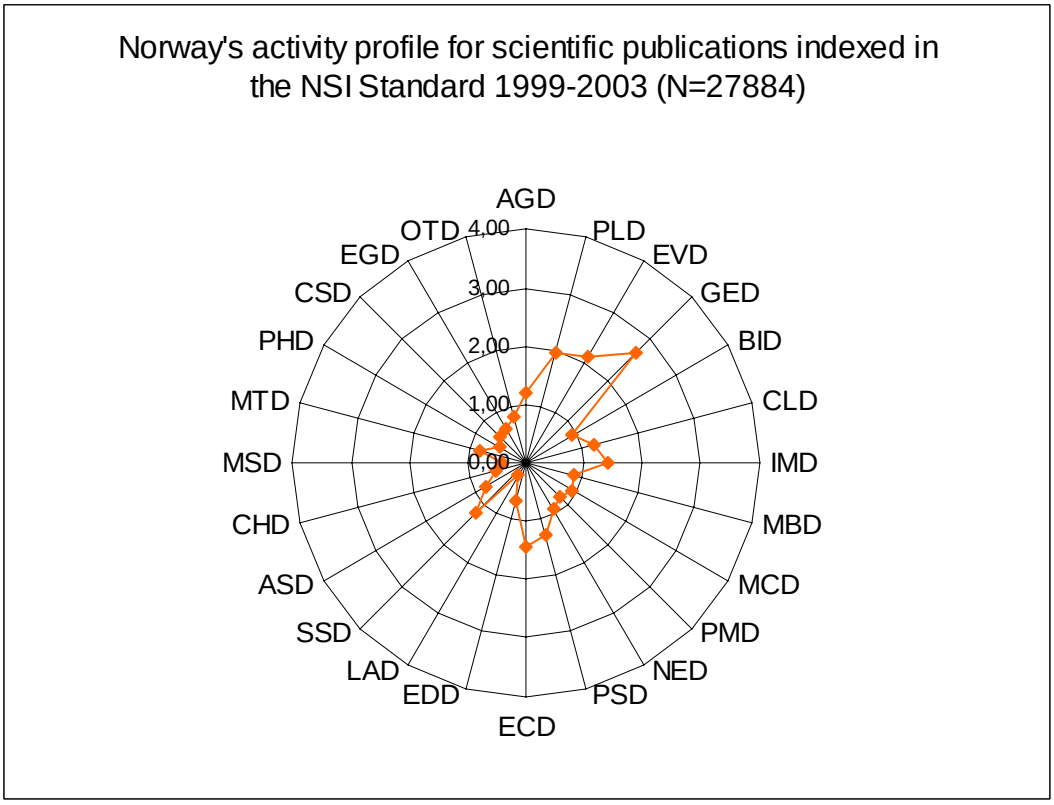
As a result we can see that South African research has a high activity level in fields related to the natural resources like ecology / environment, geosciences, plant & animal science and agricultural sciences. Glänzel suggested that South Africa's research is characterised by the mentioned 'bio-environmental model' (Glänzel, 2000, pg. 127). The achieved level of impact is still under the world average. Only immunology has both an activity level and an impact level around the world average. This can be understood on the background of the high needs for research in the field of HIV/Aids.

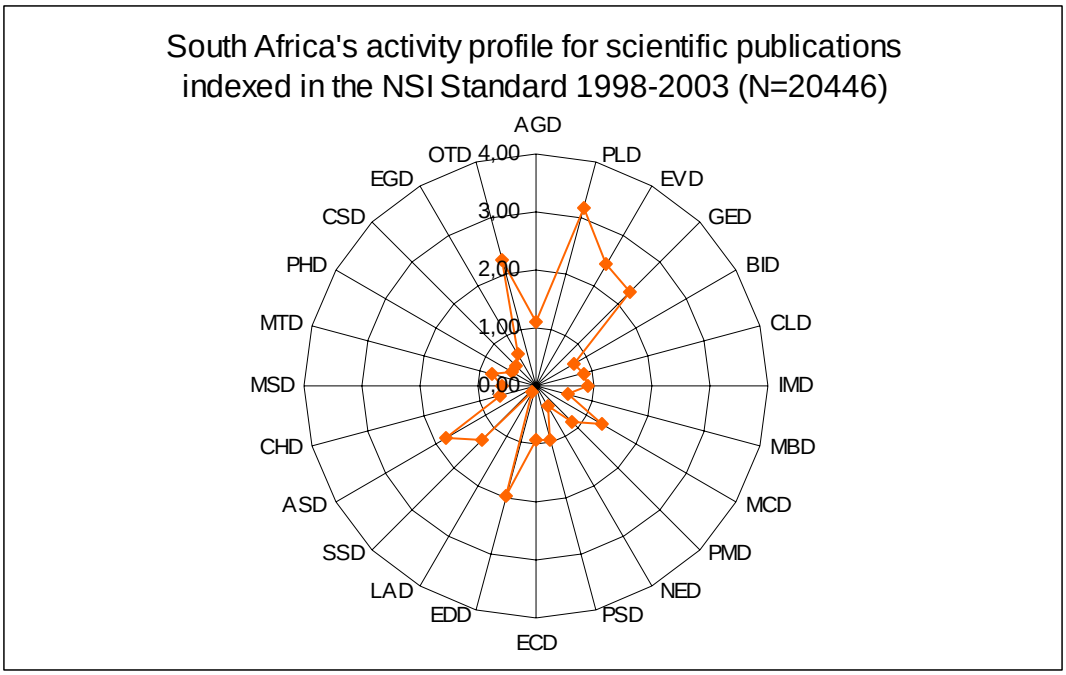
Additionally we would like to mention the high activity level for space science, education, social sciences, psychology / psychiatry and economics & business. Interesting is also the achieved impact of mathematics – despite of a relatively low level of activity.

