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The need for knowledge integration in renewable energy innovation projects

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Abstract

Literature on knowledge and knowledge integration has mainly focused on its importance for firms and companies, but we should not forget the importance of knowledge for value creation for the society as a whole. The main focus in this paper is to discuss academic-industry collaboration through the concept 'Mode 2', which will be connected and discussed in relation to the Norwegian Centres for Environment-friendly Energy Research (CEER) scheme. This is accomplished through an analysis of the Norwegian CEER scheme in relations to the five attributes of 'Mode 2'. It is evident that the research program has picked up several suggestions from the latter. However, the analysis also shows that the CEER scheme is mixed with regard to 'Mode 1' and 'Mode 2' on several attributions. The mixed approach is illustrated by the objectives for the CEERs, which is set by the Research Council. The research in CEERs should at the same time both be disciplinary scientific and applied by companies. This analysis is supplemented with a short review of some empirical studies of the 'Mode 2' phenomena'. Based on these studies it is apparent that there is a need for further empirical investigation of empirical micro-dynamic of collaboration between academia, industry and government. It is suggested that empirical investigation should apply the framework of Tell [1], to understand knowledge integration between academics and people working in enterprises collaborating within a CEER. This should enable us to identify best practice and improved design in the CEER scheme that will enable better commercialization of innovations.

Keywords: Knowledge integration, Norwegian Centres for Environment-friendly Energy Research (CEER), Mode 2

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1. Introduction

Knowledge is one of the key factors for creating value and sustaining competitive advantage for firms [2-5]. The central idea in the knowledge-based theory of the firm is that the firm's primary role is the integration of knowledge from individual organizational members to organizational capabilities [6]. The implication of viewing firms as institutions for integrating knowledge is that a hierarchical structure is ineffective as a mechanism for knowledge integration, since no manager can efficiently integrate the knowledge of his/her subordinates [6, 7]. In stead, the key task for the management is to coordinate the integration of the knowledge of several specialists into goods and services, and this done most efficiency if knowledge transfer between organizational members is minimized [4, 6].

Literature has long distinguished between tacit and explicit knowledge [2]. Explicit knowledge can be put on paper, formulated in sentences, or captured in drawings, while tacit knowledge is tied to the senses, body movement, individual perception, physical experience, rules of thumb, and intuition [8]. Knowledge integration following this perspective is focusing on transferring individual tacit knowledge into explicit knowledge available and manageable for organizations [2, 5]. Although Nonaka (and colleagues) refers to the famous quote from Polanyi [9] "we know more than we can tell", it is possible that the original insight has been misunderstood [10]. According to Polanyi [11], all knowledge and knowing is originating from human experience and is inherently personal and tacit, and thus not "transferable" at all. This implies that that sharing of knowledge does not involve a simple transfer of a fixed entity of knowledge between two people. If so, what is happening in efforts of knowledge transfer?

Instead, the sharing of knowledge involves two people that are actively inferring and constructing meaning [12]. The construction of meaning is necessary because there is always a tacit element attached to any form of knowledge, which is usually lost in transfer and translation. This means that the 'receiver' needs to recreate the lost knowledge; however, this recreation is done within their own contextual and tacit knowledge. Thus efforts of knowledge transfer and sharing can thus actually be viewed as a source for knowledge creation.

Although much of the literature on knowledge and knowledge integration has focused on its importance for firms and companies, we should not forget the importance of value creation for the society as a whole. This is one of the reasons why governments is engaged in development of new knowledge through supporting universities, research institutions, industry and companies through research programmes and other schemes. This is also some of the background of the development of the concept of 'Mode 2' [13, 14], which among other issues is concerned with higher demands for relevance of science and research, and the quantitative and qualitative expansion of the involvement of social actors in the research process. This alleged transformation of both science and society points to the need for closer cooperation between many different actors.

