Willy Østreng, editor

Confluence

Interdisciplinary Communications 2007/2008

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Centre for Advanced Study
at the Norwegian Academy of Science and Letters

CAS OSLO

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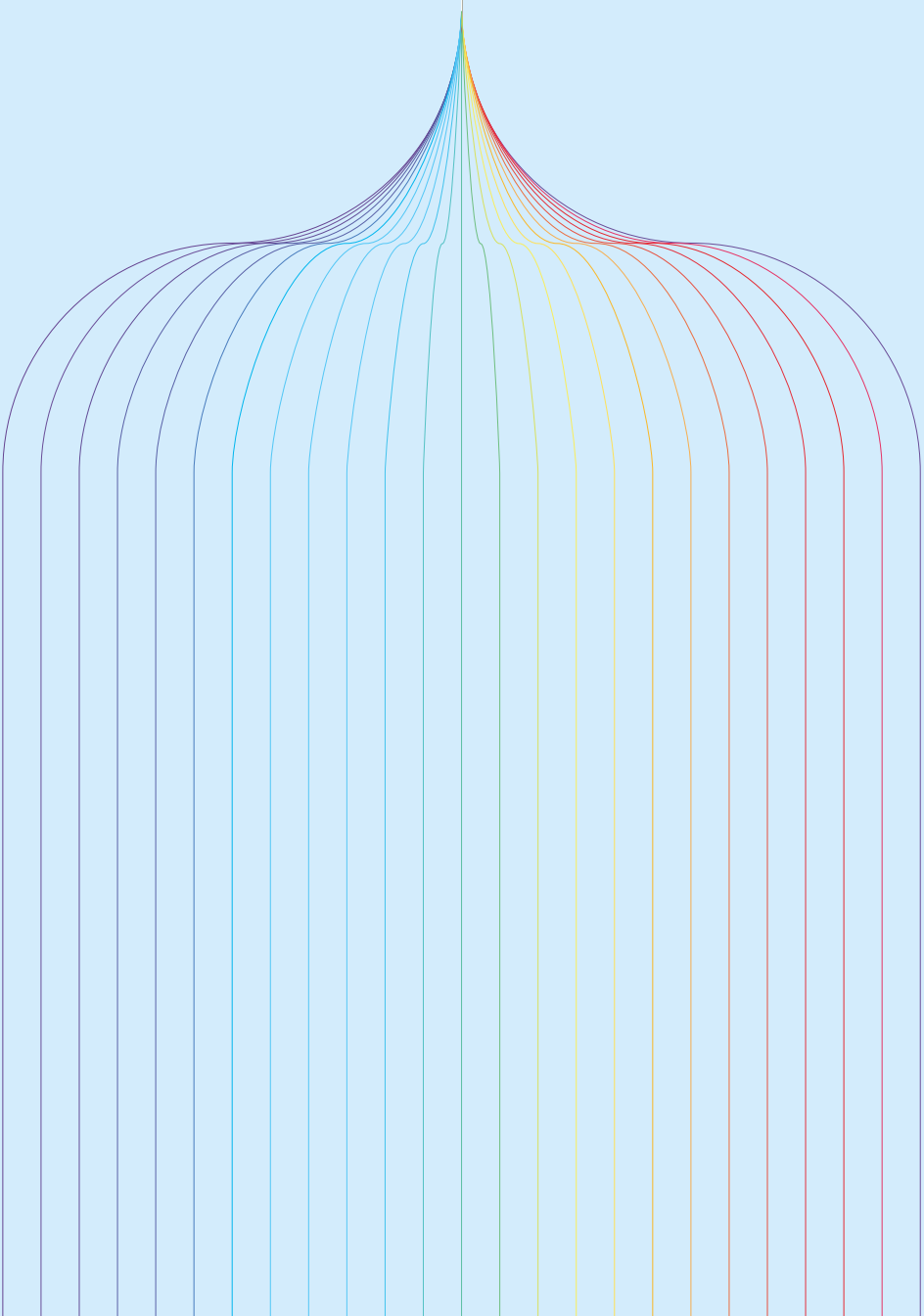

Centre for Advanced Study in Oslo

The Centre for Advanced Study (CAS) is an independent private foundation which was established by the Norwegian Academy of Science and Letters in 1989. Its purpose is to promote basic research – disciplinary as well as interdisciplinary – on the highest international level within the humanities/theology, the social sciences/law and the natural sciences/medicine/mathematics. The Centre's academic activity is of a long-term nature and is to be permanent and academically independent of political and economic influences and the influence of research policy.

Outstanding researchers from Norway and abroad are nominated for one-year stay to engage in research in the Centre's premises in the Norwegian Academy of Science and Letters' mansion in Oslo. The activities are organized in three groups – one in the humanities, one in the social sciences and one in the natural sciences – each with from six to ten members whose affiliation is long-term. In addition come numerous researchers who spend shorter periods conducting research, altogether some 40–45 fellows of around 15 nationalities a year. Each group is planned and organized around a unifying theme and headed by one or two recognized Norwegian researchers. The groups have no other obligations than their own research and to take part in internal seminars. They receive administrative and financial support from the Centre in formalized cooperation with six Norwegian universities and two high-level research college, i.e. the University of Oslo, the University of Stavanger, the University of Bergen, the University of Tromsø, the Norwegian University of Science and Technology in Trondheim, the Norwegian University of Life Sciences in Ås, the Norwegian School of Economics and Business Administration in Bergen, and BI Norwegian School of Management.

The Centre has a Board appointed by the Norwegian Academy of Science and Letters, the Norwegian Association of Higher Education Institutions and the Research Council of Norway. The every day operation of the Centre is conducted by a four member-administrative staff.

Centre for Advanced Study
at the Norwegian Academy of Science and Letters
Drammensveien 78
NO-0271 Oslo
Norway

Telephone: +47 22 12 25 00
Fax: +47 22 12 25 01
E-mail: cas@cas.uio.no
Web site: http://www.cas.uio.no

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Research groups 2007/2008

Nature-inspired Chemical Process Design
Group leader:
Professor Signe Kjelstrup, NTNU Trondheim

The aim of this project was to learn from the architecture and function of nature so as to improve man-made processes. The members of the project team have skills in non-equilibrium thermodynamics, statistical physics, biology, chemical engineering and computational chemistry on the macroscopic scale as well as the molecular scale. The interdisciplinary team studied the available energy in natural systems, how it is used and what the efficiency of the conversion depends on. They studied biological systems (lungs and molecular motors) and chemical process equipments in fuel cells.

An example problem:
The swordfish is diving for food during the day down to temperatures near 4ºC. On those occasions, the temperature of the brain is regulated to a higher value, so the activity can continue. What is the mechanism of this thermogenesis? How does energy conversion take place in the muscles?

Understanding Innovation
Group leader:
Professor Jan Fagerberg, University of Oslo

During the last two decades innovation has increasingly become a central focus for policy makers. The reason for this is the central role innovation is assumed to play for income and employment growth (and quality of life more generally). However, in spite of its obvious importance, innovation has not always received the scholarly attention it deserves. This is now changing. Research on the role of innovation for economic and social change has proliferated in recent years within a number of different disciplines/specializations, reflecting the fact that no single discipline deals with all aspects of innovation.

However, this diversity in backgrounds and orientations among researchers in this area may also create problems. The research community in this area may be seen as composed by "tribes" that do not speak the same "language" (e.g., apply the same terminology) and therefore

have problems in communicating with each other. One attempt to face these challenges (in which several of the participants in this project were involved) was the TEARI-project (2002-2004). That project, which sought to develop a comprehensive overview of the scholarly work in this area (published in 2004 by Oxford University Press as the "Oxford Handbook of Innovation), may be seen as a first stage in a more ambitious intellectual attempt. Taking the conclusions from the TEARI project as point of departure, the group aimed at this stage to go more deeply into the conceptual and theoretical basis for the study of innovation and its role in social and economic change.

The research was carried out, first and foremost, by a small team of Norwegian researchers (consisting of Jan Fagerberg, Magnus Gulbrandsen and Thomas Hoff) supplemented by some younger scholars recruited to work on aspects of central importance for the project. A group of leading international researchers took part in the project, and stayed in Oslo for shorter/longer periods, and contributed to the research tasks described above.

The Power of the Ruler and the Ideology of Rulership in Nordic Culture 800–1200

Group leader:
Professor Gro Steinsland, University of Oslo

Power/ideology of rulership is a central element in the development of society, religion and culture in the Nordic societies in the period of transition from the Viking Age to The Middle Ages. By 'nordic societies' is meant the societies within the geographical area of the Nordic countries and the north societies within the North Atlantic islands as well. The period studied encompassed the change of religion in the late Viking Age and this made terms such as change, transformation and continuity important.

Ideology of rulership was deliberately chosen as the focal point for a broad spectre of analyses because the political, social and religious changes in the period become visible in the ideas and practice linked to the kings, earls and chieftains. One of the main theses in the project was that ideology of rulership can be regarded as a focal point for the transformation of the Nordic culture and religion from the 9th to the 13th century.

The scholarly debate concerning rulership and its ideological foundation has until now mainly focused on the relationship between the Nordic countries and Europe in the High Middle Ages. The epoch preceding the 12th and the 13th centuries has received little attention, and thus also the questions concerning the pre-Christian contribution and its possible transformations in the Middle Ages. This complex field of research, with broad implications for source criticism, method- and theory-developing, has not yet been underlain a broad, interdisciplinary investigation. The actual group of scholars represented the fields of history of religion, history, Norse and anglosaxon philology, archaeology and place-name research.

Content

Content

Foreword

The Centre for Advanced Study (CAS) in Oslo has two paramount long-term objectives. The first is to raise the quality of Norwegian basic (fundamental) research to the highest international calibre and standards, not least by improving in-depth specialization and penetration. The second objective is to promote high quality in an effort to reach the same level of excellence when it comes to interdisciplinary basic research. This calls for a holistic approach, i.e. for integration in breadth as well as in depth, to improve basic complex system science. The two objectives relate equally to the humanities, the social sciences and the natural sciences, and the intention is that they find expression within and between the three fields of academe.

CAS has no scientific staff of its own. Consequently, to meet its objectives, the Centre recruits among the most distinguished, accomplished researchers, and provides first-rate working conditions that enable them to devote themselves completely to research. Six Norwegian universities and two high-level research college contribute towards this end (see the presentation of CAS at the back of the title page). Through formalized cooperation arrangements, these institutions nominate candidates for an annual competition among leading scientists. The winners will spend one year at the Centre as heads of international research projects and teams. The rather lengthy selection process is guided by one criterion only: *scientific quality*. It involves multiple screening phases and international peer reviews of the more promising nominees. After eight to nine months of screening and assessment, three outstanding scientific groups are selected by CAS' Board of Directors for a one-year stay at the Centre. The Board selects one group in the humanities, one in the social sciences and one in the natural sciences. In cooperation with its partners, the Centre provides full funding for these groups.

There are no preferences regarding the topics chosen for research at the Centre. As long as the topics are researchable and the project proposals and team members can be held to high scientific standards, any topic is eligible for nomination. Thus, CAS has no enduring thematic profile. CAS' profile is compositional, in that humanists, social scientists and natural scientists are present at the Centre at all times. This opens up interesting opportunities for interdisciplinary work, not least because CAS' premises are physically restricted, i.e. the logistical structure is one of oneness. This means that CAS is located in one building, and has one seminar room, one luncheon room, one administrative staff and one scientific director. This is a new situation for most of CAS' guest professors. Most of them are used to working at different faculties located in different buildings and in different departments located on different floors, using different seminar rooms, auditoriums and dining facilities. On an ordinary campus, professors are separated by lawns (do not step on the grass?), asphalt (hard to walk on?) and floors (linked by steep stairs and out-of-order elevators?). All such small but telling obstacles must be overcome to meet with colleagues in other departments. At CAS, the fellows are all located in the same multidisciplinary faculty. They share all facilities, so there are no obstacles to overcome. This mix of academic special-

ties, the physical closeness of the groups and the oneness of the infrastructure, makes CAS a suitable arena for science dialogue across disciplinary boundaries and academic fields.

This book embraces the results of a series of weekly luncheon seminars at which the Centre's fellows have presented their respective specialties for the purpose of fostering multi- and interdisciplinary dialogue between the groups and across disciplinary delineations. Three scientific groups were in operation throughout the 2007/2008 academic year. The humanists addressed the topic of *The Power of the Ruler and the Ideology of Rulership in Nordic Culture 800–1200*. The social scientists aimed at *Understanding Innovation*, while the natural scientists were concerned with *Nature-inspired Chemical Process Design*.

It turned out that the central topics of discussion at the seminars focused on differences, overlaps and similarities in methods, theories and approaches. World views were contrasted and compared. The natural scientists had a common denominator in quantitative methods and mathematically based statistics, whereas the methodological tools of the humanist group involved qualitative assessments and the interpretation of ancient texts and archeological finds. The social science group took a middle position in between the two former applying a mix of interpretive and quantitative instruments. This made up a highly diverse and varied basis for the intellectual interchange of ideas between partly contrasting and partly overlapping research cultures, highlighting their pros and cons, flaws and strengths, individuality and similarities.

In line with this discussion and to provide an overall unifying synthetic perspective on the book, the editor has contributed an introductory article on *Science versus Scholarship or Scholarship as Science?*, arguing that the dichotomy of science and scholarship are gradually being replaced by concepts like academic research and post-academic science. This is due to a growing awareness that research in all fields share a common methodological feature: interpretation. Subjectivity and aesthetic judgments is part of the baggage of all, mathematics and physics included. The differences between the fields are not one of kind, but of degrees.

All the articles in this book have been peer reviewed and adapted to preserve a reasonable standard of popularization without compromising the high standards of sound scientific and scholarly research and reporting. Altogether, specialists from eleven countries took part in the evaluation process.

CAS is publishing this book for two reasons: first, to make the multi- and interdisciplinary discussions of the groups available to a wider readership, nationally as well as internationally. Hopefully, providing the e-mail addresses of the authors will facilitate communication between readers and authors. Second, and closely related to the first point, we aspire to help break down the alleged "ivory tower of basic research" by disseminating a scientifically reliable book written to appeal to readers outside the realm of pure experts.

Enjoy!

Oslo, February 2009
Willy Østreng
Scientific Director and Editor

Acknowledgement

This booklet involves the work and involvement of many individuals. Bjarne Røsjø, project leader at *Bjarne Røsjø Media* has effectively coordinated the work process between the designer, CAS and the printer, whereas Ketill Berger at *Film & Form* is responsible for the attractive design of the book. The language editing has been competently done by our language consultant Linda Sivesind at *Informatic Translations*, whereas Trude Gran Peters at CAS has invested long hours in a most conscientious proof reading process. Marit Finnemyhr Strøm has – as always – assisted where and when need be. A special thank goes to Maria M. L. Sætre who took care of all the organisational and planning matters involved in producing the book. She also took all the nice looking portraits of the authors, and made the proof-reading process smooth and effective. Indeed, she has filled the function of an assistant editor compensating for all the shortcomings of the editor. The referees – whose names for obvious reasons can not be disclosed – took time off from hectic workdays to secure the popularized scientific quality of the publication. They deserve the collective gratitude of CAS. Last but not least, the Board of directors of the Centre should be commended for forging a book policy that complies with the strict scientific standards embedded in the overall objectives of the Centre. To all these individuals, the editor would like to express his deep appreciation.

WILLY ØSTRENG

Science versus Scholarship or Scholarship as Science?

This booklet contains articles written within the auspices of three research cultures: the natural sciences, the humanities and the social sciences. These cultures are similar in that they all produce knowledge that requires stringent methods, conceptual clarity and guiding theories. For all of them, knowledge production is systematised, rational, structured and targeted. In this sense, they are all part of a *joint research culture* that applies the same strict requirements and ethos to secure the validity and reliability of the knowledge production. Their ways part in that they study different subjects which can only be studied through methods and approaches reflecting the individuality and uniqueness of those subjects.

These differences are to some extent accounted for by two concepts: *science* and *scholarship*. The first usually describes the natural and formal sciences, whereas the latter refers to studies in the humanities and, to a certain extent, also in the social sciences.

Scientific Director and Editor
Willy Østreng
Centre for Advanced Study
at the Norwegian Academy
of Science and Letters
E-mail: willy.ostreng@cas.uio.no

The purpose of this introductory article is to provide a brief historical account of the explanatory utility of the two concepts in the light of changing philosophies and practices in research.

The classical concepts of science and scholarship

The concept of science is derived from the Latin word, *scientia*, which means knowledge, and *scientificus*, which means making or producing knowledge. In this definition, the concept of science is applicable to all manner of systematic studies, including the humanities. Here, the focus is on the act of knowledge production, not on cultural specificities.

The classical notion of scholarship is exclusive, comprising only the study of ancient Greece and Rome. In continental Europe, this field became known as 'classical philology', denoting the study of languages and literature in an expanded and more general way. In both versions, the notion is culture-specific while still fitting the Latin definition of science. However, the broadness of the early notion of science eventually faded.

The origins of modern science

Inspired by Galileo, Newton laid down the principles of the modern scientific method of investigation by comparing theories and models with experiments and observations of the real world. The defining criteria of science during the Newtonian era were narrowed down to three: the ability to *predict*, to unmask *cause-effect relationships* and to discover *universal laws*. The reference was to the earth sciences, which by definition were considered 'real sciences.' Their focus was on the 'natural Universe',

i.e. on measurable, observable variables, leaving the interpretive 'social Universe' to the scholars. As has been observed "Social scientists became obsessed with the question 'Is it a science?' where 'science' referred to Newtonian physics and classical mechanics (E.D. Klemke *et al.*, 1998: 106)." In light of this redefinition of science, a fair amount of social scientists were convinced that there was no alternative but to copy the natural sciences and gauge social realities by way of mathematical methods and statistical analysis to qualify as real sciences. Those who qualified were allocated a function in the positivist *Unity of Science thesis*, which reduced all sciences to one mother discipline: Physics. In a long chain of hierarchical subordination and superordination, the qualified social sciences were reduced to psychology, psychology to biology, biology to chemistry and chemistry to physics. In other words: all research is based on objective observation and emotionless gauging connected to physics in a subordinate position. This entailed that the quantifiable social sciences were considered scientific, whereas the interpretive fields of the social sciences and humanities fell outside the definition of what was real science. "Science does not think", Heidegger once touted.

The condescending attitude of the Unity of science thesis contributed to unleash the Science War in which humanists took an active part changing the philosophical underpinning of what science is and is not.

The impact of post-positivism

Stefani Collini summarises the intrinsic values of post-positivism nicely: "The activities conventionally referred to as 'science' do not … , all proceed by experimental methods, do not all cast their findings in quantifiable form, do not all pursue falsification, do not all work on 'nature' rather than human beings; nor are they alone in seeking to produce general laws, replicable results, and cumulative knowledge … it has become more and more widely accepted that different forms of intellectual enquiry properly furnish us with a variety of knowledge and understanding, no one of which constitute the model to which all the others should seek to conform (Collini,1998, xlv)."[1] The differences between science and scholarship are getting smaller. The physicist and Nobel Laureate Steven Weinberg complies: "Physicists get so much help from subjective and often vague aesthetic judgements that it might be expected that we would be helped also by philosophy, out of which after all our science evolved (Weinberg, 1992, 166)."

In this post-positivist line of reasoning, the most common criteria for what constitutes science also applies to work in the historical-philosophical fields, such as falsifiability, corroborability, verifiability and empirical testability. The procedure of formulating hypotheses and testing them empirically also operates with the interpretation of texts and, by extension, with the reconstruction of historical processes, which is always based on textual interpretations. In philology, "data take the form of the physical properties of manuscripts, linguistic rules and textual and ideological coherence … On this background it is reassuring to conclude that scholarship nonetheless seems to possess an intrinsic self-regulatory ability, which in the long run allows truth to prevail over sensation (Thomassen, 2006/2007, 112)".

1: Stefan Collini: "Introduction" to C.P. Snow: *The Two Cultures, …* op.cit. pp. xlv–xlvi.

Thus, the physical and social universes share similarities in terms of uncertainties that can only be accounted for through skilled interpretations. In this post-positivist perspective, there are similarities and even compatibilities between the cultures, which are also evident from the *hybridisation of disciplines.*

The hybridisation of disciplines

Adhering to English linguistics and positivist philosophy to describe science and scholarship is also being complicated by the constantly growing number of *hybrid disciplines,* i.e. conglomerates of multiple disciplines sharing a common focus and/or object of interest or study. These hybrids build across disciplinary delineations by spinning off from their parent disciplines and finding new expressions in fresh disciplinary constellations resulting from the process of hybridisation.

Hybridisation implies an overlapping of and contact between segments of two or more disciplines, a recombination of knowledge and competence in new specialised fields. The recombination among disciplines arises from the borrowing of concepts, theories and methods. In the history of science, a two-fold process can be observed: specialisation within disciplines, accompanied by their fragmentation, is the first process, whereas the recombination of specialities across disciplinary borders is the second. Some of these fresh cluster disciplines embrace both the hard and the soft sciences, making it a bit odd to apply different conceptions of systematic studies to different parts of a unified discipline. As a mix of cognitive psychology, artificial intelligence, linguistics, anthropology, genetics and philosophy, cognitive science is one of several examples of the hybridisation of research. Geography that aims at building bridges between the social and natural sciences is another. Economists address societal questions with the instruments of the formal and natural sciences: mathematics and statistics. There seem to be no clear-cut and absolute delineations between cultures and disciplines; to a certain extent, the fields overlap and blend. In addressing problems such as global warming, ecosystem management of live wild stocks, poverty, etc., involving a mixed bag of social and natural scientists, the investigations of the man-made causes of these problems will be labelled scholarship, whereas the research on the natural effects is called science. What, then, should we call the research undertaken in the trading zones between two or more fields, where social and natural variables intermingle and mix?

On these grounds, Wolf Lepenies is using the term 'science' in the German sense of Wissenschaft, to cover the entire *systematic body of enquiry* (Lepenies,1989:64). In a similar fashion, the concepts of *academic research* and *post-academic science* are increasingly being used as a collective notion to depict systematic study in all cultures and disciplines (Ziman, 2000). In this vein, the concept of research is widening to depict systematic studies in the humanities, social sciences and natural sciences alike. This indirectly comes to expression in concepts such as *political science*, *behavioural science*, *social science, linguistic science, etc*. Scholarship has become identical with the notion of 'soft science', whereas the concept of 'hard science' is used to depict the quantifiable natural sciences. The differences between the cultures are one of degree rather than of kind. Some are more interpretive than others, but all lean on interpretations as a means of understanding. In general, research is a human activity that can not be under-

taken without leaving traces of its inventor and implementer. All cultures contain doses of scholarship and elements of science. The concepts are relative and their demarcation lines blurred. We are slowly but surely returning to the Latin meaning of concepts of science focusing on the process of knowledge production, including all kinds of research.

The name of the child: Does it matter?

The above discussion may seem an unnecessary scholastic exercise. The name of the child is of course less important than its intrinsic character, i.e. the restricted ability of methods, theories and approaches to restrict the human impact on results in *all* fields of research. In this respect, the changing philosophies and practices of research have shown that the cultures are akin to each other without being 'identical twins'. The differences are of degree, rather than kind. To preserve the differing nuances of kinship, the distinction between science and scholarship still makes some sense. If, however, the emphasis is on the core genetics of kinship, the old dichotomy may seem an anachronism. The intermingling of science and scholarship in all kinds of research makes the concept of *academic research* a reasonable replacement, covering the area of overlap between the two notions. Thus, the renaming exercise only makes sense in the historical context, correcting for the philosophical exaggerations and definitional inaccuracies of past history. The contributions to this booklet provide good examples and empirical insights to the usefulness of sustaining the differences between science and scholarship in research.

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OLOF SUNDQVIST

Aspects of Rulership Ideology in Early Scandinavia with particular references to the Skaldic Poem *Ynglingatal*

Lecturer Olof Sundqvist
Department of Humanities and Social Sciences, University of Gävle, Sweden
ost@hig.se
CAS Fellow 2007/2008

In earlier stages of the history of religions, it was argued that the ancient Svear had a "sacral kingship" with a centre in Uppsala (e.g. Schück, 1904; von Friesen, 1932–34; Ström, 1954). There the ruler was regarded as a god, contracting a symbolic marriage with a goddess, playing ritual roles in cultic contexts, and even letting himself be sacrificed to guarantee the welfare of his people. This theory was largely built on the skaldic poem *Ynglingatal* which was considered to be of pre-Christian origin. In 1991, Claus Krag published his dissertation *Ynglingatal og Ynglingesaga,* in which he questioned the traditional dating of *Ynglingatal,* arguing that this poem was young and should be dated to the 12th century. Although this opinion was not new in the research on *Ynglingatal* (cf. Bugge,1894, pp.108–153; Neckel, 1908, pp. 389–421), Krag emphasised it even more strongly. He also stated that the content of the poem never originated from Eastern Scandinavia, but was rather built on traditions circulating in medieval Iceland. Hence this poem lost most of its relevance as a source for a pre-Christian kingship in Svetjud. This criticism of Krag represents serious problems for those supporting the "sacral theory". The question is whether the arguments on which it has been based are tenable and valid. I will therefore examine some of Krag's arguments and discuss the value of *Ynglingatal* as a source of information about the religious and political conditions which prevailed in ancient Svetjud. Thereafter, I will illuminate some aspects of the rulership ideology discernible in this poem.

Ynglingatal – dating and provenance

Ynglingatal has been preserved to the present via Snorri Sturluson's prose text *Ynglinga saga* (c. 1230), where it is quoted. According to Snorri, it was composed by Thjodolf of Hvin who was King Harald Finehair's skald sometime towards the end of the 9th century. It is a genealogical poem composed in his native tongue, which recounts the reigns of 29 rulers from the Swedish-Norwegian royal Ynglinga family. This poem was made in honour of King Rognvald, a minor ruler in Vestfold, Norway, the son of Olaf Geirstadaalf and a relative of King Harald. *Ynglingatal* has 27 stanzas. Each stanza briefly describes the deaths, burials and sometimes

the burial places of the kings. The first eight stanzas concern heroic rulers of the Svear. The next 13 stanzas are about legendary Svea kings. Finally, the last six stanzas describe six possibly historical Norwegian kings.

Scholars have commonly held that Snorri's information concerning the dating of *Ynglingatal* is reasonable, i.e. c. 890 (see e.g. Åkerlund, 1939). This dating was, however, challenged by Krag (1991). He argued that there are medieval Christian values and ideas present in the poem, indicating an anachronism, and he presented a few examples of this. Krag stated, for instance, that the *kenning* of fire in the poem, *sævar niðr*, i.e. 'the relative of sea', presupposes the Christian medieval teaching on the four elements. This doctrine of Empedocles was disseminated in Christian Europe through Bede's commentary on the Bible and a Latin translation of Plato's *Timaeus*. According to Krag, the poem must have been composed after this doctrine had become known in Scandinavia, i.e. in about the 12th century. In my opinion, this argument is questionable. Ideas about the relations of the different elements to each other are not exclusive to Christian culture. There are expressions similar to *sævar niðr*, for instance, in Vedic literature (see e.g. Krause, 1930, p. 17; Fidjestøl, 1994, p. 195). The Indic fire-god Agni is sometimes called *apām napāt* 'the child of water'. Perhaps this is an ancient formula connected to a fire god among those people who spoke Indo-European languages. Thus the kenning *sævar niðr* could not be used as an argument indicating an anachronism in *Ynglingatal*. There is actually no reason to abandon the traditional dating of *Ynglingatal*. The formalistic language, its metre and its important content, could all have allowed it to retain its original shape for centuries. Snorri's attitude towards old poetry makes it difficult to imagine his attributing a poem from the 12th century to a 9th century skald. It would definitely have risked his reputation in the view of all educated contemporary Icelanders who would have known the actual creator of *Ynglingatal*. In my opinion, there are therefore reasons to adopt Snorri's view on the dating of the poem (for a more thorough criticism on Krag's thesis, see e.g. Fidjestøl, 1994; Dillmann, 2000; Sundqvist, 2002, pp. 43–52).

The question of *Ynglingatal*'s background is also very important in the perspective of present study. *Ynglingatal* can only be used as a reliable and valid source for the rulers of the Svear if it is based on traditions with an eastern Scandinavian origin. Krag thinks, however, that these traditions originated elsewhere. He argues that most of the content in *Ynglingatal* was built on late Western Scandinavian traditions, i.e. the same traditions which also formed the unreliable *fornaldarsögur*. According to him, the connection between the name Ynglingar and the Uppsala dynasty was nothing more than a 12th century construction. In my opinion, this is highly unlikely. There are, in fact, several indications connecting the *Ynglingatal* to Eastern Scandinavia. Strong support for an eastern origin of the traditions is provided by the place names occurring in the poem. In fact, names such as *Uppsala*, *Fýri*, *Taurr* and *Ræningi* can be identified with toponyms in the Mälar region (see e.g. Sundqvist, 2002, pp. 47ff.). Specialists on toponymy have made a distinction between close-horizon and remote-horizon names in *Ynglingatal* (see Vikstrand, 2004). The remote-horizon names do not say anything about the provenance of the poem. *Uppsala*, for instance, was known throughout Scandinavia. The name *Skúta*, however, i.e. a close-horizon name, was probably unknown

outside the local community. It refers to *Skutån*, an obscure tributary of the River Fyris, located in a little parish, north of Uppsala. It is highly unlikely that the name of this little creek was common knowledge among Norwegians in the Viking Age (800–1100). Most likely, it and other close-horizon names were part of an ancient eastern tradition associated with the Swedish Ynglinga kings. This tradition was transferred to Norway, perhaps at the end of the Vendel Period (i.e. 8th century). But even if Thjodolf built his poem on eastern traditions, he could have revised them and added ideas and ideological aspects to reflect contemporary Western Scandinavian society. This is, of course, a problem in my study. In any case, I am inclined to count *Ynglingatal* as an important source for ideological aspects of both Sweden and Norway during the Late Iron Age.

Denominations and rulership ideology

Is it possible to grasp a specific rulership ideology in *Ynglingatal*? Since the content of this poem is fragmentary, scholars have searched for a method to use for analysing it beyond the ambiguous narrative structure. In a previous study, I investigated *Ynglingatal* by studying the denominations of the rulers in the poem (Sundqvist, 2002, pp. 141ff.; cf. Marold, 1987). They appear as poetical expressions, so-called *kenningar* as well as common appellations. Obviously, they served to characterise the ideal image of the ruler. The semantic spectra of these expressions were thus important means for construing royal power. In this study, I classified the denominations into five different groups. Most expressions referred to leadership, power and warlike qualities. A few connoted wealth and generosity. Three kennings emphasised cultic aspects of the king. Four mentioned that the kings were of divine descent. Other genealogical references also occurred frequently. The denominations in *Ynglingatal* thus indicated an ideology where power and warlike qualities, as well as religious aspects, were essential. In what follows, I will investigate the expressions referring to religious matters and discuss their significance to the rulership ideology and its setting in the Svea society.

There are clear indications that the Ynglinga dynasty was really honoured for its divine origin. In *Ynglingatal*, kings carried denominations such as 'Freyr's offspring' (*Freys afspringr*) and 'the kinsman-of-gods' (*goðkynningr*), and the entire Yngling dynasty is called 'the line of the mighty god' (*þróttar Þrós niðkvísl*). Freyr was a fertility god and most likely regarded as the divine forefather of the Ynglinga kings. Adam of Bremen (c. 1075) mentioned that Freyr's image in the "temple" of Uppsala was phallic. There are several place names in the Mälar region containing Freyr's name, indicating that he was one of the most important deities in the area (see e.g. Vikstrand, 2001). There are also other genealogical references in *Ynglingatal* to indicate that descent was essential in ideological contexts.

Ynglingatal also refers to the cultic functions of the king. In one kenning, King Yngvi is called *vörðr véstalls*. The basic meaning of the word *vé* is 'something holy', but often it refers to 'cult site, sanctuary'. In the compound form *véstallr*, it means 'sacred stand' or 'altar'. Thus the kenning suggests that the ruler was the keeper or custodian of the altar. There are several similar denominations of rulers in primary sources. In the runic inscription of Rök (9th century), Östergötland (Ög 136), the chieftain Sibbe is called *viaværi* with a meaning similar to *vörðr*

véstalls. Another chieftain appears in the runic inscription from Synnerby, Västergötland (Vg 73), with a byname *Vīurðr* 'guardian of the sanctuary'. Several sources indicate that the ruler cared for and arranged cult feasts at the sanctuaries. These practices also had economic implications, and were grounded in a redistribution system. During a cult feast in the hall, the ruler distributed gifts to his men under ritual circumstances. In *Ynglingatal*, King Vanlande is called *menglötuðr* 'spendthrift of jewellery', i.e. a generous person. The ruler's gifts created alliances and friendship relations between the king and his subjects. These gifts also required compensation in the form of military service, loyalty, goods, raw materials, labour and other service. The cult was thus integrated into the social, economic and political life of the Svear.

This type of ruler ideology may be supported by recent archaeology. Evidence found at ancient aristocratic residences in Sweden indicates several activities such as production and trade, but also cultic practices. In connection with the Iron Age representation hall of the ruler at Helgö, Uppland, interesting finds have been made, such as the "guldgubbar" and ceremonial glass (see Herschend, 1995). The "guldgubbar" are small gold-foiled figures depicting mythical scenes. They most likely played an important role in the ideological apparatus of the rulers (see Steinsland, 1991). Some of them were deposited near the high seat of the hall, probably as sacrificial gifts to the gods. A concentration of exclusive glass has also been found there. Most likely the ruler of Helgö was sitting at this place when celebrating sacrificial feasts. The ruler's entering of the high seat probably comprised a complex of religious ideas.

Summing up

Ynglingatal is probably a pre-Christian poem dating back to the end of the 9th century. There are clear indications that Thjodolf based his poem on Eastern Scandinavian traditions. In my opinion, it is therefore possible to reconstruct a pre-Christian rulership ideology by means of *Ynglingatal*, which is valid for both Swedish and Norwegian conditions. This ideology involved religious aspects. The rulers there were related to the mythical world by descent. In addition, they performed important ritual roles in the hall at the royal residence.

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JAN FAGERBERG

A Guide to Schumpeter

Josef Schumpeter was born in 1883 in the then Austrian empire and died in 1950 in the United States. He grew up in Vienna around the turn of the century and studied law and economics there. During the early part of his career, he tried his luck both as a businessman (director of a bank) and as a politician (minister of finance) without much success. It is as a writer and social scientist that we remember him today. He became a professor at the University of Bonn in 1925 and later at Harvard University in the USA (1932) where he remained until his death.

In a series of writings, Schumpeter developed a highly original approach to the study of long-run economic and social change, focusing in particular on the crucial role played by innovation and the factors influencing it. In so doing, he distanced himself from the (then) emerging neoclassical strand of economics because, in Schumpeter's own words, it assumed that "economic life is essentially passive … so that the theory of a stationary process constitutes really the whole of theoretical economics … I felt very strongly that this was wrong, and that there was a source of energy within the economic system which would of itself disrupt any equilibrium that might be attained" (Schumpeter 1937/1989, p. 166). It was this 'source of energy', innovation, that he wanted to explain.

Professor Jan Fagerberg
Centre for Technology, Innovation and Culture (TIK), University of Oslo, Norway
jan.fagerberg@tik.uio.no
CAS Group Leader 2007/2008

His major theoretical treatise on the subject, "The theory of economic development", published in German in 1912 and in a revised English version in 1934, focused in particular on the interaction between innovative individuals, who he called 'entrepreneurs', and their inert social surroundings, while later works, particularly "Capitalism, Socialism and Democracy" from 1942, extended the approach to also take into account organized R&D (Research and Development) activities in large firms. This brief note outlines some of the main elements of his approach.

Schumpeter's approach

Schumpeter's theorizing was inspired by the main approaches that he encountered as a student in Vienna around the turn of the century, namely Marxism, the (German) historical school in economics and the (emerging) neoclassical strand. From Marx he took the dynamic outlook, from the historical school, the emphasis on historical specificity and from the neoclassicals, the need for a micro-based approach, in which evolution is explained through the interaction of individual actors, rather than, say, at the level of the nation or the state.