An increased international co-authorship in fields with a high activity level could enhance the impact of these fields as has been shown for Scandinavian countries (Glänzel, 2000, pg. 135ff.; Sivertsen, and Aksnes, 2000a).



2.3 A comparison of Norway's and South Africa's research profiles





The comparison of the research profiles is again based on the relative specialisation index; the value 1.00 indicates the world average for a field. We could find some similarities: both countries have strong positions in the 'green' fields – agricultural sciences, plant & animal sciences, ecology / environment and geosciences. Both countries have also high activity levels in social sciences and economics & business. Fields in medicine are mostly around the world average, some of them marginally below and others above. Sciences like chemistry, physics or mathematics are below the world average. There are also registered low values for both countries for engineering and computer science.

The largest difference between the two profiles is probably the stronger position of space science, multidisciplinary research and education for South Africa in comparison to Norway.

Table 1: Norway's and South Africa's activity profiles for scientific publications indexed in the NSI Standard 1999-2003 (N_{Norway}=27884, $N_{SouthAfrica}$=20446) (Data: NSI Standard 2003)

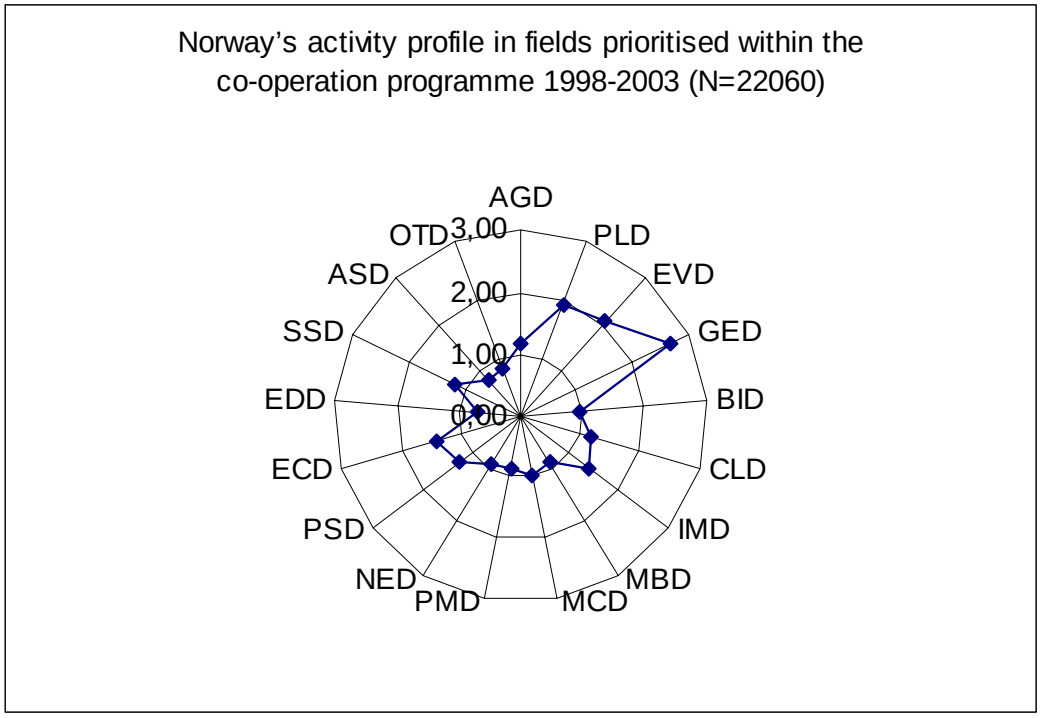
Research field		Norway	South Africa
Agricultural Sciences	AGD	1,18	1,10
Plant & Animal Science	PLD	1,94	3,16
Ecology/Environment	EVD	2,07	2,43
Geosciences	GED	2,66	2,30
Biology & Biochemistry	BID	0,94	0,76
Clinical Medicine	CLD	1,19	0,86
Immunology	IMD	1,40	0,91
Molecular Biology & Genetics	MBD	0,87	0,59
Microbiology	MCD	0,94	1,32
Pharmacology	PMD	0,82	0,87
Neurosciences & Behaviour	NED	0,91	0,43
Psychology/Psychiatry	PSD	1,25	0,95
Economics & Business	ECD	1,44	0,92
Education	EDD	0,69	1,95
Law	LAD	0,25	0,13
Social Sciences, general	SSD	1,19	1,32
Space Science	ASD	0,77	1,79
Chemistry	CHD	0,54	0,67
Materials Science	MSD	0,42	0,59
Mathematics	MTD	0,82	0,79
Physics	PHD	0,50	0,49
Computer Science	CSD	0,60	0,49
Engineering	EGD	0,67	0,61
Multidisciplinary Research	OTD	0,83	2,24

2.3.1 Selected research fields

According to the first bilateral programme for research co-operation between South Africa and Norway there are eight thematic areas given priority. These fields were Health and medical sciences, HIV/AIDS, Information and communication technology, Aquatic resources, Environment ecology and energy, Governance, democratisation and social development, Economic growth and globalisation and Education. Some of these fields are quite large, others are highly specialised. The definition of the 24 fields in the ISI database Science Indicators Standard Edition is rather rough. It is therefore difficult to use only the Science Indicators Standard Edition.