The main focus in this paper is to discuss academic-industry collaboration through the concept 'Mode 2', which will be connected and discussed in relation to the Norwegian Centres for Environment-friendly Energy Research (CEER) scheme. The first sections introduce the 'Mode 2' concept and its five main attributes. After an assessment of the concept, the following sections introduce the Norwegian CEER-scheme, discuss it in relation to the five attributes of 'Mode 2, and reviews other empirical studies. The paper end with an shortoutline of the aims with the overall research project,

2. 'Mode 2' knowledge production

There is a considerable debate about the possible transition of the science systems away from traditional 'Mode 1' science, in which knowledge production is the domain of academic disciplinary-

based science, towards 'Mode 2' knowledge production, in which knowledge is co-produced in the context of application by heterogeneous and trans-disciplinary communities from a range of organizations and actors in the society [13, 14]. Table 1 gives a summary of the distinct features of 'Mode 1' and 'Mode 2'.

The main thesis in 'The new production of knowledge' is that science is moving from being conducted in isolation within academic institutions toward a more open, both socially and globally, knowledge production systems. The collaborative research project that this thesis is built on was conducted by six prominent scholars coming from the field of science policy studies: Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schartzman, Peter Scott and Martin Trow. The project was funded for three years by FRN, the Swedish Council for Research and Planning [13, 15]. Although it is said that 'Mode 2' is emerging alongside the traditional knowledge production systems of 'Mode 1 and is rather supplementing than supplanting it [13], it is still hold to become increasingly dominant. Before we move to a more detailed description of the five main attributes of 'Mode 2' as shown in Table 1, it should be mentioned that there also exist several competing approaches for studying changes in the science system like Post-normal science [16], Innovation systems [17], Academic capitalism [18], Post-academic science [19], and Triple helix [20] [for a comparisons and an overview, please see 15].

Table 1. Summary of attributes to different institutional logic of knowledge production

Features of knowledge production	'Mode 1' knowledge production	'Mode 2' knowledge production
Focus of knowledge	Problems defined by academics and professional communities	Knowledge produced in the context of application
Disciplinarity	Disciplinary knowledge	Transdisciplinary knowledge
Form and sites of knowledge production	Homogeneous sites/types of knowledge production	Heterogeneous sites/types of knowledge production
Research practice	Research as autonomy objective investigation	Research as reflexive and social accountability
Quality control	Traditional quality control by the 'invisible college' through peer review	Novel and expanded quality control by several actors in the society

2.1. The five main attributes of 'Mode 2' science

First, *knowledge is produced in the context of application* [13]. While problem solving in 'Mode 1' is carried out following the codes of practice within particular disciplines, problem solving in 'Mode 2' is organised around a particular application. In the former, academic science or basic research is usually carried out in the absence of some practical goals. This implies that it is necessary to overcome a knowledge gap between academia and industry through a successful knowledge transfer. In contrast, knowledge produced within 'Mode 2' is from the beginning intended to be useful for someone in the society like user, industrial or governmental actors.

Second, problem solving is based on the mobilisation of a diverse range of specialists than works *transdisciplinary* to reach an empirical and theoretical consensus that goes beyond that of any single contributing discipline [13]. In contrast to 'Mode 1', the new knowledge production may not fit easily into any of the disciplines that contributed to its development. Results are not communicated mainly through institutional channels like papers but are more available to those who have participated in the problem solving effort and through their formal and informal communication networks.

Third, 'Mode 2' knowledge production is much more *heterogeneous* than 'Mode 1' knowledge production, in which knowledge generation usually took place within homogeneous and traditional

universities [13]. Participating people can come from a number of potential sites for knowledge production like non-university institutes, research centres, government agencies, industrial laboratories, think-tanks, high-tech spin-off companies, and consultancies. These sites interact together in mutual communication network based on a variety of means which includes electronically, organisationally, socially and informally links.

Fourth, operating in 'Mode 2' and a context of application makes participants more *reflexive* and sensitive to the broader social consequences and implications of what they are doing [13]. Growing public awareness and concern about issues like environment, health, privacy etc. has increased the number of groups that wish to influence and be involved in the research process. Thus social accountability permeates the whole knowledge production process, which implies that researcher no longer can work as autonomously as in 'Mode 1'.

