



The knowledge triangle in policy and institutional practices - the case of Norway

Siri Brorstad Borlaug, Siri Aanstad, Espen Solberg and Taran Mari Thune

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Preface

This report presents the findings from a study of the knowledge triangle in Norway carried out by the Nordic Institute for Studies of Innovation, Research and Education (NIFU) in the period September 2015 to January 2016. The study was commissioned by the Norwegian Ministry of Education and Research, and is part of an OECD project organised by the Committee for Scientific and Technological Policy (CSTP) and the Working Group on Innovation and Technology Policy (TIP). The goal of the project has been twofold: i) to inform policymakers and institutional actors on the ways the “knowledge triangle” policy framework for the integration of research, education and innovation activities in higher education could enhance their impact on the national and regional economies; and ii) to identify best practices in terms of operationalising the knowledge triangle framework at the institutional level. Sixteen countries participated in the project.

We are grateful for this opportunity to study the knowledge triangle in policy and in practice. In particular, we would like to thank our informants at the three case institutions: UiT- the Arctic University of Norway; the Norwegian University of Science and Technology (NTNU); and Buskerud and Vestfold University College (HBV).

Oslo, 19.12.2016

Sveinung Skule
Director

Liv Langfeldt
Deputy research director

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Summary

This report presents the findings from a study of the knowledge triangle in Norway carried out by NIFU in the period September 2015 to January 2016. The mandate for the study was to map and analyse knowledge triangle policies and practices in Norway at the national and institutional levels, based on a template developed by the OECD. This summary presents the main findings on the national level, how national policies affect the behaviour of the institutions and the differences between institutions and disciplines in terms of knowledge triangle practices.

Fragmented governance structure, emphasis on the link between research and innovation

At the national policy level, the responsibility for education, research, and innovation is divided between several government ministries. The Ministry of Education and Research is responsible for education policies and for the coordination of national research policies. The Ministry of Trade, Industry and Fisheries has the coordination responsibility for national innovation policies. According to the so-called sector principle, other ministries are responsible for research and innovation within their respective sectors. Although this “sectorised” governance structure is a well-established and accepted principle, it is widely recognised that it poses a challenge for policy coordination, and several studies have pointed to a need for stronger and more efficient coordinating mechanisms on the ministerial level.

The Research Council of Norway (RCN) is an important coordination mechanism at the implementing level. Norway stands out by having only one research council which is responsible for supporting research across all disciplines and sectors as well as research-based innovation. This means that the research-innovation link is strongly embedded in the institutional set-up. There is also institutionalised cooperation between RCN and the main innovation policy agency, Innovation Norway, and other agencies with a role in innovation policies, such as SIVA, which has the responsibility for incubators etc., are increasingly included in the discussion of coordination on this intermediate level.

Education policy has been relatively loosely linked to research and innovation policies, and is based on a different policy logic where major importance has been paid to quality assurance through standardisation and accreditation, allowing for common degree structures, transparency and mobility of students. The main higher education policy agency, the Norwegian Agency for Quality Assurance in Education (NOKUT), has for a large part operated independently of the agencies supporting research and innovation. NOKUT's role is also rather different, as RCN and Innovation Norway play important roles as funding mechanisms, while NOKUT primarily focuses on accreditation and quality assurance.

Increased attention to linking education to research and innovation

A review of actual policies and support measures shows that while they mainly address the interplay between research and innovation, increasing attention is paid to the importance of developing linkages between these two areas and education. This intention was evident in the first national *Long-term plan for research and higher education* that was launched by the Government in 2014. The plan has, however, been criticised for focusing mainly on research and not sufficiently addressing higher education. In the ongoing work on a white paper on quality in higher education, strengthening interaction between education and research and cooperation between education and working life are central focus areas. Moreover, assessment of the interplay between education and research has recently been introduced as an element in national research evaluations.

While these policy developments do not necessarily represent an *integrated* knowledge triangle approach, such an approach – where there is an explicit focus on systematic interaction between all three “corners” in the triangle – is found in some policy areas. This is true for:

- certain sectoral policies, notably health and oil and gas, which are sectors of high national strategic importance and with dedicated sector ministries;
- policies for innovation in the public sector, where large programmes administered by the Research Council support interaction between education, research, and professional practice in the educational sector (FINNUT), and health, care, and welfare services (HELSEVEL);
- policies for entrepreneurship in education – an area where Norway has been a pioneering country, and a new pilot funding scheme for student entrepreneurship projects has been introduced (FORNY StudENT); and
- cluster policies, where knowledge cooperation between HEIs and industrial firms is a central element and there are national programmes supporting early-phase, immature clusters (Arena), mature clusters with a national position (Norwegian Centres of Expertise), and mature clusters with a global position (Global Centres of Expertise).

State-owned higher education institutions assigned a central role in the knowledge triangle

The Norwegian higher education sector is the second largest research-performing sector in Norway, after industry, and dominated by state-owned universities and university colleges. The university colleges have historically been responsible mainly for shorter profession-oriented education. According to the most recent R&D statistics, the eight universities account for 66 per cent of total R&D expenditure in the sector (NIFU/R&D-statistics 2016). When university hospitals are included, the universities account for more than 83 per cent. As part of an ongoing structural reform in higher education aimed at strengthening quality through concentration, a number of universities and university colleges have merged or are in the process of merging. This means that the institutional landscape is changing, and one clear outcome is that the role of universities will be further strengthened, while the number of university colleges and their share of R&D resources will be reduced.

The state-owned HEIs are assigned a central role in developing knowledge triangle interaction through their legal mandate to carry out research, offer research-based education, and contribute to innovation and value creation. As the owner of HEIs, the Ministry of Education and Research emphasises institutional autonomy in its model of governance, and the institutions are fairly autonomous in deciding how to fulfil their mandate.