In "Capital", Marx had suggested that the main way for capitalist firms to keep competitive was to increase productivity by introducing new and more efficient machinery. Firms that succeeded in introducing new and

more efficient technology would see their competitive position improved (and hence be rewarded by above average profits), while those who failed, Marx argued, would be unprofitable and eventually driven out of the market. Schumpeter essentially adopted this argument and made it the centerpiece of his theory. For him, this (technological) competition was the true nature of capitalist competition, in contrast to the so-called "price competition" envisaged in traditional text-books:

> " … in capitalist reality as distinguished from its textbook picture, it is not that kind of competition that counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (…) - competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives. " (Schumpeter 1943, p. 84)

As is evident from the quote, compared with Marx' writings, Schumpeter broadened the perspective from focusing mainly on cost-cutting through the introduction of new machinery (so-called process innovation) to include other types of innovation as well (product innovation, organizational innovation, etc.). Schumpeter also departed from Marx by making an attempt to develop a theory of innovation. First of all, he added a definition of innovation (or "development" as he initially phrased it) as "new combinations" of new or existing knowledge, resources, equipment and so on (Schumpeter 1934, pp. 65). Second, he pointed out that innovation needs to be distinguished from invention. The reason why Schumpeter stressed this difference is that he saw innovation as a specific social activity (function) carried out within the economic sphere and with a commercial purpose, while inventions in principle can be carried out everywhere and without any intent of commercialisation. Thus, for Schumpeter innovations are novel combinations of knowledge, resources etc. subject to attempts at commercialization (or carried out in practice).

This "combinatory" activity he labeled "the entrepreneurial function" and the social agents fulfilling this function "entrepreneurs". For Schumpeter, these are key to innovation and long-run economic change. One main reason for this was, in his view, the prevalence of inertia, or "resistance to new ways" as he phrased it, that entrepreneurs had to fight to succeed in their aims. He described their situation vividly as follows:

> "It is not objectively more difficult to do something new than what is familiar and tested by experience, but the individual feels reluctance to it and would do so even if the objective difficulties did not exist. (…) Thought turns again and again into the accustomed track even if it has become unsuitable and the more suitable innovation in itself presents no particular difficulties. (…) In the breast of one who wishes to do something new, the forces of habit raise up and bear witness against the embryonic project" (Schumpeter 1934, p. 86).

Thus, following Schumpeter, there are many factors at work at the individual, group and social level that make it a very challenging task to succeed in innovation. The problem is not so much with the new ideas, which may be simple enough to comprehend, as with their successful economic implementation. To overcome this strong "resistance", Schumpeter argues, more than the ordinary managerial competence is required. It is this "special quality" that he, in his early work, associates with entrepreneurs. In his early work, what is sometimes called "Schumpeter Mark I", Schumpeter focused mostly on individual entrepreneurs. In later works, he also emphasized the importance of innovation in large firms (so-called "Schumpeter Mark II"), and pointed to historically oriented, qualitative research (case studies) as the way forward for research in this area (Schumpeter 1947, 1949).

Conclusion

During the decades that followed Schumpeter's death, interest turned away from the dynamic outlook that characterizes his work. Instead, economists gradually adopted static, mathematical equilibrium approaches of the type that Schumpeter admired but had found to be of little value for understanding the subject matter. However, more recently the tide has turned and today the need for understanding the causes and effects of innovation is generally accepted, as is Schumpeter's role as the main theorist in this area. Arguably, his contribution is as relevant as ever.

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CRISTINA CHAMINADE

Understanding the Changes in the Global Distribution of Innovation Activities. A Challenge for Innovation Studies

In recent years, there has been increasing, if still somewhat limited, evidence suggesting that some Asian firms in certain regions and industries are starting to move up the value chain from competing on the basis of low costs to competing as generators of innovations (Parthasarathy and Aoyama, 2006; Altenburg *et al.*, 2008; Chaminade and Vang, 2006). Increasingly more firms are currently locating their R&D departments in Asian countries, notably China and India (UNCTAD, 2005), while R&D activities and other innovation and knowledge intensity activities have traditionally been retained in the home country of the trans-national corporation (TNC). This is particularly evident for some industries and regions such as the IT industry in India or the automotive industry in China (Altenburg *et al.*, 2008). Furthermore, in certain sectors, Asian firms seem to be rapidly moving up the value chain by providing R&D services to TNCs. One example is the case of the embedded software firms in Bangalore, India (Parthasarathy and Aoyama, 2006). Moreover, Asian firms have started to locate R&D departments in OECD countries (for example, Chinese or Indian firms locating R&D departments in the US) or even acquiring firms in OECD countries to get hold of their technological knowledge (Saxenian, 2001). This global re-location of R&D activities has run in parallel, and it is closely related, to the growth in internal research capabilities in these countries (China and India). In 2005, China was number three in the world in terms of gross domestic expenditure on R&D in absolute terms, following only the US and Japan (although as a percentage of Gross Domestic Product, the figure is only 1.4 per cent, which is similar to that of southern EU countries) and number two in the total number of researchers, following only the US (OECD, 2006).

Associate Professor
Cristina Chaminade
Centre for Innovation, Research and Competence in the Learning Economy, Lund University, Sweden
Cristina.Chaminade@circle.lu.se
CAS Fellow 2007/2008

In specialised literature as well as in more popular outlets (e.g. *The Economist*), there is growing debate on whether this evidence is indicative of a changing pattern in the global generation of innovation following the global shift in the location of production activities (the "made in China" syndrome). The main concern in the literature is to assess the impact of this global shift on developed as well as developing countries. The key question is whether the literature on innovation is able to provide some explanation about what might be expected from this global shift.

What do we really know …

The previous discussion on the possibilities of some Asian countries for becoming innovation powerhouses seems to be anchored in a very old paradigm in innovation studies. In the 1950s and 1960s, it was believed that innovation was the result of a sequential linear process (Arrow, 1962, Nelson, 1959). It was postulated that investments in R&D would almost automatically lead to new products or services. That is, there was a quasi-linear relationship between invention and innovation. This paradigm has been severely criticised. Innovation is not a linear process that starts with R&D, but is a complex interactive process (Kline and Rosenberg, 1984). Moreover, R&D is considered to be only a minor input of innovation activities for certain industries and types of firms (e.g. services and small firms). Consequently, looking almost exclusively at R&D investments in China and India or at their ability to attract FDI on R&D will provide a very narrow and limited picture of their capacity to innovate.

The innovation systems (IS) approach might provide a valuable alternative for assessing the innovation potential of China and India. For scholars in the IS tradition (Lundvall, 1992, Nelson, 1993, Freeman, 1987, Edquist 1997), innovation is not the result of heavy investments in R&D but of the continuous interaction with other sources of information for innovation, such as users (Fagerberg, 2004; Lundvall, 1988), universities (Mowery and Sampat, 2005), other competing or collaborating firms, etc. The IS approach emphasises the social nature of economic and innovative activities. In that sense, it is the institutional setup and relationships with other organisations that determine the ability of firms to innovate. In other words, the IS approach to innovation is not so much about how much the different organisations invest in research but rather how they interact, share and use that new knowledge. According to this alternative theoretical approach to the linear model of innovation, we might expect innovation to occur in well functioning innovation systems, that is, in those with strong and multiple organisations, institutions and relationships.

A closer look at the systems of innovation in certain dynamic regions of India, such as Bangalore, shows that there is a clear accumulation of capabilities, yet the system of innovation remains rather weak and fragmented (Chaminade and Vang, 2006). Collaboration with other firms, final users or universities is very limited. Given the IS approach, we could conclude that some firms in certain regions and industries in China and India are catching up, but that important constraints remain before they can become innovators on a global scale.

Conclusions

China and India are investing significantly in R&D and research-related capabilities. However, this does not necessarily mean that they will become innovators, at least not in the short- and mid-term, as important constrains seem to exist with regard to the functioning of their innovation systems, e.g. limited interaction between firms, users and universities or the low capability level of a large proportion of firms and local universities. Existing indicators based on R&D expenditure or R&D FDI flows are not sufficient to understand the functioning of the innovation systems in these countries. They reflect an old paradigm in innovation studies. Alternative approaches such as the system of innovation (SI) approach seem to be more adequate in theoretical terms, but there is very limited

data available on the functioning of those systems, meaning it is not possible to assess the extent and scope of the global distribution of innovation activities and their impact on developed and developing countries.

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MARTIN SRHOLEC

Innovation is a Multidimensional Phenomenon

Introduction

The question of economic development is one of the oldest and perhaps also the most intriguing topics that researchers tend to share across many fields of social science. Schumpeter (1934) put forward the idea that the main driving force behind economic development is innovation, i.e. qualitative change endogenously generated in the economic system, which has inspired thinking along these lines for generations. Schumpeter's original understanding of innovation was very broad, generally involving the "carrying out of new combinations" which need "by no means be founded upon a discovery scientifically new" (Schumpeter 1934, pg. 66).

Senior Researcher Martin Srholec
Centre for Technology, Innovation and Culture (TIK), University of Oslo, Norway
martin.srholec@tik.uio.no
CAS Fellow 2007/2008

All too often the concept of innovation is dominated by a very narrow view of it as resources devoted to formal research and development activity (R&D), at least insofar as mainstream economic tradition is concerned. However, a debate about innovation and economic development needs to be based on a broad approach to innovation. The argument elaborated in this paper is that an analysis of innovation needs to embrace the multidimensional nature of the innovation process. I would also argue that we need to use analytical methods that take this on board.

A need for quantitative evidence

One major challenge for empirical literature is to strike a balance between the analysis of qualitative and quantitative aspects of innovation. For a long time, innovation has been studied using qualitative methods such as detailed case studies of particular firms and/or projects. Among the prime reasons for this was the fact that innovation in the broad sense, i.e. not limited to R&D statistics, proved to be difficult if not impossible to measure quantitatively over a long period of time. Nowadays, it is clearly understood in the innovation literature that, on one hand, innovation does not depend on how much is spent on R&D and, on the other, that quantitative evidence constitutes the key input for the design, implementation and evaluation of modern innovation policies.

As a consequence of frustration in the field of innovation studies regarding the use of R&D as the main proxy for innovation activity, enormous efforts have been devoted to developing new approaches to measure innovation since the early 1990s. The concrete outcome of this work is a series of surveys of innovation activity, the so-called Community Innovation Survey, organised by Eurostat and the OECD. It provides a

battery of new quantitative indicators which move beyond the traditional focus of R&D statistics (for details, see OECD 2005). As a result, a vast sea of new micro data on various aspects of the innovation process has become increasingly available for research purposes. One question that presents itself involves how we can make the most of this new evidence.

Factor analysis

Most of the empirical analysis on innovation continues to emulate methods employed in the old "R&D-based paradigm", such as the standard toolkit of conventional regression estimates. However, we need to use analytical methods that are appropriate for the complex nature of innovation which the new sources of data aim to capture. It should come as no surprise by now that the main inspiration should come not from tools used by the mainstream economic profession, but rather from other fields of social science and the humanities, such as psychology and sociology, in which researchers are accustomed to dealing with somewhat similar methodological challenges. How, then, can we analyse qualitative phenomena using quantitative methods? Let me briefly put forward one of the most promising candidates.

Factor analysis is a method of multivariate analysis that is used to indicate the structure and reduce the complexity of multidimensional data (Basilevsky 1994). The idea is that highly correlated indicators are likely to reflect the same underlying dimension and can therefore be combined to represent latent aspects of the data without loss of much information. In other words, the aim of factor analysis is to reduce a complex set of variables into a small number of (principal) factors that account for a high proportion of the variance. One of the most attractive aspects of factor analysis is that the method allows us to analyse multidimensional phenomena that cannot be observed directly and would therefore otherwise defy quantitative measurement. For the first time, factor analysis has been used in psychology to identify various facets of intelligence (Spearman 1904) and then diffused to other social sciences (Hotelling 1933).

Like the problem of measuring intelligence, measuring innovation is a multidimensional phenomenon. As has been already emphasised, innovation refers to new combinations of productive means, which often involve a diverse set of resources and capabilities far beyond R&D spending (Dosi 1988, Nelson 1991, Teece and Pisano 1991), but this has not been reflected in the quantitative analysis of innovation for a long time. Until relatively recently, factor analysis has not been used in the field of innovation studies, although this new stream of work clearly demonstrates how this method can help to derive new insight into the innovation process.

For example, Hollenstein (2003), Leiponen and Drejer (2007) and Srholec and Verspagen (2007) show that factor analysis can be applied to micro data from the innovation surveys to identify latent aspects of the innovation process in firms. Fagerberg *et al.* (2007) use the method to construct new indicators of technological and capacity competitiveness that proved to be significant explanatory factors for differences in economic growth between countries. Likewise, Fagerberg and Srholec (2007) confirm in a large sample of countries that many indicators of economic, technological and social development can be reduced with the help of factor analysis into a few principal factors that jointly explain

almost three-quarters of the total variance. More research along these lines has a strong potential to improve our understanding of the multifaceted nature of innovation.

Reflections

The application of quantitative methods that are widespread in economic literature has led to great improvement in the analysis of innovation, but opportunities for new insights based on these methods are increasingly being depleted. Although useful for the purpose of the innovation research, it should be noted that factor analysis has rarely (if ever) been used in mainstream economics. Perhaps we tend to use methods developed in economics to study innovation too often. Needless to say, the application of methods used in other sciences to a new field often opens entirely new avenues for original (and interdisciplinary) research. This is the road being paved by the application of factor analysis in the field of innovation studies.

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DICK BEDEAUX AND SIGNE KJELSTRUP

Muscular Contraction and the Calcium Pump

As was shown by Huxley (1953), Huxley & Niedergerke (1954) and Huxley & Hanson (1954), the contraction of skeletal muscles is due to the sliding motion of myosin filaments along actin filaments. The interaction between the filaments is created by cross bridges (Fig. 1) extending from the myosin. According to the theory by Huxley (1969), the heads of the filaments first attach to the actin and then undergo a conformational change whereby the angle of attachment is changed. This then causes a movement of the myosin along the actin. The energy for this process is derived from the hydrolysis of ATP to ADP and inorganic phosphate Pi. ATP binds to the myosin head and hydrolysis takes place. The calcium ions are stored in the sarcoplasmic reticulum, an organelle made for that purpose. When the nerve releases sodium and potassium ions, the surface of the reticulum depolarizes and the calcium ions are released into the sarcoplasm around the muscle fibers (Fig. 2). The calcium then binds to the actin, after which the myosin head also binds to the actin. The ADP and the Pi then detach from the myosin head, which uses the energy for the conformational change to shorten the muscle fibre. When the muscle relaxes, Ca^{2+}-ATPase pumps the calcium ion back to the reticulum, the myosin head detaches from the actin, and ATP binds to the myosin head. (Fig. 3)

Adjunct Professor Dick Bedeaux
Department of chemistry, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
dick.bedeaux@chem.ntnu.no
CAS Fellow 2007/2008

Professor Signe Kjelstrup
Department of chemistry, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
signe.kjelstrup@nt.ntnu.no
CAS Group Leader 2007/2008

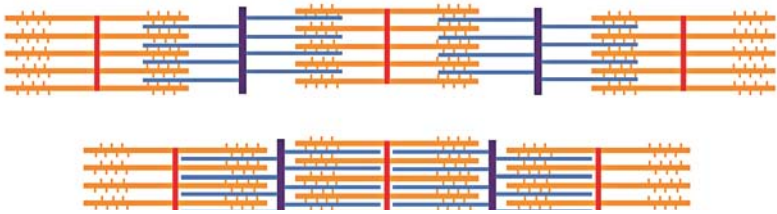
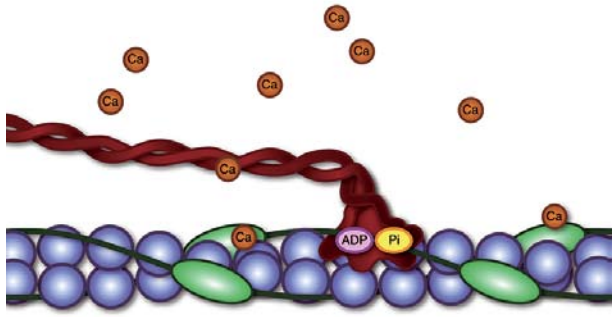


Fig. 1: The top figure illustrates a relaxed muscle fibre and the bottom one a contracted muscle. The orange lines are myosin and the blue lines are actin.

Fig. 2: After two calcium ions (brown) attach to the actin, the myosin head also attaches to the actin molecule.



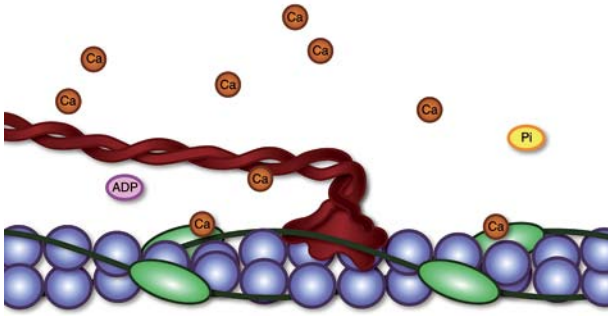


Fig. 3: After ADP (purple) and Pi (yellow) detach, the myosin head changes conformation and moves the actin relative to the myosin.

The calcium pump, the Ca^{2+}-ATPase (a protein), plays an important role in the whole process, and we will mainly focus on the description of this pump using non-equilibrium thermodynamics. It is common to describe how this works by using a diagram of the enzyme cycle, i.e. a so-called Post-Albers diagram, see Fig. 6. The protein has two configurations, E_1 and E_2. In the first state in the left top corner, the protein is in the E_1 configuration and nothing is bound to it. In the first step, two calcium ions are bound inside the protein. In the second step, ATP is bound to the protein and splits into ADP, which goes back into the sarcoplasm, and organic phosphate, Pi, which binds to the protein. In the third step, the Pi changes location in the protein and the energy is used to modify the E_1 configuration into an E_2 configuration. In the fourth step in the cycle, the high energy of E_2 allows calcium ions to go into the reticulum. In the fifth

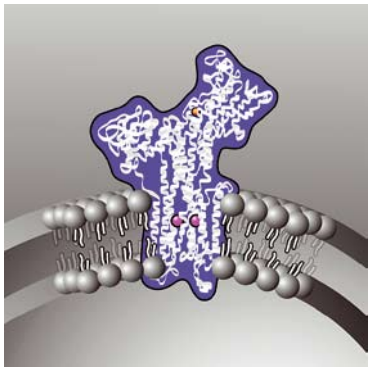


Fig. 4: The Ca-ATPase with 2 bound Ca ions in the lower part and 1 ATP molecule in the upper part.

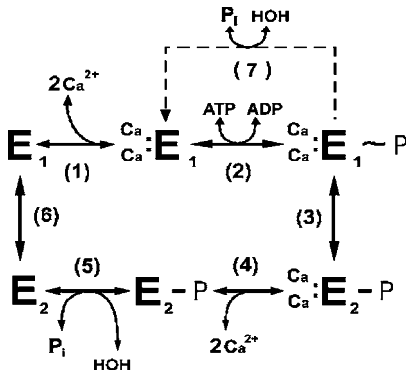


Fig. 5: The enzyme cycle.

step, Pi unbinds. In the sixth step, the configuration changes back to E_1. Depending on the thermodynamic forces involved, all these steps may be in a forward or backward direction. The process just described is completely coupled in the sense that each ATP molecule that reacts leads to the transfer of two calcium ions into the reticulum. An alternative process, indicated by step 7 in the diagram, occurs after the second step when inorganic phosphate leaves the protein, while the energy is dissipated as heat. Calcium ions can leave the reticulum when we add a leak pathway to the membrane. This path is parallel to the transport through the protein and is not indicated in the diagram in Fig. 6. Both return pathways results in an *uncoupled* overall process.

The description that follows from this diagram is not satisfactory for one reason in particular. It describes the processes in terms of pure reaction kinetics. Temperature differences and heat flows are not described. As shown by de Meis and others (1997, 2001), temperature plays an important role (e.g. in thermogenesis), and this description is therefore not thermodynamically satisfactory.

Classical non-equilibrium thermodynamics (de Groot and Mazur 1984, Kjelstrup and others 2006, Kjelstrup and Bedeaux 2008) gives linear relations between the Gibbs energy differences involved and the temperature difference with the reaction rate of ATP, calcium ion flux and heat flux. The linear nature of this description is not satisfactory.

A new methodology called mesoscopic non-equilibrium thermodynamics has been developed in recent years to address this problem. In 2005, Kjelstrup, Rubi and Bedeaux gave the first description of a calcium pump, which is nonlinear and contains the temperature as a variable. A short overview of the results is given here, indicating further work in progress.

In equilibrium, the reaction, Gibbs energy for the ATP conversion, ΔG^i, is zero and the chemical potential and temperature outside the membrane, μ^i_{Ca} *and* T^i, are equal to those in the reticulum, μ^o_{Ca} *and* T^o. Outside equilibrium, this is not the case, and a reaction rate, calcium ion flux and a total heat flux develop as a result. Both fluxes are positive when they are into the reticulum. Using mesoscopic non-equilibrium thermodynamics, we were able to show that

$$r = -\,D_{rr}[1 - \exp(\frac{\Delta G^i}{RT^i})] - D_{rd}[\frac{\mu^o}{RT^o} - \frac{\mu^i}{RT^i}] - D_{rq}[1 - \frac{T^i}{T^o}]$$

$$J^o_{Ca} = -\,D_{dr}[1 - \exp(\frac{\Delta G^i}{RT^i})] - D_{dd}[\frac{\mu^o}{RT^o} - \frac{\mu^i}{RT^i}] - D_{dq}[1 - \frac{T^i}{T^o}]$$

$$J_q = -\,D_{qr}[1 - \exp(\frac{\Delta G^i}{RT^i})] - D_{qd}[\frac{\mu^o}{RT^o} - \frac{\mu^i}{RT^i}] - D_{qq}[1 - \frac{T^i}{T^o}]$$

In the paper, expressions were given for the elements of the D conductivity matrix in terms of the parameters used in the mesoscopic context. For now, one only needs to know that the matrix is not symmetric. The important tasks currently being worked on are to:

i) Rewrite the equations using the measurable heat flux $\mathcal{J}_q'$ rather than the total heat flux $\mathcal{J}_q$ and to obtain the D' conductivity matrix using available experimental results. Convert these conductivities into those in the D matrix using the necessary enthalpies.
ii) Obtain some of these enthalpies from a first law analysis of the experiments.
iii) Obtain additional enthalpies from a quantum mechanical analysis of the calcium ions in the protein in the E_1 and the E_2 conformations.
iv) Obtain the conductivities in the mesoscopic description.

Once this is done, phenomena such as, for instance, thermogenesis may be described. Depending on the success of the analysis in the description of various details, the model can be further developed.

In this manner, we hope to learn much about this important and highly efficient element of biological systems. Such knowledge may be useful to develop other efficient chemical processes at the nano level. A better understanding of the Ca^{2+}-ATPase molecule could, for instance, give us new insight into obesity, a growing problem in many affluent countries.

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JÓN VIÐAR SIGURÐSSON

Politics and Personal Abilities in Iceland, Norway and Orkneys

The aim of this presentation is to compare the personal abilities of earls of Orkney (*jarlar*), kings of Norway (*konungar*) and Icelandic chieftains (*goðar*) in sagas written on Iceland, mostly in the 13th century, and how qualities attributed to these three groups of secular leaders expose significant differences between these three societies.

We will start this discussion by looking at the descriptions of three rulers and the key concepts the sagas use to describe them. The Icelandic chieftain Gizurr Þorvaldsson (d. 1268) "became a great chieftain, intelligent and powerful".[1] Earl Þorfinnr Sigurðarson of Orkney (d. 1065) "grew to become a great chieftain. He was unusually tall and strong […] a forceful man, greedy for fame and fortune. He did well in battle, for he was both a good tactician and full of courage".[2] Finally King Haraldr Harðráði [Hardruler] (d. 1066) who "distinguished himself above all other men by wisdom and resources of mind […] He was the bravest of all men, and he was also victorious […] King Harald was most greedy of power, and of all distinction and honour. He was very generous to friends who suited him".[3]

Professor Jón Viðar Sigurðsson
Department of Archaeology, Conservation and History (IAKH), University of Oslo, Norway
j.v.sigurdsson@iakh.uio.no
CAS Fellow 2007/2008

Shrewdness is the characteristic that the sagas emphasise most in descriptions of the chieftains on Iceland, and use to explain why some chieftains survived the power struggles while others perished. On the whole, the smartest, most politically savvy chieftains became the most powerful. Gizurr Þorvaldsson is a good example of such a chieftain. He waited as long as possible before making up his mind. He did not make decisions until he could be virtually certain of what the outcome would be and thus of what would be best for himself and his supporters. This emphasis on the chieftains' wisdom shows that the political battles in the Free State were usually fought with wits, and rarely with weapons. Power struggles were a question of mental tactics and political manoeuvres.

The kings' sagas emphasise the importance of astuteness, as in the saga of Haraldr *Harðráði*, who was "stronger and stouter than other men, and so wise that nothing was impossible to him, and he had always the victory when he fought a battle; and he was also so rich in gold that no man could compare with him in wealth".[4] However, wisdom was just one of many abilities good kings required for success.

1: Sts I, 402.
2: Íf XXXIV, 43.
3: Íf XXVIII, 198–199.
4: Íf XXVIII, 95.

Orkneyinga saga only mention the earls' cleverness in a few cases, and it appears as though this ability was of less consequence for the earls of Orkney than it was for kings in Norway or chieftains on Iceland. This departure may be due to the predominant activities of the Orkneys, where Viking raiding was more important than in the other two societies, hence the *Orkneyinga saga*'s particular attention to the personal abilities that result in victory in war and battles. To be a successful warlord, one usually has to be intelligent, so the *Orkneyinga saga* is indirectly stressing this personal quality.

One would expect the sagas to articulate the legal expertise and role of the secular leaders in legislation, but this is not the case. Though Icelanders with law skills are mentioned in the sagas frequently, chieftains are hardly ever included among them. Although the legal knowledge of the chieftains is hardly ever mentioned, most of them were well versed in the law. This was taken for granted, so there was no need to mention it. The law was a critical tool in the political game, which the chieftains could use to their advantage to put pressure on their opponents. For this reason, a good understanding of the law was essential.

The legal knowledge of the earls of Orkney is not mentioned, and on only a few occasions are kings of Norway said to be in possession of this ability, the reason being that this ability did not play any significant role in the political struggle in Norway and on the Orkneys. However, the Norwegian kings did participate in the legislation process, and sometimes used new laws to create popularity among the householders. Even though kings of Norway officially had control over the Orkneys, they were never involved in establishing laws there. There were only two cases in which the earls of Orkney were involved in organizing new laws. Nonetheless, it is rather likely that the earls controlled legislation on Orkney, and this fact was so obvious in itself that it was usually not worth mentioning. Consequently, the sagas do not give us a complete picture of the secular leaders' involvement, but through descriptions of their appearance and personal abilities underline the most important areas of activity.

The sagas place a great deal of emphasis on the generosity and wealth of kings, earls and chieftains. Gifts and feasts were used to create and/or renew ties of friendship, and it was through friendship that secular leaders built up their power base. Strong obligations of loyalty were associated with friendship; therefore it was the only means secular leaders had to ensure support. If the recipient could not afford to give a gift in return, the gift was to be paid for by rendering services. Otherwise, it could be taken back, and it was the service or a counter-gift that ensured the right to own or dispose of the gift. Because of the strong obligation to reciprocate, gifts were a good instrument by which secular leaders could bind supporters to them.

In all three societies, powerful secular leaders were described as *vinsælir*, that is, a person rich in friends. Generous leaders achieved great honour and thus more individuals wanted to be their friends. The generosity of the kings, earls and chieftains is usually expressed by the distribution of wealth down through society. However, the kings usually gave gifts to chieftains in Norway, whereas the earls and chieftains gave gifts to householders. The gift-giving process could not stop: if the secular leaders did

not continue to arrange feasts and give gifts, their friends would start looking for other, more generous leaders. The powerbase was therefore highly unstable, and boiled down to the economy of the leaders.

The reciprocity between secular leaders and their friends was the fundamental basis of friendship, and if the leaders failed to provide their friends with gifts or to arrange feasts, they knew that their support would fade away. This notion of mutual obligation attached to friendship was an intrinsic component of Norse culture. Another important aspect of friendship that we see in all three societies was the obligation of the leaders to support and protect any friends who were involved in disputes. Neglecting to perform this duty meant they could not expect their friends' support in return at a later point. Helpful, resolute and generous leaders became *vinsælir*; in other words, they became powerful, and on this foundation could further expand their power.

Sagas describing kings and earls, and especially in the portrayals of kings, extol the virtues of strength, fighting and leadership skills in battle. The societies of Norway and Orkney were more concerned with wars and armed conflicts, and were therefore more violent than Icelandic society in the 11th and 12th centuries. The power struggle between kings dominated the political scene in Norway during this period, while the earls of Orkney engaged in wars and plundering.

In the description of the leaders in the three societies, the sagas reveal an important difference between the political games that were played in these societies. The main difference was that Icelandic society was more peaceful than the two others, so the sagas paid more attention to the chieftains' cleverness, where as in Norway and on the Orkneys, the descriptions of the rulers focus on their gift for leading men into battle and their warlike abilities.

The main point of this comparison between kings, earls and chieftains is that all the sagas were written in Iceland. Can we safety assume that the saga authors give an accurate and trustworthy picture of the differences between the three groups of secular leaders? This question is fundamental to the study of Norse culture. It does appear that the saga authors were aware of the differences between the three societies, otherwise one would expect more Icelandic anachronism in the stories about kings and earls. We should not, however, overestimate the saga authors' capabilities. Although they may have made their mistakes, we are nevertheless left to rely on the picture they present, since it is the best we have.

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JOANNA SKORZEWSKA

Olaf Haraldsson's Relics – an Example of 'Hagiocracy' in Scandinavia

The analysis of the ideology of leadership in the medieval North would not be complete without the study of the source material concerning the three Scandinavian kings: Olaf II of Norway (k. 1015–1028/30), Knut IV of Denmark (k. 1080–1086) and Eric IX of Sweden (k. 1150–1160), who were reputed to be saints. The questions which are central to my research concern the cult of those individuals and the perception of their authority as reflected in written sources dating from about 1000–1250. Since the number of extant writings is quite large, it provides relatively good information about the way this authority was skilfully used to promote certain ideologies concerning the rule of particular sovereigns. The impact of such ideologies (understood, to use the simplified popular definition, as "a set of ideas proposed by the dominant class of a society to all members of this society") on medieval mentality was crucial.[1] As the main purpose behind an ideology is to promote change in a society through a normative thought process, a study of this kind may enable us to better understand socio-political changes in medieval Scandinavia.

Researcher Joanna Skórzewska
Department of Archaeology, Conservation and History (IAKH), University of Oslo, Norway
joann272001@yahoo.co.uk
CAS Fellow 2007/2008

The holy heritage

The model of "the suffering leader" was quite a common model of saint-hood in the medieval North.[2] Throughout the Middle Ages, the majority of the saints venerated in the West (especially in non-Mediterranean countries), were kings and princes. One cannot fail to note that a large number of the kings who were considered to be saints died a violent death, whether on the battlefield or struck down by their enemies. In both cases, they were later venerated as martyrs.[3] The phenomenon continued for a few centuries as the evidence for the *cultus* of Saint Olaf, Eric and Knut demonstrates. Olaf died in a battle which was the result of his territorial power struggle with Norwegian chieftains and the Danish King Knut the Great (c. 995–1035), while the assassinations of both Eric and Knut were provoked by their demands for tithes and taxes to be paid to support the Church. All three kings were involved in the constitution of laws in favour of the Church, which was honoured with the title *rex iustus*

1: http://en.wikipedia.org/wiki/Ideology.
2: See e.g. Bloch 1961, Folz 1986, Vauchez 2005: 158-167.
3: The new interpretation of martyrdom has been discussed e.g. by Gunnes 1972. It wouldn't be wrong to assume that, contrary to the *vitae* of the first martyrs, in the case of those individuals any pro-ecclesiastical works plus a violent death guaranteed the aura of martyrdom.

by writers and compilers of texts. The origins of this so-called 'hagiocracy' and its arrival in Scandinavia are difficult to pinpoint with precision.[4] Nevertheless, the concept was adapted on a wide scale and used to legitimize the royal power of the successors of the holy rulers as well as their conquests of large areas of land.

The context of Olaf's death, for instance, is clearly political, and the Christian hagiography as well as national identity played a crucial role here. Olaf could hardly be described as a king who defended the new faith against paganism in his newly converted country, but his piety and sense of justice were frequently underlined in the sources. Two skaldic poems honouring Olaf and proclaiming his holiness were composed within a decade after his death, which signifies a rather dynamic initiative, at least in certain circles.[5] The contents of the poems might have circulated around the country and led to a relatively sudden change in the popular opinion of him. However, their origin might have been the actual result of the king's growing popularity. If later texts are to be trusted as well, many people were dissatisfied with the Danish rulers after Olaf's death. Submission to the deceased sovereign became an act of repentance and penitence, but also a means to express patriotism. Also the acknowledgement of Olaf's *fama sanctitatis* was not limited to purely hagiographical or liturgical texts, designed for ecclesiastical use.

Heimskringla, a collection of histories of the Norwegian kings whose authorship is commonly attributed to the Icelandic skald, lawspeaker and politician, the Chieftain Snorri Sturluson (1178–1241), puts a particular emphasis on the political aspects of Olaf's sainthood. According to the text, the coffin had raised itself almost to the surface of the earth shortly after the burial. What is more, it looked brand new, and the king looked as if he had just fallen asleep. Also, Olaf's hair and nails had grown as much as if he had lived all the time that had passed since his fall.[6] It does not seem that his hair or nails were ever used as relics in order to trigger a miracle. To understand the ideological meaning of those remains it is necessary to recall the story of Harald Fairhair/Finehair (who reigned in the years 872–930), Olaf Haraldsson's predecessor and forefather. According to the legend (also elaborated by Snorri Sturluson in *Heimskringla*), he was a petty king in Vestfold who fell in love with Gyda, the daughter of King Eric of Hordaland.[7] Gyda refused to marry him before he was the king over all Norway. Harald, in turn, refused to comb or cut his hair before having achieved his goal. His conquest was successful, which also led to his marriage with Gyda. Nevertheless, Norway did not remain a unified country, the conflict among petty kings and chieftains proceeded. Olaf Haraldsson's saintliness reportedly played a decisive role in the unification of Norway, not less than his determination in battles.

As *Heimskringla* informs, Olaf's son, Magnus "the Good" (k. 1040–1047), who later became the king of Norway and managed to unify quite a big area, had an impressive reliquary made and would open it once

4: The term, a combination of words 'hagiography' and 'aristocracy', has been used i.a. by Vauchez (2005: 173) and implies a "natural" co-existence of sanctity, power and aristocratic distinction.

5: *Glælongskviða* by Þórarinn loftunga and *Erfidrápa* by Sighvatr Þórðarson.

6: ÍF XXVII, p. 404.

7: ÍF XXVI, pp. 94-149.

a year in order to clip his father's growing hair and nails regularly.[8] He was also quite successful at continuing the task of the unification of the country, and his father's spiritual support was, according to the texts, crucial in this process. However, it was Magnus's paternal uncle, Harald Sigurðarson "the Hardruler" (k. 1045–1066), who successfully continued the task started by Harald Finehair and Olaf Haraldsson. This might also have been the implicit reason why he was the last one to take care of Olaf's hair and nail clipping. When Harald was ready to leave Nidaros he went to Olaf's shrine, unlocked it, clipped his hair and nails, and locked the shrine again. The keys were thrown into the river Nid, and since then, as the author/s maintain, Olaf's shrine has never been opened.[9] Nevertheless, the very nearness of Olaf Haraldsson's body (which, never parted like many other relics, could be interpreted as the symbol of the country's integrity) was perceived as vital for Norwegian monarchs for decades and centuries later.

The proximity of the king

The physical presence of this particular royal saint had a vital meaning for his followers, as the pseudohistorical text of *Heimskringla* demonstrates. Not only the veneration of Olaf's body but also the placement of the relic was of utmost importance, especially for the closest family members of the King. Magnus Olafsson built a new royal residence and a new church close to it (Olaf's Church), where his father's relics were later moved from Clemet's Church.[10] Harald Sigurðarson moved the relics to another church which he had built (Mary's Church), and his son, Olaf "the Peaceful"/ "the Silent" (k. 1067–1093), moved the reliquary to a church for whose building he had been responsible (Christ's Church).[11] All the three kings were buried in churches which during their lives served as Olaf's shrines: Magnus in St. Clemet's Church, Harald in Mary's Church and Olaf – in Christ's Church.