Fifth, the new production of knowledge also brings along novel and expanded criteria the *quality control* process [13]. Within the traditional quality control regime through peer review in 'Mode 1' science. In addition to the traditional discipline-based peer review systems, several additional economic, political and social criteria are added in 'Mode 2' due to the context of application. Quality is thus determined by a wider set of criteria that illustrates the broadening awareness of the increasing number of involved actors and interest groups. However, because the criteria for quality control is expanded and broadened, quality assessment by scholarly peers is only one among several dimensions of quality.

Although the authors of *The new production of knowledge* obviously emphasized the importance of the 'social', considerations of wider social transformation went largely unexplored. In order to correct the avoidance of substantial discussion of this issue, three of the original authors, Helga Nowotny, Peter Scott and Michael Gibbons, published a second book: *Re-thinking science: knowledge and the public in an age of uncertainty* [14]. In this volume, the authors attempt to provide a more solid sociological foundation for their thesis about a transition towards 'Mode 2'science. Applying the concept of co-evolution they argue that 'Mode 2' science is developed in the context of the development of a 'Mode 2' society, which is characterised by growing complexity. The complexity of society is illustrated by comparing two accounts of social transformation, Knowledge society [see e.g. 21] and Risk society [22], which is related to the conceptualization of 'Mode 2'. The co-evolution of science and society is a result of the blurring and de-differentiation of the social spheres of state, market and culture, which implies greater intertwining between them that makes it hard to separate the developments in the different spheres. Because of this, scientific knowledge production has now a much greater direct impact on society, which is counteracted with more vigorous attempts to influence science. "In modern times, science has always 'spoken' to the society … But society now 'speaks back' to science" [14].

2.2. Assessments of 'Mode 2'

In their review of the debate surrounding 'Mode 2' knowledge production, Hessels and van Lente [15] summarises the main criticism against the thesis put forth in *'The new production of knowledge'*. On an overall level, several scholars highlights the limitations in the empirical foundation that the concept of 'Mode 2' is built on. I will address two of these criticisms. First, the described transition in the science system from 'Mode 1' towards 'Mode 2' is built on the premise that there is a uniform science system and uniform science practice and values which can be characterized as belonging to one of the two modes. Gibbons et al. [13] thus disregard the diversity of scientific practice and fails to take account of the well established heterogeneity of scientific practices [23], both within scientific disciplines [24] and national context [25]. Hessels and van Lente [15] suggest that 'Mode 1' and 'Mode 2' should be rather regarded as ideal types at the extremes of a continuum than as mutually exclusive categories.

Second, because of a generally weak empirical foundation, several scholars are critical to what they perceive as an uncritical description coupled with a normative content. Hessels and van Lente [15] express such a view when they concludes that 'Mode 2' has been a successful manifesto that has raised considerably attention in the area of science policy with its broad scope and evocative claims.

All in all Hessels and van Lente [15] argue that there is no compelling reason to why the five attributes of the 'Mode 2' concept should operate together. However, on the other hand this also implies that the different attributes, and the claimed trends they represent, could and should be disconnected and investigated separately. In the next sections I will introduce the Norwegian CEER-scheme and discuss it in relation to the five attributes of 'Mode 2'

3. The CEER scheme and innovation

Norway has developed ambitious goals to become one of leading environment friendly energy nations. According to the broad-based political agreement on climate policy achieved in the Storting in 2008, promotion of renewable electricity production is perceived as one of the main solution for reducing greenhouse gas emissions. Through the Energi21 initiative, Norway's national R&D strategy for the energy sector, it is also evident that Norway has the potential to become a major exporter of both energy related technology and environmentally friendly power to Europe. The Norwegian Research Council proposed the establishment of the Centres for Environment-friendly Energy Research (CEER) scheme as one of the main measures for addressing these goals.

Based on the Description of the CEER scheme, innovation is a prominent component and one of the main goals with this scheme. The CEER scheme seeks to develop expertise and promote innovation through focus on long-term research in selected areas of environment-friendly energy, in close cooperation between prominent research communities and users like industry and public administrative bodies. It is expected that innovation and value creation will be generated mainly by the company partners, although another outcome of a centre's activities may be the start-up of research-based companies to commercialise ideas that fall outside the core areas of the company partners. A further target is to enhance researcher training in areas of importance for user partners and generate research-based knowledge and technology transfer. Finally, the main assessment criteria in the selection and evaluation of centers were and will be the scientific merit of the research and the potential to generate innovation and value creation.