The national funding and governance systems for HEIs promote knowledge triangle interaction to varying degrees. When it comes to funding, general university grants account for 75-80 per cent of total funding in the sector. The grants are allocated partly as basic funding in the form of long-term and strategic funds, and partly as performance-based funding. In 2015, basic funding accounted for ca. 70 per cent and performance-based funding ca. 30 per cent. Performance-based funding is allocated

according to a set of quantitative indicators – the so-called education and research incentives. The national funding model has so far no incentives for innovation-related activities. Income from contract research and education will be introduced as a performance indicator from 2017 with the explicit aim to encourage interaction with industry and society.

State-owned HEIs are governed by a board, where students, staff and societal stakeholders are represented. In 2005, it was decided by law that the institutional boards should have four external members, partly to strengthen the links to industry and society at large. Since 2009, the institutions have moreover been expected to establish a Council for cooperation with working life (*Råd for samarbeid med arbeidslivet*, RSA), which is to ensure relevance in education.

At the national level, the Ministry of Education and Research governs the state-owned HEIs through a reporting and evaluation system based on statistical data, written reports, and governance meetings with the institutional boards. The institutions report on a broad range of goals and performance indicators relating to education, research and innovation. However, it is only their reported performance in the areas of education and research – as measured by the set of quantitative indicators in the performance-based funding – that is rewarded by the Ministry.

Recruitment and promotion to teaching and research posts in HEIs follow national regulations and criteria that are based primarily on academic qualifications. At the same time, the institutions are free to develop additional recruitment and promotion criteria, and career policies are to a large extent the responsibility of each institution.

The institutions' strategies emphasise the knowledge triangle, but challenging to develop the interlinkages in practice

To investigate policies and practices at the level of HEIs, the study includes three institutional case studies. In accordance with the OECD template, they cover a comprehensive university, UiT- the Arctic University of Norway; a technical university, the Norwegian University of Science and Technology (NTNU); and a regional university college, Buskerud and Vestfold University College (HBV).

All three case institutions have strategies emphasising the interlinkages between education, research and innovation. In their leadership structures, however, all three institutions have a pro-rector for education and research respectively, while only NTNU has a dedicated pro-rector for innovation. At HBV and UiT the pro-rector for research is also responsible for innovation, and UiT has a vice-rector for regional development. This may indicate that innovation does not have the same status as research and education, despite it being a central mission of HEIs. The mandatory representation of external members on the institutions' boards is perceived as important – according to the informants, the external members bring in stakeholder perspectives, contribute to anchoring the HEI in society and give societal legitimacy to strategic decisions. When it comes to the Council for collaboration with working life (RSA), the case studies show that both deans and academic staff perceive it to be too general for the specific needs of the faculties and departments.

Although the institutions emphasise the interlinkages between education, research and innovation in their strategies, the case studies show that it is challenging to develop these interlinkages in practice. Informants point out that the institutions have practically no incentive mechanisms for innovation-related activities, neither in the job description of academic staff nor in the recruitment and promotion practices. External engagement and commercialisation of research are seen as positive assets by the leadership, but are not decisive for recruitment and promotion, which remain primarily based on scientific track record. All informants further point out that the institutions' reporting systems are based on the indicators in the national performance-based funding system, which are limited to education and research. This means that cooperation with the public and private sector is not systematically reported by the academic staff and thus not rendered visible for the leadership.

Differences in size, profile and geographical location matter for knowledge triangle practices

The case studies show that there are considerable differences between the three HEIs in terms of their framework conditions for KT practices. Their size, profile and regional conditions are important variables in this respect. While all three institutions have arenas for cooperation with industry and the public sector on education and research, the large technical university, NTNU has several institutionalised councils and meeting places and the leadership focuses considerably more on commercialisation of research and entrepreneurship, as do the academic staff.

The comprehensive university, UiT, has an academic profile and covers all the major academic fields. The ties to the public health sector are particularly strong, but the regional industry is generally small, which makes cooperation with regional industry challenging. The regional university college, HBV, on the other hand, is characterised by rather applied fields of research, and is located in a region with technology-intensive industries. The university college has strong ties to industry and the public sector, and cooperate with these actors in their efforts to strengthen education, research and innovation. HBV has systematically developed research capacities and educational programmes relevant to regional industry and the public sector, and has taken a leading role in developing the region.

Different conditions for knowledge triangle-practices in different fields

Furthermore, we find significant differences in the conditions for and types of knowledge triangle-practices in the different scientific fields. The case studies show that there is a variety of practices in the field of health. Medicine is characterised by a strong integration of education, research and innovation through the national system for interaction between the medical faculties and the public hospitals, in which the latter have an obligation to contribute to profession-oriented education and to perform research. Academic staff at the medical faculties engage in commercialisation and entrepreneurship activities, and research-based innovation collaboration. The health disciplines that offer shorter professional education on the other hand, cooperate more closely with the municipal primary healthcare services on education. These fields have relatively weaker traditions for research, and innovation is to a greater extent related to incremental improvements in services and the implementation of health and welfare technologies in collaboration with service providers and technology firms.

Within the field of science and technology, KT practices are generally initiated by individuals and bottom-up initiatives facilitated by regional funding and national competitive funding schemes. Cluster schemes which provide long term funding have been especially important mechanisms for developing research and teaching programmes at HEIs in cooperation with the public and private sectors. The case studies show, however, that KT practices are more developed in applied fields compared with discipline-oriented fields.

Local initiatives for developing linkages in the knowledge triangle

The three institutions subject to case studies have all developed specific mechanisms for integrated KT practices, and the studies reveal several interesting examples. At UiT and HBV, new categories of adjunct positions have been established. The Faculty of Health Sciences at UiT has expanded the traditional use of dual affiliations in medicine to other healthcare professions. At HBV, the Faculty of Technology and Maritime Sciences has recently introduced the adjunct position "R&DI Experts" for industry employees, with the aim to develop networks and learn about the research needs of industry.