Therefore, we attempt to investigate the activity level for both countries in these selected fields with mixed methods: first we will highlight selected fields from the first analysis based on the Science Indicators Standard Edition; second we will present an analysis for selected fields based on Science Indicators Deluxe Edition where 105 fields are used; third we will use results from a search on ISI Web of Science for the field HIV/AIDS. Furthermore we will give results of an analysis of co-authorship between Norway and South Africa.

1. The comparison of the research profiles shows: strong positions in the 'green' fields – agricultural sciences, plant & animal sciences, ecology / environment and geosciences; high activity levels in social sciences and economics & business. Fields in medicine are mostly around the world average. The largest difference between the two profiles is probably the stronger position of space science, multidisciplinary research and education for South Africa in comparison to Norway.



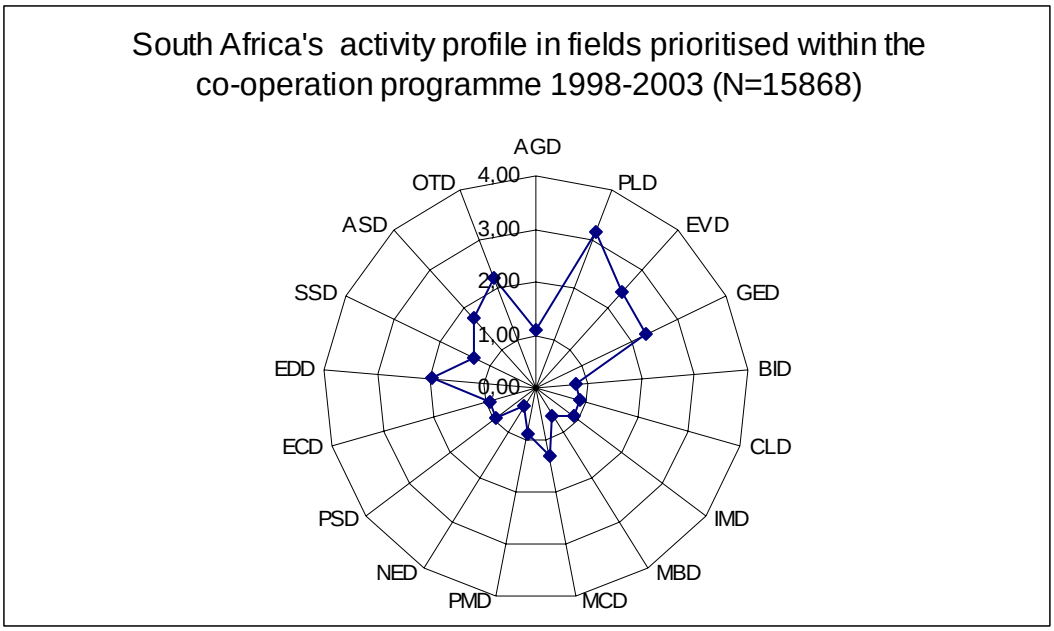


Table 2: Norway's and South Africa's activity profile for selected fields 1998-2003 (N_{Norway}=22060, $N_{South\ Africa}$=15868) (Data: NSI Standard 2003)

Field		Norway	South Africa
AGD	Agricultural Sciences	1,18	1,10
PLD	Plant & Animal Science	1,94	3,16
EVD	Ecology/Environment	2,07	2,43
GED	Geosciences	2,66	2,30
BID	Biology & Biochemistry	0,94	0,76
CLD	Clinical Medicine	1,19	0,86
IMD	Immunology	1,40	0,91
MBD	Molecular Biology & Genetics	0,87	0,59
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PMD	Pharmacology	0,82	0,87
NED	Neurosciences & Behaviour	0,91	0,43
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ECD	Economics & Business	1,44	0,92
EDD	Education	0,69	1,95
SSD	Social Sciences, general	1,19	1,32
ASD	Space Science	0,77	1,79
OTD	Multidisciplinary research	0,83	2,24

2. For a better coverage of the selected priority fields we used the Science Indicators Deluxe Edition 2003. Fields like economics and education differ not so much from the Standard Edition, but fields like Aquatic sciences and Information Technology & Communication Systems are not so visible in the Standard edition. Here we could identify very strong positions for the former for both countries, but rather low activity levels for the latter. The activity levels for Political science correspond to that of social sciences. In Environment / Ecology South Africa has a very high level of activity, even higher than Norway. But the impact of South African research needs to be improved. Only Aquatic sciences are at the same level as the world average.