However, since the announcement of the establishment of eight CEER centres in February 2009, it has become evident that challenges for the centres regarding innovation and commercialisation are more complex than expected and anticipated. In a report written by NIFU STEP, which review and analyse the eight CEERs' innovation and commercialisation strategies and activities, it is pointed out some difficult issues connected to a) intellectual property rights (IPR) in the consortium agreement, b) the research communities is more accustomed to scientific publishing and PhD education than innovation activities, and c) the intensity in collaboration between researchers and user partners like companies is very variable ranging from close collaboration on concrete research projects to lack of active participation. Although the centres have not existed for long, these preliminary findings are of some concern.

3.1. The CEER-scheme and 'Mode 2'

The first attribution of 'Mode 2' is concerned with the production of knowledge which could be either defined by the academic community or produced in a context of application. In the document "Description of the CEER scheme", the Norwegian Research Council states:

"The host institution for a centre may cooperate with one or more research institutions, organisations or enterprises on the establishment, operation and financing of the centre. It is primarily the companies,

other industrial enterprises and public institutions participating in the centre's activities that will reap the benefits of the centre's research findings and expertise."

It seems clear from this description that the Research Council indeed wants the CEERs to operate in a context of application by including companies, industrial enterprises and/or public institutions as active user partners within the centre. However, at the same time it seems like they expect that innovation and value creation would primarily be applied by the company partners. Based on this description we gain an impression that academic partners are not expected to take a leading, or even an active part in the application process of the new knowledge produced. It is thus possible to interpret this description as an expression of an underlying belief in the separation of 'basic research' and 'applied research'. In this case, it is therefore not possible to say that the Research Council has adopted fully a 'Mode 2' perspective on the *focus of knowledge*. The mixed signal is also clearly visible in their description the objectives for CEERs:

"- Promote the development of application-oriented research communities which lie at the forefront of international research and which participate in dynamic international networks;
- Enhance researcher training in areas of importance for user partners and generate research-based knowledge and technology transfer."

What they are saying here is that a CEER should at the same time both be at the forefront of international research and develop application-oriented research. This is a rather clear statement that seeks to promote development that combines 'Mode 1' and 'Mode 2' through a focus on both the academic community and a context of application. The same mixed signal is also sent regarding the emphasis on *disciplinary or transdisciplinary knowledge production*. In the first call for application the Research Council has listed several technological thematic priority areas. However, the Research Council has also written that "A centre may only encompass one or parts of one of these thematic priority areas." This suggests that the target is to develop disciplinary research. However, the portfolio of the thematic priority areas suggests a wish to develop more than one scientific field. Thus the program may be more transdisciplinary than the individual centre. This view is also strengthened by the fact that the Research Council holds a bi-annual 'Contact meeting' between representatives for the CEERs and the Research Council. This meeting is perceived as an arena to "communicate with each other, share experience, and raise common issues for the CEERs". Later the Research Council and the Norwegian Government explicitly asked for 'multidisciplinary' research collaboration in their second call for application, which was directed to social science studies of energy. In a section named 'CEER as for science policy instrument', it is stated several science policy instrument objectives:

- To strengthen the collaboration between the best research communities within social science studies of energy and climate.
- To promote multidisciplinarity in social science studies of energy.
- To promote more collaboration between social science and technology energy research.

Based on these objectives, it seems like the Research Council is moving toward promoting more *transdisciplinary research* than before. However, it is still clear that the importance of disciplinary knowledge has not been replaced. Thus the Research Council again seems to be mixed between 'Mode 1' and 'Mode 2' research.