All three institutions have developed cooperation structures with the public and private sectors, but to different degrees and with somewhat different focus. UiT and NTNU especially have focused on establishing infrastructures for commercialisation of research and entrepreneurship education, in which the technology transfer offices have a central role. In the case of HBV, three out of four campuses are co-located with research parks housing the management of industry-clusters. This seems to facilitate cooperation between HBV and the public sector and industry.

Recommendations for strengthening knowledge triangle interaction

The report shows that including knowledge triangle perspectives in policy may be challenging due to the different logics that underpin the areas of education, research and innovation. At the same time the report points to several conditions that may enhance KT practices at the institutional level, and thus inform policy developments at the national level. They include:

- Long term funding directed towards developing and institutionalising cooperation structures between HEIs and public/private actors is important. It offers the possibility to work strategically to strengthen interaction between education, innovation and research.
- A strong policy environment, and especially a sector ministry (e.g. health) facilitates the development and institutionalisation of KT practices at the institutional level.
- A reporting system which also incentivises co-operation between academics and firms/public sector in RCN- and EU-funded projects.
- New types of adjunct positions and expanding the use of dual affiliations can enhance knowledge exchange and facilitate KT practices.
- Academic career systems can be used to incentivise KT practices, by including innovation and education as promotion criteria.

1 Background, mandate and research design

1.1 Background and mandate

This report presents the findings from a study of the knowledge triangle in Norway carried out by the Nordic Institute for Studies of Innovation, Research and Education (NIFU) in the period September 2015 to January 2016. The study was commissioned by the Norwegian Ministry of Education and Research, and is part of an OECD-project organised by the Committee for Scientific and Technological Policy (CSTP) and the Working Group on Innovation and Technology Policy (TIP). Through national case studies of knowledge triangle policies and practices, the project aims to develop policy advice on how to improve the collective performance of education, research and innovation systems. The project has four modules: Higher Education Institutions; Financing and governance; Place-based policies; and Evaluation and impact assessment.

The mandate for the study was to map and analyse knowledge triangle policies and practices in Norway at the national and institutional levels, based on a template developed by the OECD. At the national level, the study should describe the Norwegian education, research and innovation system and analyse the current state of the knowledge triangle. At the institutional level, case studies of three higher education institutions should be carried out to explore the relationship between institutional policies, strategic initiatives, and practices.

1.2 The “knowledge triangle” concept

The knowledge triangle is, according to the OECD (2015), a policy framework that stresses the need for an integrated approach towards research, innovation and education policy. It is also a conceptual tool for analysing the interactions between research, innovation and education. Each of these elements influence the others, while “orchestration tools” may strengthen the synergies between the components. Figure 1 illustrates the knowledge triangle. This project is especially concerned with the role of higher education institutions in the knowledge triangle.

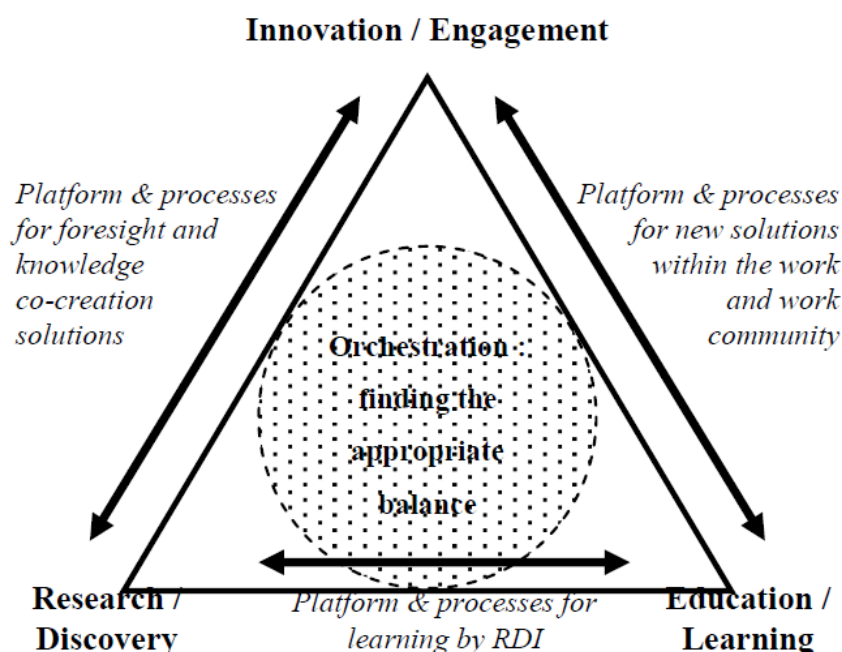


Figure 1 The knowledge triangle. Source: OECD 2015

In the background documents for the project, it is underlined that definitions of the knowledge triangle may vary, but that the project will refer to education, research and innovation as core elements. It is further emphasised that the definition of research, education and innovation should not be too restrictive. For example, innovation is considered to also include non-technological innovation such as organisational or marketing innovation, and training related to creativity, entrepreneurship or vocational training. Thus, innovation also refers to “engagement” or interactions with external actors. This understanding of the concept “knowledge triangle” is the point of departure for this report.

1.3 Research design, data and methodology

The study is organised in two parts: a national level study and an institutional level study.

The national study provides an overview of the current state of the knowledge triangle in Norway by outlining central features of the national education, research, and innovation system, including national policies and policy instruments, and interaction between higher education institutions and other sectors. It is based on an analysis of policy documents and relevant national studies and evaluations, as well as existing statistical data and interviews with three key policy actors – the Ministry of Education and Research, the Ministry of Trade, Industry and Fisheries, and the Research Council of Norway.

The institutional level study consists of three case studies of knowledge triangle policies, instruments, and practices in Norwegian HEIs. The case studies cover a comprehensive university, a technical university, and a regional university college, cf. table 1. This is in accordance with the OECD template, and allows for comparisons between different types of institutions. To explore disciplinary differences, we have chosen to focus on two specific faculties at each case institution – one within medicine/health, and one within science and technology (S&T).