The "journey" of Olaf Haraldsson's relics might be preceived in a few different ways.[12] Read as a historical text, the story might serve as a proof for a national, dynastic *cultus*, and it would not be wrong to mention rivalry among Olaf's followers in this context. At the same time, accepting all the information mentioned in *Heimskringla* as historical facts may be misleading. It must be borne in mind that despite certain historical truth (which had to be included in order to make the the text credible to the audience), the stories are to a large extent based on the authorial concept of the past and a subjective interpretation. Thus, it is also very possible that the tales of the multiple translations of Olaf Haraldsson's relics should rather be read as a foundation myth in the political, not religious, sense. Knowing the church topography and not knowing its history, the author/s of *Heimskringla* might have invented it. Since the aim of the whole work was to give an account of all the Norwegian kings and show a certain continuity between particular rulers and their actions, a motif better than the relics of the country's protector could hardly be found.

8: ÍF XXVIII, p. 20.
9: "ok hefir ekki síðan upp verit lokit skríni ins helga Óláfs konungs" (ÍF XXVIII, pp. 175-6).
10: ÍF XXVIII, p. 121.
11: ÍF XXVIII, pp. 121 and 208.
12: See the discussion in Røthe 2004: 202-14.

The *cultus* of Olaf Haraldsson demonstrates that the authority of holy sovereigns, based on their alleged martyrdom for faith, could be used for ideological reasons in a variety of ways throughout centuries. A purely religious authority is debatable in case of this royalty, even in the initial decades of the veneration. Still, it is interesting to observe how the authors (compilers) of a much later non-liturgical text used Olaf's *cultus* in order to legitimize the unified land as an inheritance and the process of unification as a royal duty. Olaf's shrine served both as a pilgrimage site and a symbol of national identity. The fact that a holy Christian king was depicted as an heir of a heathen ruler never seemed to have been an obstacle. Quite the opposite, the family lineage has served as a convincing argument, which only underlines the persuasiveness of the 'hagiogracy' concept.

Abbreviations

ÍF – Íslenzk Fornrit, Hið Íslenzka Fornritafélag

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JEAN-MARC SIMON

Mass Diffusion: A Molecular Description

Introduction

By definition, diffusion is the action to spread a given property i.e. a physical quantity (mass, energy) or a concept (new ideas), outside an initial space zone to the surroundings. It is a transport process that takes its origin in the interaction of a given property with the medium or system (surrounding + initial space zone). This definition is very broad and is used to label situations as either concrete or abstract, and the word itself has been used both in common language since the ancient times (*diffusio* in Latin) and in different fields of knowledge such as biology, chemistry, physics, economy, sociology, etc [1].

Associate Professor
Jean-Marc Simon
Department of Chemistry,
University of Bourgogne, France
jean-marc.simon@u-bourgogne.fr
CAS Fellow 2007/2008

The aim of this article is to give a simple description of what is known as diffusion in the physics of mass transfer from the perspective of the molecule (nano-scale), where it originates.

A molecular mechanism

In physics, the transfer of mass by diffusion was first described by Brown in 1827, and then subsequently explained by Einstein in 1905 [1]. At a molecular level, matter is heterogeneous and every molecule is in perpetual motion due to interaction with its surroundings. To paint a nice picture, authors say that molecules are dancing in a never-ending ballet [1]. In physics, this is called thermal motion, and the phenomenon increases with temperature. Colliding with other molecules, each one follows a random path and then they tend collectively to fill whatever volume is available to them. In liquids, this spreading effect is counterbalanced by strong attraction interactions between molecules, and the molecules preferentially diffuse inside the liquid itself rather than escaping it. In solids, the difference between the attraction and the effect of thermal motion is even greater as the molecules are trapped between other molecules that act as a cage, meaning diffusion is several orders of magnitude lower than in liquids. The surface acts as a barrier to the transfer of matter. In the gaseous state, the thermal motion is large, the gas diffuses everywhere and the spatial limits of the gas are only given by external properties such as the volume of a container, a liquid or a solid surface, or even an external force like gravity.

The origin of mass diffusion is thus purely stochastic and, like a lot of other physical, chemical and biological properties, it is simply the consequence of instantaneous heterogeneous distributions of matter and energy at a molecular level. As diffusion is due to the perpetual motion of the molecules, it can be studied both under equilibrium, where the distribution of matter is homogeneous at a macroscopic level and no mass

flow can be observed, by Nuclear Magnetic Resonance or Quasi Elastic Neutron Spectrometers (QENS), and under non-equilibrium conditions where the distribution of matter is heterogeneous at a *macroscopic* level and a mass flow can be observed (transient techniques).

In the 19th century, Fick described, at a macroscopic level, the diffusion of molecules from a high concentration zone to a low concentration zone. The flux of molecules in one direction, $\mathcal{J}$, due to diffusion processes which are linearly proportional to the gradient of concentration c, ∇c, along the same direction:

$$\mathcal{J} = -D\ \nabla c, \qquad \text{(equation 1)}$$

the coefficient of proportionality D is called the diffusion coefficient (see appendixes)[1]. Similarly, Fourier found the same linear relation between the flux of energy and the gradient of temperature. These gradients represent the heterogeneous structure of matter and energy at a *macroscopic* level. Temperature and density are thermodynamic properties, that is, their gradients play the same role as a force in mechanics (a driving force) and they are called thermodynamic forces.

Molecular dynamics simulation [2]

Although the study of the diffusion process from the mechanical point of view was impossible more than 50 years ago, it is now possible by using super computers. In 1957, Alder and Wainwright [2] were the first to use computers to simulate molecular dynamics (MD). The aim of this method is to simulate a system of atoms interacting through analytical potential or forces. The trajectories of all atoms through time are generated by a simple integration of Newton's equation of motion and then analysed using the tools of statistical mechanics. Under equilibrium conditions, the diffusion coefficient can be easily obtained from Einstein's law [1]:

$$D = [r(t)\text{-}r(0)]^2 / 2nt, \qquad \text{(equation 2)}$$

where $[r(t)\text{-}r(0)]$ is the mean distance between position r of a molecule at time 0 and later at time t. t has to be large compared with a characteristic time. n is the space dimension, and for diffusion on a surface, it equals 2. This MD method is able to provide diffusion coefficients in excellent agreement with experiments; it is also able to explain the molecular mechanism involved in the processes. It is particularly useful to get data when the experiments are dangerous or very costly or perhaps not even accessible, given the present technology. Diffusion properties across and along surfaces are of that sort and they are hardly known although they play a key role in many processes in nature (membranes in biology) as well as in industry (separation processes).

In a recent article [3], we obtained surface diffusion coefficients of hydrogen adsorbed on graphite at different temperatures using the QENS technique. These results are presented in figure 1 and compared with new data we got using MD simulations. The agreement is very good. Additional simulations have shown that the trajectory on the surface before being desorbed was significant, around 5 nanometers, whatever the temperature (a range from 70 to 300K). At 300K, the number of adsorbed H_2 molecules on graphite is very small and their effects are often considered to be negligible, see the recent review paper by Strobel *et al.*

about H_2 storage [4]. This new result suggests that this should not be true. The system studied is a part of fuel cell system and this result gives new insight in their working mechanism. This will be presented fully in a forthcoming article.

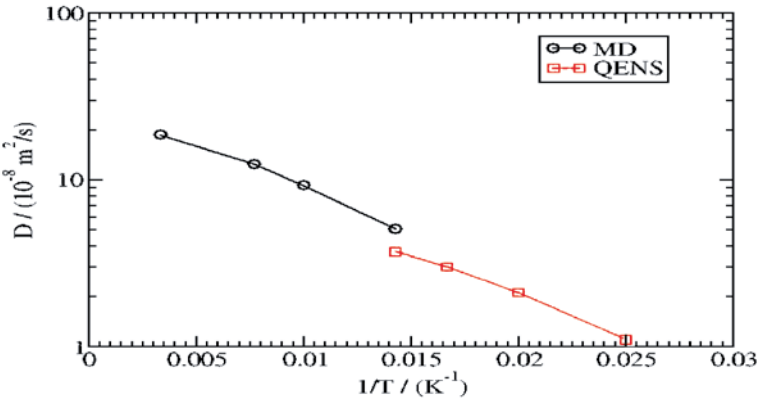

Figure 1: Arrhenius plot comparing surface diffusion coefficients of H_2 on graphite obtained by MD and QENS techniques [3].

Conclusion

Mass diffusion is a stochastic process, i.e. a consequence of local heterogeneity of matter distribution and of the energy at a molecular level. It makes a contribution to particle transport and is often coupled with or hidden behind other phenomena. This can make it difficult to analyse, even though its definition is simple.

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[1] For general discussions about diffusion in the context of natural science, the reader is referred to a textbook edited by Jörg Kärger after the first conference: Diffusion Fundamental I, *Leipzig, Einstein, Diffusion*, at the Leipziger Universitätsverlag, Leipzig (2007).

[2] M.P. Allen, D.J. Tildesley, *Computer Simulation of Liquids*, Clarendon Press Oxford (1987).

[3] O.E. Haas and others, *A quasi-elastic neutron scattering investigation of the hydrogen surface self diffusion on polymer electrolyte membrane fuel cell catalyst support*. Accepted by the Journal of Physical Chemistry C.

[4] R. Strobel and others, *Hydrogen storage by carbon materials*. Journal of Power Sources, vol *159*, 781–801 (2006).

Appendix 1

The gradient of c, ∇c, in a spatial direction x is

$$\nabla c = dc/dx$$

In first approximation that can be calculated from the knowledge of the value of c in two different positions is x. If in position x_1 we have c_1 and in x_2 we have c_2.

∇c will simply be the difference between c divided by the distance between the two positions:

$$\nabla c = (c_2\text{-}c_1)/(x_2\text{-}x_1)$$

When the concentration in the system is uniform (i.e. if there is homogeneous particle distribution), the gradient vanishes and the resulting

flux is null (cf. equation 1). On the contrary, when ∇c differs from zero, it results in a mass flux from the higher concentration to the lower concentration.

The units of the different variables are: x and r in m, c in mol/m^3, $\mathcal{J}$ in mol/(m^2.s), D in m^2/s, t in s.

Appendix 2

Diffusion is a result of the heterogeneity of mass distribution and interaction energy with the surroundings. Fick's equation is based on the main term, i.e. the interaction with mass heterogeneity. In its above noted form (equation 1), Fick's equation applies to one phase. At interfaces like, e.g. on the surface of liquids, we saw that this equation is not valid although the difference of concentration is very different (between the liquid and the surrounding gas). It has been shown in fact that the full expression should include energetic terms; the thermodynamic force is then the gradient of the ratio between "chemical potential" (μ) and temperature. μ is a function of the energy and temperature and concentration of the molecule. As a consequence a difference of temperature can then lead to a diffusional flux, this is the thermal diffusion effect.

ANDERS HULTGÅRD

Studying Religion – Concepts, Methods and Dilemmas

My paper aims at addressing some of the problems and challenges faced by the study of religion(s) and at presenting briefly the academic context of that study.

The forming of concepts

Every branch of science works with a set of concepts and terms that convey the framework and the objects of its study. The *History of Religions* or *Religious Studies* is a branch of the humanities that is concerned with the study of religion or rather religions. This immediately brings us to the essential question: what do we mean by 'religion'. Concepts have their own history and their first use belongs to a specific culture. Thus, much of our western scholarly terminology has its origins in the Greek and Roman civilizations. The modern concept 'religion' is no exception.

Professor emeritus
Anders Hultgård
Faculty of Theology,
Uppsala University, Sweden
anders.hultgard@teol.uu.se
CAS Fellow 2007/2008

The concept is derived from the Latin word *religio* which is difficult to translate in a precise manner but which represents a fundamental preoccupation with the ancient Romans. *Religio* is mainly expressed in a careful, sometimes meticulous, observance of prescribed rituals. That's why Cicero could say of the Romans that they are the most 'religious' (*religione … multo superiores*) of all peoples and he defined 'religion' as 'worship of the gods'.[1] Latin writers presented two different etymologies of *religio*. Cicero derived it from the verb *relegere* meaning "to take up again with care" whereas Lactantius (a 4th century Christian writer) related it to the verb *religare* "to tie, to bind".[2] The idea of *religio* was taken over by Roman Christianity and transformed into a new concept with much of the same meaning the word 'religion' has today in western languages. The Christian concept was shaped in contrast to paganism and *religio* could only apply to the Christian tradition. It was not until in the 17th and 18th centuries that attempts were made to apply the use of the concept also to traditions outside Christianity. In the 19th century, the concept became more widely used to denote religious beliefs and practices of non-European traditions. The concept 'religion' is an abstraction, and consequently the object of our study is not religion in itself but the concrete cultural manifestations that we call 'religions'. The problem of definition apparently remains, however. I will not go into the details of the discussion of defining what religion is but will limit myself to some remarks on the concept itself. Being a modern scholarly construct, the

1: Cicero, *De Natura Deorum* II,8.
2: Cicero, *De Natura Deorum* II,72 Lactantius, *Div. Inst.*

term 'religion' raises the question of its applicability to traditions outside the western world. There is an ongoing discussion on this issue within the discipline.

Human experiences and cultural developments accrue to concepts and categories over a long period of time. Their study is in many ways illuminating. The monumental publication by Reinhart Koselleck and his fellow workers entitled *Geschichtliche Grundbegriffe* (8 volumes, 1972–1997), that is 'Basic concepts in history' is indispensable to historians and can also be taken as a model for historians of religions. It investigates the history of some one hundred concepts used in modern political thinking such as 'state', 'liberty', 'revolution', and 'emancipation'. In the field of religious studies, an analogous work, although with a somewhat different purpose, has actually been published by German scholars under the title *Handbuch Religionswissenschaftlicher Grundbegriffe* (5 volumes 1988–2001). It is more modest in scope, and the choice of concepts treated reveals the opinion of the editors about what is or should be the current terminology. Thus, several traditional concepts such as 'sacred marriage' and 'sacred kingship' have been discarded or replaced with other concepts judged to be more appropriate.

History of religions and theology

Another concept is *theology* which, in its modern usage, carries different meanings. It denotes for example the academic discipline of 'theology' which is mainly devoted to the study of Christianity. A particular issue, sometimes hotly debated, is the relationship between history of religions or religious studies on one hand and theology as an academic discipline on the other. Since the Middle Ages, theology has been an important subject at Western universities and most universities still have faculties of theology. The emergence of history of religions as a discipline of its own can be roughly dated to the late 19th century. If a more precise year must be chosen, it would be 1886, when the École pratique des Hautes Etudes in Paris established a section called *sciences religieuses* devoted entirely to the study of religions. At the same time, the theological faculty at the Sorbonne was shut down. Unlike in most other countries where the history of religions and theology are dealt with by separate institutions, The Netherlands, Denmark, Finland and Sweden have state universities with theological faculties that also include chairs in the history of religions.[3] The problem with 'theology' in an academic context is that it usually stands in the service of the churches and also includes some normative elements. For example, the elaboration of a good theology for Christians may be one of the tasks of a theological faculty. Academic theology has a strong focus on the interpretation of canonical texts, that is, the Bible, which may cause theological scholars to lose sight of important historical aspects. Thus, to understand fully the religion of the Old Testament, it is necessary to study it in the context of the other religions of the ancient Near East. Similarly, early Christianity must be seen and interpreted as one among the many religions in the Hellenistic-Roman world that flourished during the first centuries of our era.

3: This situation can occasionally be found also in Germany, Switzerland and the United Kingdom.

Historians of religions study Christianity based on the same premise as other religions. This means, among other things, that the distinction between canonical and non-canonical texts is of less relevance (unless specific questions such as the process of canonization are addressed). Discussion of the different positions taken by the history of religions and theology as academic disciplines should not conceal the fact that the concept of 'theology' can be an important category in the general study of religions, provided we are dealing with religions that believe in the category of supernatural beings we call deities.

I suggest we have to look first at the meanings the concept had in its original Greek context in order to find guide lines for its modern scholarly use.

The Greek word *theologia* with the verb *theologein* and the noun *theologos* were first used by Plato and Aristotle, but were used more frequently by later authors. The basic meaning of *theologia* is talking or thinking about the gods or God. In a cultic context, *theologia* can be used in the sense 'praise of a god (or 'gods'). The verb *theologein* denotes the activity that has *theologia* as its result. The noun *theologos* refers primarily to a profession which was associated with religious teaching and rituals. We may note that, unlike *religio,* the use of *theologia* emerged rather late in Greek-speaking Christianity. Sometimes the meaning of *theologia* comes close to that of "religious tradition".[4] Finally it can be observed that, in Antiquity, the use of *theologia* was not clearly distinguished from that of *mythologia.* Some uses of 'theology' as a general concept in the study of religions are proposed here:

- In accordance with the basic meaning of *theologia* in its Greek context, 'theology' denotes ideas, teachings and discourses about deities or a particular deity.
- Second, we may apply 'theology' to systematizing interpretations or reworkings of traditional beliefs about gods and goddesses.
- Third, 'theology' may be used for systematic elaborations and presentations of the fundamental doctrines of a given religion. In this sense, 'theology' usually belongs with a particular type of religions where sacred texts serve as basis for further theological work. Thus, we speak about Jewish, Christian and Islamic theology.
- In some traditions, the foremost Christian and Islamic 'theology' may also stand for a religious science.

To sum up the discussion about concepts, the study of religions cannot leave things as they are. It must constantly commit to renewing category formation and to reconsidering established concepts.

Methods

The history of religions is characterized by its multiplicity of methods. A historian of religions makes use of all kinds of materials that are relevant to his or her purpose, written sources, archaeological remains and iconographic materials, oral and visual information. Consequently, methods vary according to the type of source materials and the purpose of a given investigation. In spite of this variety, some methods are more common than others.

4: See for example Josephus, *Apology* I, 78, 225, 237.

Since verbal expression usually conveys a clearer meaning than other types of human activity, and may in addition be preserved over time through written or oral transmission, *philology* stands out as one of the main methods in the discipline. Philology must be taken in a broad sense, including linguistic competence, awareness of text and source critical tools, knowledge of literature and other cultural phenomena as reflected in the texts (also the oral ones).

The *comparative approach* is the hallmark of the history of religions. The terminology and categories we use, such as myth, divination, sacrifice, priests, etc., have been elaborated on the basis of comparisons which aim at bringing out similarities as well as differences. The process of comparison raises many theoretical and methodological problems that are beyond the scope of this article. Making comparisons is a basic act of human cognition and it is also essential in much scholarly work. It is indispensable for historians of religions, particularly when we are faced with the interpretation of religious traditions that have come down to us only fragmentarily, as is the case with the religion of the ancient Scandinavians. Below, I propose some reasons for making cross-cultural comparisons (with special reference to religions of the past that are incompletely known):

- To discern the influence of one tradition upon another.
- To reconstruct a common prototype or to establish some sort of genetic relationship.
- To gain a better understanding of the particular religion or religious phenomenon with which we are primarily concerned.
- To support the ancient origin of myths, ideas or rituals that have been poorly studied or appeared late in the religion studied by pointing out correspondences with earlier, more complete sources from other religions.

Dangers and dilemmas

There are many dangers and dilemmas involved in the study of religions. When dealing with religions outside his or her own cultural sphere, the scholar runs the risk of missing important aspects. This leads to the question of whether it is possible to get a real understanding of a religion without being a believer or practitioner of it. Should we, then, leave the study of Christianity to Christians, Hinduism to Hindus, and Judaism to Jews? A similar dilemma faces the scholar who attempts to create an image of a religion belonging entirely to the past. We are confronted with a world view that is largely irrecoverable, and what we reconstruct may risk being biased and is anyway incomplete. Moreover, our own modern world-view and values cannot be kept out completely, but the awareness of this fact may prevent the historian of religions from making too serious misinterpretations and anachronisms.

Dangers of a more concrete kind may confront the historian of religions. In 2007, a German university professor lecturing on Islam and the Qur'an received a murder threat. The case attracted much attention and lead to a vivid debate. Yet the incident is just one of many that have been recorded in connection with the scholarly study of the holy scripture of Islam. It is not just western scholars who are involved. Some years ago, an Egyptian Muslim professor making an attempt at taking a historical-critical approach to the Qur'an was tried in court, judged as an apostate and therefore forced to divorce his wife.

The Qur'an is considered by Muslims to be the pure word of Allah sent down to his prophet Muhammad. As such, it cannot be subject to criticism or to a study of its historical background. This creates a dilemma for historians of religions who want to address the issues of how the Qur'an came into being and about the influences that shaped it. Scholars who work with Islam today tend to avoid taking up such issues and concentrate on other aspects instead. However, historians of religions should not stop short of studying the Qur'an in the same way they study the sacred texts of other religions such as the Bible or the Vedas.

Two more recent finds of utmost importance for the textual history of the Qur'an will renew the interpretation of Qur'an and also reopen the debate on the historical-critical approach to the holy scripture of the Muslims. One is the recovery of the Bergsträsser film archive of Qur'anic manuscripts that was thought to be lost in the turmoil of the Second World War. The evaluation of that archive is in the hands of scholars at Freie Universtät in Berlin, i.e. the Corpus Coranicum project.[5] The other is the sensational find made some time ago in Yemen. During reconstruction work on the great mosque of Sanaa, one of the oldest in the world (built in 628), thousands of Qur'an fragments were discovered. Many of them dated from the 7th century and some were written only fifty years after the death of Muhammad. The task of restoring and combining the fragments has now been completed. The German scholars at the University of Saarbrücken who were responsible for that work estimate that one-fifth of the Qur'an must now be read in a new way.[6] What is at stake is the ambiguity of the early Arabic script, the so-called *rasm*, which allows for reading the transmitted consonant text in more than one way and which also helps show the underlying Aramaic influence.[7]

Yet the intricate problem of interpretation has only begun and may imply new challenges for the history of religions. In my opinion, the nature of the Qur'an as the last important document of Late Antiquity religious traditions will appear more clearly and lead to a reconsideration of the origins of Islam.[8]

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5: Corpus Coranicum – Textdokumentation und Kommentar zum Koran; for further information see *http://www.bbaw.de/Forschung/Forschungsprojekte/Coran/de*

6: For the find and its signification, see Ohlig & Puin 2005.

7: See also Luxenberg 2000.

8: This would be along the lines proposed by historians of religions already in the first half of the 20th cent., such as Tor Andrae and Geo Widengren.

KOSON SAPPRASERT

Acknowledging Organisational Innovation

A need to study organisational innovation

Recent decades have seen a remarkable increase in the attention devoted to innovation by interdisciplinary scholars (see Fagerberg, 2004; Fagerberg and Verspagen, 2008). Despite the great importance of organisational innovation, e.g. in economic 'forging ahead' and 'catching up' at different points in time (Bruland and Mowery, 2004), thus far, technological innovation in the sense of new or significantly changed products and processes has received more attention and been taken into account in a far greater number of analyses.

Research Fellow Koson Sapprasert
Centre for Technology, Innovation and Culture (TIK), University of Oslo, Norway
koson.sapprasert@tik.uio.no
CAS Fellow 2007/2008

Actually, the organisational aspect of innovation started to receive conceptual attention at the very beginning of research in this area. Back in the early 19th century, Schumpeter (1934, 1950), a pioneer in innovation studies, presented a broad notion of innovation as the introduction of new products, new processes, new sources of supply, the exploitation of new markets and new ways of organising business (for a discussion, see e.g. Fagerberg, 2003, 2004). This remains valid today, especially in a majority of industrialised countries whose 'national systems of innovation' are composed of and significantly fostered by all these essential innovative changes (Freeman, 1987, 1995). At the micro level, Lazonick (2004) points out that innovative forms of organisation differ greatly across time, industrial and institutional contexts. Moreover, in constituting an innovative firm, the technological and non-technological aspects of innovation are both of importance (Chandler, 1962; Nelson 1991). The effort to implement technological innovation will meet only limited success unless accompanied by organisational change and vice versa, as they are, in fact, interdependent (Freeman, 1995). Thus 'organisational' innovation should never be neglected. It is the sort of innovation that, together with certain key technological innovations, has helped to improve firms' performance and growth in many leading and catching-up countries (e.g. the US, Germany and Japan) from the first industrialisation through different 'business cycles' (Schumpeter, 1939) or, to use Freeman and Louca's (2001) label, 'techno-economic paradigms' (see a discussion, especially in Bruland and Mowery, 2004). More recent evidence confirms that organisational innovation is also crucial in our times as it complements a key technological driver like Information and Communication Technology (ICT) in elevating a firm's performance and growth (Brynjolfsson and Hitt, 2000; Brynjolfsson *et al.*, 2002; Sapprasert, 2007). As Bresnahan *et al.* (2002) argue, firms cannot simply plug in computers

and achieve product/service quality or efficiency gains. On the contrary, they must go through a process of reorganisation in combination with making considerable changes to their products and processes, i.e., it is not ICT alone, but a joint effort between ICT and organisational change that is the compulsory recipe for true success in our modern era (Brynjolfsson *et al.*, 1997).

A brief note on organisational innovation

Different lines of research apply the term 'organisational innovation' in different ways (see a review in e.g. Lam, 2004). Thus it is important to flag that organisational innovation in this sense does not refer broadly to the adoption of 'any' novelty in the organisation such as that defined in, for instance, Damanpour (1991) and Sorensen and Stuart (2000). 'Organisational innovation' is defined more narrowly in this respect as a new or significant change in the firm structure and management methods often termed by researchers in management/organisational studies (Daft, 1978; Damanpour, 1987, 1991; Kimberly and Evanisko, 1981; Teece, 1980) as 'administrative innovation', as opposed to 'technical innovation' (both are referred to as organisational innovation), or what Edquist et al. (2001) called 'organisational process innovation' (*vis-à-vis* 'technological process innovation', leaving aside product innovation). Put another way, 'organisational innovation', as discussed here, denotes innovative change in the organisation in a customary and institutional manner that is related more to organisational nature, structure, arrangements, practices, beliefs, rules and norms, than to its technical facets (see, e.g. Pettigrew and Fenton, 2000).

Routine organisational innovation and structural inertia

While technological innovation is deemed to refer more to innovative change in products and processes, organisational innovation seems to be related relatively more closely to change in the way of doing things in the firm or what so called 'organisational routine' (Nelson and Winter, 1982). This type of change is no less crucial since, as time goes by, some of the best practices or prevailing routines in the firm may become less effective or even no longer acceptable, especially by comparison with that of competitors (Dosi and Nelson, 1994). Organisational transformation is thus crucial (Romanelli and Tushman, 1994), i.e. old routines need to be replaced by new ones if the firm is not to be driven out of business. Following the adaptation perspective (e.g. Nelson and Winter, 1982; Teece and Pisano, 1998), to survive or co-evolve with industrial dynamics, the firm has to search for better solutions and make changes, especially if its performance falls below its 'aspiration level' or a new window of opportunity opens up (Cyert and March, 1963; Greve, 2003). Although changes in routines are clearly important to all firms, there is considerable 'heterogeneity' among them (Nelson and Winter, 1982). Firms have a wide variety of characteristics that make them different in how they decide to approach routine change and to benefit from such an attempt.

Another research community, on the other side of the road, emphasises the importance of environmental selection (e.g. Stinchcombe, 1965; Aldrich, 1979; Hannan and Freeman, 1984). In particular, inertia theory (Hannan and Freeman, 1984) indicates *inter alia* that age and size are associated with strong structural inertia, i.e. the force that hinders organi-

sational change. Inertia increases monotonically with age as the firm's working relationships become more formalised, routines become more standardised and structure becomes more stabilised (Kelly and Amburgey, 1991). Size increases inertia because being larger makes the firm more rigid and inflexible (Downs, 1967). Inertia arisen from these attributes in turn makes the firm resistant to change (Carroll and Hannan, 2000).

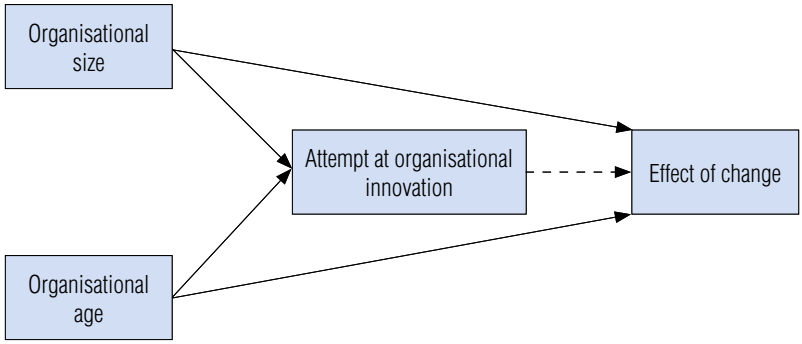

Figure 1: The relationships between organisational age, size, innovation and outcome

Although firm age and size may increase inertia as the theory suggests, when looking separately at their relationships with: (i) the firm's tendency to attempt organisational innovation; and (ii) the effects of this attempt on firm performance, these two organisational factors may count differently due their other properties (see Figure 1). Kimberly and Evanisko (1981) argue that firm size can necessitate and facilitate the firm's innovative behaviour. Larger firms might be more inclined to undertake organisational change because of their 'deep pockets', i.e. higher level of financial and other resources. In other words, since larger firms generally have a greater capability to innovate (Schumpeter, 1950), they are probably more ready and likely to do so, not only technologically but also organisationally (Kimberly and Evanisko, 1981; Damanpour, 1987). Further, it is also possible that the age of a firm supports organisational innovation because, as compared with immature or undefined routines possessed by younger firms, the greater maturity of routines in older firms may serve as a more powerful impetus to innovation. While younger firms are busy dealing with many basic operational issues (e.g. cash flow, formalising relationships and so on) or paying more attention to innovating new products or processes to enter the market, older firms can be expected to be relatively less occupied and ready for reorganisation.

On the other hand, the inertial properties that limit organisational change, which Hannan and Freeman (1984) point out are more prevalent in large, old firms, may in fact have greater influence on the outcomes of efforts at organisational innovation (Sapprasert, 2008). Put differently, firm age and size are more likely to impede the effects of organisational innovation on firm performance. Older firms are purported to have more standardised routines and rigid internal structures (Stinchcombe, 1965, Hannan and Freeman 1984). Accordingly, they may be more reluctant to unlearn past routines and less able to transform their structure and, as a result, be more likely to get stuck in a 'competency trap' (Levinthal and March, 1993) or to remain path dependent (Arthur, 1994; David, 1994). Although it is managerial authority that leads to most undertakings in the

firm (Witt, 1998; Knott, 2001), this authority is often subject to limits in practice when it comes to organisational change (Leibenstein, 1987). This implies that, unlike youngsters that usually are more adaptive, older firms that usually stay committed to the past would not substantially benefit from reorganisation that has been strategically implemented. Likewise, the effects of organisational change might decrease with size, since that typically increases the distance between decision makers and practitioners. And increasing distance through a hierarchy is likely to vary commands or plans set out by the former (Beckmann, 1977), hindering the organisational change required. In a large but lean organisational structure, however, there are typically a number of links within each unit, i.e. complexity (Simon, 1962), which can also hamper organisational innovation. In addition, since organisational members usually prefer the *status quo* and thus oppose change, efforts at organisational innovation in larger firms with more people frequently encounter internal opposition or 'political force' (Pfeffer, 1992). These conditions result in greater ossification and inflexibility which may cause larger firms to benefit less from attempts at organisational change.

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MAGNUS GULBRANDSEN

The Role of Basic Research in Innovation

This short article discusses the role of basic research in innovation. Policy-makers and researchers tend to agree that basic research is important for society, also for innovation and economic growth. There is, however, considerable debate about why it is important and the implications of this importance.

A practical example may serve as an illustration of the disagreement surrounding issues like the organisation of basic research, the need for improved university-industry relations and the increasing emphasis on academic patenting. In 2003, around 300 of the world's leading innovation researchers were gathered at the Science Policy Research Unit (SPRU, University of Sussex) in Brighton in memory of one of the field's greatest researchers, Keith Pavitt. During a panel debate, the audience was asked whether "increased user relations at universities are detrimental to basic research". The vote was 50/50, and after an hour of debate about the role of basic research in innovation, the vote was still 50/50. Pavitt himself, summarising many years of innovation research, had argued for broad funding of basic research but against any exaggeration of direct linkages between basic research and innovation. He warned against too much emphasis on "relevance" and "commercialisation": "Dealing with deficiencies in business R&D by making basic research more 'relevant' is like pushing a piece of string" (Pavitt 1991:117).

Senior Researcher
Magnus Gulbrandsen
NIFU STEP, Oslo, Norway
magnus.gulbrandsen@nifustep.no
CAS Fellow 2007/2008

One major problem is the frequent lack of definitions and precise formulations of the questions to be discussed. "Basic research" has many different meanings and definitions, and alternative terms like "strategic", "fundamental", "curiosity-driven", "researcher-controlled" and "autonomous" only contribute to making the issue more confusing. The research and development (R&D) statistics use an intentional definition where basic research refers to activities that have "no practical application in mind". Scientists themselves often use other flexible definitions, e.g. based on the degree of theoretical content or ambition in a project (Calvert 2006; Gulbrandsen & Langfeldt 2004). Sometimes basic research is regarded as the same as university research, but this is not necessarily correct. Statistical data show that in many countries, e.g. Norway, only about half of the R&D activities in the university sector are classified as "basic research". Some firms also carry out basic research, although this is most often too risky for private companies even though they may benefit from it in the future (Rosenberg 1990). Finally, it has been argued that influential researchers have often strived for fundamental understanding, yet worked primarily with projects of an applied nature (Stokes 1997).

Stokes calls this "Pasteur's quadrant", claiming that research policy should aim to fund projects that *combine* fundamental understanding and considerations of use. In other words, "basic research" is not a clear concept and may refer to many different activities.

It should also be added that there are numerous definitions of innovation, counting at least in the hundreds. Current literature (see Fagerberg et al. 2005) emphasises that innovations are not only new products and technological production processes, but refer to many more and wider phenomena, including new organisational forms and the creation of new markets. Furthermore, most of the innovation literature defines an innovation as something that is new to the firm adopting or developing it, rather than new to the whole market or indeed the whole world (e.g. Van de Ven et al. 1989). Given this wide definition, it is clear that basic research will not play a major role in many types of innovations.

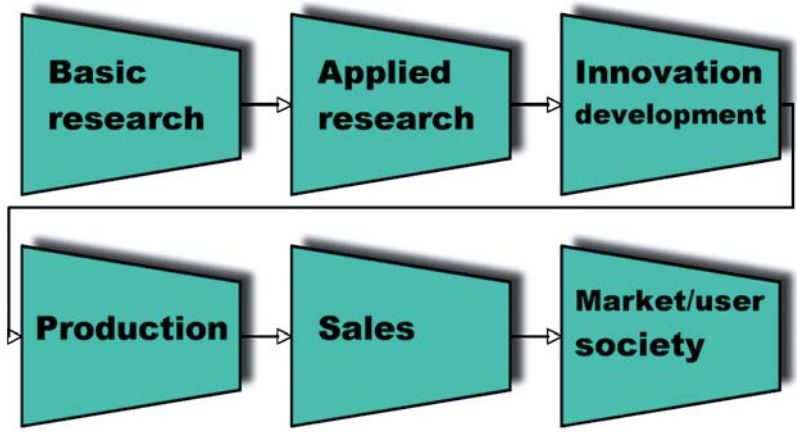

Figure 1. The linear model of innovation.

One reason for the heated debate about basic research and innovation is the historical strong dominance in many countries of what is known as the linear model of innovation (see Figure 1). This model states that the results of basic research feed into applied research and development, which in turn lead to production and sales on a market. Although perhaps never formulated as simply as in Figure 1, this way of thinking was nevertheless central, for example, in the creation of research units and science support structures from the end of the 19th century and after the Second World War. "Science invents, industry adapts and society conforms", which was the motto of the 1933 World Exhibition in Chicago.

For more than 30 years, however, the field of innovation research has presented empirical evidence that most innovations do *not* occur in this way. There are three main problems with the linear model (see Kline & Rosenberg 1986). First, it portrays research as the driver of innovation, while in most cases the key driver is a need found among certain users in the market or within a company. Second, it underestimates the many reverse processes and feedback loops inherent in technological change. A commonly used example is the transistor, which was developed years before the underlying scientific principles were formulated. Innovations and applied research may thus constitute an important *input* into basic research. Third, the linear model underestimates the importance of incre-

mental changes, particularly related to production processes. Very few innovations are radical or disruptive – although research may be relatively more important in these cases (see Abernathy & Clark, 1985). Belief in the linear model may therefore lead to too much attention to the basic research end of the pipeline, assuming that the rest of the chain takes care of itself, and perhaps to overly high expectations of the impact and applicability of basic research results.