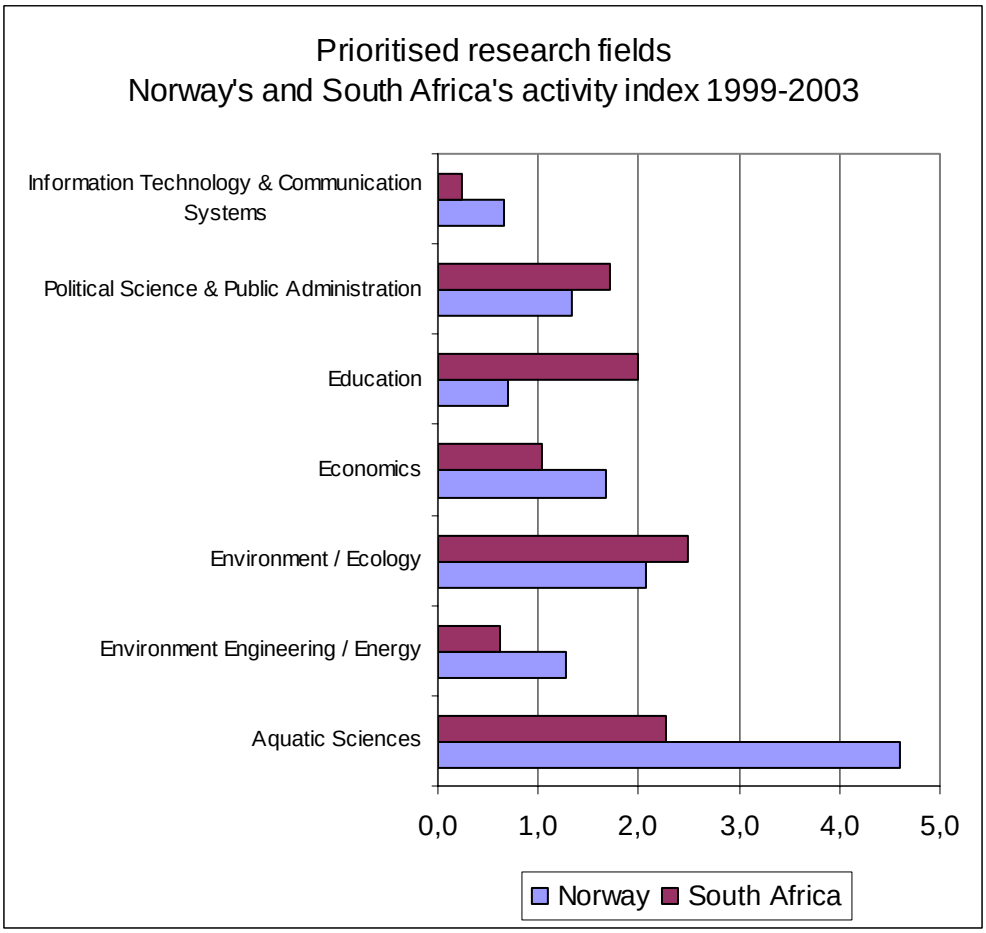
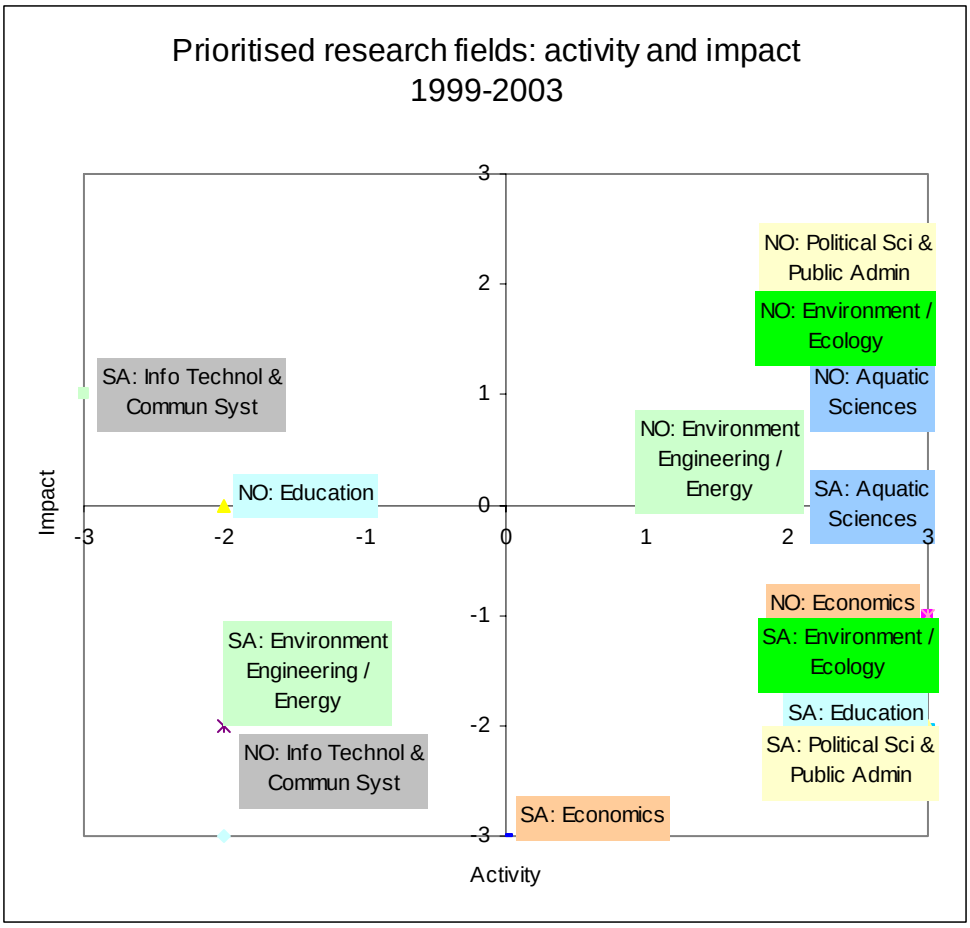


Table 3: Publications in prioritised research topics 1999-2003 (Data: NSI Deluxe 2003)

Research field	Norway	Norwegian papers	South Africa	SA papers
Aquatic Sciences	4,6	1432	2,3	506
Economics	1,7	439	1,0	193
Education	0,7	63	2,0	130
Environment Engineering / Energy	1,3	214	0,6	74
Environment / Ecology	2,1	1367	2,5	1180
Information Technology & Communication Systems	0,7	90	0,2	23
Political Science & Public Administration	1,3	188	1,7	172



3. The comparison of activity levels in the area HIV/AIDS is based on a search in the Web of Science database of ISI. We identified only 223 papers with HIV as a topic and a Norwegian author address from 1999 to 2005, but 1119 papers for South Africa in the same period.