Table 1 Research design

Type of institution	Name of institution	Name of faculties
Comprehensive	UiT The Arctic University of Norway	The Faculty of Health Sciences The Faculty of Science and Technology
Technical	The Norwegian University of Science and Technology	The Faculty of Medicine The Faculty of Engineering Science and Technology
Regional	Buskerud and Vestfold University College	The Faculty of Health Sciences The Faculty of Technology and Maritime Science

The classification of NTNU as a technical university is based on the institution's specialisation in science and technology and position as the central Norwegian HEI in the field. NTNU does, however, cover a broad range of other scientific disciplines, and is as such a comprehensive university with S&T as its main profile.

In addition to the analysis of documents, web-page information, and national statistics on the central institutional and faculty level, the three case studies are based on interviews with the leadership and academic staff at the faculties involved. For each faculty, we have conducted an individual interview with the dean, and a group interview with 2-4 members of the academic staff. The main purpose of these group interviews was to get detailed insight into what the faculties consider to be good examples of knowledge triangle practice. For practical reasons, the groups did not represent all scientific fields and relevant activities at the faculties. Hence, the case studies do not provide a comprehensive and fully-representative overview of institutional knowledge triangle practices.

Investigating the linkages between research, innovation and education at all levels is a rather complex and resource demanding task, and we have therefore in this report concentrated on education at the master degree level, and have as such omitted the bachelor's and Ph.D levels.

It should also be noted that all the three case institutions merged with other HEIs on January 1 2016, as part of the ongoing structural reform in Norwegian higher education. The data collection for this report was carried out primarily in the autumn of 2015, and the institutional case studies are based on the situation prior to the mergers.

2 The knowledge triangle: national level

In this chapter, we look at recent policy developments in Norway with a specific focus on issues related to the so-called knowledge triangle. We then give an overview of national and regional competitive instruments with direct and indirect relevance for promoting cooperation between research, innovation and higher education. Thereafter we move on to discuss the higher education sector and its role in the knowledge triangle. We discuss the structure of the sector, its funding, governance and evaluation practices at the national level. We also provide data on the degree of interaction between research, innovation and education activities.

2.1 Institutional set-up and key actors

In order to provide a general overview, we first give a brief description of the key actors in the Norwegian education, research and innovation system.

2.1.1 *National and regional authorities responsible for research, education and innovation policy*

The responsibility for education, research and innovation policies is divided between several ministries. The Ministry of Education and Research has the coordinating responsibility for national research policies, and is also responsible for education policy, from the level of preschools to higher education. The Ministry of Trade, Industry and Fisheries is responsible for the coordination of national innovation policies, and the Ministry of Local Government and Modernisation for innovation policy at the regional level. In addition, the so-called “sector-principle” means that all ministries are responsible for research and innovation within their respective sectors.

The Ministry of Education and Research provides the largest share of public R&D funding. A number of other ministries are significant funding sources, in particular the Ministry of Health and Care Services, which is the second-largest research funding ministry, and the Ministry of Trade and Fisheries, which has the main responsibility for funding business-oriented R&D and innovation.

Coordination of policies across ministries is achieved by high-level consultation meetings and cross-ministerial work on strategic policy documents and the fiscal budget. Since 2001 there have been several so-called 21-strategy processes on areas seen as important for the Norwegian society and economy. These processes are initiated by the Government or a Ministry and include important research and innovation actors. The aim of the processes is to carve out a common strategy for research based innovation and development of important societal areas. In total there have been nine 21-processes.

Norway has 19 administrative regions – called “counties”; since 2007, the county authorities have had an explicit responsibility for initiating, funding and implementing regional research and innovation policies. However, the current Government has put stronger emphasis on policy instruments that can promote innovation and business start-ups in all parts of the country. Hence, recent fiscal budgets have seen cuts in funding for regional development allocated to the county authorities.

When it comes to R&D funding and policy implementing agencies at the national level, Norway has only one research council, the Research Council of Norway (RCN). Unlike research funding agencies in many other countries, the Research Council of Norway covers all disciplines and research-performing sectors, and also provides support for industrial R&D and research based innovation. It also has the mandate to advise the government on research policy and to facilitate networking and communication between different actors in the Norwegian research and innovation system. The rather unique model of having one research council covering all disciplines, sectors and forms of R&D means that the research-innovation link is strongly embedded in the institutional set-up.

In accordance with the sector principle, each sector ministry allocates funding to RCN with relatively strong provisions. This means that there is a strong “vertical” coordination in the Norwegian system. On the other hand, this model may pose a challenge for the RCN’s ability to function as an overall strategic advisory body and coordinate funding across sectors. Furthermore, ministries differ largely in terms of how much R&D funding they allocate through RCN. While some ministries, such as the ministries for Oil and Energy (OED) and Food and Agriculture (LMD), allocate most of their R&D funds through RCN, others, such as the ministries for Health and Welfare (HOD) and Local Government and Modernisation (KMD), allocate the majority of their R&D funding outside RCN.

The two public agencies, Innovation Norway and the Industrial Development Corporation of Norway (SIVA), are the primary public institutions providing support for innovation in firms. Innovation Norway provides funding and services with the objective of promoting innovation at the regional and national level, with a particular focus on small and medium sized companies. SIVA is involved in the provision of science parks, incubators and services mainly to start-up firms. Although RCN, Innovation Norway and SIVA have a rather clear cut division of labour, there is an increasing institutionalised cooperation between them. For instance, the three agencies have a collaborative agreement aimed at promoting linkages between research and innovation.

There are two main public agencies with responsibilities for implementing higher education policies: NOKUT, which is the Norwegian Agency for Quality Assurance in Education, and SIU – the Norwegian Centre for International Cooperation in Education. NOKUT is an independent expert body under the Ministry of Education and Research with the primary task of certifying and ensuring quality in education programmes. SIU promotes international cooperation in education and research through grants and programmes (e.g. Erasmus+).