Some innovations are indeed developed in the way portrayed by the linear model. Sometimes – albeit rarely – important new inventions emerge from basic research organisations which may be transformed into innovations in a rather linear fashion. There are also big differences between disciplines and between technologies. Biotechnology is often used as an example of a field with somewhat more "linear" characteristics of its innovation processes. Furthermore, the stage of development of a scientific discipline may matter for the types of innovation that it can help create.

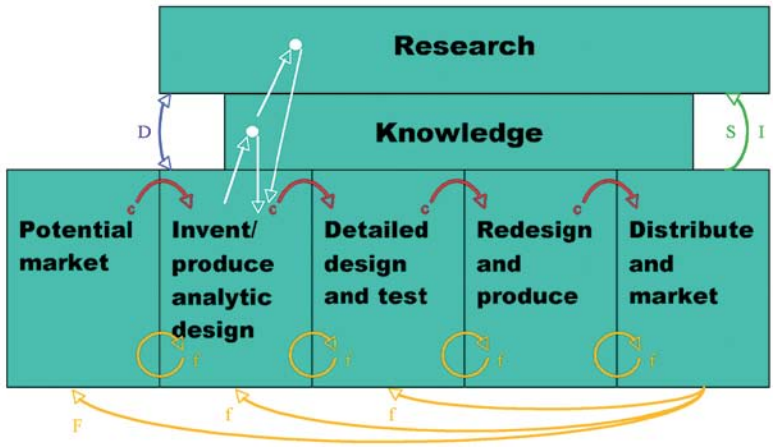

Figure 2. The chain-linked model of innovation.

A more up-to-date and commonly used model of technological innovation is the so-called chain-linked model (Kline & Rosenberg 1986, see Figure 2). The key process is to create a design based on needs and demands. Although the process can be sequential, there are numerous feedback loops. When a problem arises, participants turn to existing scientific and technical knowledge to look for solutions. Only when this fails is new research needed. Figure 2 shows how basic research is first and foremost an important contribution to the stock of existing knowledge and therefore an indirect influence on innovation, although it may give rise to new designs directly (the line marked D) and be influenced by innovations, particularly related to scientific instruments (the line marked I). Implicit in this view of innovation is that the knowledge and skills of the involved firms and individuals matter when it comes to being able to utilise relevant scientific and technical knowledge, an aspect often referred to as "absorptive capacity" (Cohen & Levinthal 1990). In other words, exploiting basic research also requires certain types of knowledge and experience that may be a more important bottleneck to the use of science in innovation than the quality of the research itself.

The most important effect of basic research on innovation is most likely through the training that PhD and other students receive, and they then move on to find work in innovative firms and increase their absorptive capacity (Pavitt 1991). Basic research is an excellent means of learning both specific knowledge and methodical ways of working, and it helps import and filter knowledge produced in other countries. These are more important justifications for public support of basic research than any direct contributions to innovation.

To some extent this is a problem for the scientific community, which used to receive funding and autonomy based on the view expressed in the simpler linear model. In a period with constraints on public expenditures and reduced core funding of basic research, scientists are eager to present evidence of a direct linkage between their professional activities and politically desired goals of innovation and economic growth. However, as the innovation literature has shown, even if the main linkages between innovation and basic research are indirect, this does not imply low importance of basic research, but perhaps even a strengthened argument for its public support and protection. The literature on the topic of university-industry relations is still only in its infancy, and more results will emerge in the years to come. So far, the studies have concluded that there seems to be a positive relationship between commercialisation and academic quality, but also that patenting may have harmful effects on knowledge production in the long run. Finally, it should not be forgotten that a cultural argument can be put forward – basic research is of course more than a servant of society's short-term needs. For many scientists, the opportunities for long-term immersion in important scholarly problems without immediate demands to utility value, is a key motivation to devote a lifetime to research. This perspective is not always visible in innovation theories.

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BEN R. MARTIN

Research Misconduct – Does Self-Policing Work?

Introduction

The world of academic research has been described as 'The Republic of Science'. This has various characteristics, one being that it operates on the basis of 'self-policing'. This self-policing is believed to be effective in ensuring that academic misconduct is rare, generally low-level and self-correcting. Any serious misconduct, it is assumed, will be quickly detected by peer review and stopped. The risks of being caught and the severity of the sanctions that follow are presumed to be so great that few will be tempted to stray down this route. While plagiarism is increasing among students, such misconduct has not generally been seen as a major problem among academics. However, the case described below should force us to reconsider our preconceptions about the efficacy of self-policing.

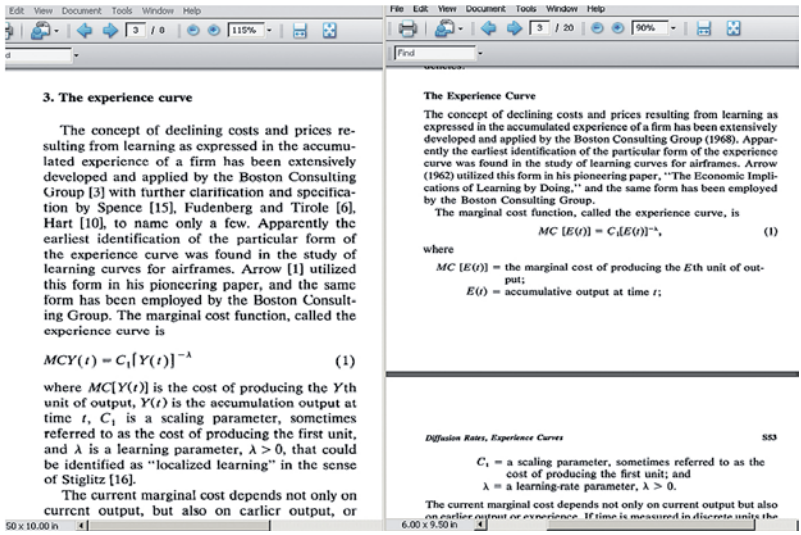
Professor Ben R. Martin
SPRU, The Freeman Centre,
University of Sussex, UK
B.Martin@sussex.ac.uk
CAS Fellow 2007/2008

I focus here on plagiarism, one of three main forms of research misconduct (the others being data fabrication and falsification). "Plagiarism is the copying of ideas, data or text (or various combinations of the three) without permission or acknowledgement".[1] In the academic world, plagiarism is generally regarded as a serious 'crime'. If it were allowed to flourish unchecked, researchers would be discouraged from publishing their findings, and the reputation system operating in the academic world would be seriously damaged.

The tip of an iceberg

As Editor of *Research Policy* (*RP*), I recently had to investigate a case of plagiarism. In June 2007, a PhD student reported that a 1993 *RP* paper by Hans-Werner Gottinger was similar to one published by Bass in 1980 in the *Journal of Business*. Perhaps this would prove to be borderline plagiarism? I got hold of the two papers and compared them.

1: See section on 'Scientific misconduct' at www.elsevier.com/wps/find/editorsinfo.editors/ethicsglossary (original source: Royal College of Physicians, 1991, p.3).



3. The experience curve

The concept of declining costs and prices resulting from learning as expressed in the accumulated experience of a firm has been extensively developed and applied by the Boston Consulting Group [3] with further clarification and specification by Spence [15], Fudenberg and Tirole [6], Hart [10], to name only a few. Apparently the earliest identification of the particular form of the experience curve was found in the study of learning curves for airframes. Arrow [1] utilized this form in his pioneering paper, and the same form has been employed by the Boston Consulting Group. The marginal cost function, called the experience curve is

$$MCY(t) = C_1[Y(t)]^{-\lambda} \qquad (1)$$

where $MC[Y(t)]$ is the cost of producing the Yth unit of output, $Y(t)$ is the accumulation output at time t, C_1 is a scaling parameter, sometimes referred to as the cost of producing the first unit, and λ is a learning parameter, $\lambda > 0$, that could be identified as "localized learning" in the sense of Stiglitz [16].

The current marginal cost depends not only on current output, but also on earlier output, or

The Experience Curve

The concept of declining costs and prices resulting from learning as expressed in the accumulated experience of a firm has been extensively developed and applied by the Boston Consulting Group (1968). Apparently the earliest identification of the particular form of the experience curve was found in the study of learning curves for airframes. Arrow (1962) utilized this form in his pioneering paper, "The Economic Implications of Learning by Doing," and the same form has been employed by the Boston Consulting Group.

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$$MC\ [E(t)] = C_1[E(t)]^{-\lambda}, \qquad (1)$$

where

$MC\ [E(t)]$ = the marginal cost of producing the Eth unit of output;

$E(t)$ = accumulative output at time t;

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C_1 = a scaling parameter, sometimes referred to as the cost of producing the first unit; and

λ = a learning-rate parameter, $\lambda > 0$.

The current marginal cost depends not only on current output but also

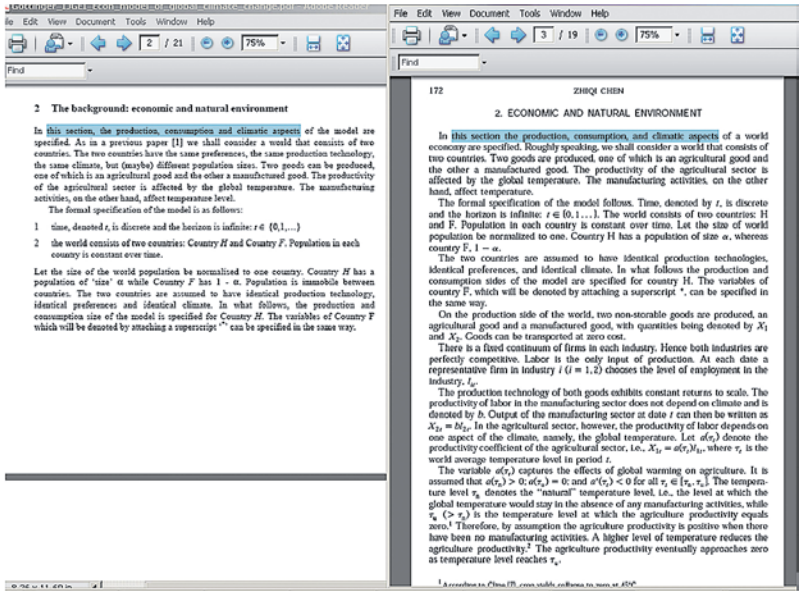
The main sections were 80–90 per cent identical. I informed the *RP* publisher, Elsevier, which has a formal procedure for investigating such cases. The papers were passed to two referees who had been sent the original *RP* paper. They confirmed that Gottinger had extensively plagiarised the Bass paper. (One also spotted that he had fabricated the data as well.)

Perhaps the author had produced just a single paper, then disappeared? A check with the *Citation Index*/Web of Science revealed that HW Gottinger had published nearly 120 items in the international journals covered by the database. But perhaps the *RP* paper represented a one-off 'moment of madness'? On the off chance, I Googled "Gottinger" + "Plagiarism".

I immediately found that in 1999 the Editors of *Kyklos* had retracted a 1996 paper by Gottinger because it plagiarised a 1992 article by Wyatt.

The *RP* paper was published in 1993 and the *Kyklos* paper in 1996, so perhaps the problem occurred only during a relatively brief period when Gottinger was under stress? Once exposed in 1999, presumably he

stopped? Just to be sure, I checked three of his papers from after 1999. I quickly found that his 2002 article in the *International Journal of Global Energy* heavily plagiarised a 1997 article by Chen.



2 The background: economic and natural environment

In this section, the production, consumption and climatic aspects of the model are specified. As in a previous paper [1] we shall consider a world that consists of two countries. The two countries have the same preferences, the same production technology, the same climate, but (maybe) different population sizes. Two goods can be produced, one of which is an agricultural good and the other a manufactured good. The productivity of the agricultural sector is affected by the global temperature. The manufacturing activities, on the other hand, affect temperature level.

The formal specification of the model is as follows:

1 time, denoted t, is discrete and the horizon is infinite: $t \in \{0,1,\ldots\}$

2 the world consists of two countries: Country H and Country F. Population in each country is constant over time.

Let the size of the world population be normalised to one country. Country H has a population of 'size' α while Country F has $1 - \alpha$. Population is immobile between countries. The two countries are assumed to have identical production technology, identical preferences and identical climate. In what follows, the production and consumption side of the model is specified for Country H. The variables of Country F which will be denoted by attaching a superscript '*' can be specified in the same way.

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2. ECONOMIC AND NATURAL ENVIRONMENT

In this section the production, consumption, and climatic aspects of a world economy are specified. Roughly speaking, we shall consider a world that consists of two countries. Two goods are produced, one of which is an agricultural good and the other a manufactured good. The productivity of the agricultural sector is affected by the global temperature. The manufacturing activities, on the other hand, affect temperature.

The formal specification of the model follows. Time, denoted by t, is discrete and the horizon is infinite: $t \in \{0, 1 \ldots\}$. The world consists of two countries: H and F. Population in each country is constant over time. Let the size of world population be normalized to one. Country H has a population of size α, whereas country F, $1 - \alpha$.

The two countries are assumed to have identical production technologies, identical preferences, and identical climate. In what follows the production and consumption sides of the model are specified for country H. The variables of country F, which will be denoted by attaching a superscript *, can be specified in the same way.

On the production side of the world, two non-storable goods are produced, an agricultural good and a manufactured good, with quantities being denoted by X_1 and X_2. Goods can be transported at zero cost.

There is a fixed continuum of firms in each industry. Hence both industries are perfectly competitive. Labor is the only input of production. At each date a representative firm in industry i ($i = 1, 2$) chooses the level of employment in the industry, L_i.

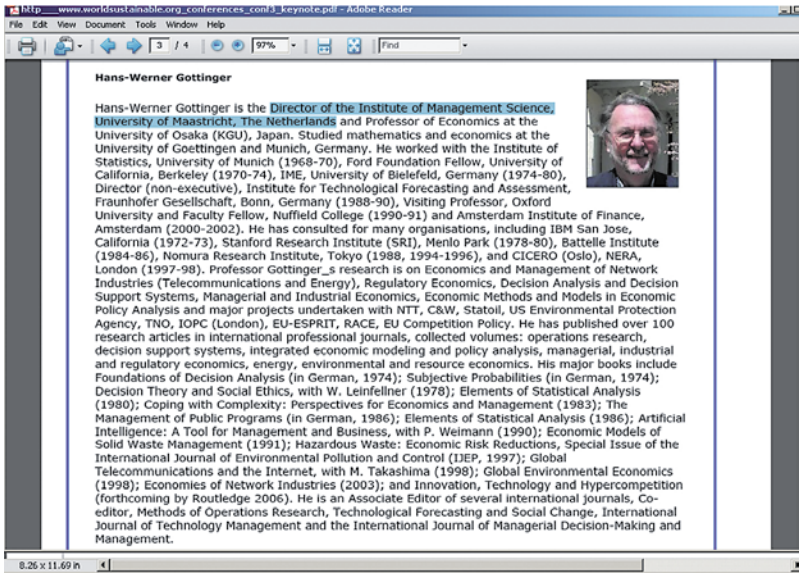
The production technology of both goods exhibits constant returns to scale. The productivity of labor in the manufacturing sector does not depend on climate and is denoted by b. Output of the manufacturing sector at date t can then be written as $X_{2t} = bL_{2t}$. In the agricultural sector, however, the productivity of labor depends on one aspect of the climate, namely, the global temperature. Let $a(\tau_t)$ denote the productivity coefficient of the agricultural sector, i.e., $X_{1t} = a(\tau_t)L_{1t}$, where τ_t is the world average temperature level in period t.

The variable $a(\tau_t)$ captures the effects of global warming on agriculture. It is assumed that $a(\tau_t) > 0$; $a(\tau_t) = 0$; and $a'(\tau_t) < 0$ for all $\tau_t \in [\tau_a, \tau_b]$. The temperature level τ_a denotes the "natural" temperature level, i.e., the level at which the global temperature would stay in the absence of any manufacturing activities, while τ_b ($> \tau_a$) is the temperature level at which the agriculture productivity equals zero.[1] Therefore, by assumption the agriculture productivity is positive when there have been no manufacturing activities. A higher level of temperature reduces the agriculture productivity.[2] The agriculture productivity eventually approaches zero as temperature level reaches τ_b.

Now things were getting serious. Not only did we have a serial plagiariser, but more worryingly he had not stopped when caught in 1999. However, now it was time to hand the case over to his employer for a full investigation of his other 100 articles and dozen books.

Who is his employer?

A search of the institutional addresses in his papers and on-line revealed that Gottinger was a professor in the Institute of Management Science (IMS) at Maastricht University in the Netherlands, where he had held a chair since 1983, including a period as IMS Director from 1987–90 and as Dean of Faculty from 1983–87.

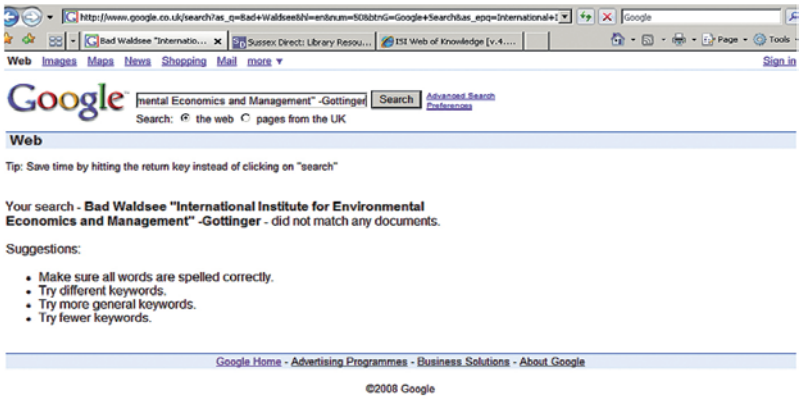


Hans-Werner Gottinger

Hans-Werner Gottinger is the Director of the Institute of Management Science, University of Maastricht, The Netherlands and Professor of Economics at the University of Osaka (KGU), Japan. Studied mathematics and economics at the University of Goettingen and Munich, Germany. He worked with the Institute of Statistics, University of Munich (1968-70), Ford Foundation Fellow, University of California, Berkeley (1970-74), IME, University of Bielefeld, Germany (1974-80), Director (non-executive), Institute for Technological Forecasting and Assessment, Fraunhofer Gesellschaft, Bonn, Germany (1988-90), Visiting Professor, Oxford University and Faculty Fellow, Nuffield College (1990-91) and Amsterdam Institute of Finance, Amsterdam (2000-2002). He has consulted for many organisations, including IBM San Jose, California (1972-73), Stanford Research Institute (SRI), Menlo Park (1978-80), Battelle Institute (1984-86), Nomura Research Institute, Tokyo (1988, 1994-1996), and CICERO (Oslo), NERA, London (1997-98). Professor Gottinger_s research is on Economics and Management of Network Industries (Telecommunications and Energy), Regulatory Economics, Decision Analysis and Decision Support Systems, Managerial and Industrial Economics, Economic Methods and Models in Economic Policy Analysis and major projects undertaken with NTT, C&W, Statoil, US Environmental Protection Agency, TNO, IOPC (London), EU-ESPRIT, RACE, EU Competition Policy. He has published over 100 research articles in international professional journals, collected volumes: operations research, decision support systems, integrated economic modeling and policy analysis, managerial, industrial and regulatory economics, energy, environmental and resource economics. His major books include Foundations of Decision Analysis (in German, 1974); Subjective Probabilities (in German, 1974); Decision Theory and Social Ethics, with W. Leinfellner (1978); Elements of Statistical Analysis (1980); Coping with Complexity: Perspectives for Economics and Management (1983); The Management of Public Programs (in German, 1986); Elements of Statistical Analysis (1986); Artificial Intelligence: A Tool for Management and Business, with P. Weimann (1990); Economic Models of Solid Waste Management (1991); Hazardous Waste: Economic Risk Reductions, Special Issue of the International Journal of Environmental Pollution and Control (IJEP, 1997); Global Telecommunications and the Internet, with M. Takashima (1998); Global Environmental Economics (1998); Economies of Network Industries (2003); and Innovation, Technology and Hypercompetition (forthcoming by Routledge 2006). He is an Associate Editor of several international journals, Co-editor, Methods of Operations Research, Technological Forecasting and Social Change, International Journal of Technology Management and the International Journal of Managerial Decision-Making and Management.

Surprisingly, a search of the Maastricht website revealed neither Gottinger among the listed faculty nor the Institute, so I contacted the University. They checked and confirmed Gottinger had never been an employee and that the University had never had an 'Institute of Management Science'. They wrote an official letter to Gottinger, instructing him to stop claiming this bogus affiliation forthwith.

In other papers, Gottinger stated that he worked at the International Institute for Environmental Economics and Management (IIEEM), at Bad Waldsee in Germany. A check on Google found no website for such an institute; the only person ever to have listed this address was Gottinger.



In more recent papers, Gottinger claimed to be at the International Institute of Technology Management and Economics (IITME), where he was Director for four years. Again, a check on Google found no website for such an institute, and the only person ever to have given this as his institutional address was Gottinger. Indeed, the postal address Gottinger had given for this institute turned out to be identical with the home address for Gottinger listed in the German telephone directory.

Other instances where self-policing failed

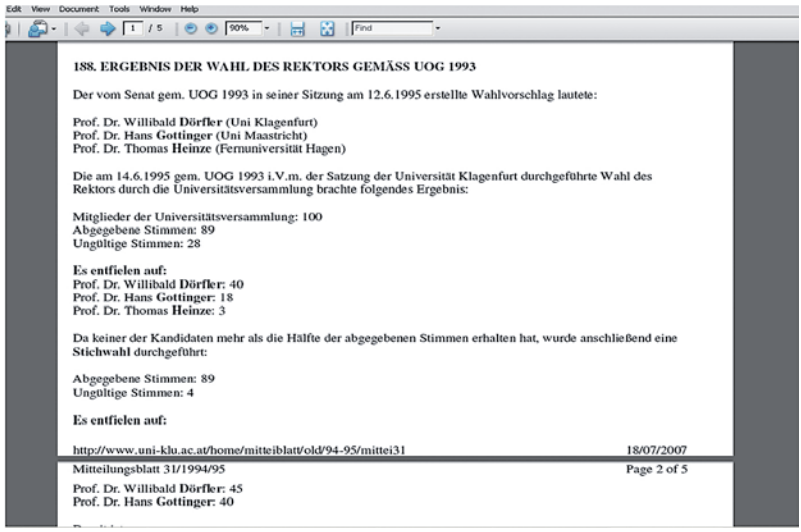
Now things were getting even more serious. We had no employer to pursue a full investigation. In the meantime, Elsevier had contacted Gottinger for an explanation about the 1993 paper. Gottinger blamed this on two (mythical) students; he also claimed he never intended it to be original – it was "a review paper" (as though that excused wholesale plagiarism).

What to do next? One option was to publish a simple retraction in *RP*. However, *Kyklos* had done that in 1999, and that hadn't stopped the plagiarism. We decided to launch a fuller investigation and publish a detailed exposé. We also brought in *Nature* to expand the investigation and double-check the facts. The German Editor of *Nature* confirmed all the above facts and various others. In particular, several other institutional affiliations claimed by Gottinger in his publications turned out to be bogus too (e.g. Visiting Professor of Economics, University of Oxford; Department of Meteorology, Istanbul Technical University; Institute of Economic Analysis, University of Osaka).

Moreover, it was not just referees and editors of journals that had been deceived. While one might expect peer-review occasionally to slip up with regard to ensuring the research integrity of publications, surely it works more thoroughly when appointing individuals? For example, when a department in a top university seeks to appoint someone a Chair of that department, presumably no stone will be left unturned in checking not only that they have the best candidate but also that he/she is *bona fide*.

In 1999, Rensselaer Polytechnic Institute (RPI) had ambitious plans for social science. In particular, they sought an economist of international stature to head their Economics Department. After being interviewed and giving a lecture, Gottinger was appointed to the Chair. A few weeks later, a PhD student came across the recent retraction by *Kyklos* of Gottinger's 1996 paper and informed the university. The Dean, having summoned Gottinger to account for this, was singularly unimpressed by Gottinger's 'explanation' and he was forced to leave almost immediately.

Well, surely peer review works *even more* thoroughly when choosing the Rector or President of a university? In 1993, the University of Klagenfurt in Austria was seeking a new Rector. From all the candidates, they drew up a shortlist of three.



188. ERGEBNIS DER WAHL DES REKTORS GEMÄSS UOG 1993

Der vom Senat gem. UOG 1993 in seiner Sitzung am 12.6.1995 erstellte Wahlvorschlag lautete:

Prof. Dr. Willibald **Dörfler** (Uni Klagenfurt)
Prof. Dr. Hans **Gottinger** (Uni Maastricht)
Prof. Dr. Thomas **Heinze** (Fernuniversität Hagen)

Die am 14.6.1995 gem. UOG 1993 i.V.m. der Satzung der Universität Klagenfurt durchgeführte Wahl des Rektors durch die Universitätsversammlung brachte folgendes Ergebnis:

Mitglieder der Universitätsversammlung: 100
Abgegebene Stimmen: 89
Ungültige Stimmen: 28

Es entfielen auf:
Prof. Dr. Willibald **Dörfler**: 40
Prof. Dr. Hans **Gottinger**: 18
Prof. Dr. Thomas **Heinze**: 3

Da keiner der Kandidaten mehr als die Hälfte der abgegebenen Stimmen erhalten hat, wurde anschließend eine **Stichwahl** durchgeführt:

Abgegebene Stimmen: 89
Ungültige Stimmen: 4

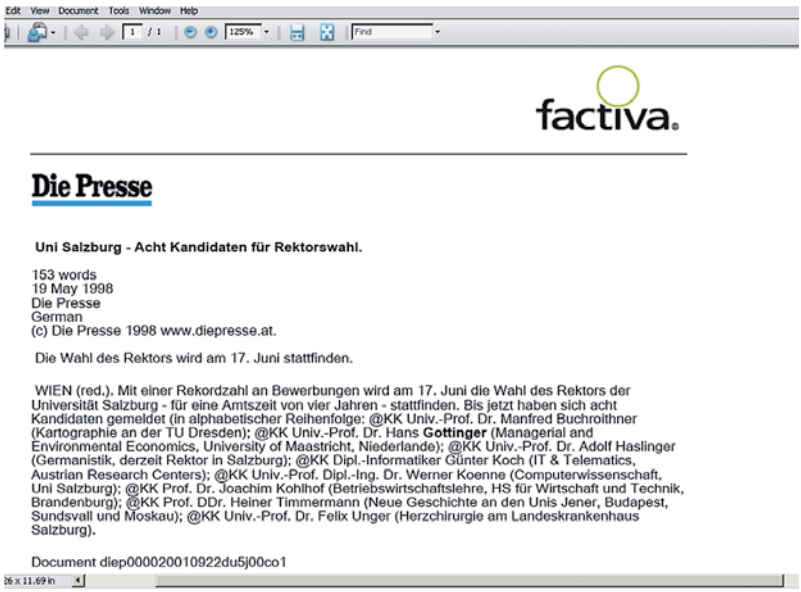
Es entfielen auf:

http://www.uni-klu.ac.at/home/mitteiblatt/old/94-95/mittei31 18/07/2007
Mitteilungsblatt 31/1994/95 Page 2 of 5

Prof. Dr. Willibald **Dörfler**: 45
Prof. Dr. Hans **Gottinger**: 40

Included on this was Prof. Dr. Hans Gottinger from the University of Maastricht. In the first round of voting, he came second, while in the second round he more than doubled his votes – indeed with 6 more votes, he'd have won. Klagenfurt was apparently unaware that the Maastricht affiliation was bogus.

Surely no other university would make that mistake? In 1998, the University of Salzburg was seeking a new Rector. After reviewing the candidates and making all the necessary checks, they drew up a shortlist of eight candidates. Among them was Prof. Dr. Hans Gottinger, who (they had established to their satisfaction) was "Professor of Managerial and Environmental Economics, University of Maastricht". Or so they thought.



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Die Presse

Uni Salzburg - Acht Kandidaten für Rektorswahl.

153 words
19 May 1998
Die Presse
German
(c) Die Presse 1998 www.diepresse.at.

Die Wahl des Rektors wird am 17. Juni stattfinden.

WIEN (red.). Mit einer Rekordzahl an Bewerbungen wird am 17. Juni die Wahl des Rektors der Universität Salzburg - für eine Amtszeit von vier Jahren - stattfinden. Bis jetzt haben sich acht Kandidaten gemeldet (in alphabetischer Reihenfolge: @KK Univ.-Prof. Dr. Manfred Buchroithner (Kartographie an der TU Dresden); @KK Univ.-Prof. Dr. Hans **Gottinger** (Managerial and Environmental Economics, University of Maastricht, Niederlande); @KK Univ.-Prof. Dr. Adolf Haslinger (Germanistik, derzeit Rektor in Salzburg); @KK Dipl.-Informatiker Günter Koch (IT & Telematics, Austrian Research Centers); @KK Univ.-Prof. Dipl.-Ing. Dr. Werner Koenne (Computerwissenschaft, Uni Salzburg); @KK Prof. Dr. Joachim Kohlhof (Betriebswirtschaftslehre, HS für Wirtschaft und Technik, Brandenburg); @KK Prof. DDr. Heiner Timmermann (Neue Geschichte an den Unis Jener, Budapest, Sundsvall und Moskau); @KK Univ.-Prof. Dr. Felix Unger (Herzchirurgie am Landeskrankenhaus Salzburg).

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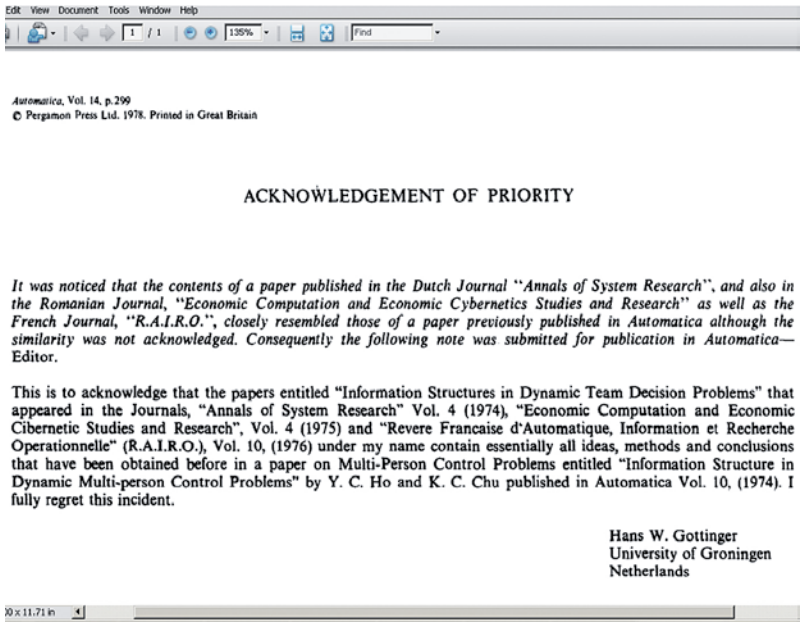
Nature and *Research Policy* go public

By August 2007, the main facts of the case had been established and thoroughly checked, so *Nature* published an exposé (Abbott, 2007) and *RP* published their editorial (Martin *et al.*, 2007). Suddenly, numerous individuals remembered they had come previously across Gottinger and volunteered further information. This made possible a more comprehensive reconstruction of Gottinger's career. In this, he had engaged in plagiarism on at least 13 occasions. And he has been fired or forced to resign six times. But not just for plagiarism. During 1976–79, he held two full-time professorial posts (at Bielefeld and Groningen Universities) at the same time. When Groningen found out, he was forced to leave (although Bielefeld was not informed). Gottinger went off and promptly get another second job, this time at the National Research Centre for Environment and Health (GSF) in Southern Germany. Bielefeld only found out about this a year later, when he was forced to quit. Later, Gottinger served as Director of the Fraunhofer Institute for Technological Trend Analysis from 1988–90, but when his 1983 book was discovered to have plagiarised a 1974 US government report, he was asked to leave (again rather quietly).

Furthermore, rather than becoming involved in plagiarism late his career in the 1990s, as we first assumed, the new information revealed that Gottinger has been engaged in plagiarism for over 30 years – virtually his entire academic career. The first identified case took place in 1974. It came to light in 1978, when Gottinger was forced to admit that he had taken "essentially all ideas, methods and conclusions" from a 1974 paper by Ho and Chu.



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Automatica, Vol. 14, p. 299
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ACKNOWLEDGEMENT OF PRIORITY

It was noticed that the contents of a paper published in the Dutch Journal "Annals of System Research", and also in the Romanian Journal, "Economic Computation and Economic Cybernetics Studies and Research" as well as the French Journal, "R.A.I.R.O.", closely resembled those of a paper previously published in Automatica although the similarity was not acknowledged. Consequently the following note was submitted for publication in Automatica— Editor.

This is to acknowledge that the papers entitled "Information Structures in Dynamic Team Decision Problems" that appeared in the Journals, "Annals of System Research" Vol. 4 (1974), "Economic Computation and Economic Cibernetic Studies and Research", Vol. 4 (1975) and "Revere Francaise d'Automatique, Information et Recherche Operationnelle" (R.A.I.R.O.), Vol. 10, (1976) under my name contain essentially all ideas, methods and conclusions that have been obtained before in a paper on Multi-Person Control Problems entitled "Information Structure in Dynamic Multi-person Control Problems" by Y. C. Ho and K. C. Chu published in Automatica Vol. 10, (1974). I fully regret this incident.

Hans W. Gottinger
University of Groningen
Netherlands

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Gottinger evidently liked the Ho and Chu paper so much he plagiarised it not once but three times in separate journals (*Annals of Systems Research*, 1974; *Cybernetic Studies and Research*, 1975; and *RAIRO*, 1976). This is astonishingly reckless behaviour, even for a plagiarist. Did he want to get caught at this early stage? Please note that all he received was a gentle 'slap on the wrist' – the low-key retraction is labelled an "acknowledgement of priority", rather than "admission of plagiarism". Hence it had little impact at the time. Fortunately, one person remembered it and drew it to our attention.

Questions raised by the case

The Gottinger case raises several questions. The first is, 'How many of Gottinger's other 100 articles and dozen books are based on plagiarism?' Thus far we have come across nine cases where the article (or book) was published and the plagiarism was only detected later, compared with just four cases where the plagiarism was caught *before* publication by alert referees. As for his other numerous publications, we don't know. Until they have each been checked, they must all be regarded as suspect. The problem is that checking them all would require a huge effort, not least because in some cases he was 'cleverer' in trying to disguise the source he had plagiarised. Instead of copying journal articles, he took an evident fancy to PhD theses, presumably assuming these were unlikely to be published so his chances of being detected were slim. In particular, he went round American universities such as Berkeley, Cornell and Harvard looking for suitable PhD theses to plagiarise.

The second question is, 'If he was making up these institutional affiliations, where did he get his income from?' As far as one can tell, he was never out of a job for long, holding a succession of some 25 posts over 39 years. Indeed, as noted earlier, on two occasions he held two jobs simultaneously, drawing two salaries. So salary was not a problem. And whenever he was sacked, he seemingly had little difficulty in finding another position, although over time he was gradually forced to go more 'downmarket'.

Thirdly, 'How did he evade detection for so long?' There are a number of possible answers. First, many people have described him as "a loner", and for the great majority of his publications he was the sole author. Additionally, his papers were often highly mathematical, so referees and others may have been tempted to skip over the equations, failing to spot that they involved plagiarism. But the main explanation was probably those bogus affiliations. The Maastricht 'Institute' had a different PO Box from Maastricht University. Any request to the 'IMS Director' for a reference could therefore be intercepted and a suitable 'reference' provided. Likewise for any request for a reference addressed to IITME (which would be delivered to his private home). All very neat, but also quite premeditated.

In addition, Gottinger had some extremely impressive referees listed on his CV, including a Nobel Prize winner and the president of a national Academy of Science. Many had known Gottinger for 20 or 30 years and, when informed of his serial plagiarism in Autumn 2007, expressed astonishment as well as great sadness.