2.3.2 Co-authorship between South Africa and Norway

Co-authorship analyses are used to document research co-operation between countries and institutions. We looked in the ISI Web of Science for documents co-authored by at least one author from South Africa and one author from Norway.
There were 141 co-authored papers indexed for the period 1999 to 2004. The co-authorship between South Africa and Norway has increased significantly since 1999.

1999	9
2000	16
2001	24
2002	27
2003	38
2004	27

Of these 141 papers were 121 articles, 11 meeting abstracts, 6 reviews, 3 editorial materials and 2 letters.

Following institutions were especially active with at least 4 co-authored documents:

Table 4: Most active institutions in terms of co-authored papers between South Africa and Norway 1999-2004 (Data: ISI Web of Science)

South Africa	Number of documents	Norway	Number of documents
University of Cape Town	39	University Oslo	29
University of Pretoria	15	University of Tromsø	25
South African Astronomical Observation	13	University of Bergen	21
University of Witwatersrand	12	Institute of Marine Research	9
University of Stellenbosch	10	Geological Survey Norway	8
University Natal	8	Norwegian Institute of National Resources	4
University Orange Free State	8	Norwegian University of Science and Technology	4
Rand Afrikaans University	7		
University Western Cape	5		
Groote Schuur Hospital	4		
South African Weather Service	4		

The co-authored papers were especially concentrated in medicine, plant and animal sciences, geosciences and ecology and environment. Interesting to mention is also the position of space sciences.

Health and medicine sciences is one of the priority areas of research collaboration agreement between South Africa and Norway and the co-authorship data – almost one third of all co-authored papers – show that these topics are indeed in the focus of the cooperating researchers from both countries.

HIV/AIDS is another priority area for research cooperation. The topic is quite important to the South African society, and 4 percent of all analysed South African scientific papers study HIV/AIDS. But HIV/AIDS is a topic in only 4 of the co-authored papers, Norwegian researchers independently have written only 223 papers in the same period (0.6 percent of all Norwegian papers). This means that here are still considerable collaboration opportunities in this area.

Information and communication technology was not visible in co-authorship study. According to the comparison of activity and impact levels have both South Africa and Norway a rather low activity level in that field, Norway has also a very low impact, but South Africa could achieve an impact above world average.

Aquatic sciences achieved both high activity and impact levels for both countries. The co-authorship study did not identify this field; the papers can be included in fields like environment, ecology or multidisciplinary sciences.

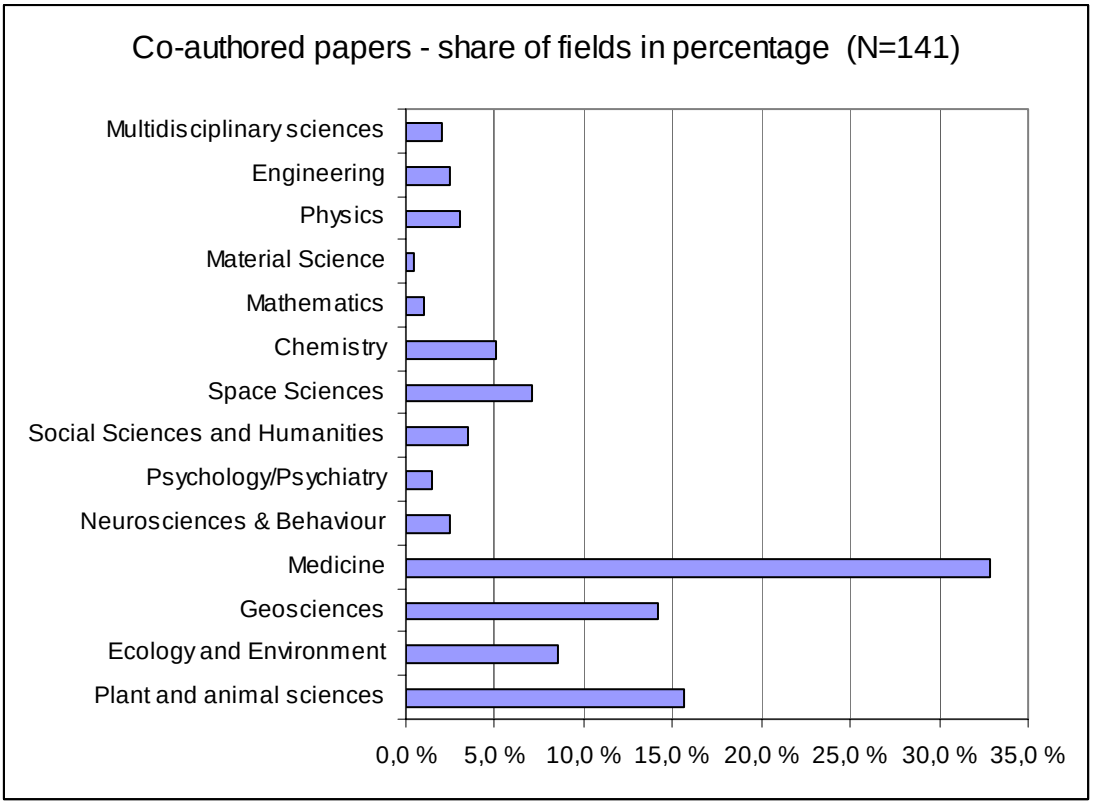
Environment / ecology is a topic of about nine percent of the co-authored papers. Both countries have rather high levels of activity in ecology and environment. *Environment engineering / energy* is a field linked to the above mentioned, but here the values differ significantly: South Africa achieved rather low activity and impact levels and Norway has a high activity level and an impact level at world average. These topics should be more in the focus of the research cooperation.