While there are developed links between research and innovation in the institutional set-up, e.g. through the sector principle, the role of RCN, and the institutionalised cooperation between RCN, Innovation and SIVA, the links to education are less developed. According to our informants, education policy has traditionally been organised as a “silo” with few mechanisms for interaction and coordination with research and innovation policies. There is, however, increasing focus on developing such mechanisms, and both SIU and NOKUT have entered into closer cooperation with RCN over the recent period.

2.1.2 Research performing sectors

The three main research-performing sectors in Norway are industry, higher education and research institutes. Higher education is the second largest R&D performing sector after industry (see Table 2), and accounts for approximately one third of total national R&D expenditure and human resources within R&D.

Table 2 R&D expenditure and human resources by performing sector (2013)

	Expenditure		Human resources	
	EUR (M)	per cent	full time equivalents (FTEs)	per cent
Industrial sector	2688	44	11508	40
Higher education sector	1907	32	10054	36
Institute sector	1453	24	6749	24
Total	6049	100	28311	100

Approximately half of all Norwegian R&D is performed by private enterprises. Thus, compared with other European countries, the total level of business R&D in Norway is relatively low, while public R&D expenditure is well above the EU average.

The applied research institute sector is today the smallest, but is nonetheless an essential element which plays a more pivotal role than in many other R&D and innovation systems (Solberg et al. 2012; Gulbrandsen et al. 2012). As of 2013, the sector accounts for 24 per cent of total R&D expenditure and comprises institutions which are included in the Business enterprise or Government sector in official international R&D statistics. It is a recurring debate in Norway whether the research institutes function as a bridge between higher education institutions and industry, or whether they represent a barrier to collaboration and the development of KT activities and practices in HEIs.

In national R&D statistics, Norway sometimes also operates with Health trusts as a fourth sector. This “sector” consists mainly of university hospitals (officially included in the higher education sector) and health-related research in hospitals and institutes outside the universities (included in the institute sector in official statistics). The “health sector”, thus defined, accounts for approximately 8 per cent of total R&D in Norway.

2.1.3 Key observations

The responsibility for developing and implementing education, research, and innovation policies is divided between several ministries and agencies, and even though coordination mechanisms are in place, there seems to be room for stronger horizontal coordination. First, the sector principle is generally held to contribute to a fragmented governance structure (see e.g. NOU 2016) and may pose a challenge for developing a strong overall approach to integrated knowledge triangle policies. Second, while the institutional set-up facilitates linkages between research and innovation policies, mechanisms for interaction and coordination between these two policy areas and education policy are relatively weak.

2.2 Recent governmental policies and strategies related to the knowledge triangle

Since the beginning of 1990s, Norwegian research policy has addressed the importance of collaboration between public research institutions and industry (Gulbrandsen, 2011), and since the year 2000, innovation and commercialisation of research have been central policy issues along with excellence in research.

A recent review of Norwegian policy documents shows that the knowledge triangle concept has been used infrequently over the past few years (Borlaug et al. 2015). Norway has a long tradition and a strong focus on promoting interaction between research and innovation. There is, however, a growing

awareness of the importance of linking education to both research and innovation. In the following section we highlight a few central policy documents and processes.

The Long-term plan for research and higher education (2014) outlines a framework for “how the Government will reinforce research and education to meet the challenges and seize the opportunities in the Norwegian knowledge society in the period from 2015 to 2024” (p.6). The Government has set three overarching objectives: 1) Enhanced competitiveness and innovation; 2) tackling major social challenges; and 3) developing research communities of outstanding quality. These main objectives are rather similar to the priorities of Horizon 2020. Although the Long-term plan includes higher education in the title, the implications and measures related to higher education seem more implicit. Hitherto research quality and excellence have received most of the attention, evident in rhetoric and in development of instruments – centres of excellence being one important example. This has to some extent been decoupled from education. The Government intend to update the plan every fourth year.

The structural reform in higher education was launched in 2014. The point of departure was a recognition that there are too many small public higher education institutions, which are vulnerable and geographically dispersed. There was also a general worry of lack of critical mass, inappropriate competition and insufficient internationalisation. A white paper on the future university structure was presented in March 2015. Based on voluntary mergers between HEIs, the goal is to strengthen quality in higher education and research through larger institutions. An argument is that this will also contribute to develop the role of higher education institutions in regional development, as regional industry will get easier access to a broader set of expertise. The structural reform has also implied adjustments in the funding system and opened up for future structural consolidation, also including research institutes.

Reforming the structure in the higher education system is one measure to strengthen quality in education and research. Currently, the Ministry of Education and Research works on a white paper on quality in higher education, with the ambition of stimulating the HEIs to develop a strong culture for quality in higher education programmes through strengthening the interaction between education and research and the cooperation with external actors to ensure relevance. The white paper will be launched in 2017.¹

In autumn 2015, the Ministry of Trade Fisheries and Industry launched the *Entrepreneurship plan*. This is at present the most central policy document in terms of innovation policy in Norway. In total, the plan announces an allocation of €42m to various measures for increased entrepreneurship and industry renewal. Some key initiatives in this plan are better access to early-phase capital and stipends that encourage students and PhD students to become entrepreneurs.

The national plan for *entrepreneurial education* is also worth mentioning in this context. The first plan was launched already in 2004, and Norway has been one of the pioneering countries in this area. The goal is to strengthen the quality of entrepreneurship education and include this as an aspect in all subject areas and on all levels in the education system. One central measure was the qualification framework in 2009 launched by NOKUT, which states that education on all levels shall contribute to innovation and entrepreneurship. Hence, all HEIs have entrepreneurship education, either as a special study programme or as a course embedded in other programmes.