Fourthly, 'When he was caught in the past, why was he not stopped?' Surely self-policing is meant to ensure that offenders are 'outed' and shamed into stopping or denied the opportunity to publish further plagiarised work? Apparently not. Whenever anyone detected plagiarism or other misconduct, they assumed it was a 'first offence' and let him off with a gentle warning. The 1978 retraction in *Automatica* attracted virtually no attention, the 1999 *Kyklos* retraction little more. The organisations that fired him were so embarrassed at having been hoodwinked that the dismissal was handled quietly. So Gottinger continued on his merry way. Several people undoubtedly became suspicious but they left it to 'someone else' to sort out the problem. This constitutes a form of 'tragedy of the commons'. It may be too much trouble for an individual to pursue their suspicions; but in long run their failure to do so makes the overall situation much worse for the academic community. Economic game theorists who observe games like 'the dictator game' or 'the ultimatum game' find that players divide into cooperative observers of the rules and 'free-riders' or 'defectors'. The latter flourish unless some of the former adopt the role of 'punishers'. But this comes at a personal cost, so few are prepared to do so; most remain 'second-order free-riders', leaving the task of punishing to someone else. This is precisely what happened here.

Fifthly, 'Is plagiarism a 'victimless crime'?' Some academics are apparently more relaxed about plagiarism. They assume that plagiarists don't dare publish anything significant, so they are seldom cited. Indeed, by taking material from an obscure source, they may even help give it greater impact. But there are strong counter-arguments. Gottinger has earned over 250 citations, many (most?) effectively 'stolen' from other researchers. Those who have had their work plagiarised understandably feel 'violated'. Likewise, those who came second to Gottinger when he got his various posts might well have been appointed instead. In addition, referees, editors and publishers have all had their trust broken. Lastly, huge amounts of effort are needed to investigate cases like this.

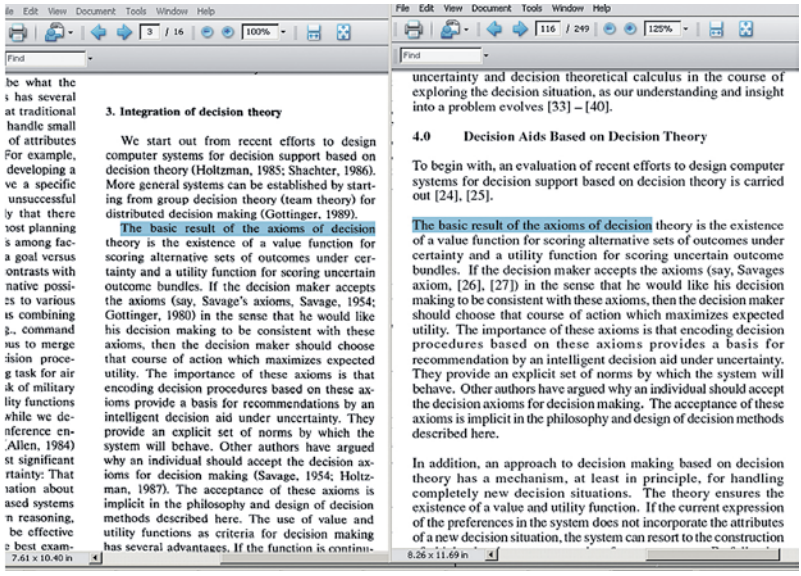
Sixthly, 'Is Gottinger a one-off? If not, how many more serial plagiarisers are out there?' No-one knows. But serial plagiarism is clearly on the increase. There was just a single case reported in the 1980s and another in 1998; but in the last five years, half a dozen have come to light in science,

social science and humanities (Martin *et al.*, 2007, note 32). And no-one knows how many more are out there yet to be discovered. The same factors that account for the growing incidence of detected plagiarism among students (the growing availability of electronic material making it easier or more tempting to 'lift' that material, and search engines making it easier to detect) probably apply to academic researchers.

Lastly, 'How much plagiarism remains undetected?' Again, no-one knows. There is some information about the level of detected plagiarism, but we have no idea about the level of *undetected* plagiarism. This is what Donald Rumsfeld would call "a known unknown".

A twist in the tale – 'the case of the biter bit'

In nearly all of his 100 or more publications, Gottinger was the sole-author, quite unusual these days, even among social scientists. However, in two papers, he had the same co-author. Did this co-author actually exist, or was he an 'imaginary friend' invented to give the impression that Gottinger did collaborate, just like everyone else? The co-author, it turns out, does exist – he's now a professor at a German university. Was he aware of Gottinger's misconduct? To check, I Googled strings of words from the 1992 paper by Gottinger and his co-author.



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3. Integration of decision theory

We start out from recent efforts to design computer systems for decision support based on decision theory (Holtzman, 1985; Shachter, 1986). More general systems can be established by starting from group decision theory (team theory) for distributed decision making (Gottinger, 1989).

The basic result of the axioms of decision theory is the existence of a value function for scoring alternative sets of outcomes under certainty and a utility function for scoring uncertain outcome bundles. If the decision maker accepts the axioms (say, Savage's axioms, Savage, 1954; Gottinger, 1980) in the sense that he would like his decision making to be consistent with these axioms, then the decision maker should choose that course of action which maximizes expected utility. The importance of these axioms is that encoding decision procedures based on these axioms provide a basis for recommendations by an intelligent decision aid under uncertainty. They provide an explicit set of norms by which the system will behave. Other authors have argued why an individual should accept the decision axioms for decision making (Savage, 1954; Holtzman, 1987). The acceptance of these axioms is implicit in the philosophy and design of decision methods described here. The use of value and utility functions as criteria for decision making has several advantages. If the function is continu-

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uncertainty and decision theoretical calculus in the course of exploring the decision situation, as our understanding and insight into a problem evolves [33] – [40].

4.0 Decision Aids Based on Decision Theory

To begin with, an evaluation of recent efforts to design computer systems for decision support based on decision theory is carried out [24], [25].

The basic result of the axioms of decision theory is the existence of a value function for scoring alternative sets of outcomes under certainty and a utility function for scoring uncertain outcome bundles. If the decision maker accepts the axioms (say, Savages axiom, [26], [27]) in the sense that he would like his decision making to be consistent with these axioms, then the decision maker should choose that course of action which maximizes expected utility. The importance of these axioms is that encoding decision procedures based on these axioms provides a basis for recommendation by an intelligent decision aid under uncertainty. They provide an explicit set of norms by which the system will behave. Other authors have argued why an individual should accept the decision axioms for decision making. The acceptance of these axioms is implicit in the philosophy and design of decision methods described here.

In addition, an approach to decision making based on decision theory has a mechanism, at least in principle, for handling completely new decision situations. The theory ensures the existence of a value and utility function. If the current expression of the preferences in the system does not incorporate the attributes of a new decision situation, the system can resort to the construction

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I quickly got a 'hit' – large sections were virtually identical with those in a conference paper published by the Research Council of Zimbabwe. That seemed to confirm the plagiarism. Then I suddenly realised that the latter had been published in 2004, 12 years after the 1992 paper. I had just discovered perhaps the world's first case where the work of an academic plagiarist had been plagiarised by a second plagiarist! (It should be stressed that there is absolutely no evidence that the 1992 paper is based on plagiarism; this may well be one of the (few?) Gottinger papers where no plagiarism was involved.)

However, the implications of this bizarre discovery are distinctly troubling. What are the chances of a second plagiarist picking one of Gottinger's papers to plagiarise? If the overall incidence of plagiarism is small, then surely the chances of this must be remote? One of the few empirical studies on the extent of plagiarism was conducted by Enders

and Hoover (2006). Their survey of 1200 economists suggests approximately 1 in 100 papers are plagiarised, although most in a relatively minor way (e.g. an unattributed phrase or idea). Perhaps only 1 in 1000 papers is the victim of wholesale copying on the scale witnessed here. Yet I'd examined only about 10 of Gottinger's papers before finding one plagiarised by someone else. The odds of this happening are only around 1% if 1 in 1000 papers are the subject of whole-scale copying.

So what are the possible explanations for this bizarre finding? First, it could be just a freak coincidence. Perhaps divine retribution? Second, it could mean the actual occurrence of *previously undetected* plagiarism is some two orders of magnitude greater than the incidence of known/detected plagiarism. But that would mean only about 1 in 100 instances of plagiarism is detected through the normal peer review process, which is hardly very comforting. Thirdly, have we perhaps chanced upon an unusual 'hot spot' of plagiarism? It is, after all, a rather mathematical area where perhaps the referees don't check things very thoroughly. Yet the implication that peer review breaks down when confronted with more technical material is hardly very comforting, either.

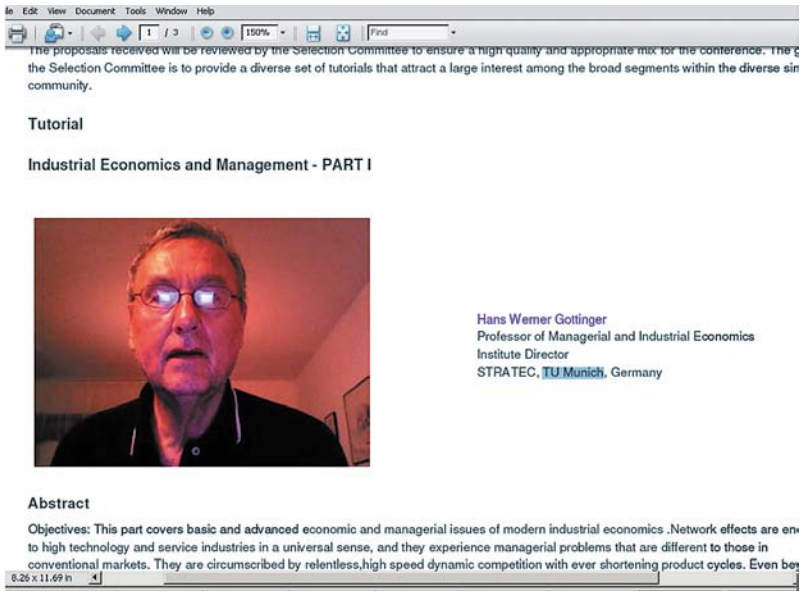
Conclusions

If self-policing worked in the way traditionally assumed, virtually none of this should have happened. Gottinger should not have been able to get away with repeated plagiarism over 30 years. His bogus affiliations should have been detected. He should not have attained such a senior level in his profession. The misconduct should have stopped when he was first caught. Although he was caught on several occasions, each time those involved assumed it was his first offence and let him off with a warning or quietly got rid of him without informing others. Hence in this case, a life of academic 'crime' does seem to have paid.

If we are to reduce the risk of similar misconduct, greater vigilance and a willingness to pursue any well-founded suspicions are required on the part of *all* of us – whether referees, editors, publishers or readers. We may also need to consider establishing some authoritative database where confirmed details of first-time offenders are registered so that others can check if a particular suspect has been found guilty on a previous occasion.

Epilogue

Well, at least his misdeeds have now been fully exposed, so that should finally have put an end to the misconduct. Not quite! Just one month after the *Nature* and *RP* articles, Gottinger tried to submit a paper for a conference on the 'Dynamics of Science-Based Entrepreneurship'. The conference organiser, having read the *RP* editorial, rejected this. But at least he'd surely never go so far as to create a new academic affiliation or a new institute? In March 2008, a colleague Googled 'Gottinger' + '2008' and obtained a 'hit'.



It was for the 5th Annual Future Business Technology Conference, organised by EUROSIS, the European Multidisciplinary Society for Modelling and Simulation Technology, where the Guest Lecturer due to give an 11-session tutorial course was Hans Werner Gottinger. According to the website, Gottinger is "Professor of Managerial and Industrial Economics" and "Institute Director" of STRATEC at the Technical University of Munich. Except, of course, he's not on the faculty of the TU Munich, nor does the University have an institute called 'STRATEC' (Abbott, 2008).

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SJUR KASA

Industrial Revolutions and Environmental Problems

The current environmental problems have been created by the development of industrial society since the industrial revolution. Successive industrial revolutions have since increased man's capacity to transform nature. Technological change has interacted with socio-economic change in the core countries of the world economy. In this paper, I look at the relationships between macro-level technological change and environmental problems. Freeman & Louca (2001) suggest that the Western world has lived through four industrial revolutions since the late 18th century and is currently moving into a fifth. Table 1 provides details about these revolutions, which tend to emerge in 50-year cycles. I also include three extra columns related to environmental problems. First, as environmental problems are often related to energy use, there is a column demonstrating the main energy source during different periods.

Senior Researcher Sjur Kasa
Centre for International Climate and Environmental Research (CICERO), Oslo, Norway
sjur.kasa@cicero.uio.no
CAS Fellow 2007/2008

Second, there is a column suggesting main environmental problems (both problems for ecosystems and human health). Third, I have added a column that demonstrates how each industrial revolution has contributed to the amelioration of pre-existing environmental problems. While I do not make claims about the importance of these paradigms for the long waves of the world economy, I still find this periodization of technology history to be interesting as a background for understanding the evolution of environmental problems in the capitalist core.

1780–1930: The environmental problems of the industrial revolution in Britain and the US/German catch-up

The industrial breakthrough in Britain both created new environmental problems and resolved some of the existing problems. Urbanization and the increasing use of coal relieved the pressure on land in the UK. Pomerantz (2000) describes how less demand for fuelwood in the wake of increasing coal consumption reduced land constraints and contributed to increasing agricultural production. Combined with new crop rotation techniques and expanding food imports, this alleviated old Malthusian constraints. However, unconstrained exploitation of workers in factories and mines, abysmal housing and hygienic standards, as well as thickening black smog and soot from burning coal aggravated socio-environmental problems (infections, respiratory problems, poisoning, workplace accidents) in the expanding urban slums and factories of the industrial revolution in the UK, portrayed by Dickens as *Coketown* in his 1854 novel "Hard Times". While black smog from coal burning came predominantly from

Upswing/ downswing	Constellation of technical and organizational innovations	Core input and other key inputs	Carrier branch and other leading branches	Main energy source	Environmental problems	Solutions to previous problems
1780-1815 **1815-1848**	Water-powered mechanization of industry	Iron, raw cotton, coal	Cotton spinning Iron products Water wheels Bleach	Waterpower/ Coal	Socio-environmental (slums), smog	Forest depletion, hunger
1848-1873 **1873-1895**	Steam-powered mechanization of industry and transport	Iron, coal	Railways and rail equipment, steam engines, machine tools, alkali industry	Coal	Socio-environmental (slums), smog	
1895-1918 **1918-1940**	Electrification of industry, transport and households	Steel, copper, metal alloys	Electrical equipment, heavy engineering, heavy chemicals, steel products	Electricity (mostly based on coal)	Water pollution (mainly from chemical industry)	Fewer work hazards, improved housing, reduced urban air pollution
1941-1973 **1973-??**	Motorization of transport, civil economy and war	Oil, gas, synthetic materials	Autos, trucks, tractors, tanks, diesel engines, aircraft, refineries	As above, but also nuclear	Smog, acid rain, climate change and its effects, radiation	Mass-consumption reduces poverty
??	Computerization of entire economy	Computers, software, telecom equipment, biotech	Telecommunications	As above		Emerging decoupling of energy use and production/consumption

Table 1. Five industrial revolutions and their environmental problems

Source for the 4 columns to the left: Freeman & Louca (2001, p. 141).

steam engines and metal smelting in many industrial towns, emissions from the pollutive burning of coal in open hearths in homes was important everywhere and dominated as a source of the notorious London smog.

On the factory floor, transmission belts from steam engines caused work accidents. The alleviation of socio-environmental problems linked to the livelihoods of the working classes was slow in spite of pressure from emerging trade unions, medical doctors, and new laws and authorities trying to curb smoke and soot emissions and bad sanitary conditions. The bad health of British soldiers fighting in the Crimean, Boer and First World War illustrated the slowness of the progress (Mjøset & Kasa, 1994).

With the demise of British textile and railway production, industrial hegemony was passed on to the US and Germany. These states dominated the next industrial revolution, led by organic chemicals, electricity and steel. While the chemical revolution was driven by consumption of items such as synthetic dyestuffs for clothing and medicines became important applications of newly developed chemical compounds from coal tar, steel production found its main markets in investment goods such as infrastructure, buildings and armaments.

Electricity reduced many of the problems linked to urban smoke and dangerous working environments, as emission sources became concen-

trated on fewer power stations often located outside the cities, and electrical machines replaced steam engines. Better housing conditions for factory workers improved the livelihoods of workers, as seen, for example, in Berlin´s famous *Siemensstadt*.

Soda production, a key input for other industries, was also made less pollutive in the 1860s with the introduction of the Solvay process, which reduced hydrochlorine gas emissions, sulphur emissions and toxic waste, compared with the existing Leblanc process. While the Solvay process diffused rapidly in Germany, less innovative UK industrialists stuck to more polluting processes until almost 1920, being part of a wider process in which British industrial hegemony was eclipsed by Germany and the US.

For the environment, however, the new industries also led to problems: Increasing consumption of chemicals led to the poisoning of European rivers, climaxing in the 1971 pollution scandal in the Rhine which finally led to massive efforts to clean up the river. While industries did not use coal as a key factor during this period, energy supply was still dominated by coal and coal consumption for steel production increased steeply in the most dynamic industrial regions such as the Ruhr and Pittsburgh. Here, the use of coal for steelworks produced serious smog problems. In addition, the smog problems characterizing Britain in the 19th century were not sufficiently ameliorated. Extension of electricity networks lagged behind here, and coal burnt in ineffective open hearths was still common. The adequate regulation of smoke only emerged after the smog disaster of 1952, when 4 000 people died within a few days in London.

Fordism, cars and oil producing acid rain and climate change

Following the emergence of mass-produced cars and the further extension of electricity to consumers, the US saw a middle class-based boom of consumer durables during the 1920s. Car consumption was based on the discovery and use of oil, particularly from Texas, for gasoline. The Great Depression and WW II postponed the surge of consumption of consumer durables assisted by collective wage agreements characterizing post-war US 'Fordism'. During the Cold War, this fourth industrial revolution became generalized in the Western world. For socio-environmental problems, this led to progress. Mass consumption linked to productivity-indexed wage formation in combination with decreasing inequality reduced poverty in OECD countries.

Through its dependence on oil, this match between technologies and consumption patterns led to environmental problems. Locally, increasing car density produced new kinds of smog. This was first noted in car-dominated, sunny Southern California. The California smog was created by sunlight-assisted reactions between exhaust fumes producing particles and ozone that were hazardous for humans, animals and plants. Catalytic converters introduced during the 1970s reduced, but failed to eliminate this problem.

However, Fordism was above all characterized by the emergence of transnational and global environmental problems. The main problems are acid rain stemming both from industries and road transportation – and most importantly – climate change. In its 2007 report (IPCC, 2007), the UN IPCC concludes with virtual certainty that anthropogenic climate change mostly due to emissions from fossil fuels is taking place. Future

temperature increases will probably cause the sea level to rise, cause more intense tropical storms and disappearing Arctic summer sea ice, as well as more heat waves, aggravating problems such as hunger and poverty.

Increases in carbon emissions leading to today's problems accelerated as Fordism became generalized in the Western world. Figure 1 below shows a dramatic increase in emissions from the consumption of oil prior to the 1973 OPEC oil shock.

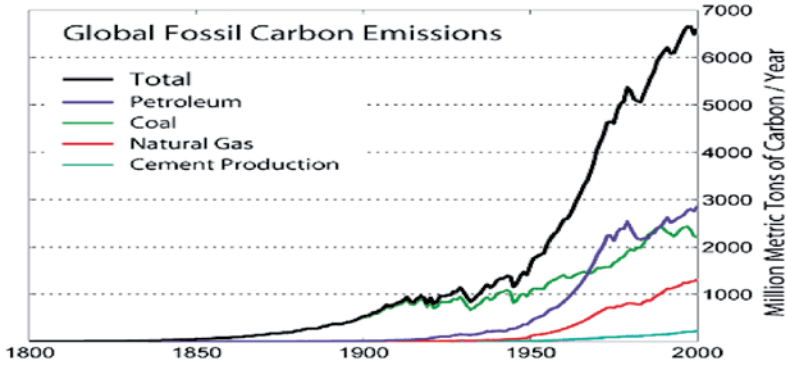

Figure 1: Global Fossil Carbon Emissions 1800–2000.

Source: Marland *et al*. (2005).

Previous work (Perez 1985, Mjøset & Kasa, 1994) suggested that the fifth industrial revolution that began to build up in the late 1970s offered an exit opportunity from the environmental and resource constraints of Fordism. From the OPEC shock until the 1990s, Japan was a case in which energy demand and pollution were rapidly decoupled from economic growth. Growth was fuelled primarily by *information* and not *energy* intensive production. This industrial model was combined with heavy investments in extraordinarily energy efficient and widely used railways. Social and cultural barriers to expanding mass consumption peculiar to Japan, as well as a very high level of dependence on imported energy, were also important factors behind this energy extensive social model. Japan has remained heavily dependent on exports to spendthrift US consumers, and Japanese savings have directly assisted US consumption through purchases of US treasuries and currency.

The re-emergence of the US as a leader in the ICT economy also, combined with the demise of Japan and the rise of China as a chief supplier of consumer durables to the US market, appears to have blocked the generalization of the opportunities emerging in the Japanese model. The current US model is a hybrid in which leadership in ICT and biotech is combined with the path-dependent maintenance of some of the world's most oil- and energy-intensive consumption patterns. The "Fordist-like" (mass consumption financed by consumer debt, cf. Boyer 2000) component of this hybrid is undermined by two sets of environmental and resource constraints (besides the financial constraints emerging from the current global crisis which has its origin in the combination of excessive financial liberalization and a mismatch between US wages and consumption levels) . *First*, the expansion of energy intensive *consumption* patterns in the US partly supported by the rise of energy intensive *production* patterns in China, threatens to outstrip global oil supplies. *Second*, climatic constraints: While recent years have seen brisk growth in global emis-

sions, these have to be cut by more than 80% by 2050 to limit exceedingly serious global problems linked to global warming of more than 2 degrees (Rive *et al.*, 2007). As the top emitters, China and the US may face the greatest challenges, but none of these states are currently willing to commit to emission cuts (Kasa *et. al*, 2008).

A failure to implement cuts may lead to the re-emergence of Malthusian constraints on food production. The dampening of these constraints by the first industrial revolution and their removal by inventions in fertilizer production during the third (Smil, 2001, Cline, 2007) are essential, but often overlooked elements of modern technological and environmental history. It is as yet unclear whether these constraints can be ameliorated by new biotechnologies, and even more uncertain if the current global institutional framework can facilitate the diffusion of such technologies (IAASTD, 2008). This reminds us about a main point in this paper: As new industrial revolutions often supplied technologies that eased existing environmental problems, this relief was often only partial. Exploiting the benefits of new technologies for environmental improvements has always been dependent on complimentary socio-political changes.

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THOMAS HOFF

Mapping the Organizational Climate for Innovation:

Introducing SWOT as a Process Based Tool

Introduction

To be innovative, i.e. to be able to implement novel ideas in order to gain a competitive advantage, an organization should be organized in a way that facilitates rather than inhibits innovative practices. In particular, it has been argued that the organizational climate is a key factor for explaining the innovation capacity of a firm (Amabile *et al.*, 1996; Kanter, 1983; Patterson *et al.*, 2005).

Associate Professor Thomas Hoff
Department of Psychology,
University of Oslo, Norway
thomas.hoff@psykologi.uio.no
CAS Fellow 2007/2008

Survey tools are a common method used today for assessing the organizational climate for innovation. Two well-documented survey tools are the Organizational Climate Measure (OCM) (Patterson *et al.*, 2005) and the organizational survey KEYS (Amabile *et al.*, 1996). These tools are typically used in two ways: The first refers to academic research questions, for example, regarding the relationship between organizational climate and innovation performance. The second refers to consultants who use these tools as process-based tools to improve performance in a company.

There are challenges related to the use of survey tools as process-based tools. Three challenges particular to mapping the organizational climate for innovation are summarized below. As a means of improving some of these issues, an alternative method for mapping the organizational climate for innovation is introduced. Some key data from a case study are then presented in an effort to illustrate the practical use of the tool.

A) The problem of interpreting survey data

In a firm, it is often difficult to interpret statistical survey data owing to a lack of discriminatory validity and clear implications of the findings. Schein (1999) neatly summarizes the issue: "Organizations frequently purchase surveys in order to determine how their employees feel about certain issues or even to 'diagnose' their culture. When the 'expert' information comes back in quantitative form, I have observed managers poring over graph data, trying to figure out what they now know when they note that sixty-two percent of the employees think the organization has a poor career development system. What kind of information value does such a statement actually have, given the problems of sampling, the problems of questionnaire construction, the semantics of words like career and development, the ambiguity of whether sixty-two percent is really good

or bad outside some broader context, the difficulty of determining what the employees were thinking when they answered the question, and so on? Reality in this situation is an elusive concept."

B) The problem of reflection

Many scholars in the field argue that 'reflection' within the firm is a key success factor (West, 2002). Organization surveys, as a process tool, do not prompt any reflection on behalf of the employees, as they merely need to put down a mark on a five-point Likert-scale. Even though the result of such surveys can act as a framework for reflection (so-called survey feedback sessions), the act of assessing the climate hardly prompts reflection.

C) The problem of organization levels

Models for organization climate tend to mix phenomena that arise at different levels of the organization (see e.g. West *et al.*, 2004). For example, creativity and employee skills refer to the individual level; team processes and team composition refer to the team level; management practices refer to the management level, and organizational values and culture refer to the organizational level. It is vital for the firm to be aware of this distinction, and that it does not focus on one level only, particularly as long as the firm's problems might be located at other levels. Survey tools do not fully support the firm in addressing this issue.

Developing a SWOT based tool

SWOT is a qualitative method, where information is gathered by way of semi-structured interviews, guided by a general framework of Strengths, Weaknesses, Opportunities and Threats (SWOT) of the organization. This framework emphasizes a positive-negative dimension, a present-future dimension and an internal-external dimension. This general framework forms the basis of self-generated reflection on behalf of the employees. Statements are then extracted from the interviews, and coded according to which organizational level they are targeted at. In order to avoid blind spots (the employees might talk about irrelevant topics, or fail to address important topics), and to provide a direction for future change, the statements are coded according to established, empirically proven models for innovation. As opposed to traditional SWOT analysis, the present tool aims at quantifying the information gathered and subsequently shared with the company. This makes it possible to compare data over time, and across different populations.

Case study illustration

To illustrate the material presented to the firm as a basis for future improvements in organizational climate for innovation, some case data are presented below. The OCM climate model (Patterson *et al.*, 2005) was applied as the referent model.

The companies in question are two medium-sized international companies headquartered in Norway. They both promote themselves as innovative organizations. All 15 interviewees are members of executive or middle management. The interviewees produced a total of 660 statements. There were no statistical differences between the two organizations.

SWOT	Total	Mean	Std. Derivation	Percent
Strength	299	19.9	6.1	45 %
Weakness	222	14.8	4.3	34 %
Opportunity	71	4.7	2.6	11 %
Threat	68	4.5	1.6	10 %
Total	660	44	3.7	100 %

Table 1. Distribution of statements by SWOT categories (*N* = 15)

SWOT	Total	Mean	Std. Derivation	Percent
Individual	48	3.2	1.6	7 %
Team	94	6.3	6.3	14 %
Leader	42	2.8	2.3	6 %
Organization	476	31.7	10.9	72 %
Total	660	44	5.3	100 %

Table 2. Distribution of statements by Organizational level (*N* = 15)

Tables 1 and 2, figure 1, and table 3 represent feedback to the individual organizations as a basis for further organizational development with respect to innovation performance. Table 1 shows the relative emphasis in the company on SWOT-related dimensions. Table 2 shows the relative emphasis in the company on different levels of the organization. Figure 1 illustrates the interaction between organization level and SWOT dimensions. Table 3 represents the mapping of statements onto an already established model of innovation capacities of organizations (OCM).

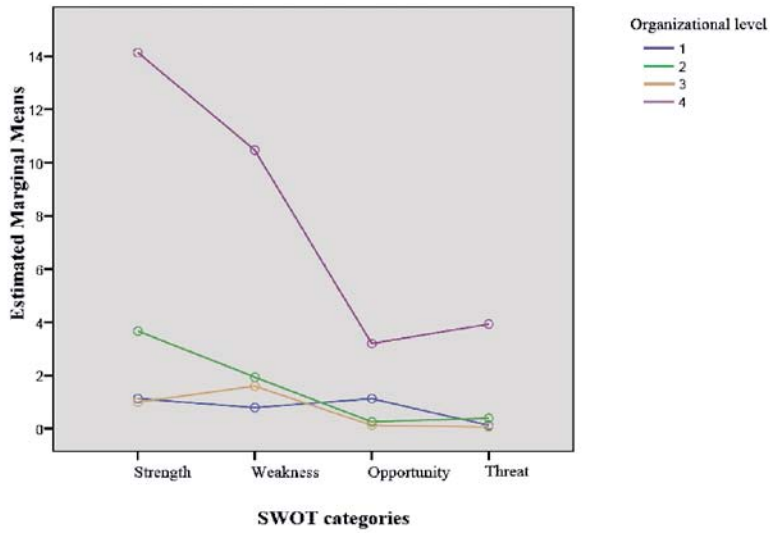

Figure 1. Mean distribution of statements by SWOT categories and organizational level.
Note. Organizational level: 1 = Individual, 2 = Team, 3 = Leader, 4 = Organization.

A feedback session with the individual firm would typically start with SWOT data. An example of important information in the present case is that the firms display low reflexivity on aspects of the future, compared with the here-and-now situation (Tab. 1). Then, the feedback would typi-

cally concentrate on organization level (Tab. 2). In these data, there is relatively little emphasis on individual and team aspects, compared with organizational aspects. Furthermore, one can present the interaction effects between SWOT aspects and organizational level (Fig. 1). In this case, there is a clear skew in the data towards aspects related to strengths and weaknesses on organizational level.

To avoid blind spots in the interviews, the statements are mapped onto established models of organizational antecedents of innovation performance (Tab. 3). In this case, OCM was applied, but other models, such as e.g. KEYS, or Organizational Citizenship Behaviour (Podsakoff *et al.*, 2000) might equally well have been applied. OCM is based on the competing values model (Quinn and Rohrbaugh, 1983; Quinn and McGrath, 1985; Gifford *et al.*, 2002) which implies that there are inherent tensions in the organization between the four umbrella values (Open Systems, Human Relations, Rational Goal and Internal Process, respectively).

The variables Flexibility, External Focus and Reflexivity constitute core aspects of innovation capacity (Open systems quadrant), whereas Autonomy, Integration, Involvement, Support, Training and Welfare (Human relations quadrant) represent variables that indirectly support innovation capacity, but might also to some extent hinder innovation. The remaining variables, Formalization and Tradition (Internal process quadrant) and Clear Goals, Effectiveness, Effort, Feedback, Production pressure and Quality (Rational goals quadrant), represent aspects that might be counterproductive for the innovation capacity of the firm. All quadrants are presented here, because there might be trade-offs in company values that the firm needs to handle.

As an example of relevant information for the firm, see, for example, the Reflexivity dimension, where the company in question provides no more than five statements of a grand total of 239 statements. For a full description of the sub-categories of OCM, please consult Patterson *et al.* (2005).

	S	W	O	T	Tot
Autonomy	19	15	8	6	48
Integration	14	10	2	0	26
Involvement	3	12	2	2	19
Support	3	2	0	0	5
Training	8	3	1	0	12
Welfare	6	0	0	1	7
Formalization	3	1	0	0	4
Tradition	1	8	0	3	12
Flexibility	26	20	4	1	51
External Focus	16	9	13	12	50
Reflexivity	2	3	0	0	5
Clear goals	9	1	1	1	12
Effectiveness	2	7	5	2	16
Effort	5	0	0	0	5
Feedback	4	2	0	0	6
Production pressure	0	5	0	4	9
Quality	1	0	1	1	3

Table 3. Statements distributed over SWOT and sub categories of OCM, Company 1, ($N = 7$)

Conclusion

The aim of the development of the present tool was to preserve the quality of the surveys (representative information with a clear reference to an underlying causal model), while also avoiding some of the challenges inherent in using surveys in organizational development, particularly with respect to the interpretation of data and the potential lack of reflection involved in answering a survey instrument. Being a very time-consuming method, the present tool should probably be used in conjunction with survey instruments, as only a fraction of employees can be interviewed. Top management groups and subgroups in the firm are likely candidates for benefiting from the present tool.

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ANDERS UNDERTHUN

The "Scalar Struggle" for Norwegian Gas

Introduction

In 2006, Norway's export of natural gas was surpassed only by Russia and Canada, and accounted for 15 per cent of total European gas consumption (NPD 2007). By contrast, barely 1 per cent of Norway's total gas production was consumed domestically. In 2005 and 2006, a national interest network, the "Gas Alliance", gained parliamentary acceptance for two policy suggestions about how Norway could enhance this share and thus embed the natural resource more firmly in domestic space. First, the parliament decided to support the intention of state-financed gas infrastructure. Second, the Gas Alliance gained support for a NOK 1.1 billion research programme on the industrial utilisation of natural gas feedstock called "Gassmaks". This chapter briefly discusses how these strategies demonstrate the *scalar struggle* associated with pressures of globalisation and Europeanisation on other scales of social and economic organisation.

Research Fellow Anders Underthun
Department of Geography, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
anders.underthun@samfunn.ntnu.no
CAS Fellow 2007/2008

Scale and scalar struggles

Scale refers to "[…] one or more levels of representation, experience and organisation of geographical events and processes." (Johnston *et al.* 2000). This definition implies that scale is socially constructed and represents an important dimension of power. For instance, Lefebvre (1990) focuses on the spatial power of the state bureaucracy, whereas within Marxist geography, the social construction of scale has been explained by the expansionary logic of capitalism (Harvey 1982). The concept of 'scalar struggle' stems from the Gramsci-inspired work of Neil Smith (1984) who analysed how the hegemony of capitalist organisation at the national level has been challenged by other spatial scales, most notably the global one, through neoliberal legislation and expansionary capitalism. The rise of the *supra-national* (i.e. the European), *regional* or *local* scale as geographical markers of capitalist organisation and competition, also demonstrate this *rescaling* (Brenner 2004). However, Swyngedouw (1997) emphasises that the national scale still retains considerable spatial powers. Rescaling has rather led to definitional 'clashes of scales', where resurgent nationalisms often object to the way in which globalisation standardises and/or disrupts scalar configurations of wage settlements, employment schemes and the like. Thus, scalar struggles are often strategies for social struggles. The politics of natural gas in Norway aptly demonstrates dimensions of scalar struggles.

Figure 1

Source: The Norwegan Petroleum Directorate (2007)

The scalar dynamic of natural gas

Historically, the volatile nature of natural gas made it a highly *localised* asset due to the cost and difficulty of long distance transport. In fact, most of the US natural gas discovered in association with oil in the beginning of the 20th century was flared off. In 1947, American geologists estimated that approximately 1000 billion cubic metres of gas were flared each year in the US oil fields from the 1920s onwards (Arneson 1998). In comparison, total gas production of 2006 in Norway was 90 billion cubic metres (NPD 2007). The difficulty of transport also explains the historical concentration of infrastructure and feedstock utilising industrial facilities close to the source, for instance, along the American Gulf Coast (Chapman 1991). Moreover, gas surpluses far from major markets are still used as localisation advantages in the Middle East as these gas resources offer energy and feedstock at a good price for profit-seeking companies. Norsk Hydro's establishment of aluminium production in Qatar is a good example.

During the 20th century, the geographical expansion of gas markets in the USA was enabled by advances in the steel industry, while the existing infrastructure for coal-based gas helped the development of the European natural gas grid (Arneson 1998). The scalar dynamic of natural gas thus developed from a largely local phenomenon, to a regional, national and trans-national one, where end-users could locate relatively far from the original source. The petrochemical industry in Austria is an example in point. The technological development of cooling gas to liquid form (LNG), originally a US patent from the late 1950s, has enabled even longer distance transportation of gas and diminished the need for excess flaring in remote locations such as Qatar.

Though portrayed above in evolutionary scalar terms, the dynamic of gas markets has not always been the strict 'ladder' of geographical levels from the local to the global. Both the European and the Canada-USA natural gas grids were connected from an early point. It is, however, important to remember that the national level still enjoys the role of the landlord, collecting economic rent from company profits.

The case of Norwegian gas is interesting in scalar terms as the first deliveries of natural gas from the North Sea oil and gas fields did not go via the Norwegian mainland and were not operated by Norwegian operators. Here, a European market already existed while the market in Norway was almost non-existent due to the historical abundance of hydroelectric power. It therefore made sense to construct direct infrastructure to European locations from the Norwegian Continental Shelf.