Based on the above descriptions it is seems quite clear that the Research Council is firmly rooted in a 'Mode 2' approach in their view on where and by whom knowledge is produced. The purposeful demand that user partners should be included both in the technological and social science CEERs suggest

that the Research Council expect both research and user partners as capable of producing knowledge. However, the wording of the participating institutions as either researchers or users nevertheless suggest an underlying assumption that knowledge is primarily produced in the research institutions, which is an example of 'Mode 1' thinking. On the other hand, the Research Council expect "the user partners must take active part in the centre's research projects, conduct their own extensive innovation activities, and have the capacity to make use of advanced research." Thus user partners should be involved in the concrete research activities in the centers, as well as conducted such activities on their own. In addition they are given the opportunity to influence the overall strategic research agenda by having "majority representation on the centre's board" in the eight technological CEERs. It is clear that user partners is expected to take active part in the research activities of the CEERs and its knowledge production, although there seems to be no expectation that they should contribute on completely equal terms as the research partners. Thus the sites and *production of knowledge is regarded as heterogenic* and closer to 'Mode 2' than 'Mode 1'.

Because the Research Council insist on multiple partners that includes both user and research partners, it is difficult to argue that the research in the CEERs is completely governed by the academic community and its quest for autonomously objective investigation. Through the design of the CEER scheme the Research Council have strived to expose the researchers and the research institutions to the demands and expectations from the wider society. Thus they have clearly established a framework to promote research as more *reflexive and social accountability* in line with 'Mode 2'. However, the design can only increase the probability, and cannot guarantee that the researchers actual become more reflexive and aware of their potential impact on the wider society. It is therefore also interesting to note that one of the objectives for the CEERs is to "enhance researcher training in areas of importance for user partners and generate research-based knowledge and technology transfer." The focus on researcher training and young researchers as the main target for incorporating a 'Mode 2' view on research, might suggest that the Research Council do not expect that such values is easy to transfer to more senior researchers.

The last attribution of 'Mode 2' is a novel and expanded quality control system. In both calls for application it is stated that there is two main assessment criteria that will form the basis for the selection of the CEERs. First, the scientific merit of the research proposed in the application. The second criteria are relevance, which is formulated as: "Relevance and potential for innovation and value creation". The Research Council designed the process for choosing the CEERs by relying on the assessment from two different panels for these two different sets of criteria. The scientific merit was assessed by a science expert panel, consisting of international scientist, while the relevance was assessed by a generalist expert panel, consisting of people with relevant user competence, would also rate the application based on nine assessment criteria on a scale between 1 to 7 (see table 2 below), as well as to give an overall grade.

Based on the broadness of the criteria used in the evaluation of the applications, there is no doubt that the Research Council applies many more criteria than just scientific peer review. Thus it is possible to argue that the Research Council is following the suggestion from the 'Mode 2' concept. On the other hand there are several important aspects which are connected to the quality control system. First, the Research Council demands that the applications should contain a long list of sections with a particular focus on clear objectives and statements that can enable measures of progress. The following description is derived from the first call:

"Applications for funding and status as a CEER must be submitted by the host institution for the centre in consultation with user partners and other partners that will be participating in the centre's activities and financing. Applications must specify the centre's objective, its significance for competence development and potential future innovation among the user partners, its significance for broader competence-building in the field, and a project description including the following: the national and international

state-of-the-art of the relevant technologies/research topics, research tasks, research methodology, organisation, international cooperation, project timetable with milestones, cost plan broken down by the individual partners, funding plan with an outline of contributions from the individual partners, any user partners and other groups from Norwegian industry. An explanation of how the centre will be organised, operated and managed must also be attached."

Second, the contract between the Research Council and the individual CEERs also contains demands for a number of annual and bi-annual reports. These includes an Annual work plan, which contains detailed description of the sub-projects as well the cost and financing of the individual sub-project, Annual account report, Annual report, and bi-annual progress reports. The demands for these reports can be seen as an expression of an increasing accountability of research and research projects from the society, thus being in accordance with what is proposed within the 'Mode 2' concept.