To strengthen the relevance of educational programmes, the Government proposed in a white paper on education in 2008² that all HEIs should have councils for cooperation with working life (RSA). Their mandate is to strengthen the link between education and working life and to ensure relevance in the educational programmes. The RSA is seen also as a measure to strengthen the cooperation between HEIs and industry and the public sector.

¹ For further information (in Norwegian) see: <https://www.regjeringen.no/no/tema/utdanning/hoyere-utdanning/innsikt/kvalitet-i-hoyere-utdanning/stortingsmelding-om-kvalitet-i-hoyere-utdanning/id2462030/>

² St.Meld. nr 44 (2008-2009) *Utdanningslinja*. Oslo: Ministry of education and research

In both research and education policies *internationalisation* is a general objective, including an explicit ambition to increase the coherence between international cooperation within education, research and innovation. One key driver in this direction is the strong coupling between research and innovation in Horizon2020, combined with the Government's ambitious goals and strategic initiatives for strengthening national participation in the EU arena. In addition, there is a focus on strengthening the linkages between higher education and research in cooperation with priority partner countries outside the EU, through support for institutional partnerships that may also include cooperation with enterprises in the private and the public sectors.

The above policies address to varying degrees all corners of the knowledge triangle. In general, they emphasise two dimensions – either research and innovation or education and innovation. Some sector policies, however, put emphasis between all three aspects, particularly within health and care.

2.2.1 Knowledge triangle in sectoral research and innovation policies – an example from health care

As mentioned earlier, the sector principle means that government ministries are responsible for research and innovation within their respective sectors. Over the past decade, several ministries have initiated so-called 21-strategies, which are national research and innovation strategies within priority areas for research based development and value creation in the 21st century. There are currently nine such strategies, ranging from oil and gas to health and care, that have been developed with involvement from several ministries, research institutions, industry, and other societal stakeholders.

The strategies are characterised by an integrated approach to research and innovation. Education is included, but to a more limited extent. One strategy – Health&Care21 – stands out by stressing the importance of integrating all three areas of education, research and innovation. It is the only strategy that makes explicit use of the “knowledge triangle” concept, and places it at the core of the strategic approach for achieving the three main objectives of contributing to better public health, breakthrough research at international level, and national economic and business development.

The Health&Care21 strategy is concerned with facilitating innovation through increased interaction between education, research and the health care services, as well as between education, research and industry. Linkages between educational and research institutions and industry are described as underdeveloped, reflecting – among other things – the limited size of the Norwegian health industry and a lack of culture and incentives for cooperation. Thus, key recommendations include introducing incentives for HEIs and health trusts to engage in patenting, commercialisation and innovation cooperation with industry, as well as compulsory courses in entrepreneurship and innovation in health-related educational programmes.

When it comes to interaction between education, research and the health care services, a key point is that hospitals have a legal responsibility for contributing to education of health care personnel and for performing research. The regional health authorities receive dedicated research funding from the Ministry of Health and Care, which is allocated to the hospitals in close cooperation with universities and university colleges. Collaboration between the professional and academic fields is moreover underpinned by a widespread use of dual affiliations. Hence, the collaboration between the university hospitals and medical faculties is particularly strong, with a high degree of integration in terms of staff, buildings and infrastructure.

According to the Health&Care21 strategy, there is a need to develop the system to also include other professions, and it is recommended to introduce many of the same mechanisms that are in place in the hospitals to municipal health care services. This includes giving the municipalities a stronger legal responsibility as well as dedicated funding for contributing to education and research, and the establishment of regional cooperative bodies for municipalities, HEIs, and other research institutions.

2.2.2 Key observations

Overall, we may claim that the majority of the policies focus on the linkage between research and innovation, whilst education has mainly been handled separately. Other studies point to this as well, and argue that education is characterised by an own strong policy logic which primarily has concentrated on developing accreditation, standards and guidelines for the study programmes,³ and to a lesser extent on coupling education to research and innovation. However, we observe an emerging focus on including education in the research and innovation agenda. This intention is evident in the Long-term plan, which is the first overall strategic policy document that covers both higher education and research, and applies a long-term perspective. Moreover, two out of three overriding goals for research and education are to contribute to societal and economic development, and as such the plan includes a KT perspective. In practice however, the first edition of the plan is relatively weak in terms of concrete measures and policies on higher education, and it remains to make the role of education more explicit.

Within some sectors like health, there is an integrated approach towards KT activities. The extent to which this is developed relates, among other things, to the characteristics of the scientific fields and the existence of a strong policy environment, herein a sector ministry.⁴

2.3 National and regional instruments related to knowledge triangle – a brief overview

In general, the Norwegian R&D and innovation system is characterised by a broad portfolio of measures and a relatively generous level of public funding. Total public allocations to R&D (GBARD) are expected to reach 1 per cent of GDP in 2016, after several years of annual real growth of 4-5 per cent. Likewise, total public expenditure in the higher education sector has experienced a long period of steady growth. In the last ten years (2004-2014), the number of students has increased by more than 20 per cent, and the number of new doctorate holders by nearly 75 per cent.

During this period of expansion, Norway has introduced a number of new and strengthened instruments, many of which include direct and indirect incentives for cross-sectoral cooperation. In the following section we provide an overview of some of the most important instruments with relevance to KT policies.

2.3.1 General profile of cooperation incentives in competitive R&D funding

Several public agencies are involved in the funding and administration of competitive funding for research, education and innovation, notably the Research Council of Norway (RCN) Innovation Norway (IN) and, to some extent, the Norwegian Agency for Quality Assurance in Education (NOKUT).

The table below gives an overview of the extent to which the instruments address the interplay between research and innovation, education and research, education and innovation, or the whole triangle. The mapping exercise indicates that a majority of instruments and funding is devoted to strengthening the axis *research-innovation*. Only two instruments are directed towards *research-education* and *education-innovation* respectively, while six include the whole triangle.