The first scalar struggle for Norwegian gas

Strong national interest groups advocated the landfall of gas for domestic refining and industrial utilisation from the mid-1970s despite the non-existent Norwegian market (Arneson 1998). There were several reasons for this. The oil crisis of 1973 had prompted a discussion on national energy security. There was also a general fear of the "curse of natural resources" (Auty 1995), where historical examples shed gloomy light on the negative effects of export reliance. This argument was coupled to potential industrial synergies (innovations and employment) from grand infrastructure projects, often highlighted as a contrasting advantage of successful resource economies to the resource curse hypothesis (Bridge 2008). The gas from the giant gas fields Statfjord and Troll was finally brought ashore in the late 1980s and early 1990s to Norway for refining before being redirected to the European market.

The state contributed first and foremost through investments by state-owned Statoil, which was, at the time, a principal instrument of Norwegian industrial policy (Ryggvik 2000). Second, Norwegian sub-contractors were favoured at the expense of foreign companies when it came to the construction work and this aided the build-up of a world-class industry in offshore petroleum facilitation. Third, the state was highly influential in contributing to the establishment of the Norwegian petrochemical industry in a conscious attempt to utilise natural gas feedstock. It is fair to say that all these efforts were clear demonstrations of the production of scalar configurations that enjoyed hegemony on a national scale at the time.

The second scalar struggle for Norwegian gas

Throughout the 1990s and early 2000s, Norway's politics of natural gas management were challenged by other scales of influence. The Norwegian affiliation with the EU through its membership of the European Economic Agreement from 1994 entailed that the state lost some of its regulatory powers both in terms of direct subsidies to firms and regions, and in terms of the favourable contracting of Norwegian suppliers. Furthermore, the EU gas market directive from 2001 made it difficult to subsidise Norwegian gas markets as the directive was meant to provide more open and equal access to gas flows on the part of buyers. The scalar context thus limits state intervention in a manner that is very unlike Qatar's conditions for offering cheap gas to multinational companies.

The partial privatisation of Statoil in 2001 may have amplified the global direction and specialisation in which this company and the oil and gas unit of Norsk Hydro, now merged as StatoilHydro, oriented their activities. As part of their corporate restructuring, the two companies have also sold most of their natural gas-utilising downstream activities in Norway. The incentive for StatoilHydro to direct more gas to the Norwegian market is therefore very limited. Even though two more landfalls have been established in Hammerfest and Nyhamna in recent years, the infrastructure has not been constructed to encourage local exploitation to a great extent, but rather to serve as export platforms.

It is thus fair to suggest that there has been a rescaling of natural gas management to the European and the global level, but that this has not left the national level deprived. By the end of 2007, the Norwegian "Petroleum fund" had grown to a staggering NOK 2019 billion (Norges Bank 2008). Nevertheless, the Gas Alliance, a powerful political network consisting of Norwegian coastal regions, the Confederation of Norwegian Trade Unions (LO) and the Confederation of Norwegian Enterprise (NHO), have challenged the tendency towards rescaling by suggesting more active state policies in promoting domestic gas consumption.

For the coastal regions and LO, these strategies were seen as an opportunity to capture capital investments and secure employment, while NHO saw easy access to natural gas and related research funding as vital for the global competitiveness of certain manufacturing industries. The network attempted to revitalise the state as the primary scale of intervention, while it also was forced to adapt this strategy to the other scales of influence[1]. The two policy outcomes mentioned in the introduction mirror this adaptive scalar strategy. First, the Norwegian parliament voted in favour of providing financial support to domestic gas infrastructure, though in a manner that was commensurate with European competition imperatives. The creation of a research programme intended to boost industrial utilisation of natural gas feedstock (NFR 2006) is perhaps a stronger expression of the scalar struggle. To receive grants, all applicants to the programme must guarantee that activities will be performed *exclusively* within Norwegian space. Another interesting dimension to this strategy is

1: See Underthun 2008 and Reitan *et al.* 2008 for a more thorough background and analysis of these networks at the regional and national level.

that LNG research was eliminated from the programme as LO in particular considered LNG-related activities as promoting exports rather than domestic consumption.

It remains highly questionable whether these strategies will prove effective for resisting the pressures of globalisation and Europeanisation. However, they do demonstrate the windows of opportunity for prolonged national scalar influence as well as how scalar struggles take different shapes depending on the scalar configuration in which they are based.

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SIGNE KJELSTRUP

Non-Equilibrium Structures: How can they be maintained?

A hypothesis

The work we have done over the past 10 years concerns systems that are out of global equilibrium [1]. These systems can be found everywhere, in nature and in industry. Nature has evolved over billions of years and, according to Darwin, only the fittest have survived. It is therefore likely that the systems that have survived are efficient in some sense. Can the understanding of natural structures be helpful for man-made designs of energy-efficient systems? Our hypothesis is that they can be, in a wide sense, for our survival. But what does efficiency mean in this context? And what is meant by a non-equilibrium system or a structure out of equilibrium? How can we obtain, measure and maintain non-equilibrium structures? Let us answer these questions by examining some examples, and then look at the consequences.

Professor Signe Kjelstrup
Department of chemistry, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
signe.kjelstrup@nt.ntnu.no
CAS Group Leader 2007/2008

An equilibrium structure

The most well-known examples of structures in equilibrium are minerals and crystals. A crystal possesses a particular order, and this order does not change over time, at least not on a time scale that we can observe. A rock crystal is composed of silicon and oxygen atoms arranged in a tetrahedron. Table salt (NaCl) has a cubic structure, see Picture 1.

A measuring scale was established already in 1860 to measure order. The measure is called entropy, with the symbol S. Perfect order has $S = 0$. In a collection of many particles, the entropy is very large. It grows if there are more and different particles. Negative entropies do not exist.

Picture 1.
The crystal structure of table salt
http://www.scienceclarified.com/images/

A non-equilibrium structure

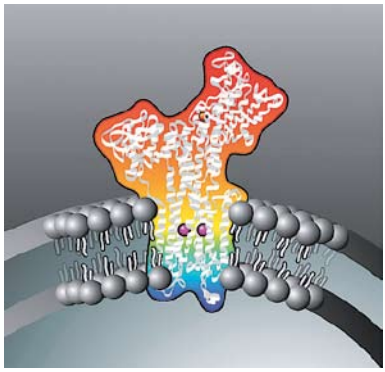
In a non-equilibrium structure, the components are moving in a measurable way. There are many examples that components move in an orderly

Picture 2. A dynamic structure: flying geese
http://www.scienceclarified.com/images/

fashion. Take, for instance, a flying flock of geese (Picture 2). The group of birds fly in a V-shape. We know that this conserves energy for the group as a whole. It is the same in professional teams of bicyclists. Supporting team members take turns leading at the beginning of a race in order to conserve the energy of a potential winner. How can geese or bicyclists maintain their structure? By eating or by obtaining energy from the outside, of course! *A non-equilibrium structure is maintained by a supply of energy from the outside.*

Picture 3. Giant's causeway in Ireland. Is this a frozen dynamic structure?
(Private photo)

A non-equilibrium structure collapses if the energy source is removed. However, we can observe structures that have been dynamic, but are now locked or fixed in position. Take, for example, the "Giant's causeway" in Ireland, see Picture 3. Hexagonal or pentagonal cells seem to be frozen in an enormously large collection of cells. In some geological past time, each cell may have been a unit in a larger system with an overall order; an order that was maintained by a large geothermal gradient. But we need not go to Ireland to see a former dynamic structure. We can do experiments in the kitchen. Cook rice with a high influx of heat to the pot, and observe a pattern of regular gas pockets in the rice when the water has evaporated. Do the same with



Picture 4. The Ca-ATPase. An enzyme that pumps calcium ions uphill towards higher concentrations and more order, by means of chemical energy

spaghetti in an abundance of water, and see the regular pattern in which the long soft threads arrange themselves when the water disappears. The experiment has already been done by Adrian Bejan, so you might want to compare your results with his by looking into his book [2]. The molecular pump that we study [3] creates order by storing calcium ions in a closed vesicle (a small pocket) at a high concentration. Picture 4 gives a cartoon. Chemical energy is used to accomplish this.

The earth as a non-equilibrium system

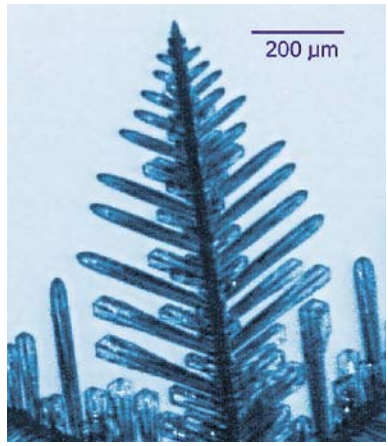
The method that we use to study dynamic structures can be applied to the earth. The earth contains numerous dynamic structures. All living beings can be seen as such. More living beings therefore mean lower entropy on the earth. Order is maintained by a *net* flux of entropy away from the earth. The entropy influx from the sun leads to order decrease or positive entropy, while the entropy outflux from the earth, $\mathcal{J}_s^{out}$, leads to a decrease in entropy. A balance equation links the contributions:

$$\frac{dS}{dt} = \mathcal{J}_S^{in} - \mathcal{J}_S^{out} + \mathsf{s} = \frac{\mathcal{J}_{energy}^{in}}{T^{sun}} - \frac{\mathcal{J}_{energy}^{out}}{T^{earth}} \qquad (1)$$

This balance is the second law of thermodynamics. It governs all conversions involving energy. On the left hand side is the internal (negative) entropy change per unit of time and volume, *ds/dt*. After the first equality, we have the net flux of entropy into the earth, $(\mathcal{J}_s^{in} - \mathcal{J}_s^{out})$ plus the entropy that is produced in the process of creation and maintenance of structures, σ. This quantity represents the friction that has to be overcome in a dynamic structure (remember the efforts of the team of bicyclists) and is always positive. The entropy flux is defined by the energy flux divided by the appropriate temperature. If the energy flux from the sun is not accumulated on earth over time, it is equal to the energy flux out, according to the first law of thermodynamics. This gives $\mathcal{J}_{energy}^{in} = \mathcal{J}_{energy}^{out}$. The entropy flux difference is therefore negative, because the temperature of the sun is 5000 K, while that of the earth is around 300 K. This is what we want. But a positive entropy production may, at least in principle, threaten that situation.

Are there limits to growth caused by the production of entropy?

Can we change a non-equilibrium structure? The answer is yes. We do so by changing the rate of energy input into the system or by altering the stress on the system. Take the formation of ice crystals, for example. When the air is rather humid and the temperature is close to zero degrees centigrade, ice tends to form needle-like crystals like those in Picture 5. When the temperature is well below zero, ice grows in largely different forms, for example, in flat hexagonal crystals, or so-called depth hoar crystals. The structure can be seen as an adaption to the external stress.

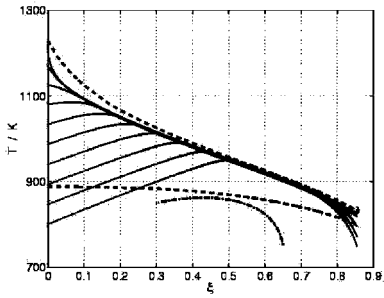


Picture 5. Ice needles
http://www.scienceclarified.com/images/

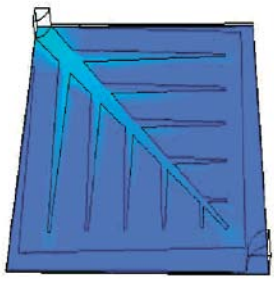
Considering the earth as a system once again, we know that the stress on our resources increases as the population grows. More entropy will be produced for this reason. A solution may be the creation of new structures. Changes are necessary for many reasons. And changes come with entropy costs. There is always a positive entropy production to pay for maintenance and construction. In this manner, there may be a limit to growth if the entropy production becomes too high. One might say that humanity *is facing an entropy challenge*. Entropy production cannot be too large as the earth must be able to sustain it. It is very difficult to calculate these quantities for the earth as a whole, but a systematic approach has now started.

Energy efficient designs are needed

What can we do to counteract the increased entropy production in the world? Clearly, we can become more efficient in our use of resources. We destroy order when we use fossil fuels. For this and many other reasons, it is important to look for possibilities for more energy efficient design. By studying the natural lung system, Gheorghiu *et al.* [4] found that the entropy production was *constant* in the bronchial as well as in the alveolar regime of the human lung! This finding was also a property of the energy efficient apparatuses studied by Kjelstrup and co-workers, see ref. [5] for further references. For instance, Johannessen and Kjelstrup [6] found that chemical reactors with *minimum* entropy production (a minimum waste of energy) had *constant* entropy production. The reactors operated along a so-called highway, illustrated in Picture 6. The highway picture was adopted because the highway is often used for driving that is beneficial for fuel use. We know that it is better for a car engine to avoid sudden acceleration and braking. It is this experience that has now been generalised, by us [4-6] and others [2], to design many processes that involve energy conversion. They should be constructed after determining the dynamic structure of the process that leads to minimum entropy production.



Picture 6. The highway in state space for chemical reactors defined by temperature and composition along the black band. Reprinted with permission of *Chem. Eng. Sci.*



Picture 7. A new design of oxygen supply system to fuel cells? From Morgan Fuel Cells, 2003.

The sum total of such activities will reduce the strain on the systems of the earth. We are now working to find structures, e.g. fuel cells that are beneficial according to these views. Does the structure in Picture 7 have these properties? This is just one example. A series of similar studies should be undertaken to meet the entropy challenge.

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JAN ERIK REKDAL

Transmission of Kings and Texts in Medieval Irish Tradition

The Irish king is a vexed issue which, for a long time, was chiefly discussed by historians. The bulk of mediaeval king-tales in the Irish tradition have traditionally been named 'the Historical cycle', which reveals the perception of them as historical documents. More recently, however, the king has been approached by other disciplines also, such as literary historians. It is high time now to ask how these tales, as well as the praise poems, were conditioned by those who composed them.

When the king was presented in public, it was not the actual king who was presented but the ideal of a king. This becomes clear from the literary representation of a king. In all genres where he occurs, his ideal is held up before him like a mask (persona) for the audience. This observation raises a series of questions about how and by whom the king was presented.

Professor Jan Erik Rekdal
Department of Linguistics and Scandinavian Studies (ILN), University of Oslo, Norway
j.e.rekdal@iln.uio.no
CAS Fellow 2007/2008

The mute king

The Irish king never spoke for himself. At his inauguration, he was identified and presented by druids, or later, by clerics. At the court, his legal authority was presented by the lawyers, his martial career ('caithréim') was presented by his court-poet, so also his birth, marriage and death, his reign and his conduct were presented by the learned elite, whether a *fili* or a *cleric*. The *filid* offered panegyrics which heightened reputation in the same manner as satire attacked it. They were in many ways both the patrons/suppliers and protectors of the honour of the laity. But the *filid* also delivered knowledge of legal precedents, stories (*scéla*) and other lore (*senchas*).

In other words, the king never represented himself in early Mediaeval Irish literature. The king represented his ideal through either fulfilment or deviation. The king was spoken *of*, not *to*. Even in much of the praise of early pre-Norman date, he was described in the 3rd person[1]. (The exceptions seem to be the poems where the poet plays a lover's part, addressing the king in sensual wording in the 2nd person – representing the king as an object of love and desire. There is a question of whether these poems approached the king in public – but appear or, more likely, were meant to appear as part of private communication.) Praise-poems and early tales were exchanged in public and were thus intended to be part of the official normative and formative discourse. Thus, I would claim that this is the result of seeing the ideal king/the ideal of a king in much the same way as a canon (text).[2] Addressing the king in the 3rd person could then be seen

1: K. Meyer, *Bruchstücke der älteren lyrik Irlands* Gesammelt und mit überrsetzung heruasgegeben, erster teil Berlin 1919.

2: Jan Assmann: Religion and Cultural memory: 64ff.

as a commentary to the ideal of the king rather than as a speech to the actual king. If, however, a speech was made to someone, it would address the society upheld by the king's sovereignty. The actual king was the problem because he would tend to deviate from this ideal as only a dead person can be canonized. The actual king was cocooned in silky words. Our futile question, then, is who was that king who was so wrapped in words?

The representation of the king

The representation of the king was always taken care of by others, all of them specialists in history, law, genealogy, etc., and they also had special training in the technique of representation: rhetoric, style and genre – the entire medium. The king would not be part of these various specialities, even if he may have been trained in law.[3] When writing was introduced, the king appears to have remained, in most cases, illiterate, thus leaving the *talking* to the learned classes while keeping the *acting* to himself and his warriors, that is, the king was to *live* what the learned *put into words*. Only by means of the words of the learned could the king act as the physical representation of the ideal king. The actual king had to be recognised as the fulfilment of the ideal king, and this recognition was taken care of by the learned elite. At the same time, the king's sovereignty and kingship were the raisons-d'être for the same learned elite. The learned elite acted as commentators of the canon of the ideal king, with its absolutely normative validity represented by the king's exemplum.

It was when the king did not act according to his own example that the critique of the king cropped up in form of legitimate satire.[4] When the authority of the canon was threatened, the elite were also threatened since their foundation rested on the validity of the norm. This was why, in their effort to retain the canon, they would criticise the king rather than reformulate the canon. After all, the king was temporary whereas the ideal of him was to be eternal. Legitimate satire placed effective pressure on people of high rank to obey the law. When the poet turned his satire against the king, it was the king's face that was ruined, not the ideal. Satire was the other side of praise. There were seven grades of satire, one for each rank of the hierarchy. (Kelly:137 n.90)

The three equal hierarchies

The learned elite of *filid* were ranked by seven grades and three subgrades, exactly like the lay nobility, so a chief poet (*ollam*) would praise a king, a minor poet a minor king or lord, etc.[5] The Church had a similar scheme of hierarchy – from bishop to doorkeeper. In a law, a king and an *ollam* were juxtaposed as the protectors of a *túath* – the petty kingdom.[6] The chief poet (*ollam*) may have been engaged by the *túath* itself or by the king. The ecclesiastical scholar did not have a similar hierarchy but he belonged to the same stratum as the others. However, we see how representatives of the four groups are juxtaposed in the following formulation from the law *Bretha Nemed* (a law on the status of the *filid*):

3: Ó Cróinín, D. 1995:76.
4: Cf. McLaughlin 2008.
5: See more about the grades of the *filid* in Uraicecht na Ríar; Breatnach 1987.
6: Charles-Edwards 2000: 127 n.13.

> 'A *túath* is not a *túath* without an ecclesiastical scholar, a churchman, a poet (*fili*), a king by whom contracts and treaties are extended to (other) *túatha*'. (*Uraicecht na Ríar*, p. 90)

King and warrior

The king was usually depicted as deviating from his example when he acted violently, i.e. more in the manner of a warrior. Enacting protection and peace – vital components of his example – took personal strength, courage, weapons and warriors. The warrior also represented the king – the king in action – an action in which the warrior played a central part. The warrior resembled the king more than the learned but was not part of the aristocracy. However, he had more features in common with the king as they both acted within the same semio-sphere[7] of action and, consequently, with different semiotics than those of the learned elites. This semio-sphere of acting, combat and battle was also described and interpreted by others, i.e. by the learned elite. The actual dialogue of mutual agreement between the king and his warrior seldom surfaced in texts unless they expressed disagreement or contention between the two, but even then we hardly hear them speak. In his praise-poems, however, the king was always praised for his martial deeds as *the* heroic warrior but not together with his warriors. In the literature, the warrior appeared as the greatest obstacle between the king and his royal ideal. The warrior ethos, with its stark features of paganism, was a threat not only to the ideal of a king but no less to the learned elite and their hierarchy whose raison d'être it was to act as custodians of that ideal. I suggest that there was constant fear among the learned elite underlying their praise and critique of the king, i.e. a fear that the warrior champion intrinsic to the king as protector would gain the upper hand on the king. This may explain why they did not speak directly to the king in the texts they produced about him.

Face and façade

Dallán Forgaill was the name of the alleged poet of the elegy on the Irish apostle Colum Cille composed shortly after Colum Cille's death in 597. His name means 'the little blind man of superior testimony.' It is, however, not a name but a title referring to his function. *Forgall* means 'superior testimony, overriding testimony (of one of higher rank)' and is the verbal noun of *forgall/forgell* 'testifies.' Dallán Forgaill belonged to that category of learned men called *filid* ('seers') – *fili* (sing.). Etymologically, *fili* could be translated 'a seer' – related as it is with the word to 'see' in Welsh: *gweled*. The poet testifying often described himself as a witness (*fíadu*[8]). *Fíad* (related to Welsh *gwydd* 'presence') means 'presence' and 'front', although it usually translates 'in front of, before'. The term *fili* may refer to the fact that the poet claimed to have been an eye witness and to have seen what he would relate. One could also say that what he had seen was imprinted not only in his eyes but also on his face. Could *fili* refer not only to a 'seer', but also to one who, by his face, could act as a witness, by showing his face as proof?

In early society, the transmitter and transmitting not only took place in the public space but the terms the elite used on themselves and their

7: A sphere of semiotics or signs – a term coined by Jurij Lotman.

8: Thurneysen Grammar: 212.

acts point very much towards face and façade, presence and presentation. This word for presence or countenance makes the main component of the verb 'to tell' and 'to show'[9]. The words for satirizing in Irish *áerad* and *rindad* both share the meaning of 'to strike, to cut'.[10] When we consider how seriously verbal assaults were treated, we suspect how much praise was valued to retain a person's honour. This is illustrated by one of the laws where the honour of a satirized king may be restored if the satire is overruled by a praise-poem[11]. Honour was the axis upholding the nobility and the axis around which the entire aristocratic society evolved. Honour was measured according to rank and the person's honour-price (*lóg n-enech*) means literally 'the price of a person's face'- honour-price. That the word for honour (*enech*) also meant 'face' implies public space. Honour was sustained by words of praise – words pertaining to the learned poets. An insult to the face was to be compensated by the fixed honour-price according to rank. A face could easily be harmed or blemished. It was all a matter of public appearance which the poet guarded by his praise and the king by his warrior. We can see from this how the poet and the warrior both presented the face of the king. The poet acted as a witness when he spoke of the king – and would, accordingly, bind his witness, i.e. his face (*fiadnaise*[12]) to his representation of the king.

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9: Pedersen :.363, Thurneysen 36, 356.

10: Idem. 137.

11: Kelly 1998:138.

12: Compound of *fíad* and *nass* perf. pass. av *naiscid* 'binds'.

SUSAN E. COZZENS

Equality as an Issue in Designing Science, Technology, and Innovation Policies and Programs

Inequality is an important global challenge. Inequalities between countries are growing. While some poor countries are rapidly expanding their economies, others are stuck at a low level and the gap is therefore widening between countries. Inequality is also growing within many countries, including affluent ones. Inequalities in basic needs such as food and water violate human rights as identified by the international community.

An inequality is a barrier – a steep differential that someone must scale to achieve his or her full potential. Human progress as a whole is therefore hampered by inequalities, which keep our efforts from adding up to all they could. This happens through vertical inequalities, differences between individuals and households generated by the structure of the economy, and through horizontal inequalities, differences by culturally-defined categories like gender, ethnicity, and religion.

Professor Susan E. Cozzens
Ivan Allen College,
Georgia Institute of Technology, USA
susan.cozzens@pubpolicy.gatech.edu
CAS Fellow 2007/2008

Why talk about inequalities in the context of science, technology, and innovation (STI) policies? On the one hand, STI policies link directly to basic needs when they deal with food, health, and the environment – all topics that are virtually universal on national STI policy agendas. On the other hand, STI policies link indirectly to inequalities in income when they affect the dynamics of economic growth. STI policy practitioners think of their work as providing a public benefit, but any public intervention can contribute to cumulative advantage if it is more accessible to the members of society who have greater resources. Public interventions, including STI policies and programs, need to be specifically designed to reach disadvantaged groups if they want to be redistributive.

My colleagues and I distinguish three types of redistributive policies: (1) Pro-poor policies aim to reduce poverty or alleviate its conditions. (2) Fairness policies work on eliminating horizontal inequalities, e.g. by gender or race. (3) Egalitarian policies attempt to reduce vertical inequalities, through economic activities that increase income for people in the middle of the distribution. I illustrate each type here, drawing on a mix of research, human resource, and innovation policies from the STI realm.

Pro-poor interventions

A first example comes from research my team is doing on innovation in water supply and sanitation in developing countries. The core of the problem is provision of these basic services to very poor urban and rural communities, and both government agencies and non-governmental

organizations try to target their efforts to those areas. Poor sanitation and bad water are serious health problems, and bad health holds back development. Interdisciplinary research, involving social scientists as well as engineers, is helping to help make those programs more effective.

A second example concerns access to essential medicines. Patent policies have been designed in affluent countries to allow companies to recoup the high costs of developing new research-intensive products like drugs. Under patents, companies can charge high prices for new products. In Europe and the U.S., this is not a problem for poor people, who get access through public programs. But in low-income countries, high costs stand between the drugs and those who need them. In relation to HIV/AIDS drugs, an international coalition of civil society organizations took action, negotiating a much lower price with generic producers in India. Unfortunately, recent developments in international regulations have undermined this solution, and the search is on for other creative approaches.

Another example comes from the research agenda for African agriculture. On any map of world hunger, Africa stands out; and most of the hungry people in Africa are subsistence farmers living on the land. International agricultural research is therefore targeting the search for locally helpful strains to improve yields for these families. Community-based innovation is also being tapped, since local farmers know their own crops and conditions best.

Fairness interventions

Fairness interventions can be illustrated both within and outside the pro-poor approaches. Water supply and sanitation in poor communities in the developing world are a women's issue. Women fetch and carry water when it is not available in the home, and girls stay away from school when sanitation arrangements are not adequate. Public interventions in this area are explicitly trying to make sure that women's voices are heard, and women are providing leadership in community-based technological choices.

In a very different context, U.S. research policy offers several examples of fairness interventions. The Women's Health Initiative at the National Institutes of Health has focused both on getting more women into careers in biomedical research, and on developing a research agenda that focuses on the female experience. Similarly, the U.S. has a number of programs devoted to reducing health disparities, which underlie the still-large difference in life expectancy between African- and European-Americans. The health disparity programs also have strong human resource elements, trying to attract more African Americans into science careers, but they also invest in building institutional capacity in historically black medical schools and are linked to community-based research.

A final example comes from the other side of the world. Maori research policy has been established under the framework of the treaty between indigenous and newcomer New Zealanders. Research that involves the Maori community must be "by Maori, for Maori, and working from a Maori world-view", i.e. strong local control.

Egalitarian interventions

Finally, we have a number of examples of egalitarian interventions, those that decrease inequality by changing the shape of the economy.

Technology-based local economic development efforts fall into this area. In the U.S., the Experimental Program to Stimulate Competitiveness in Research (EPSCoR) illustrates. The federal program provides funds for local plans to develop human resources and institutional capacity in research and link it to the local economy.

In other well-known examples, industrial policy has been used. Korea, Finland, and Ireland have all achieved dramatic growth by adding large numbers of middle-wage jobs to an economy in export industries. The rapid expansion reduces unemployment to a minimum, and thus cuts into poverty directly.

Strategies for rural development likewise reduce the difference between urban and rural living. Examples from STI policy include bringing the Internet to the countryside, commercializing rural innovations like fish-drying techniques on the coast of Kerala, India; and encouraging rural entrepreneurship, like the pump-repairing businesses that can follow in the wake of rural water supply projects, increasing sustainability of the pumps themselves and building skills in the local workforce.

Design principles

The three different kinds of programs described above each involve a different set of people and thus call for distinctive design principles and processes, as well as particular attention to implementation, evaluation, and assessment with involvement of the groups they are intended to benefit. These apply to all STI policies, including those designed to benefit marginalized groups.

The pro-poor interventions involve people living at the edge of subsistence. They know their living conditions and personal challenges better than any outside experts and they have often invented creative alterations in technologies to match their own needs and resources. What they generally lack, however, is the technical expertise to keep a technology effective even if it is altered. All these characteristics suggest strongly that pro-poor interventions should combine the inventiveness of poor communities with the problem-solving skills of scientists and engineers. Without community participation, the scientists and engineers are unlikely to find appropriate solutions on their own. Programs that build the marketable skills of community members are also the most valuable.

Fairness interventions similarly require development through a feedback process that incorporates the experience of program participants. These programs target previously disadvantaged groups, but their goal is a research and innovation enterprise in which everyone feels welcome and can achieve their best. Empowerment is an essential element to readjust previous relationships. If the programs do not address the cultural ideas that created the original inequality, they will leave unequal structures in place even while they change the occupants of privileged positions.

Design principles for the egalitarian programs focus on finding the economic opportunity that matches a country or region's capabilities. The chance for rapid expansion is probably a rare occurrence as compared with incremental growth. These efforts must also keep the other re-distributive goals in view. Korea unfortunately built its export competitiveness based on large wage differentials between male and female workers – not a model for other countries to follow.

In summary, inequality-reducing options are available in STI policy. Expanding efforts to reach disadvantaged groups will make a difference over the long run in the distributional consequences of this set of policies.

	Goal	Examples	Design Principles
Pro-poor	Reduce poverty or alleviate its conditions	• Focused water innovation programs • Negotiated low prices for essential medicines • Community-based innovation in African agriculture	Combine the inventiveness of poor communities with the problem-solving skills of scientists and engineers
Fairness	Eliminate horizontal inequalities, e.g. by gender or race	• Women leading water programs • Women's Health Initiative • Minority Health Initiative • Maori research policy	Empowerment to readjust previous relationships
Egalitarian	Reduce vertical inequalities; grow the middle of the income distribution	• EPSCOR • Industrial policy • Rural innovation programs	Match local capabilities with wider opportunities. Keep the other goals in view

Table 1. Redistributive STI Policies

GRO STEINSLAND

Vǫluspá

– a Source to Norse Pagan Mythology or a Christian Revelation in Disguise of a Classical Sibylline Oracle?

Anton Christian Bang's hypothesis of *Vǫluspá* as a Norse Sibylline oracle

Working with *the myth of future* in Norse mythology, a theme most fully unfolded in the eddaic poem *Vǫluspá*, an old hypothesis has become reactivated and strengthened on new conditions. In an article published in 1879, the Norwegian bishop Anton Christian Bang argued that *Vǫluspá* was most probably created as a Norse parallel to the classical Sibylline oracles, a literary genre productive over a long span of time, from pagan Antiquity into early Christianity. Bang argued that both the structure and the main mythic themes of *Vǫluspá* to a rather amazing degree do indeed correspond to the Sibylline oracles.

Professor Gro Steinsland
Department of Linguistics and Scandinavian Studies (ILN), University of Oslo, Norway
gro.steinsland@iln.uio.no
CAS Group Leader 2007/2008

Vǫluspá

Uncovering the whole cosmic history, *Vǫluspá* has the character of an apocalypse. The vision of the world's destiny from primeval times to the end of cosmos and even further into a brand new future, a revelation laid in the mouth of a female prophet called *vǫlva*, makes this poem outstanding among the eddaic poems.

The poem devotes its deepest attention to the visions of the *eshcaton*, the end of the world. In one of the two textual sources of *Vǫluspá, Hauksbók,* the future myth even contains a vision of a heavenly Man, a ruler of the New Age. More than 30 stanzas of the poem are occupied with the disasters of Ragnarǫkr, painting horrifying scenes of cosmic collapse, heaven and earth broken down; gods, giants and monsters mutually ruining each other. The final scene is a beautiful vision of a new age and a new earth to come with brand new conditions for life.

Vǫluspá has been looked upon as the most important source of the pagan Norse world view and mythology, dated to the late Viking Age. The poem has been given a special authority, from Snorri Sturluson on, who structured his learned presentation of Norse myths in his work *Edda* about 1220, down to modern scholars in the field. It is not surprising that any hypothesis that could change the common view of the source (origin or dating) would provoke heavy debate. The hypothesis of Bang did not

gain much support, either in his own lifetime or later. Just a few scholars, among them the Norwegian philologist Sophus Bugge, a comparative oriented scholar, lent Bang his full support.[1] The thesis was, however, strongly opposed by representatives of the Germanic school who maintained the view that Norse mythology belonged to an age-old Germanic culture. Bang's thesis was soon ignored by scholarly world.

The antique Sibyls

The antique Sibyls were known as god-inspired pagan prophetesses with the ability to look into past and future. They became channels of revelation in an antique, pagan oracle genre that was accorded great authority by the Christian church as well. In the antique world, the oracles were brought into circulation through text collections and they took the form of apocalyptic visions with a strong eschatological emphasis. The Sibyls present the end of the world, *eschaton*, in frightening and horrifying mythical images. The oracles often had the form of the socalled *vaticinia ex eventu*, fictive prophecies of the future that often were so well constructed, that representatives of the early church took them for genuine ones. For example, the Church Father Augustine made use of the pagan Eritrean Sibyl's prophesy about the wondrous child who was going to be born for the salvation of the peoples, in his *De civitate Dei*.[2] In several of the Sibylline oracles the cosmic catastrophe is followed by a new age in which the world is recreated or reshaped. The climax of the visions may be the arrival of a future ruler who will come in a wondrous fashion, either born as an extraordinary child, or most often, as a fully-grown, divine man, a king, described within the pattern of traditional royal mythology and ideology.[3] The Church Fathers saw an apologetic meaning in the old pagan oracles: through the frightening Sibyls, paganism had realised its own downfall. The Sibyls, though pagan, were inspired to reveal the breakthrough of a new cosmic order which was interpreted by the Church as the coming of Christianity. Obviously, there are important parallels between the Sibylline oracles and *Vǫluspá*. However, it must be admitted that there was a serious problem with the thesis of Bang: no potential intermediaries could be identified between the antique Sibylline oracles from the first centuries AD and *Vǫluspá* transmitted in text-collections from the 13th century.[4]

Notwithstanding, recent research has established that some Latin Sibylline oracles were in use in Anglo-Saxon England during the Viking Age, in the liturgical traditions of the Anglo-Saxon Church. The then Norse people might have come to know elements of the Sibylline prophetic traditions through contacts with the Anglo-Saxons or through Irish or Spanish channels.[5]

1: Bugge 1881. Bugge proposed that the name *Vsp* is a translation of *Oracula Sibylla*, *oraculum* and *spá* being identical idioms.
2: *De civitate Dei*, book XVIII, 23.
3: Collins 1998.
4: Rydberg 1881.
5: Dronke 1996 and 1997: 93 ff., cf. Clunies Ross 1992 on the *Prologue*, *Snorra Edda,* cf. Samploniuis 2001.

The myth of future

Bang was occupied with several similarities between the Norse and the continental prophecies that seem rather convincing: the female figures of prophetesses of the two traditions do resemble each other; the number of cosmic worlds following each other is nine. The revelations end up with a total breakdown of the actual world and then a new Age follows, in the pagan sources a king or a wondrous child will come, in one of the Norse sources to *Vǫluspá*, it is a mysterious heavenly Man – who I have elsewhere interpreted as the pagan Heimdall, a Christ in sophisticated disguise. It has been the *myth of future* with the future ruler in *Vǫluspá* that convinced me about the strength of Bang's hypothesis. The future-myth seems to be difficult to defend as a genuine pagan Norse creation. The ideas about a common, messianic future would be meaningless in a pagan society built upon kinship, with a folk religion with no ideas about individual salvation and eternity. It seems reasonable to propose that the myth of a common, cosmic future was an innovation brought to the North by Christianity.

Bang's hypothesis seems to be strengthened

The old hypothesis of A. Chr. Bang seems to have been strengthened from the perspective of History of Religion, focusing on an analysis of mythology. In *Vǫluspá* the Norse culture got its Sibyl, probably inspired both from a genuine Norse tradition of pagan seeresses, in combination with specific ideas brought from the antique, Jewish-Christian traditions of the Sibyls. Then *Vǫluspá* seems rather to be a creation of the learned Middle Ages than a product of the late Viking Age, with a probable dating of closer to 1150 than to 1000.

To the question of how *Vǫluspá* should then be looked upon as a source to pagan mythology and world view, I would dare to answer that the broad picture of the pagan cosmology transferred in the poem might be reliable to some degree. But there are obvious medieval innovations, such as the anthropogonic myth with *Askr* and *Embla* resembling the biblical Adam and Eve; the *imago dei*-motif of the creation myth, alluding to the creation myth of the Bible[6]; the role of the world-tree embracing cosmic history as in the Bible, and not least the myth of the Future as argued here.[7] Thus *Vǫluspá* is a modified source to pagan mythology and a masterpiece of Christian revelation in diguise as well.

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6: Steinsland 1983; 2001.