Together these aspects of quality control of the activities in the CEERs can be said to restrict the participant's room for working on the unexpected. This regime of quality control is a quiet bureaucratic form of control that seems to at odds with the fluidity and the emerging of unexpected results that is a central assumption in the 'Mode 2' concept [13, 14]. This can also be interpreted as an illustration of the existence of colliding intuitional logic, in which policies which is aimed at 'Mode 2' knowledge production are sought to be implemented with means derived from 'Mode 1' logic [26]. In the next section I will look closer at some of the empirical studies of 'Mode 2' research.

3.1. Empirical studies of 'Mode 2' research

Despite an ongoing debate in management research about applying 'Mode 2' research to bridge the 'relevance gap' [27-29, see e.g. 30], a recent Special issue on the generation and use of academic knowledge and its application to practice noticed a striking lack of empirical examination of this important phenomena [31]. However, there are several interesting articles that are based on researchers' experience and reflection on collaboration between academic institutions and industrial partners.

Newell et al. [32] discuss how expectations of scientific rationality are central to the funding process. They also describe rituals of verification, in which the research team involved in the research project, actively engaged in impression management towards the funding body. Although both projects discussed were perceived as successes, they were merely successful in producing the necessary pre-specified deliverables and reports, thus hiding the lack of coherence in the research project across the different partners involved. They argue that funding bodies assume that knowledge creation during research happens through a rational decision-making and planning process, which leads to the identification of the optimal solution to a given problem, which is again is diffused to users as best practice. Because of this research projects puts their emphasis on achieving their pre-specified deliverables and targets. Although government policies can shape knowledge creation and dissemination, it is also possible that the underlying belief in a rational planning mode rather stifle than stimulate knowledge creation processes across academics and industry [32].

In their article, Knights and Scarbrough [33] departs from the conventional view of perceiving the problem of relevance of academic research to organizational practice as one of improving the diffusion of knowledge from research to practice. Through an examination of their experience in setting up academic-practitioner network, they find that relevance is not easily attained through better communication and dissemination of academic knowledge. This was rather achieved in particular contexts through emergent processes of instances of translation between practitioners and academic groups. However, this highlights the highly situated character of knowledge production, which implies that the search for relevance will continue to be recreated and reconstructed when academics and practitioners tries to collaborate in jointly projects. Interestingly, they applied 'Mode 2' in their analysis

to help explain the constrains on changes in knowledge production. Overall they found that the interest of academics and practitioners tended to be more accommodated by compromise rather than harmonized in a common understanding. Only minor modifications occurred in the academic research agenda, taken as evidence of the persistence of 'Mode 1' institutional context, in which academic career tracks and the RAE (Research Assessment Exercise) lead to the pursuit of publishable academic research at the expense of solving short-term practitioner's problem.

Similar argumentation is also found in the empirical study by Swan et a. [26]. In this article they explain the dialectic tension that happens when policies directed at promoting 'Mode 2' knowledge production is sought to be implemented by communities of scientist that have been trained within 'Mode 1' forms of knowledge. They conceive this as colliding institutional logic and underscore the importance of remembering that there is also an important political nature of knowledge production. The empirical material describes how the competing institutional logic could be artfully mobilized to promote the interest of different groups. They further point out that the funding body still used 'Mode 1' science as a model for understanding how research is produced and legitimated, in spite of their increasing use of 'Mode 2' rhetoric and establishment of generalist review panels. Holding on to scientific peer review quality control system, together with an evaluation system based on a rational belief in pre-stated research objectives and plans, lead in practice to a reinforcement of disciplinary boundaries. Instead of these traditional means of quality control, they rather suggests that those who are accountable for call for application and quality control, should rather initiate negations with the project teams to find out what sort of output measures that should be applied.

Also Mitev and Venters [34] points to institutional pressure, pulling academia, industry and government in different directions, as the main explanation for why transdisciplinarity was not achieved. This article is also based on a reflexive account of the experience with research programme involving several different academic institutions and industrial partners. They conclude in retrospect that no real consensus was reached between the participating partners, which resulted in diverging agendas between academia and industry, within industry between private and public companies, and within academia passed on disciplinary differences. They therefore suggest that the context of application does not pre-exist, but has to be re-created in each case by negations between different institutional logic. Importantly, they also notice the lack of inclusion of non-elitist industrial partner at the expense of dominating companies, and suggest that marginal voices should not be ignored but engaged for the common good in the society.