³ Maassen, P. and Stensaker, B. (2011) The knowledge triangle, European higher education policy logics and policy implications. *High Education* (2011) 61:757–769

⁴ See Borlaug, S.B. et al (2015)

Table 3⁵ Funding programmes which included research-innovation; research-education; education-innovation; research-education-innovation, programme budget 2014

Dimensions	Budget (MNOK)	Percentage of budget	Number of programmes
Research - Innovation	3,726	82.6	26
Research – Education	13	0.3	1
Education - Innovation	20	0.4	1
Research - Education - Innovation	752	16.7	6
Total	4,511	100	34

Source: RCN yearly budget 2014, Innovation Norway

Below we will briefly describe the most important funding schemes for stimulating cooperation between HEIs and industry and the public sector, and the interaction between respectively education, research and innovation.

Research-innovation dimension

Collaboration incentives in large programmes

The dimension *Research-Innovation* includes programmes such as Centre for Research-based Innovation (SFI) and Research centres for Environmental-Friendly Energy (FME), which offer substantial funding over a period of 8 years to research groups that collaborate with public/industrial partners. Large thematically oriented programmes such as BIOTEK2021 (16.7 MEUR) and EnergiX (41.6 MEUR) are also included in this category. Many of these programmes include an element of higher education, although this dimension is less explicit. For instance, SFIs report on the number of master’s theses, but some centres do not include master’s students (Borlaug et al. 2015).

Collaborative PhDs

Included in the overview are also the *Industrial PhD* and the *Public sector PhD* programmes, both administered by the RCN and established with the purpose of strengthening the links between research and users in industry and the public sector:

- Under the *Industrial PhD scheme*, companies receive an annual grant equal to maximum 50 per cent of the applicable rate for doctoral research fellowships for a three-year period. The candidate must be an employee of the company and be formally admitted to an ordinary doctoral degree programme. The Industrial PhD scheme was introduced in 2008. It received a positive evaluation in 2012, and had at that point financed more than 150 PhD students.
- The more recent *Public sector PhD scheme* was introduced in 2014, and builds on the same model as the industrial PhD scheme, although targeted at the public sector institutions and requiring a commitment from a public employer, both in terms of co-funding and hosting the candidate. So far, 24 PhD students have been granted a Public sector PhD, and a new call for 20 PhDs will be open for 2016.

Collaboration in the Norwegian tax deduction scheme

The collaborative part of the Norwegian R&D tax deduction scheme “SkatteFUNN” is also included in the table above. In economic terms, the SkatteFUNN constitutes the largest public instrument for stimulating R&D investments in Norwegian companies. Foregone tax revenues under SkatteFUNN amounted to 1.5bn NOK in 2013 (app. €165m), which corresponds to 7 per cent of total public R&D

⁵ The table is based on a study of RCN budgets for 2014 and programme information from www.innovation.norway.no, and the description of the programmes and their goals. An important criterion was that the programmes explicitly had the goal of strengthening the interplay between two of the activities. Programmes without explicit incentives or criteria for cross sectoral cooperation, such as CoEs, are excluded.

expenditure. The support from SkatteFUNN comes in the form of a possible deduction from a company's payable corporate tax. The scheme was introduced in 2002, and has been subject to several evaluations and subsequent adjustments and extensions. As of 2016, the maximum amount for tax deduction amounts to 20m NOK (€1.8m) for business intramural R&D, and 40m NOK (€3.6m) for projects including purchase of R&D from approved R&D institutions. The latter element constitutes thereby an incentive for companies to cooperate with both higher education institutions and research institutes. Actors such as the Confederation of Norwegian Enterprise (NHO) have suggested a similar tax deduction scheme for companies' investments in continuing education and competence development (so called "CompetenceFUNN"), but as of yet, this initiative has not been developed further.

Commercialisation of research

RCN also administers the programme on Commercialising R&D Results (FORNY2020) which is the main policy instrument supporting commercialisation of publicly-funded research. It supports the early phases of the commercialisation process, in particular proof of concept and cooperates with technology transfer offices. The Government (the Ministry of Trade, Industry and Fisheries) has increased the funding of the programme substantially the past years, and in the Fiscal budget for 2016 the Government proposes a new arrangement for stipends to students and PhDs who engage in entrepreneurship.

Regional programmes

Regional Research Funds (RFF) were established in 2010 in order to promote R&D for regional innovation and development. A core aim has been to strengthen the collaboration between HEIs, public research organisations, local industry and public institutions. A fund of €0.8bn was set aside for this purpose, from which the annual yield was divided between seven regions, each with its own independent research board. The funding has recently been included as an ordinary allocation in the Fiscal budget, without altering the size and purpose of the programme.

The Programme for Regional R&D and Innovation (VRI) is the RCN's main support scheme for regional development. The programme is designed to promote regional collaboration between industry, R&D institutions and the public sector. The programme is also expected to establish links to other network and innovation measures such as the Arena programme, Norwegian Centres of Expertise (NCE), see further description below. The VRI scheme is now running towards its end, but the RCN is about to develop a new strategy for regional innovation, where the links between education, research and innovation are expected to play a more central role.

Research-education dimension

The so-called Centre for excellent education (SFU) scheme is the only instrument in the overview above that primarily aims at strengthening the link between higher education and research. The scheme was introduced in 2011 with the main purpose of increasing the quality in higher education, raising the status of teaching among academic staff and strengthening the link between research and education. At present, four centres have been selected as SFUs for a period of five years.

Education- innovation dimension

"Competence development in regional industry", administrated by Innovation Norway, is the only programme in the overview that supports strategic cooperation between regional industrial actors, HEIs and vocational schools to develop study programmes and continuing learning courses addressing the competence needs of the industrial actors. The programme was introduced in 2013 and is relatively small, but it reports great interests from both HEIs and firms.

Research-education-innovation dimension

Competence building

The RCN also administrates programmes which support the interplay between research, innovation and education. These address primarily fields characterised by practice-based learning such as education and health, but also competence building through the relatively large project category Knowledge-building projects for industry (KPN).