Political sciences are rather strong –measured in activity – in both countries, the impact level of South African political science could be improved. The analysis of the co-authored articles identified only seven articles for social sciences and humanities, of these seven only two related to democratisation processes and globalisation. This means that in this field there are considerable opportunities for collaboration.

Economy as a field is not in focus of co-authorship between Norway and South Africa, but both countries have independently high activity levels here, while the impact is below world average for both countries.

Education is a topic for rather few – only three – co-authored articles, mainly education in relation to health politics. South Africa has a high activity level in this field, but still lacks impact. Norway has an activity level far below world average, but an impact level at the world average level.

Geosciences and space sciences could be two new topics for a new bilateral research programme. In both research fields have South Africa and Norway already successfully collaborated. We could document very high activity levels in both countries for geosciences. Improvements of the impact of geosciences are still necessary, especially for South African where the impact of geosciences range still below world average. But also Norway should enhance the impact of geosciences – it is now only marginally above world average (1,165). Space science in South Africa is at a very high activity level; that is not the case for Norway. The impact level is below world average for both countries. A more targeted collaboration could improve therefore the international visibility of these research activities.



Conclusion
Both countries have a rather similar profile of scientific research: an emphasis on the sustainable exploitation of the rich natural resources located in both countries, combined with strong positions in social sciences and partly in medicine.
The impact level achieved by both countries differs considerably. Therefore we suggest an intensified bilateral and multilateral collaboration as an approved strategy for increased impact. The bilateral collaboration should make use of existing international networks for that purpose.

The list of priority areas for research collaboration should be revised, refocused and eventually expanded by geosciences and space science.

3. Areas that do not fall under the eight priorities - and advantages of Norwegian research

In part three of this paper we will ascertain research areas that do not fall under the current eight priority areas in the South Africa-Norway Cooperation Programme, and discuss this on the background of national priorities and the comparative advantages of Norwegian research. First we will discuss the term "comparative advantage".

3.1 Comparative advantage versus competitive advantage

Comparative advantage is a term most often used in economics describing an activity that is more cost efficient to perform in a certain country than others, originally often ascribed to natural resources, but today defined as being performed at a lower opportunity cost. Whether the lower costs stems from wage levels, natural resources, technological capabilities, competence, educated workforces or human capital or other sources vary depending on the topic of discussion.

In the knowledge based economy, the links between natural resources and comparative advantages are generally de-emphasized and differences in the allotment of resources is not seen as a comprehensive enough explanation, since the role of institutions, such as market structure, wage levels, tax system, educational and knowledge infrastructure and other factors are crucial for economic performance. Thus, in the context of this paper, *cost efficiency* (that defines comparative advantage) is not so interesting in itself, and *comparative advantage* is therefore operationalised as identifying areas of research where Norway can offer a high level of competence, research facilities and scientific output today, even on an international scale. The concept is therefore used more akin to the (more modern) concept of *competitive advantage*, or the advantage an organisation has because of the quality or superiority of products or services. Both *medicine and polar research* are today fields given priorities within the allocation of national research funds and can therefore be expected to offer areas of research that surpass both national and international averages.

3.2 Medicine and polar research

It is important to note that *competitive advantages* (as do comparative advantages) result from a range of sources and vary over time. Sometimes the advantages are easily identified, visible and enduring, at other times temporary and almost unheeded except in particular and highly specialised (often international) milieus of scientists. The reason is of course that while some research is brought forward through institutional practices and supporting policies with high national priorities, other research is the result of passing events such as specific group

dynamics that can be the result of more or less targeted efforts or even the genius and labours of a single individual. Consequently, Norwegian research in fields such as oil extraction and energy, ICT, marine development and welfare economics are financially supported by private industries, have dedicated research institutes, government sponsored research programmes, as well as the Research Council of Norway (RCN) and a range of other institutions that support and uphold the activity. On the other hand, some of the research areas within which Norway has a current advantage are tied to the activities of a single individual or a group of individuals.

In Norway, life and health sciences have always been given high priority, but medical research is in itself such an all-encompassing term that it is difficult to talk about research in the field in a general matter. Norwegian medical research is today strong in some fields and weak in others. In the recent evaluation of medical activities in Norway[4], it was stated that "Norwegian clinical research is, in general, lagging behind other Scandinavian countries", but still some research such as that being performed by the Cardiology department at the Rikshospitalet University Hospital was labelled as "Excellent" and with "an impressive scientific activity, even when compared to other international research in the field. In polar research the comparative advantage of *localisation* seems at first to be an obvious factor and perhaps especially the Norwegian sovereignty of Svalbard has lead to Norwegian research in the area to be deemed to be of national interest over a long period of time[5]. However, in modern times, space and localisation is more a cost factor than a decisive element in the allocation of research funding and activities; much of today's polar research is centred on *Antarctica* and is already a basis for South-African and Norwegian collaboration. In short it is not the proximity of the Arctic region, but the research interests themselves that decide the nature of and localisation of research activities within this field.

Globalisation is opening Norwegian research, and at the same time expanding the fields of operation beyond political boundaries. Thus, the main advantage of polar research in Norway is probably not only the long traditions of Norwegian polar research, that today constitutes the basis for an extensive research activity in a range of scientific fields, but also institutions that constitute the framework for this research and a high level of resources for polar research that is made available today. The current interest in the polar regions stems not only from interest in the regions per se, but also from the areas serving as laboratories and indicators concerning the future development of all nations. In addition general interest in environmental topics such as climatic changes is a driver for interest in the polar regions both among the public in general and political (i.e. funding) bodies as well. Therefore, the framework for polar research is constituted not only of research institutes, but also government agencies as witnessed by the co-localisation of two such agencies and seven research institutes at the Polar Environmental Centre.