7: Cf. Steinsland 2006 for detailed analysis.

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MARC-OLIVIER COPPENS

Nature Inspired Chemical Engineering: A New Paradigm for Sustainability

Our society is faced with urgent challenges related to increasing energy efficiency, extending access to clean and fresh water and air, and making chemical processes more selective and environmentally acceptable. Chemical engineering is ideally positioned for presenting technological advances in these areas, and they should be considered in the economical, but also the social, political, legal and cultural contexts that define viable implementations. Each of these aspects is important for sustainable development.

Professor Marc-Olivier Coppens
Department of Chemical and Biological Engineering, Rensselaer Polytechnic Institute, USA
coppens@rpi.edu
CAS Fellow 2007/2008

Tremendous progress has been made in our ability to manipulate matter on ever-smaller scales and to make accurate supporting measurements that allow us to spatially resolve structures and to follow molecular transport and reaction dynamics. Combined with theoretical scientific advances, increasing computational power, and better computer algorithms, the road is, in principle, open for the rational design of new products and processes that could address the above-mentioned issues. While advances in micro- and nanotechnology might help to synthesize these designs, the challenges remain huge because of the large gap between atomic and macroscopic scales and an enormous gap in time scales. For example, there are ten orders of magnitude (10^{10}) between the size of an atom and one meter, and twelve (10^{12}) or more between the period of an atomic vibration, and the seconds, hours or years that are relevant to macroscopic chemical processes. On the other hand, the overall phenomenological, largely empirical models that have up to now been at the basis of most chemical process and product engineering are untenable, as they likely lead to inefficient, sub-optimal designs, and offer only incremental progress, rather than leading to the required radical innovations.

We propose to learn from nature as a fertile ground for transformative innovations. Nature has frequently been a source of inspiration for artists and scientists alike [1, 2]. In catalysis, for example, the selectivity of biological catalysts (enzymes) for carrying out specific chemical reactions at temperatures close to room temperature is remarkable compared with that of typical chemical (heterogeneous) catalysts, which also typically require much higher temperatures to be active. The geometrical and chemical structure of enzymes has therefore been imitated in the design of biomimetic catalysts that employ a similar lock-and-key mechanism to selectively carry out a desired chemical reaction. The multi-scale structure of microscopic hairs (setae), splitting into nanoscopic spatulas on gecko

feet has recently inspired very strong carbon nanotube-based adhesives, using a similar hierarchical structure [3]. Likewise, the hierarchical structure of self-cleaning lotus leaves has inspired the design of water- and dirt-repellent coatings. However, when it comes to chemical engineering, the difference between nature's ways of carrying out a physicochemical process and the engineer's solution is striking. Certainly, engineers have the ability to employ different materials, and they have access to different operating conditions, such as high temperatures and pressures, which biology does not have at its disposal. This could increase the (thermodynamic) efficiency of certain processes, although even here the question of effectiveness in terms of life cycle analysis remains, e.g. the formation of non-degradable or recyclable side products and safety issues. Blind imitation of nature's solutions will not typically lead to the best solutions. Ignoring nature's solutions, however, means missing clues to very efficient and effective ways to bridge multi-scale gaps, which is one of the engineer's most difficult problems: How can an improved design at the nano- or micro-scale be translated to the macroscopic dimensions required in many applications? For example, fluid motion in a lab-scale process differs from that in the large reactor vessels that are typically used for chemical production, affecting overall performance and product selectivity, and possibly presenting safety hazards. Despite considerable progress in fluid mechanics simulations, the model-based scale-up of multiphase reactors (involving gases and liquids or solids) is a challenging problem. Because such reactors are used in some of the most important processes for fuel and chemical production, more robust, scalable designs are highly desired.

Trees and lungs hold clues to solve this problem. More generally, nature presents attractive solutions to the bridging of multi-scale gaps, typically by means of fractal geometry. Fractals are structures that look similar at multiple length or time scales. Examples include trees, lungs, river basins, mountain ranges, natural coastlines, and the vascular network. Magnifying a small part of these objects brings up images that are indistinguishable from larger parts, within a certain range of scales: the fractal scaling range. Mandelbrot first presented the common mathematical framework for these diverse objects, coining the word "fractal" to describe them [4]. Mathematical fractals, such as Cantor sets, Koch curves and Sierpinski gaskets, can be constructed to be exactly, infinitely self-similar, at all length scales; whatever the magnification, the same structure reappears. This is very different from objects in Euclidean (classical) geometry, such as circles, cones or squares, which become smooth and straight almost everywhere at sufficiently small scales. Self-similarity in nature has the same repetitive characteristic as mathematical fractals, making fractal geometry the "natural" language within this scaling range, but it breaks down at some finite scale (e.g. that of atoms or basic constituting particles, like individual cells) and it is stochastic, i.e. the similarity from one scale to another is to be viewed in a statistical sense. Fractals are beautiful, but also useful. Fractality implies symmetry, namely invariance under magnification, just like translational or rotational symmetry represents invariance under displacement or turning. Because of this, discovering a fractal structure enables us to describe a structure with much less information than through the language of classical geometry. Importantly, also *imposing* a fractal structure is a powerful simplification, often leading to very desir-

able features. It is this simplification – the ability to bridge multi-scale gaps – that can be exploited by rational fractal design over an optimal range of length or time scales.

A tree, whose branching crown and root network are fractal, grows in a self-similar way, and effectively bridges scales between the leaves and the trunk. The size of the twigs and the leaves is not related to the overall size of the tree; only the number of branching generations of the tree crown increases when the tree grows. Its desirable mechanical properties were already noted by the architect Gaudí, who utilized tree-inspired columns to support his famous *Sagrada Familia* cathedral in Barcelona. Gaudí was convinced that nature's designs are the most economical and long lasting. But a tree crown is also effective in preserving the same chemical reactions at the level of the leaves, irrespective of tree size. A tree can be viewed as a photosynthesis reactor, converting carbon dioxide and water into biomass (the growing tree) and oxygen. Similar arguments can be made about the lung. The branching structure of an adult human lung connects the bronchioles and the trachea via a self-similar structure over 14–16 generations [5]. The architecture of the lung was also shown to lead to minimal entropy generation, which is equivalent to the highest thermodynamic efficiency for air transport [6]. Such fractal structures of channels are effective fluid distributors and collectors, connecting a huge volume and surface area to a single point. This concept led us to propose a fluid distributor, the so-called *fractal injector*, which distributes gas or liquid uniformly over a large reactor volume from a single inlet [7]. The fluid leaves the injector via outlets at the deepest generation (the "twigs"), which are equidistant to the inlet, resulting in equal pressure drops from the inlet to each of the outlets, and uniform flow. The low pressure drop saves energy. In a small reactor, the distributor only has one or two generations of branching tubes. In a larger reactor, generations are added, conserving the size of the outlets and the distance in between. This differs from conventional reactor design, in which larger tubes are used to distribute fluid over larger reactor vessels, with often empirically determined outlet position(s) and added baffles or mixers to compensate for scale-dependence. It is quite similar, however, to botanical trees and to other natural distribution and collection networks like lungs, in which the smallest size (twigs, leaves or cells) is maintained with age or overall size, while the interpolation between small and large scale occurs via a self-similar fractal network whose number of generations increases with size [2]. Such designs could be applied not only to three-dimensional reactor vessels, but also to spread a fluid in the two-dimensional plane, like a shower cap over a column containing a medium that needs to be uniformly irrigated. The latter, using area-filling branching, has been applied in the context of distillation and chromatography [8]. It could also, as we suggested while working at the Center for Advanced Studies, be employed to distribute fuel or oxygen over a fuel cell.

Observing biological reactors and separation devices, such as trees and lungs, we frequently notice a change in structure below a certain length scale, corresponding to a change in the underlying dominating transport and molecular exchange mechanisms. Once again, structure and function are related. The venal architecture of leaves tends to become uniform at small length scales, approaching those of the cells that house the photosynthetic complex. Below the level of the bronchioles, the pulmonary

structure is more compact: acini, lined by alveoli (which exchange oxygen and carbon dioxide with the surrounding blood vessels) are somewhat akin in their geometry to bunches of grapes. Diffusion, rather than flow, is the dominating transport mechanism at those small scales, and the walls are flexible and permeable.

This inspires novel designs for solid porous catalyst particles. Catalysts are used to increase the rate of chemical reactions and to enhance the selectivity toward desired compounds in industrial production, environmental and energy-related processes. By using solid catalysts, traversed by a vast network of nanometer-sized pores that provide access to the "active sites" on which the catalytic reactions take place, huge catalytic activity per unit of volume can in principle be achieved. However, because these nanopores are so narrow, molecular transport via diffusion through them is slow, hence it is desirable to introduce large pore channels as "highways" to increase the overall, effective activity, and to limit catalyst de-activation by pore blockage. The optimal distribution of large channels is found to depend on the boundary conditions. Mathematical optimization shows that, for a large number of channels and uniform distribution of reactants from the boundary of the catalyst particle, the highest yield is obtained for large channels of an optimal size, with an optimal thickness of nanoporous material in between the channels [9, 10]. In the molecular diffusion-controlled regime, a uniform, rather than a fractal structure emerges, but this optimum is changed when flow is the dominating transport mechanism, or when overall robustness or other criteria are set as objectives.

These examples illustrate a common paradigm to achieve more efficient chemical processes and materials, summarized in Figure 1: biological structures are an excellent source of inspiration for engineer designs that bridge multiple length scales, maintaining efficiency under scale-up. At the

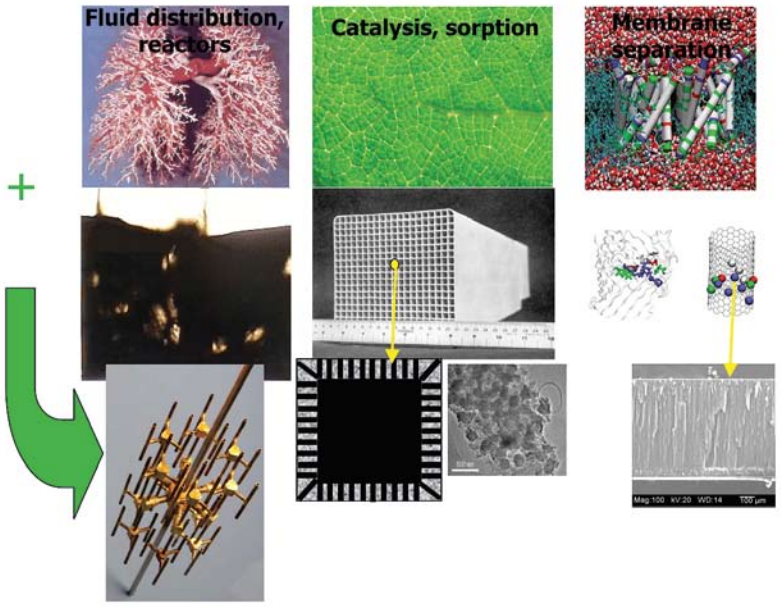

Figure 1: Multiscale nature-inspired chemical engineering. Left: fractal fluid distributors for multiphase reactors, inspired by the structure of the lungs and vascular network. Middle: design of hierarchical catalyst pore networks, inspired by the venal architecture of leaves. Right: design of membranes for high-flux highly selective separations, inspired by protein channels in cell membranes.

smallest scales, the structure is very specific, and dependent on the intrinsic function. At intermediate scales, uniform arrays appear common. At larger scales, fractal interpolation is very powerful to preserve the desired functionality. Other examples of nature-inspired chemical engineering include membranes for separation processes that imitate the key features of protein channels traversing cell walls, in order to achieve high flux and selectivity [11]. Employing a lung-like structure at larger length scales might be advantageous for creating robust, high-capacity devices, although this remains to be demonstrated.

The influence of dynamics has not been discussed, but is known to be essential to life. Chaotic systems can be dynamically perturbed to behave in a more ordered way using low energy input, and to realize steady states unachievable under static conditions. This opens the way to new classes of engineering designs that explicitly employ dynamic perturbations. Finally, it is the combination of bottom-up atomistic modeling, advances in mesoscopic theory and statistical physics, with more holistic methodologies such as chaos theory and fractal geometry that can help us to better understand, model and design systems, while considerable advances in material synthesis (self-assembly, structure-direction by templating and other means, micromachinery, etc …) help us to build them.

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PAUL NIGHTINGALE

Innovation and Speech Act Theory

Many socially desirable innovations are not forthcoming, but we don't really understand why. Market-pull theories suggest clear demand generates innovations, but cannot explain why demands for cures for cancer and non-polluting energy sources haven't produced results. Similarly, science-push theories suggest innovations emerge from basic research, but cannot explain why many innovations involve little, or no, input from science. Some innovations even exist before the science that explains how they work has been developed. Steam engines existed before thermodynamics and the Wright brothers flew before aerodynamics. Science appears to be neither necessary nor sufficient for innovation.

Technological paradigms and trajectories

Senior Fellow Paul Nightingale
SPRU, The Freeman Centre,
University of Sussex, UK
P.Nightingale@sussex.ac.uk
CAS Fellow 2007/2008

In the 1980s an alternative evolutionary theory of innovation emerged (Dosi 1982; Nelson and Winter 1982) that drew on Kuhn's idea that normal science follows shared problem-solving rules until anomalies accumulate and revolutionary paradigm shifts occur. Technological paradigms are the equivalent for innovation. Because the world is too complex to be captured by theory, innovation is uncertain and only a small proportion of all possible technical choices can be recognised and explored. The resulting trial and error experimentation generates technology-specific knowledge and problem-solving methods, with the result that innovations develop along cumulative, path-dependent trajectories, until they reach dead ends and are displaced by radical innovations that exploit entirely new problem solving strategies.

This evolutionary theory allows us to see the strengths and weaknesses of older theories. Science push theories correctly point out that fundamental knowledge can remove innovation bottlenecks and start new technological paradigms, but wrongly suggest science is necessary when problem solving routines are working well. Similarly, market-pull theories are right to pay attention to demand, but overlook the technical capabilities firms need to produce innovations (Dosi 1982). However, evolutionary theories of innovation don't yet explain why some technological trajectories emerge and prosper while others stagnate. Richard Nelson (2008) has highlighted that many of our normal explanations don't work. For example, the strong correlation between investment in R&D and innovation might suggest that differences in investment explain which technologies develop. However, the direction of causation is unclear as investments are typically based on perceptions of future success. Technologies that are unlikely to generate any pay-off aren't invested in. Similarly, the answer that some problems are just more difficult than others simply restates the question without explaining why.

Technical knowledge and speech acts

In the research I conducted at CAS, I tried to explore these questions using John Searle and John Austin's ideas about speech acts. They suggest language depends on our ability to have conscious mental states *about* the world, where the "aboutness" is referred to as intentionality. These intentional mental states have a type (fear, hope, belief, etc.) a content ('it will rain'), and conditions of satisfaction, so beliefs are true or false while desires are satisfied or not (Searle 1995). These conditions of satisfaction can be distinguished by their directions of fit. For example, beliefs have a mind-to-world direction of fit because the mind must match the world for the belief to be true. By contrast, desires have a world-to-mind direction of fit because the world must change to match the desire for the desire to be fulfilled (*ibid*).

These ideas can be used to tease apart some of the complex interactions between science and technology. As a first simplifying approximation, scientific explanations and theories are meant to be true, have a mind-to-world direction of fit and change in the light of new evidence. They are made true by facts and aim to be objective and timeless. Technology, by contrast, has a world-to-mind direction of fit and innovation processes change the world to match an idea. As such, technologies are more subjective and time-dependent. This explains why scientific explanations aim to be true for all people, at all times, and can apply to the past, but technologies are never true or false (they function or malfunction), are time-, place- and person-dependent, typically are more value-laden, and always forward looking (Searle 1995). You can't design a technology for yesterday, even if you can scientifically explain it.

This simplifying dichotomy can be made more realistic by looking at how science and technology interact within the messy, complex world of technoscience. Technological artefacts often involve many performance constraints and complex interactions between components that make the effects of large modifications analytically intractable. Because theory is a weak guide to practice, the knowledge required to design, develop, and produce artefacts is largely accumulated through trial and error (Pavitt 1987). However, knowledge from the natural and engineering sciences can guide innovation if the mismatch between simple theory and complex innovation problems can be addressed. This is typically done by simplifying the world (using technology) to create artificially purified 'experimental' conditions where theoretical assumptions hold. Knowledge gained from simplified examples guides the design of increasingly realistic prototypes as the simplifying conditions are relaxed, and experimentation proceeds from 'laboratory conditions' to models, prototypes, field tests and eventually real world applications. My research at CAS, with my graduate student Ohid Yaqub, has explored how these conditions are created during vaccine research.

HIV vaccine development

Vaccine innovation has traditionally been based on trial and error testing based on the notion that "similar problems have similar solutions". Jenner developed his smallpox vaccine after noting that cowpox infections conferred immunity. With HIV an effective vaccine has not been forthcoming after 25 years of research despite clear demand and excellent scientific understanding of the pathogen. Why?

The 'operational principle' – how a technology works – behind most vaccines is that the body's immune system clears the infection and them confers protection. Vaccines replicate this process to trigger an immune response without generating the disease itself. Using Searle's ideas about speech acts we have mapped out the 'operational principles' underpinning the HIV vaccine research process to attempt to understand why it has been so difficult. In doing so, we have mapped out how facts constructed under experimental conditions make statements true and how these facts generate reasons and explanations. This has revealed two main technical trajectories. The first is largely empirical and involves trying to either find a vaccine using a live (genetically) modified virus or using a killed whole virus. These methods are problematic because HIV is constantly mutating, creating the risk that a live vaccine might become dangerous. Similarly, if viruses are not properly killed the vaccine might actually cause infection – a risk that makes marketing a killed-virus vaccine for children difficult.

A second technical trajectory is more theoretical and involves either using a sub-unit of the virus to trigger an immune response, or infecting the patient using a viral vector that has been genetically modified to express HIV proteins and trigger an immune response. Two subunit (GP120 and GP160) and two viral vector approaches have been tried; unfortunately they have all failed in clinical trials. A sub-trajectory using DNA vaccines to insert HIV DNA into the host's cells, so that they express HIV antigens, has been suggested but carries a risk that this will disrupt important regulatory genes and cause cancer.

Within all these approaches there is a range of different technical decisions to be made that have produced a range of possible vaccine candidates. Because of the inherent uncertainty of innovation, these are tested in a formalised process of clinical trials. The first P1 tests basic safety, the second P2 tests efficacy and danger, while the third P3 establishes the clinical value of the drug. This third stage is extremely expensive and can cost well in excess of $100m. This raises a policy question about when to fund an expensive P3 trial and what basic research funding to cut to fund the trial.

In my work with Ohid Yaqub we have been mapping out the dead ends in innovation processes to try and unpack how such decision get made. Normally, vaccine innovation proceeds from the lab to trials through a series of increasingly realistic and complex models, typically involving animals. For most diseases an animal model exists or the disease is non-lethal, in which case it is possible to conduct tests on volunteers (i.e. graduate students). For HIV, the disease is fatal, and the animal models that do exist are unlike human HIV. Monkeys get SIV, which produces an AIDS-like disease, and chimpanzees can be infected with HIV, but do not readily progress to disease. The lack of animal models stops the creation of progressively more realistic scientific "facts", increasing uncertainties about candidate vaccines for clinical trials.

A second major problem occurs because there is no natural sterilising immunity associated with HIV infection: no-one who has ever been infected has ever cured themself. The virus can lie latent in the body for decades, which makes finding end points for clinical trials extremely difficult and makes comparing across experiments with different definitions of an end point complex. This latency produces a third major problem

related to the timing of trials. Because HIV infection generates AIDS after many years, trials will potentially take a very long time, which slows down the learning that is essential when developing complex technologies. A fourth major problem emerges because of the substantial genetic variation found with HIV, which means that the strains of the virus used in the laboratory can be very different from the primary isolates taken from the real world. The 'fact' a vaccine works in the lab will then tell us very little about its real world protective effect. Lastly, HIV vaccine development raises a range of very difficult ethical issues. AIDS rather than HIV causes death, so questions are raised about whether we should give up on trying to prevent infection and instead focus on producing a therapeutic vaccine that slows down the progression of the disease. Would it be ethical to produce a vaccine that doesn't prevent infection, but makes the vaccinated person less likely to pass on any infection they have? Similarly, is it ethical to abandon vaccine technologies in the West because they make organ transplants harder, when the chances of an organ transplant are remote in resource-poor countries?

In our research we have found that many of the problems facing HIV vaccine development are problems of science governance. Many research tasks would be useful for vaccine development, such as developing monkey twins, or virus typing (which is expensive because it kills monkeys), but are difficult to fund because they do not promise any advance in fundamental knowledge. When faced with difficult political and technical choices, peer review often defaults to awarding research funding based on scientific excellence, which may constrain the development of a vaccine if the bottleneck involves the co-ordination of research and the development and use of unexciting, shared research infrastructure.

The research we have been conducting is currently at the stage of using new theory to map out interactions within the research system, but it is gradually moving towards the point where the findings can be used to inform policy.

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LINUS BOMAN

The Philosophy of Modern Physics

Realism

Compared with other fields of science, modern physics[1] stands out with respect to the philosophical questions associated with it. For instance, Google searches for "interpretation of quantum mechanics" and "interpretation of chemistry" give 256 000 and 131 hits, respectively[2]. In other words, there is a factor of almost 2000 times more hits for the interpretation of quantum mechanics than for chemistry. These searches can be refined to show even more clearly that there is apparently a need for interpretation when dealing with "quantum", but that this interpretation is not needed when dealing with chemistry, for instance. Comparing the number of hits in a Google search may perhaps not be a very scientific procedure for measuring importance, but it still raises an obvious question: what is it about modern physics that makes it like that? This text is a short exposé of why quantum mechanics has been the object of many philosophical discussions.

Research Fellow Linus Boman
Department of chemistry, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
boman@phys.chem.ntnu.no
CAS Fellow 2007/2008

At the core lie the two concepts: realism and locality. Locality can, in short, be explained as the principle that things can only be directly affected by other things in their close vicinity. Einstein even called non-locality a 'spooky action at a distance'. Realism means that objects have their properties even before a human observes them, or in more colloquial terms: there is a *real* world that is independent of human observations. Local realism is thus a very intuitively attractive property of any theory. In fact, the philosopher Karl Popper once said "denying realism amounts to megalomania (the most widespread occupational disease of the professional philosopher)". However, since the first law of philosophy says that for each philosopher there exists an equal but opposite philosopher, Popper's statement should not be accepted without a further analysis.

The analysis can start with stating the fact that the world of quantum mechanics is quite peculiar and unintuitive. The list of unintuitive phenomena in quantum mechanics is very long and the Heisenberg uncertainty principle will be given the honour of representing all of them in this context. The principle says that the certain properties of an object, such as, for example velocity and position, cannot be measured simultaneously, and this is not due to inaccurate measuring methods but is a fundamental property of nature. This clearly seems to contradict our everyday

1: For simplicity, "modern physics" and "quantum mechanics" will be used here interchangeably. Although not necessarily completely correct, the subtleties involved are not relevant here.

2: For chemistry, the searches were for "interpretation of chemistry" – "interpretation of chemistry test results".

experience: I look at the table in front of me and can say exactly where it is (right in front of me) and what velocity it has (it has zero velocity, it does not move). Apparently, I am either mistaken about my table *or* the laws of quantum mechanics do not hold for tables. It is the first alternative that is the correct one: I do not know *exactly* where it is or *exactly* its velocity; however for macroscopic objects such as tables, the effects of the principle are too small to be noticed or to be of any relevance. Therefore, it still makes sense to have traffic laws, for instance, that say that a car on some occasions must come to a complete stop, even though that is physically impossible if we have a rough idea where the car is. On the other hand, for microscopic objects such as electrons and protons, the Heisenberg uncertainty principle makes all the difference and cannot be ignored. This principle, and many other unintuitive effects, caused Niels Bohr to say "If quantum mechanics hasn't profoundly shocked you, you haven't understood it yet."

The Copenhagen interpretation

How can these unintuitive effects be explained and what does it all mean? Niels Bohr attempted to answer that question. He was a very influential 20th century Danish physicist and one of the originators of what came to be called *the Copenhagen interpretation*. There is no strict definition of the Copenhagen interpretation but it basically says that a system can be described completely by a so-called wave function and the wave function is nothing but an abstraction. The Copenhagen interpretation has been summarized by David Mermin as "shut up and calculate"[3], meaning that since the equations are known and will yield the same results no matter what interpretation we make of them, there is really no point in discussing different interpretations. Heisenberg said "it is possible to ask whether there is still concealed behind the statistical universe of perception a 'true' universe in which the law of causality would be valid. But such speculations seem to us to be without value and meaningless, for physics must confine itself to the description of the relationships between perceptions."

But is describing relationships between perceptions all we want to do? Throughout history, philosophers have been occupied with the question of what is *really* going on. A similar question was discussed in 19th century France between Napoleon and the two brilliant scientists Laplace and Lagrange. Napoleon asked Laplace: "M. Laplace, they tell me you have written this large book on the system of the universe and have never even mentioned its Creator." Laplace answered "I did not need to make such an assumption." Lagrange then said "Ah, but it is a beautiful assumption. It explains many things." Laplace's response was: "This hypothesis does explain everything, but it does not permit to predict anything. As a scholar, I must provide you with works permitting predictions." Predictions are certainly important, but is *understanding* not equally important? Some people might even go so far to say that it is the quest for understanding that makes research different from engineering.

A random, non-local, non-real world?

Quantum mechanics is inherently random in that even though the wave function contains all measurable (or observable) information about a

3: D. Mermin, Physics Today, May 2004.

system, it can nonetheless only provide with probabilities of events occurring. The randomness is not due to our lack of understanding or insufficient information about a system, it is an intrinsic property of nature. Einstein, among others, found that problematic and *hidden variables* were involved. The hidden variables are variables whose randomness would disappear if we knew them, but we may never know them (hence they are called hidden). At first, this idea might not seem so bad: things we cannot explain are hidden in the hidden variables. Even though this idea probably will make some people sleep better at night, according to Bell's theorem[4] it is not possible for a local theory to "reproduce[e] exactly the quantum mechanical predictions".

Grøblacher and co-workers[5] write "Most working scientists hold fast to the concept of 'realism' – a viewpoint according to which an external reality exists independent of observation. But quantum physics has shattered some of our cornerstone beliefs. According to Bell's theorem, any theory that is based on the joint assumption of realism and locality […] is at variance with certain quantum predictions. Experiments [have] confirmed these quantum predictions, thus rendering local realistic theories untenable. Maintaining realism as a fundamental concept would therefore necessitate the introduction of 'spooky' actions that defy locality. […] Our results suggest that giving up the concept of locality is not sufficient to be consistent with quantum experiments, unless certain intuitive features of realism are abandoned."

Free will and quantum confusion

An ever present question in physics is that of determinism. If nature is governed by a set of rules, where does that leave free will? Unfortunately, many fantastic features of modern physics, especially the inherent randomness, have given rise to misunderstandings; most notably, what is called quantum mysticism (or quantum confusion). Quantum mysticism is the viewpoint that the facts of quantum mechanics have rendered objective reality obsolete, many times with references to eastern mysticism as in the case of Fritjof Capra and his book *The Tao of Physics* (1975). Jeremy Bernstein said[6] about that book that "At the heart of the matter is Mr. Capra's methodology – his use of what seems to me to be accidental similarities of language as if these were somehow evidence of deeply rooted connections." One of the most confused (not necessarily unintended confusion since the field of misleading others can be quite lucrative) is Deepak Chopra who sees quantum mechanics as the bridge between mind and body.

Where are we today?

What conclusions can we draw from all this? No experiments have ever been made to contradict the Copenhagen interpretation, even though it is easy to share Einstein's scepticism. Philosophizing does not seem to improve predictability in any way, but it does often lead to the wrong conclusions, for instance, quantum confusion. There is a fine line between wild goose chases, creative new ideas, misleading, and simple waste of

4: J. S. Bell, Physics 1, 195 (1964).
5: Grøblacher *et al.* Nature 446, 871 (2007).
6: J. Bernstein, Science observed, New York: Basic Books (1982).

time. One option is to paraphrase Mermin by saying "shut up while calculating", leaving room for some philosophizing while still adopting the simple scientific principle of Laplace to avoid assumptions that do not lend themselves to predictions of outcomes of experiments.

Where we are today will be left as an open question and this brief exposé will conclude with the words of W. H. Zurek who writes[7]: "The message seems to be that there is really no problem […]. This is quite consistent with the aim of introductory quantum mechanics courses, which has been (only slightly unfairly) summed up by the memorable phrase 'shut up and calculate'. Discussion of measurement is either dealt with through models based on the Copenhagen interpretation 'old orthodoxy' or not at all. An implicit (and sometimes explicit) message is that those who ask questions that do not lend themselves to an answer through laborious calculations are 'philosophers' and should be avoided."

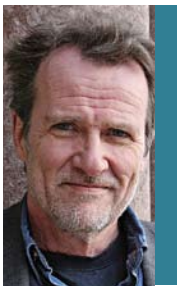
7: W. H. Zurek, Reviews of Modern Physics 75, 715 (2003).

JENS PETER SCHJØDT

Basic Traits in Religious World Views

In the research project 'The Power of the Ruler and the Ideology of Rulership in Nordic Culture 800–1200' in the spring 2008, my special focus was the relation between, on the one hand, the religious world view as we know it from the classical sources of Old Norse mythology and, on the other hand, the rulership ideology of the period in question. This involves a discussion of the definition of religion since, to most modern people, religion seems to have nothing to do with leadership; rather, 'true' religion is much more sophisticated than often seen in societies outside the western hemisphere, and it has nothing to do with politics except, of course, in cultures where leaders are able to manipulate the population by means of religion. But this dimension is not seen as part of religion 'itself'.

Professor Jens Peter Schjødt
Department of the Study of Religion,
University of Aarhus, Denmark
jps@teo.au.dk
CAS Fellow 2007/2008



In this essay, this theme will constitute the main part of the discussion, and the ruler ideology of pre-Christian Scandinavia will only be dealt with very briefly towards the end in order to maintain the importance of the theme, also in connection with the pagan religion. Contrary to the above-mentioned view that religion has nothing to do with politics, it will be argued that the religious dimension of rulership, and thus politics, is part of religion once we accept that religion as a universal phenomenon is much more than 'faith', a term which is often used as a synonym for religion by many historians of religion and especially theologians. According to the argument presented here, however, this is a serious mistake. It is also actually an obstacle to an adequate understanding of the influence of religion on what is going on in the world, both historically and in the present. Although this essay is not going to deal with 'faith', it should, nevertheless, be maintained that this term is almost irrelevant if we are to understand the role of religion outside the western world during the past couples of centuries. Religion, as it is perceived by most religious people, is not a matter of 'faith' but rather of knowledge: if we have been brought up being told all the time that a certain kind of bad luck is due to hostile magic, or – the other way round – that success is due to the right performance of certain rituals, and no one among our relatives, friends or others who we respect has told us anything to the contrary, then we would have no reason to doubt this. This is somewhat similar to the way in which modern man takes the power of electricity for granted, i.e. although he does not quite understand how it works, because those he respects tell him that it works and we can actually see that it works, why doubt it? It should thus be maintained that 'faith' in relation to religion is only important when it becomes

possible to doubt the basic religious ideas. In pre-modern societies, it was as irrelevant as if, in the modern world, we spoke about 'faith' in relation to electricity, at least for the vast majority of the population.

To return to religion, it seems to me that we must accept two prerequisites if we are to recognise a phenomenon as religion. The first of these is that the world view of the societies and individuals we designate as religious consist of at least two 'worlds': this world and the other world. On the one hand, we have the world in which we live, 'this world', which is characterised by technical skills in order for us to survive. If we do not know how to make a fish trap, we cannot catch fish and may die of starvation; fortunately, however, it is possible for almost everyone to learn these skills. In the past, many societies were characterised by a very low degree of division of labour, and most men were able to do what men were supposed to do, and most women were able to do what women were supposed to do. In later societies with a higher degree of division of labour, we were not all able to do everything required in order to survive, but the necessary technical skills were handled by specialists. If they were skilful enough, things would work – at least most of the time. Sometimes, things did not work out as they should, no matter how skilful you were: the fish did not go into the traps, the canoe would sink regardless of its construction, etc. Therefore, on the other hand, there had to be powers beyond the power of ordinary man. This 'beyond' we can, in religions, designate 'the other world',[1] which is normally characterised as being opposite in many ways to this world. Thus it is often imagined that there is no death in the other world, there is no darkness, the beings there do not have to work in order to survive, they have powers that no man possesses and so forth. Further, in this other world, there are powers responsible for the things that are beyond the control of man, but they may, nevertheless, be manipulated by certain people in society, i.e. people who have special skills which cannot be obtained by everyone because they are dependent on the other world. This brings us to the second prerequisite for speaking about religion, namely, that some communication must take place between the two worlds. If such communication does not take place, we should not speak of religion but rather of some sort of philosophy.

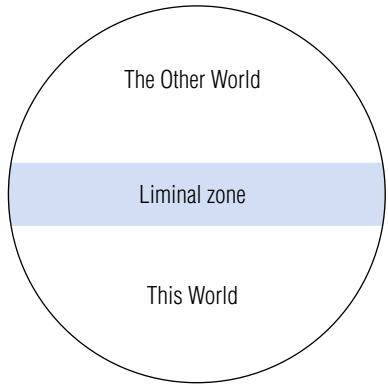
This religious communication takes place in rituals which we may define as actions meant to manipulate the beings of the other world, such as gods, spirits, demons, etc., beings that are able to do good as well as bad. In order to succeed, this communication is very often, although not always, handled by certain specialists, i.e. people trained in this communication, such as priests, magicians, shamans, etc., specialists that we may characterise as 'liminal persons'. There are individual as well as collective rituals, and the latter are mostly performed for the benefit of society as a whole, for instance, in order to secure a good harvest, victory in battle, etc. And in many cultures, the person who is most responsible for the well-being of society is the ruler, to whom I will return in a moment.

This world view with at least two worlds and the idea of possible communication between them can be found in any religion, and we could add a third characteristic, namely, that in all religions, the notion of the other world has some consequences on the way people act. If, for instance,

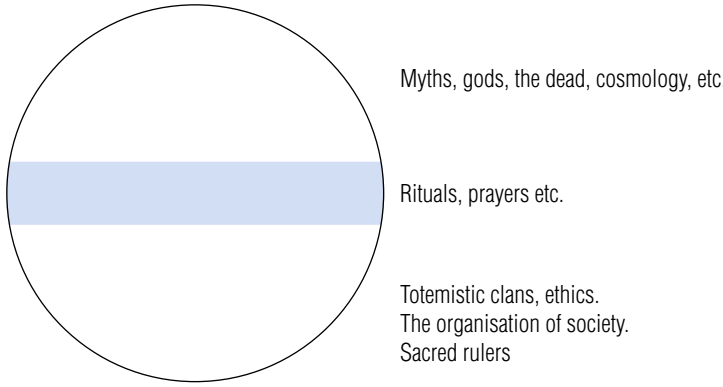
1: Actually, in most religions there are a number of other worlds: the world of the gods, that of demons, that of the dead, that of anonymous groups of beings promoting fertility etc. This, of course, differs very much from one religion to another.

in the beginning of the world, the gods had decided that men and women should not do the same work, this had to be accepted forever after; or if the forefathers were especially connected to some species, then we, the descendents, are still connected to these species such as we see them in the so-called totemistic societies. But we do not only meet these consequences at the sociological level. Also at the psychological level, the notions of the other world are important, for instance, in connection with ethics and conscience, causing people to want to behave in certain ways in order to feel good. All this can be illustrated with the following figure:

The religious world view



One advantage of this model of religion is that it can explain the relationship between many, apparently quite distinct, phenomena that we intuitively connect with religion, such as myths, rituals, totemism, priests, spirits, morality, sacrifices, etc. All these phenomena can be divided into three categories: (a) phenomena which are prerequisites for our way of living, i.e. things taking place in the other world and perhaps a long time ago; these prerequisites are most often transmitted in different narrative genres, the most important of which is myth; (b) communication phenomena, i.e. actions which endeavour to cross the liminal[2] zone between the two worlds; and finally, (c) consequence phenomena, i.e. social and psychological facts, which are explained as consequences of what happens in the other world and in the communication between this and the other world. We may thus extend the figure above with some examples from the vocabulary of religion:



2: 'Liminal', from Latin *limen*, 'threshold', i.e. the borderline between two different spheres. The importance of the term in anthropology and history of religions is due to the British anthropologist Victor W. Turner, who used it in many important publications, especially in *The Ritual Process. Structure and Antistructure* from 1969.