All in all, this set of articles suggests that the difference in institutional logic of academia, industry and the government should not be underestimated. This implies that a common understanding with research projects and between research projects and their funding body needs to be negotiated in each instance. The lack of common agreement will most likely result in efforts of successful impression management towards the funding body, although in reality the partners in the project will work independently and disconnected from each other. If funding bodies wish to promote 'Mode 2' research they need to consider their expectation of research as linear process that can be planned in detail in advance, as evident in demands for content in applications and in the evaluation process. Lastly, the demand from funding bodies that industry partners should contribute substantial amount of resources in research initiatives they wish to take part in, invitingly lead to the exclusion of companies that cannot afford to contribute. This can be unfortunate because contributing user partners is given more influence over research agenda and activities, and both researcher and government can come to ignore relevant marginal voices in the society.

3.2. Summary of the analysis

Through an extensive review of the content of the 'Mode 2' concept, as well as an analysis of the Norwegian CEER scheme, it is clear that the latter has picked up several suggestions from the former. However, the analysis also shows that the CEER scheme is mixed with regard to 'Mode 1' and 'Mode 2' on most attributions with the exception of *heterogenic sites for production of knowledge* and promotion of research that is more *reflexive and social accountability.* The mixed approach is illustrated by the objectives for the CEERs set by the Research Council:

"The CEERs are targeted toward the users' need for knowledge. They must promote cooperation between research communities and innovative users, and seek to strengthen long term research that enhances innovation and value creation. To achieve this, the CEERs must also focus on the scientific merit of the research and researcher recruitment."

The research in CEERs should at the same time both be disciplinary scientific and applied by companies. In addition, the assessment criteria, although broader than merely scientific peer review, together with the demands for detailed reports and pre-specifies deliveries, can stifle rather than stimulate knowledge creation processes across academics and industry [see also 26, 32]. It is apparent that there is a need for further empirical investigation of empirical micro-dynamic of collaboration between academia, industry and government. Because the perspective in the 'Mode 2' concept is inclined to a system level analysis, and thus focusing more on institutions than individuals, it is not very detailed in its description of how the collaboration is actually should be done in practice, nor is it clear on how they define knowledge. It is therefore a potential to apply the concept of knowledge integration to guide their research of the collaboration between academia and industry.

4. Final remark: Promoting collaboration through knowledge integration

Although the importance of knowledge integration is increasingly recognized among scholars and practitioners there is a striking lack of common and general perspective on what the concept entails. In an excellent review by Fredrik Tell [1] three main approaches to knowledge integration is identified as a) sharing or transferring knowledge, b) use of similar/related knowledge and c) knowledge integration as the combination of specialized, differentiated, but complementary knowledge. Following the last approach, Tell [1] produce an overview of empirical research where he notes the use of several levels of analyses: a) project/group, b) firm/organizational level, and c) industry/inter-organizational. He further points out that research has tended to either focus on a) factors influencing knowledge integration, often applying qualitative case studies, or on the b) outcomes of knowledge integration, mostly studied by the use of quantitative data like surveys or panels. Tell [1] concludes his review by stating that there is a lack of dynamic analyses and understanding of the underlying processes and mechanisms of knowledge integration, and calling for more in-depth case studies and inductive analyses of knowledge integration as a collaborative effort.

In my upcoming research project, the main objective is to promote innovation in the CEERs by helping the actors with the practicality and understanding of knowledge integration in practice. Applying the framework of Tell [1], the empirical investigation in this project will focus mainly on the actor's knowledge and relations, keeping in mind that the task characteristics of innovation will be an important contextual factor. The main target is to understand the social interaction and knowledge integration between academics and people working in enterprises collaborating within a CEER. In addition, it could be of interest to also study these actors' relation and interaction with people involved in policy processes, although this will only be a potential additional objective. However, the project will focus on the CEER, individual and collectively, as learning areas. At the end of this project we should have a better understanding of the knowledge integration process, which should enable us to identify best practice and improved design in the CEER scheme that enable the commercialization of innovations.

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