Polar research is experiencing a development which is strengthening the institutional backing of the research activities, and is more and more integrated into the main areas of Norwegian research. "Norway gives high priority to scientific research in the polar regions[6]" to the point of setting up a "Norwegian National Committee on Polar Research" and a range of government funded activities on both a national and a Nordic level. The activities are

[4] Evaluation of clinical, epidemiological, public health, health-related and psychological research in Norway, Research Council of Norway, 2004
[5] Norges offentlige utredninger, NOU 2003: 32, "Mot nord!"
[6] The Norwegian National Committee on Polar Research, "Policy platform document: Norwegian research in the Antarctic: Priorities for the period 2005-2009", Research Council of Norway

widespread and will "focus on research on climate dynamics (past, present and future), marine ecosystems, and the human dimension".

For both fields, comparative advantages on the national level such as the general availability of highly educated personnel, low level of corruption, language skills amongst young researchers and so on is seen as a necessary condition for a high level of academic output, but is common to all fields of studies and therefore not decisive in the formation of comparative advantages of one Norwegian area of research compared to another. Therefore these factors are not in themselves seen as the topic of interest for this paper, perhaps with the notable exclusion of the educational system. The openness and general availability of education for all Norwegians leads to a maximised pool of talent to recruit from and also to a high degree of competition amongst areas of research in order to attract the most talented researchers. One other aspect is the relative low level of corruption and high level of scientific independence. The latter is a topic of concern and debate, but is seen as a crucial element of the Norwegian research system[7].

All in all, Polar research has not in itself been a priority area of this programme, but should be considered as a natural theme for co-operation between Norway and South-Africa. Of course this should be an interdisciplinary theme, open to subfields or combinations of a wide range of studies such as environmental studies, natural sciences, life sciences and even social sciences. While medicine already is an area of research covered by the programme, some subfields could be given priorities over others based on the stature of the field. The task of exactly identifying these fields is beyond the scope of this paper, but below is a presentation of research activities deemed by external institutions or external evaluations to be of a high international quality and therefore examples of research areas of strengths and currently with comparative (competitive?) advantages.

Examples of excellent medical research

All of the following excerpts are taken from the "Evaluation of clinical, epidemiological, public health, health-related and psychological research in Norway" published by the RCN.

Institute of Clinical Dentistry, Oslo
"The committee was most impressed with the Oral Research Laboratory, which in a surprisingly short time has succeeded to build up an internationally competitive research activity in the field of biomaterials. This unit is involved in several EU projects, in one case as coordinator, and has an active and potentially financially fruitful cooperation with several biomaterial companies."

Anaesthesiology, Ullevål University Hospital
"The anaesthesiology unit has a very good scientific production, but is heavily dependent on a single individual. The pre-hospital emergency unit has an excellent scientific production with a top international position within its area."

Department of Cardiology, Rikshospitalet
"This unit has an impressive scientific activity (…). The imaging group has good cooperation with industry, which may help generate part of the substantial funding they obviously need to continue and further expand their highly internationally competitive activity."

Orthopaedics, Ullevål University Hospital
"The orthopaedic unit [has] very high goals including a positive attitude to 21st century medicine. The site visit system is highly recommendable. (…) They have the ambition to be at a top international level in clinical research. They have a large external funding, both from the NRC *and* from sources related to their interest in sports medicine."

[7] See for example publication by The National Committees for Research Ethics in Norway

NTNU – Faculty of Medicine, Institute of Cancer and Molecular Medicine
"The myeloma group and the opioid research group have an excellent scientific output and presented well-structured strategic plans for the future. Within their fields, they can be considered to be highly internationally competitive. A particular strength of the opioid research group is their focus on the pharmacogenetics of opioid therapy. The plans of the myeloma group to give high priority to translational research in the field of growth factors is a challenge that will demand new competence and methodology."

NTNU – Department of Circulation and Medical Imaging
"This is a highly successful unit with a strong technological profile. It has built up unique contact surfaces with the [Faculty of Engineering Science and Technology - NTNU], resulting in common PhD students and excellent application of technical competence to important biological problems, mainly in cardiology."

Medical division (Cardiology, Internal Medicine Research Lab, Haematology, Oncology), Ullevål
"The strength of the cardiology unit is considered to be high competence in handling large patient materials and a good recruitment situation."

Norwegian Centres of Excellence

Norwegian Centres of Excellence is the name of an initiative administered by the RCN in order to bolster the quality of research centres of "high level of scientific quality, as judged by international standards". Today there are 13 such centres, whereof two within medicine and one within climate research.

Institution	NTNU - Norwegian University of Science and Technology	University of Bergen	University of Oslo
Centre of excellence	*International Centre for the Biology of Memory*	*Bjerknes Centre for Climate Research*	*Centre for Molecular Biology and Neuroscience*
Research topics	Laboratory for molecular neuroscience, The synaptic neurochemistry laboratory, Lab. of cellular neurophysiology and ion channel function, Bacterial pathogenesis - molecular and cell biology, Genome dynamics and microbial pathogenesis, The neurotransporter group, NeSys - Neural systems and graphics computing laboratory, Forebrain development and neural stem cells, Genomic (in)stability group, Laboratory for molecular biology, Bioinformatics group	Rapid Climate Changes: causal connections, Atlantic Ocean Circulation, Seasonal to Multi-decadal Variability, Holocene Climate Variability and Forcing, Climate Predictability and Future Climate Change, Marine Climate Processes and Feedbacks, High-latitude Exchange Processes, Carbon Cycle and Biogeochemistry	Fear and space in the hippocampus, Memory in the forecourt of the hippocampus, New dimensions in the memory research, Some like similarities and others like differences

There is also a *Nordic Centres of Excellence* program, one such centre focus on Research in Water Imbalance Related Disorders (WIRED). The co-ordinator is a professor at the Institute of basic medical sciences at the University of Oslo.