Now, in the light of this model, it seems quite in accordance with the very structure of religion that the leader of a religious society, who, as all leaders, at least to some extent, is responsible for the wellbeing of his people, must have some privileged access to the beings of the other world because otherwise he cannot perform his duties. A ruler, seen as a kind of 'supernatural' human being, is thus not added to religion 'pure' but, on the contrary, is at the very heart of religion since the wellbeing of society and individuals is what religion is basically all about.

If we now turn to the pre-Christian religion of the North, it is in the nature of things, so to speak, that the ruler, whether king or chieftain, was seen as a mediator between this world and the other world. In most cultures, there were/are basically two ways of establishing this relationship, either the ruler was born as an outstanding person, or/and he ritually became such a person (in Christianity we thus have the notion of *Rex Iustus* – a just king whom God himself had chosen because of his moral standards). In Scandinavia, both possibilities were at hand.[3] Thus sources tell us that the king was a descendant of some god,[4] but it is also related that he was ritually initiated to that very god so that the god became a kind of guardian spirit for the king, helping him in battles and teaching him various kinds of magical skills.

The scope of this paper does not allow me to go deeper into all the questions that may be raised in connection with the sources for Old Norse religion and mythology. What I have aimed at here is primarily to show that the modern idea of religion as something more or less 'private' is not in accordance with religions in archaic societies. 'Private' religion has evolved in modern societies for various reasons, but 'true' or 'archaic' religion, i.e. religion as a universal phenomenon, will inevitably include a mediation between this and the other world performed by religious specialists, among whom, viewed ideally, the most outstanding one is the person who represents the totality of the society: that is, the ruler.

3: The source situation concerning Old Norse religion is rather complicated and has caused much disagreement among the scholars. In short we have, on the one hand, what we may call contemporary sources which are mostly of an archaeological nature, and on the other hand, we have the more recent sources from the middle Ages, e.g. the Icelandic sagas. Whereas the first group is very difficult to interpret as regards religious notions, the second group has often been dismissed by scholars because the texts are for the most part written a long time after the conversion to Christianity. Due to the lack of space, it is not possible to delve into these source-critical problems, but I have dealt with the problems at other places, for instance, in my book *Initiation between Two Worlds. Structure and Symbolism in pre-Christian Scandinavian Religion*, from 2008, pp. 85–107.

4: Sometimes it is said to be Odin, and sometimes Frey. There may be explanations for this apparent contradiction, which, however, are beyond the scope of this brief paper.

MIGUEL RUBI

The Causality Principle: Complexity is the Limit

Synopsis: The Causality Principle has played an important role in the development of the theory of knowledge and constitutes a solid pillar in classical logic, used so often in daily life that we do not even realize it. Through causality, we may come to the conclusion that something happening regularly will always happen. This principle can successfully be applied to cases in which one has complete information on the situation involved. However, when complexity arises and uncertainties come into play, the principle becomes questionable. Under analysis, the presence of some randomness does not necessarily impede the validity of the principle. It is when uncertainties get out of control that the validity of the principle can no longer be ensured. The more complex the nature of the situation, the more information is required. The lack of reliable information in the face of complexity imposes the limit on the validity of the principle.

Professor Miguel Rubi
Department of Fundamental Physics,
University of Barcelona, Spain
mrubi@ub.edu
CAS Fellow 2007/2008

Classical formulation

The world consists of events. All our personal experiences, historical features and scientific observations can be described as an orderly succession of events. An analysis of the nature of possible events shows that these can be of two types: those which can only be conceived and those which are truly real. Examples of the former are mathematical objects such as a triangle which are simply mental objects; the latter are all the objects and events belonging to the real world, such as a person or an experience. The Causality Principle states that all real events necessarily have a cause. The principle indicates the existence of a logical relationship between two events, the cause and the effect, and an order between them: the cause always precedes the effect.

An important property of the principle is that it entails predictability. Suppose that two causes give rise to two effects, respectively. It is easy to infer that if both causes are equal, the corresponding effects are also equal. Equal causes have equal effects and vice-versa. This fact implies the existence of a law of conservation under which the distinction is conserved. If two situations are distinct, they will remain distinct in all further evolutions and have been distinct during all previous evolutions as well.

Deductive versus plausible reasoning

We have seen that causality tacitly assumes predictability, that is, the absence of randomness or of any factor that may disturb the systematic flow of events. A fully causal world would then be a world in which all events would be perfectly determined. However, an inspection of the real

world leads to the conclusion that this is far from the case in actual fact. There are many situations, such as night following day, or the influence of gravity due to which all objects which rise will necessarily fall, in which this systematicity can be guaranteed but there are many others in which randomness wins the game. Deductive reasoning based on the application of the principle cannot always be the right way to proceed in order to reach knowledge since quite often one has to cope with complex situations in which complete information of the events involved is hardly possible. In such situations, one has to extract conclusions from sketchy knowledge. Plausible reasoning which substitutes certainties for probabilities that an event may occur is then the only way to proceed. Many of these cases can be found in daily life. The uncertainties in the evolution of the trade markets or in the weather forecast are situations we often face. Modern tendencies in science aimed at exploring the world of the small where changes are very rapid and unpredictable use probabilities instead of deterministic quantities. Examples in which probability is the principal object are commonly found in statistical physics, quantum theory and the theory of chaos. Nowadays, the importance of a probabilistic description of a system is recognized in all domains, not only in the classical experimental sciences such as physics, chemistry and biology, but in economics and psychology as well. In words of the famous physicist James Clerk Maxwell:

> "The actual science of logic is conversant at present only with things either certain, impossible, or entirely doubtful, none of which (fortunately) we have to reason on. Therefore the true logic for this world is the Calculus of Probabilities, which takes account of the magnitude of the probability which is, or ought to be, in a reasonable man's mind."

But does randomness always imply the failure of the principle?

Deterministic versus probabilistic laws

Causality establishes a univocal relationship between cause and effect which can be expressed mathematically as R(C)=E. Many laws in science are of this type in that if C occurs E will always be observed. We say that C univocally determines E and, for this reason, these laws are called deterministic laws.

The following example illustrates the nature of a deterministic law. Suppose that we dissolve a chemical product in water. If the product is introduced at the left hand side of the container, the particles will go to the right thus making the mixture homogeneous, following the tendency that systems have to evolve towards equilibrium. The evolution of the particles' concentration can be described by the flux $\mathcal{J}$ accounting for the number of particles per unit area of a cross section and unit time, travelling from left to right. Non-equilibrium thermodynamics [1] establishes the form of this flux:

$$\mathcal{J} = -D(c_R - c_L)/L$$

where L is the size of the container. This equation expresses that a difference in the concentration of particles on the left (c_L) and on the right (c_R) gives rise to the appearance of a current of particles travelling

from left to right, from high to low concentrations. The magnitude of the current depends on a parameter D, the so-called diffusion coefficient, whose value is determined from the behaviour of the particles. The law thus formulated is causal. The concentration difference is the cause and the flux of particles the effect.

But let us now suppose that in the previous situation we do not know the precise location of the particles and only have information as to the probability of finding a given particle at a given position and time. As before, the particles accumulated on the left hand side go to the right part but we do not know the precise trajectories they follow. What changes now is not the concentration of particles but the probability. We observe that with the passing of time, the probability of finding a particle on the left decreases while increasing on the right until they balance each other out when the system reaches equilibrium. Despite uncertainties in the precise location of particles, a law similar to the previous one holds:

$$\mathcal{J} = -D(P_R - P_L)/L$$

where now the flux is a probability flux, and P_R and P_L the probabilities of finding a particle on the left and on the right, respectively. We see that a difference in probabilities causes a probability flux from the left to the right. Despite the probabilities involved, this law is also causal. The cause is now the difference in probabilities, whereas the effect is the appearance of a flux of particles. But this causality refers to a situation in which we have only a partial knowledge of the system and the situation is thus intrinsically different from the previous one. To distinguish them we call the latter case *weak causality*. By means of this analysis, we may conclude that causality does not necessarily imply predictability but regularity, even for a probabilistic behaviour [2].

Causality in the lack of information

Let us consider again the previous experiment but with a new twist: the presence of an added source of particles injected from the right side. If the number of these injected particles exceeds those present on the left side, the probability of finding a particle on the right will be larger than that on the left and the difference in probabilities may change its sign, thus yielding a reverse current, in accordance with the former law. When we know of the existence of this source, we can proceed as we did previously, describing the situation by means of a causal law. But if we do not have information about the existence of such a source, we might conclude that causality is not fulfilled since the law predicts a forward current whereas what we observe is just the opposite. This example clearly shows that in order for causality to hold, we must have complete information about the situation under analysis. In the study of complex systems, one usually performs a reduction in the number of quantities by eliminating those one considers to be superfluous in the description of the system. Models proposed in different branches of science, as a caricature of what one thinks is going on, share this characteristic. Reductionism constitutes a powerful tool in science. In many cases, it is easy to identify those quantities that play a minor role in the behaviour of the system, but in others,

this cannot be performed without distorting the description of the system. Complexity, inherent to these situations, then imposes a limit on the validity of the Causality Principle.

Conclusions

We can expect regular behaviour of a system when we have complete information about its behaviour. In this case, the Causality Principle holds. We have seen that the presence of randomness does not always imply violation of the principle. A small amount of randomness not reaching chaos does not necessarily impede the formulation of causal laws in terms of probabilities. This is a case encountered in many biological processes for which a thermodynamic description is possible [2]. We have called this *weak causality*. But when indeterminacy increases greatly, the system enters an unpredictable regime in which causality cannot be ensured.

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IAN BEUERMANN

A Chieftain in an Old Norse Text:
Sveinn Ásleifarson and the Message behind *Orkneyinga Saga*

Icelanders are famous for having produced a huge volume of prose literature in Old Norse in the Middle Ages (in a Nordic context, c. 1050 – c. 1530): the Icelandic Sagas. Largely thanks to these sagas, we have formed a vivid picture of the excitement of the Viking Age (c. 800 – c. 1050). The early 13th century *Orkneyinga Saga*, focussing on the Earldom of Orkney between c. 900 and c. 1200, is a good example. One of *Orkneyinga Saga*'s most famous passages runs: "*This was how Sveinn used to live. Winter he would spend at home on Gairsay, where he entertained some eighty men at his own expense. His drinking hall was so big, there was nothing in Orkney to compare with it. In the spring he had more than enough to occupy him, with a great deal of seed to sow which he saw to carefully himself. Then when that job was done, he would go off plundering in the Hebrides and in Ireland on what he called his 'spring-trip', then back home just after mid-summer, where he stayed till the cornfields had been reaped and the grain was safely in. After that he would go off raiding again, and never came back till the first month of winter was ended. This he used to call his 'autumn-trip'.*" (OS ch. 105) Farming, entertaining followers, and ship-bound plundering raids – the man described here, Sveinn Ásleifarson, seems to epitomise the Viking Age way of life. Entertained by these and other colourful details in *Orkneyinga Saga*, popular and scholarly authors alike have therefore labelled Sveinn "the ultimate (Orcadian) Viking".

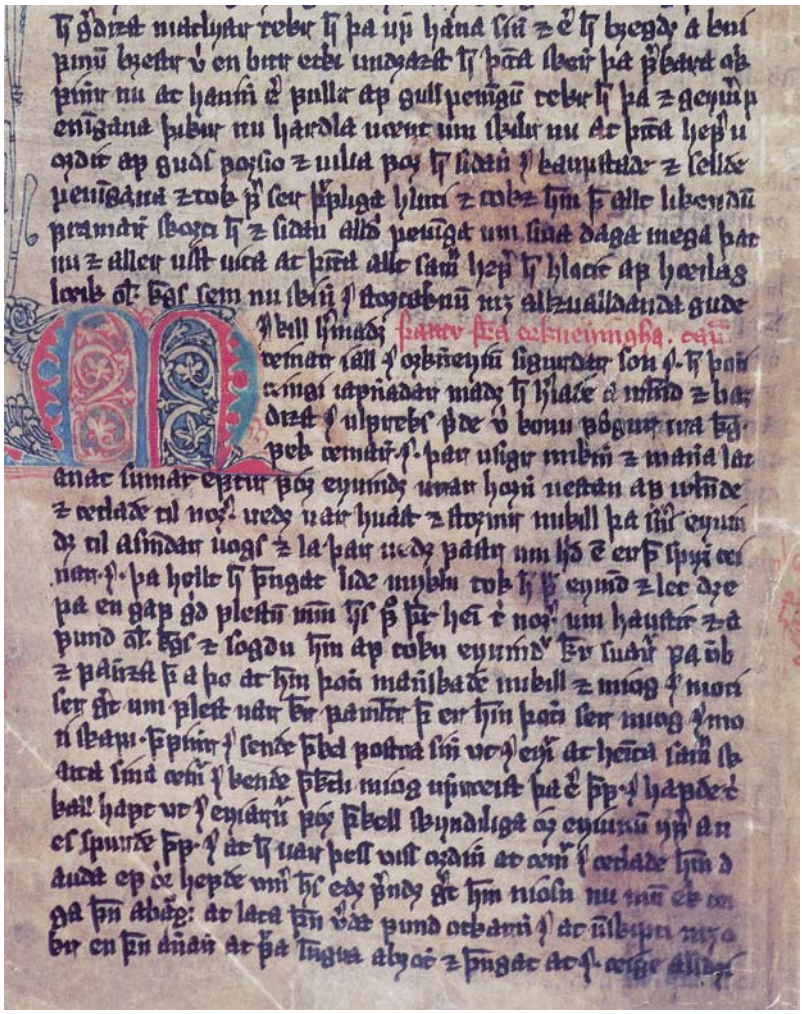
Research Fellow Ian Beuermann
Centre for Manx Studies,
University of Liverpool, UK
birian@matell.no
CAS Fellow 2007/2008

Who or what was Sveinn?

Sveinn was a young adult in about 1135, and was presumably killed in 1171. He was known to own farms in Orkney and Caithness. However, was he really such a bloodthirsty Orcadian warrior? The common view can be challenged on more than one count.

Is honour really everything?

Orkneyinga Saga recounts how Sveinn killed another man during the Christmas festivities in the early 1130s. The Saga describes in detail how the situation escalated because the two men accused each other of cheating during a typical drinking contest in the hall – a serious insult to a man's honour. Yet between the lines, one discerns that there is more to the subsequent retaliatory murder than a set piece Viking scene of a feast, drunken males, alien concepts of honour, and senseless violence. There are indications that high-ranking men may have harboured a grudge



Orkneyinga Saga was compiled, revised and copied into different manuscripts between c.1200 and c.1400. The picture shows a detail from *Flateyarbók* ("The Book of the Flat Island"), the late fourteenth century Icelandic manuscript which contains, amongst many other texts, the most complete version of *Orkneyinga Saga*.

against Sveinn's victim for a long time. Indeed, they may even have cleverly manipulated a drunken Sveinn to do their killing for them (OS ch. 66, 76).

Orkneyinga Saga also notes that Sveinn had dealings with Hebrideans on several occasions. On the face of it, Sveinn either rushed to the aid of beleaguered friends there, or he exacted terrible revenge for betrayals. With this, the Saga's account once again stresses that Sveinn met the demands of honour that applied to a Viking warrior. Reciprocal bonds of friendship held viking society together. Yet also here, the small print points to other motivations. One particularly striking example is the Saga's explanation of Sveinn's help to a man called Holdboði in the 1140s: Sveinn had "*had a request for help from the last man he could refuse, since that man had given him the greatest help when Sveinn needed it most*". Immediately afterwards though, Sveinn's honourable reputation was somewhat tarnished by the fact that before committing to any fighting, he had first discussed his reward with Holdboði: marriage to "*Dame Ingirid* [who] *had much wealth and*

[many large estates]" (OS ch. 78). In the Hebridean, just as in the Christmas episode, there is a thick layer of viking honour, beneath which *Orkneyinga Saga* conceals quite profane political and economic interests.

No betters?

Sveinn is famous for his turbulent relations with the Orkney earls. *Orkneyinga Saga* describes how, in the 1130s, Sveinn orchestrated a coup by capturing the reigning earl and clearing the way for two new joint rulers, the earls Rǫgnvaldr Kolsson and young Haraldr Maddaðarson (OS ch. 77). In the 1150s, when Haraldr reached adulthood, relations with Rǫgnvaldr became strained, and internal warfare broke out. *Orkneyinga Saga*'s account puts Sveinn's exploits in the foreground. Sveinn switched back and forth between Rǫgnvaldr and Haraldr, and eventually supported a third joint earl, Erlendr (OS ch. 92-9). Moreover, Sveinn's support was frequently decisive. Erlendr is described as a simpleton who died as soon as Sveinn stopped controlling him, while Rǫgnvaldr and Haraldr would not have become earls without Sveinn's help in the first place. The Saga does not give us any explicit reasons for Sveinn's actions; it seems more interested in underlining *that* they took place, stressing Sveinn's independence and utter freedom of action. Yet it is likely that Sveinn had reasons for changing sides. There are indications that Sveinn's 'king-making' in Orkney was connected to his economic contacts, already hinted at, with the Hebrides and the Irish Sea. Both Rǫgnvaldr and Haraldr seem to have taken an interest in Sveinn's activities there. Sveinn may, at times, have resented such interference, supporting another less intrusive earl (Beuermann forthcoming). Had *Orkneyinga Saga* simply mentioned that sound politico-economic concerns might have dictated which earl Sveinn supported, the reader's attention would have been deflected away from Sveinn as the independent and maverick 'king-maker'.

Orcadian?

This leads to the most controversial criticism of the common perception of Sveinn, i.e. that he was an *Orcadian* Viking. Even in *Orkneyinga Saga*, it is apparent that Sveinn spent a considerable amount of time in the Hebrides and the Irish Sea, whether longer periods at irregular intervals (in the 1140s, 50s, and early 70s), or shorter regular periods – remember, for example, the initial quote about the twice-yearly expeditions. It is equally obvious that Sveinn had important economic interests in the area, as argued here, important enough to influence his decisions about which earl to support back in Orkney. Historians might still be aware of Sveinn's first attempt to settle on the Isle of Man in the 1140s following his marriage to Dame Ingirid, but most ignore Sveinn's probable second attempt to emigrate, which was to Dublin in 1170 (OS ch. 78-9, 96-7, 100-1, 105-8, Beuermann forthcoming). In short, Sveinn was at least as much an Irish Sea man as an Orcadian.

The ultimate Viking?

Consequently, a careful reading of *Orkneyinga Saga* questions commonly held assumptions about Sveinn as the Orcadian arch-Viking. We might be equally justified in calling him a timeless international businessman-cum-politician, for example a 12th century Mikhail Khodorkovsky.

Unfortunately, the debate had to be based almost exclusively on *Orkneyinga Saga*. Almost surprisingly, considering his fame in the Saga, Sveinn hardly appears in other sources. This means that hardly any of the Saga's information on Sveinn can be corroborated. At this stage therefore, earlier historians would have backed off, deciding that reaching an agreement on Ranke's famous *wie es eigentlich gewesen* is probably impossible.

Yet increasingly, Icelandic Sagas, including the more historical subgroup of the Kings' Sagas amongst which *Orkneyinga Saga* can be counted, are mined less for what they tell us about "how it really was" (what Sveinn did). Instead of the history of events in the period described, we might aim to discern the ideas shaping the texts during the periods of composition or revision. This leads to a rather different question.

Why is Sveinn in *Orkneyinga Saga*?

An odd choice

Sveinn is an important character in 27 of *Orkneyinga Saga*'s 108 chapters: the colourful description of his activities takes up one-quarter of the whole Saga (ch. 66, 73-84, 92-101, 105-8). However, as mentioned, Sveinn can only tentatively be identified in other sources, most notably in some Irish Annals, Giraldus Cambrensis' *Expugnatio Hibernica*, and *La Geste des Engleis en Yrlande*. So for all we know, Sveinn might be a fictitious literary character. At the very least, the viking society Sveinn epitomises in *Orkneyinga Saga* seems outdated by the late 12th century. Sveinn appears more like a character of the 9th and 10th centuries. The Saga's only concession to the 12th century is that he is not depicted as a pagan, but he is introduced as a killer during the Christmas celebrations! In short, Sveinn might not have existed at all, or the real Sveinn was different or, if the description corresponds to the real Sveinn, then he was an exceptional character in the 12th century. The three possibilities imply that there was a deliberate authorial choice to compose fiction, give a one-sided description, or choose an unusual character. Another problem is that *Orkneyinga Saga* is usually correctly summed up as recounting the lives of the many Scandinavian earls of Orkney from the late 9th to the early 13th century. Yet the Sveinn who takes up so much space in the Saga was no earl; not even an earl's relative, but a 'mere' chieftain. So why was so much ink spent on this man, on this exceptional chieftain?

Sveinn and Orkney

Was Sveinn meant to embody an ideal? Does the post-Viking Age author use Sveinn's example to praise the values of a free Viking society, a warrior society with independent-minded honour-driven chieftains (and where one earl, Rǫgnvaldr, composes poetry in the best Old Norse tradition at every possible moment)? Or does Sveinn serve as a bad example? Are chieftains like Sveinn enemies of social progress towards a more settled state of affairs? The Saga calls him "*the greatest troublemaker in the western lands*" (OS ch. 107). Does this criticise the state of upheaval of Viking society?

Depending on the interpretation preferred, would this part of *Orkneyinga Saga* then encourage the earls of Orkney to allow their chieftains freedom,

to condone their honour-driven bravery? Or is the text rather intended to be an admonition to the earls to keep control of their chieftains, since otherwise in the worst case they might even make and unmake earls?

Sveinn and the Norse world

The debate has wider implications. *Orkneyinga Saga* is not a purely Orcadian phenomenon. As mentioned, it forms part of the group of Kings' Sagas – sagas written by Icelanders mainly about the kings of Norway and Denmark. The best known example is Snorri Sturluson's 13th century compilation *Heimskringla*. Although the details are still debated, most scholars think that *Orkneyinga Saga* was at least revised by Icelanders in the 1230s and again in the late 14th century, and that it was first written down in around 1200, probably also by an Icelander with Orcadian connections. All these periods saw important political changes which may have influenced the choice and presentation of topics in the Saga.

1190s to 1260s

The first version of *Orkneyinga Saga* was composed shortly after Earl Haraldr Maddaðarson of Orkney had unsuccessfully backed a competitor to King Sverrir of Norway. Haraldr had to surrender unconditionally, and Sverrir used the opportunity to establish Norwegian overlordship on Orkney. The 1190s therefore saw the end of the semi-independent earldom. Four decades later, when *Orkneyinga Saga* was revised by an Icelander, Sverrir's grandson King Hákon Hákonarson had already embarked on attempts to bring Iceland under Norwegian dominion, a policy that culminated with the end of Iceland's independence in the 1260s.

A less political interpretation would see the Sveinn sub-saga as either a romantic or a horrified depiction of viking life in the good or bad old days before Norwegian overlordship. Going further, the stories about Sveinn might also be read as an admonition to the kings of Norway, encouraging them not to do away with the political and cultural heritage of the Viking Age. In particular, *Orkneyinga Saga* might entreat them not to destroy an idealised viking society where chieftains have a high standing and where kings or earls rule in conjunction with them. Kings Sverrir and Hákon both had rather different ideas about their royal position and orchestrated the replacement of the traditional Old Norse aristocracy by new men who were dependent on the crown.

However, the opposite interpretation cannot be excluded either. Rather than a literary counter-measure to the policies of the Norwegian kings from the 1190s on, the Sveinn chapters might also have been intended to support the Norwegian crown in its attempts to stand firm, to root out unruly remnants of the Viking Age in Orkney. With regard to Norwegian-Orcadian history, such unruly remnants would not only include boisterous chieftains, but also unreliable earls who rebelled against and endangered a king of Norway (Beuermann 2006).

The 1390s

In the late 14th century, *Orkneyinga Saga* was revised and copied into the manuscript known as *Flateyarbók*, giving us the most complete surviving

version of the text. By then, Orkney and Iceland had long been under Norwegian dominion. But in 1387, in the very year when work began on *Flateyarbók*, the Norwegian royal dynasty ended with the death of the boy-king Óláfr Hákonarson. His mother, Margareta of Denmark, who had been ruling in his name but had no legal right of succession, managed to become ruler of Norway in her own right. Margareta seems to have been unwelcome to the Icelanders. One wonders therefore whether the all-male Norse viking society glorified in the Sveinn chapters of *Orkneyinga Saga* would also particularly have appealed to Icelanders, who faced the prospect of a Danish queen for the first time.

Ultimate Orcadian Viking or timeless Irish Sea businessman, real or fake, idealised or abhorred by authors, copiers, earls or kings, Sveinn Ásleifarson's story gives us a vivid medieval picture of the excitement of the Viking Age. It is certainly 'a good read', but we should beware of taking it at face value.

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BART VERSPAGEN

The Skew Nature of Innovation Returns

Introduction

"BlackBerry maker Research in Motion said Friday it agreed to pay USD 612.5 million to patent holding company NTP to settle a long-running dispute that had threatened to shut down the popular wireless e-mail service for its 3 million users" was the opening sentence of a news message on cnnmoney.com on 3 March 2006. USD 612 million for a single invention, the wireless transmission of email, is a tremendous amount, representing, for example, about 5% of the GDP of a developing country like Kenya at the time. The example shows that the commercial gains from innovation are potentially huge, although the Blackberry is, of course, an extreme example.

Professor Bart Verspagen
Maastricht University & UNU-MERIT,
The Netherlands
b.verspagen@Talgec.unimaas.nl
CAS Fellow 2007/2008

This paper is about extreme rewards for innovation. It will sketch the available economic evidence for the nature of innovation reward distribution, briefly present the methods that can be used to obtain estimates of this distribution, and discuss the implications, for business and policy, of the remarkable nature of innovation.

Observing the distribution of innovation rewards

Economists have very little data that directly address the nature of the distribution of innovation rewards. Corporate accounting systems are not oriented towards estimating these rewards at the individual innovation level. Moreover, information on the monetary value of innovations is sensitive so firms tend to be secretive about it. Therefore, economists have had to resort to indirect methods for estimating innovation rewards.

One method that has been popular (e.g. Schankerman and Pakes, 1986) is the use of data on patent renewal. Where patents are used to protect inventions, they must be kept in force by the payment of administrative fees to the patent office, i.e. so-called patent renewal fees. These fees differ from one patent office (country) to the next, and may also depend on the time period and type of invention. For legal purposes, information on which patents are still in force (i.e. for which the renewal fees have been paid) must be made public. Economists use these data to estimate the distribution of patent values. Although the models that have been proposed to do this are complex and far beyond the scope of a short text like this, the underlying idea is quite simple. It relies on the notion that patent renewal decisions are based on cost-benefit analyses. If the cost of keeping a patent alive one more year exceeds the (commercial) rewards, the patent holder will make a rational decision not to renew the patent (or

vice versa). Hence, the information on how many of a cohort of patents are still alive *n* years after the patent reward, for varying *n*, provides information on the distribution of commercial value within that cohort. Note that the decision to not renew a patent is final, i.e. if the fees have not been paid for even a single year, the patent will lapse and can never be re-activated. This implies that the value of renewing a patent for one year includes the value of the option to renew it again. If a future patent value is highly uncertain, this may be an important factor in the decision about whether or not to renew.

The renewal-based measures indicate that patent value distribution is indeed very skew: The modal and median parts of the distribution are found on the left, i.e. at relatively low patent values. In non-formal terms, the large majority of patents has a low value (is not renewed for very long), while a small number of patents has a very high value (is renewed to the maximum). A small number of patents represents a large fraction of the total value. A similar result is found using more indirect indicators of economic value, such as patent citations (Silverberg and Verspagen, 2007). The skew nature of patent value distribution is confirmed by recent studies on the statistical relationship between stock market values of enterprises and their patent portfolios (e.g., Hall, Jaffe and Trajtenberg, 2005). This implies that stock markets take account of important information on patent value.

Recent evidence based on a more direct measure of patent value obtained from a large-scale survey of inventors in Europe, indicates that patent-renewal estimates may underestimate total patent value (Gambardella and others, 2008). There is also theoretical corroboration for this. For example, the patent renewal decision does not give any indication of the potential value of the invention without patent protection. This has been pointed out by Arora and others (2008), who introduced the term *patent premium* to describe the part of the total value of a patent/invention that is related to patent protection. For example, when the initial years of patent protection have established a dominant market position that cannot easily be assailed by competitors, an additional year of patent protection does not represent great commercial value, even if the invention itself is still very valuable. In other words, renewal-based methods measure the patent premium rather than the total patent value.

Gambardella and others (2008) concluded that the average value of the patents in their sample was in the range of EUR 5 – 10 million, and the median value was around EUR 650 000. They quote previous estimates based on patent renewal data, arriving at estimates of average value in the range of USD 5 – 20 thousand. Figure 1 illustrates the distribution obtained by Gambardella and others (2008). It clearly shows the skew nature of patent value distribution. Note that the indicated returns are gross of lower R&D costs, i.e. they do not represent pure profits.

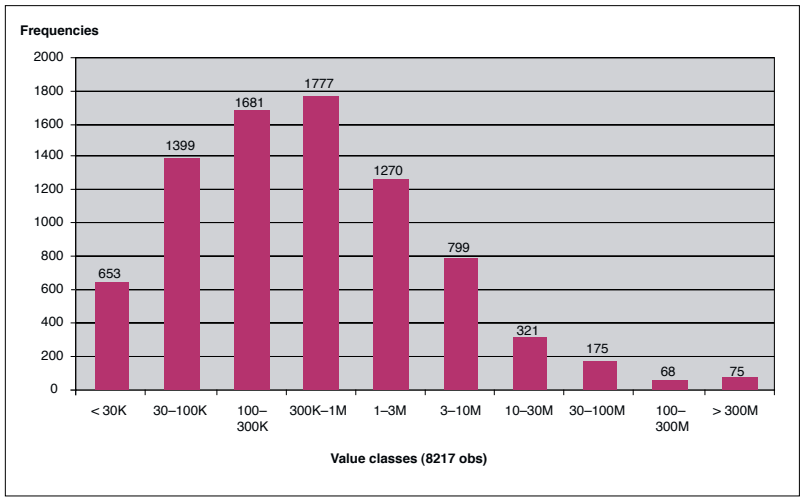

Figure 1. Distribution of patent value in the PatValEU survey
Values on the horizontal axis in EUR (K indicates EUR 1000; M indicates EUR 1 000 000).

Implications for business and policy

Firms invest in R&D and other innovation-related expenditures with the aim of generating a profit. R&D costs need to be paid upfront, while, as discussed above, the returns on R&D are very skew. The combination of these two phenomena makes innovation a very uncertain process. A firm that wants to 'hit the jackpot' and is faced with taking the *a priori* odds of drawing from the right tail of the distribution, will have to implement a large number of projects (i.e. draw a large number of times) in order to have a reasonable probability of success. Our ongoing research shows that spending resources on a single project increases the probability of a high-value invention, but significant uncertainty still remains (i.e. very expensive projects can also yield mediocre-value inventions). Judging by the skew distributions of innovation returns, mediocre returns, or even failure, are the norm, rather than the huge innovation returns that make headlines in the business press. In the aggregate, these many failures are offset by the few innovation projects with very high returns.

However, firms do not operate in terms of averages. On their own, they cannot realize the many innovation projects required to hedge against the risk that the distribution of skew innovation returns represents. This implies that failure is a realistic part of the innovation process, and it also underlines that entrepreneurship and innovation are indeed two very clearly related phenomena. Entrepreneurship is closely related to the capabilities that are needed to beat the odds, i.e. we can expect that some firms have the right capabilities and skills needed to more successfully generate high-value innovation projects than the average, or better, the median, of the distribution would predict.

Policy makers, on the other hand, have different options for influencing the aggregate distribution of innovation returns (Scherer and Harhoff, 2000). On the one hand, they have the means to influence the institutions that facilitate entrepreneurship, for example, by ensuring an efficient credit system, in particular a venture capital system, or institutions (education) that generate the human capital necessary to implement efficient

R&D projects. In implementing these institutions, policy makers need to be aware of the long-term and uncertain nature of the innovation processes they are trying to influence.

Where R&D and technology policy take a more direct form, for example, in the form of funding of R&D projects or stimulating cooperation between universities and firms, the skew nature of innovation returns implies a clear warning against overly high expectations. The majority of R&D projects generates mediocre returns, and there is no reason to expect that this should not be true for government-funded projects (in fact, firms may select the high-value projects for their own funding and leave the ones with expectations of lower value for government subsidy). Even though it is clearly beneficial to invest in the ability to select the 'right' projects for funding, government R&D policy in particular should be aimed at taking risks, and hence policy makers should be willing to accept failures.

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Personal Notes

CAS' annual book series on interdisciplinarity

In 2004 CAS commenced the publication of a long-term series of books on multi- and interdisciplinary research and communication. The books are based on weekly luncheon seminars closely related to on-going research in which the fellows of the Centre are invited to make presentations of their scientific specialties to a mixed bag of humanists, social scientists and natural scientists.

As part of the dispersion policy of CAS, the books are distributed free of charge to a wide readership – nationally and internationally – extending far beyond the ranks of experts.

Book series:

Interdisciplinary Communications, Centre for Advanced Study, Oslo
ISSN: 0809-8735
The following books have been published and are available from CAS:

Willy Østreng (ed): *Synergies. Interdisciplinary Communications 2003/2004*, Centre for Advanced Study, Oslo, January 2005, 112 pages,
ISBN: 82-996367-2-8
(A few copies are still available)

Willy Østreng (ed): *Convergence. Interdisciplinary Communications 2004/2005*, Centre for Advanced Study, Oslo, December 2005, 178 pages,
ISBN: 82-996367-3-6
(Copies are still available)

Willy Østreng (ed): *Consilience. Interdisciplinary Communications 2005/2006*, Centre for Advanced Study, Oslo, January 2007, 144 pages,
ISBN: 978-82-996367-4-2
(Copies are still available)

Willy Østreng (ed): *Complexity. Interdisciplinary Communications 2006/2007*, Centre for Advanced Study, Oslo, January 2008, 144 pages,
ISBN: 978-82-996367-5-9
(Copies are still available)

Willy Østreng (ed): *Confluence. Interdisciplinary Communications 2007/2008*, Centre for Advanced Study, Oslo, February 2009, 136 pages,
ISBN: 978-82-996367-6-6
(Copies are still available)

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" … studies have concluded that there seems to be a positive relationship between commercialisation and academic quality, … "

MAGNUS GULBRANDSEN

" … the modern idea of religion as something more or less 'private' is not in accordance with religions in archaic societies. 'Private' religion has evolved in modern societies for various reasons, but … religion as a universal phenomenon … include a mediation between this and the other world performed by religious specialists, among whom, … , the most outstanding one is … the ruler."

JENS PETER SCHJØDT

The self-policing of academic research " … is believed to be effective in ensuring that academic misconduct is rare, generally low-level and self-correcting … , the case described below should force us to reconsider our preconceptions about the efficacy of self-policing."

BEN R. MARTIN

" … those who ask questions that do not lend themselves to an answer through laborious calculations are 'philosophers' and should be avoided."

LINUS BOMAN

This book contains 27 articles related to a series of presentations held at luncheon seminars at the Centre for Advanced Study (CAS) at the Norwegian Academy of Science and Letters in Oslo in 2007/2008. The presentations were made by fellows of three research groups: *The Power of the Ruler and the Ideology of Rulership in Nordic Culture 800-1200* (Humanists), *Understanding Innovation* (Social scientists) and *Nature-inspired Chemical Process Design* (Natural scientists).

In science and scholarship, multidisciplinary venues are in short supply, and so are interdisciplinary results - applied, theoretical and methodological. The seminars at CAS have proved to be instrumental in creating a feeling of social and professional community among a wide variety of fellows that are trained exclusively to speak the "tribe language" of their own academic field. In meeting for joint seminars once a week, the fellows have the opportunity to develop an atmosphere of mutual creativity for the clarification of scientific concepts and theories and their potential for straddling disciplinary cultures and delineations. Many of the articles of this book bear evidence of this.

Confluence
Interdisciplinary Communications 2007/2008

Centre for Advanced Study
at the Norwegian Academy of Science and Letters

Drammensveien 78
NO-0271 Oslo
Norway
Telephone: +47 22 12 25 00
Fax: +47 22 12 25 01
E-mail: cas@cas.uio.no
Web site: http://www.cas.uio.no
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