Polar research

The main institution in Norwegian polar research is (obviously) the Norwegian Polar Institute, located both at Svalbard and Tromsø. In addition the University of Tromsø is active within

the field. Polar research in Norway was evaluated by NIFU in 2002, but this was mainly focused on the nature and scope of this research and not qualitative aspects[8].

Norwegian Polar Institute
"The Institute's activities are concentrated on environmental management needs at both poles. Global climate, long-range transported pollution, the effect of pollutants on the environment, biodiversity and topographical mapping of the regions are all important tasks, as is environmental collaboration in the Barents Region.[9]"

The Roald Amundsen Centre for Arctic Research, University of Tromsø

In addition, the announced focus in the *Antarctic Policy platform* on climatic research points invariably to the main climatic research centres in Norway

CICERO (Centre for International Climate and Environmental Research – Oslo)
NILU (Norwegian Institute for Air Research)
NINA (Norwegian Institute for Nature Research - Department of Arctic Ecology)

Finally, marine ecosystems and "Arctic Climate Impact Assessment" is topics for research at:

Havforskningsinstituttet - The Institute of Marine Research

[8] Dag W Aksnes, Norsk polarforskning - forskning på Svalbard, Ressursomfang og vitenskapelig publisering – indikatorer 2002, NIFU Rapport 8 / 2003
[9] Polar Institute presentation, [online], http://npiweb.npolar.no/

References

Aksnes, Dag W., Maus, Kirsten W., *Norsk polarforskning - forskning på Svalbard: ressursomfang og vitenskapelig publisering - indikatorer 2002*, 2003, NIFU report 8-2003, Oslo (www.nifustep.no)

Fagerberg, Jan, Technology and competitiveness. 1997, NUPI, Oslo

Fruin, W. Mark, *The Japanese Enterprise System. Competitive Strategies and Cooperative Structures,* 1992, Oxford University Press, Oxford

Glänzel, Wolfgang, Science in Scandinavia: a bibliometric approach. *Scientometrics* 48 (2000), 121-150.

Lazonick, William and Mass, William (eds.), *Organizational Capability and Competitive Advantage. Debates, Dynamics and Policy,* 1995, Edward Elgar, Aldershot

Lazonick, William, *Business organization and the myth of the market economy,* 1991, Cambridge University Press, Cambridge

Lazonick, William, *Competitive Advantage on the Shop Floor,* 1990, Harvard University Press, Cambridge, Massachusetts

Lundvall, Bengt-Åke et al., *The new knowledge economy in Europe: a strategy for international competitiveness and social cohesion,* 2002, Edward Elgar, Cheltenham, UK

Narula, Rajneesh and Katharine Wakelin, *Technological competitiveness, trade and foreign direct investment,* 1995, MERIT, Maastricht

Nelson, Richard R.; Winter, Sidney G., *An evolutionary theory of economic change,* 1982, Cambridge, Mas.

OECD science, technology and industry outlook 2004. Country response to policy questionnaire, Norway.

OECD, European Trend Chart on Innovation. Annual Policy Trends and Appraisal Report for Norway, 2004.

Porter, Michael E, *The competitive advantage of nations - With a new introduction,* 1998, MacMillan Press, London

Reinert, Erik S.. and Riiser, Vemund, *Recent trends in economic theory: implications for development geography,* 1994, STEP Report 12 - 1994, Oslo (www.step.no)

Reinert, Erik S., *Globalization, Economic Development and Inequality: An Alternative Perspective,* 2004, MA Edward Elgar Publishing, Cheltenham, UK

Reinert, Erik S., *How rich nations got rich : essays in the history of economic policy,* 2004, Working paper / Centre for Development and the Environment, University of Oslo, Oslo

Research Council of Norway, "Clinical Research - Evaluation of clinical, epidemiological, public health, health-related and psychological research in Norway – Panel 1", Research Council of Norway, 2004, Oslo

Schumpeter, Joseph A., *The Theory of Economic Development,* 1911, Cambridge, Mas.

Sivertsen, Gunnar, and Aksnes, Dag W. (2000a). Norge som forskningsnasjon - II. *Forskningspolitikk* 23 (2000), 12-13.

Sivertsen, Gunnar, and Aksnes, Dag W. (2000b). Hva slags forskningsnasjon er Norge? *Forskningspolitikk (2000)* 23, 4-5, 11.

Statens forvaltningstjeneste Informasjonsforvaltning, "Mot nord!", Norges offentlige utredninger, NOU 2003: 32, Oslo 2003

Statsbudsjettet 2005. Forskning og høyere utdanning i budsjettproposisjonen for 2005. NIFU STEP, 2004

Stiglitz, Joseph E., Walsh, Carl E., *Economics,* 2002, Norton, New York

The Norwegian National Committee on Polar Research, “Policy platform document: Norwegian research in the Antarctic: Priorities for the period 2005-2009”, Research Council of Norway, 2005

Walsh, Vivien, Robin Roy, Margaret Bruce & Stephen Potter, *Winning by design: technology, product design and international competitiveness,* 1992, Blackwell Business, Oxford, UK

William Lazonick, Mary O’Sullivan, *Skill formation in wealthy nations: Organizational evolution and economic consequences,* 1994, STEP Report 23 - 1994, Oslo (www.step.no)