The RCN administrates programmes for Health, care and welfare services research (HELSEVEL) and Research and innovation in the Educational sector (FINNUT), and both include an integrated approach to linking education, research and innovation. They are relatively large programmes with annual budgets of respectively €14.4m and €9.7m.

Cluster schemes

Since the early 2000s, a series of cluster programmes has been in place to strengthen collaborative R&D and innovation activities in clusters. The goal is to increase the cluster dynamics and attractiveness, the individual company's innovativeness and competitiveness. The programme is organised by Innovation Norway, and supported by Siva (The Industrial Development Corporation of Norway) and the RCN. The cluster-programmes have four strategic priority areas:

- *Cluster development*
- *Knowledge cooperation*; develop cooperation with national and international HEIs and other public research organisations on research, development and education
- *Innovation cooperation*; cooperation projects between cluster members
- *Cluster to cluster cooperation*; cooperation across sectors and technology areas nationally and internationally

In 2014, the existing cluster programmes were organised under the umbrella “Norwegian Innovation Clusters”, comprising public support to clusters on three levels:

- *Arena*: These are immature clusters in an early phase, with different preconditions and potential. They can be small or large, and the participants can be in a regional, national or international position. Arena funding is provided for 3-5 years.
- *Norwegian Centres of Expertise (NCE)*. These are mature clusters with an established national position. Clusters should have established a systematic collaboration and have developed dynamic relations with high interaction and a broad strategic action area. Within their respective sectors or technology areas, the clusters should have a strong national position and include partners with strong international ambitions. NCE funding is provided for 10 years.
- *Global Centres of Expertise (GCE)*. These are mature clusters with a global position. GCE clusters should have established systematic collaboration and dynamic relations with high interaction and a broad strategic action area. They should also have considerable potential for growth in national and international markets. So far, three clusters have been granted the status of GCE. GCE funding is also provided for 10 years.

The cluster schemes integrate KT practices, and the long term funding provides, as the case studies show, the opportunity for clusters to develop and institutionalise cooperation structures on education, research and innovation.

2.3.2 Key observations

The majority of the funding instruments predominantly support the interaction between research and innovation in terms of number and budgets. However, in the last five years we have seen the introduction of new programmes promoting the interlinkages between education and research/innovation. Thus, one may claim that education is entering the agenda.

NOKUT and Innovation Norway administer the two new programmes that in particular are devoted to education and research/innovation, the RCN administers the programmes supporting the research-

innovation dimension, while Innovation Norway and the RCN administer programmes supporting KT activities. As such, we may speak of silos in terms of responsibility for orchestrating interactions between the three corners of the triangle. However, informants report that there are coordinating mechanisms between the agencies, but that these are primarily at the top-level and to a lesser extent at the programme level – except for the cluster schemes where all agencies but NOKUT are involved. There is as such potential for better coordination.

2.4 The higher education sector in the knowledge triangle

In addition to the competitive national mechanisms described above, a number of instruments and mechanisms within the higher education sector are relevant for the realisation of triangle policies. The following sections give a brief overview of the higher education sector and highlights some aspects of particular relevance for triangle policies.

2.4.1 The sector's composition, goals and governance arrangements

In 2013, Norway had 50 higher education institutions, whereof eight universities, nine specialised university colleges, 20 state university colleges, nine private colleges, two academies of art and a police academy.⁶ State-owned HEIs dominate the landscape, and the private institutions are relatively small, except for the BI Norwegian Business School. Table 4 provides an overview of the higher education sector. This landscape is in a process of change, with several ongoing and recently accomplished mergers. Per January 2016, the number of HEIs is 38.

Table 4 Higher Education Institutions: location, R&D, scientific staff and student number

Institution type	Number of institutions	R&D Expenditure (mnok)	Total academic staff***	Total students enrolled
Universities	8	10,618.2	12294	106,349
State university colleges	20	1,412.7	5589	93,827
Specialized university colleges *	11	823.1	1334	34,401
Private colleges	9	x	454**	10,036
Academy of the arts	2	x	145	860
Total	50	12,854	19816	245,473

Source: ETER-data 2013

* missing information for four institutions, includes The Norwegian Police University College and the Norwegian Defence University College

**Private colleges academic: missing for two

***Includes personnel with 40% or more employment percentage and PhD students

X= data not available

In 2013, there were 245,473 registered students at higher education programmes in Norway. Since 2000, the number of students has increased by 28 per cent.⁷ The universities educate 43 per cent of the students, while the state university colleges educate 38 per cent, and the universities employ the majority of scientific staff – almost two thirds. There is thus a division in the system; most R&D resources in the HEI sector are concentrated in universities, while the state university colleges play a main role in providing higher education for specific professions, and/or according to regional needs. This relates to the historical mandate of the university colleges, which was to offer education and

⁶ Latest figures from ETER data.

⁷ DBH

contribute to regional development. Several R&D-intensive state colleges have attained university status during the last few years, thus increasing the concentration of HEI R&D resources within the universities. This means that the framework conditions for developing knowledge triangle practices vary between different types of institutions.

Mandate of the higher education institutions: ambitions to develop KT links?

Research, education and innovation are all legally-defined goals of public higher education institutions in Norway. There is a goal that research and education should strengthen each other, coined in the concept of research-based education, defined as a key obligation in higher education institutions by law in 1995. To strengthen the link between research and innovation, the so-called, "third mission" was added to the state-owned HEIs' tasks alongside education and research in 2003. The law amendment stated that universities and colleges have a responsibility to disseminate results of their activities and to develop understanding for, and the use of, methods and results in science. Further, it is stated that universities and colleges shall collaborate with industry and society at large. To incentivise the HEIs, the so-called professors' privilege was removed, and the right to exploit research results commercially was transferred from the individual scientific staff to the HEIs, making them responsible for commercialisation of research results, and emphasising the role of HEIs in economic development.

It is worth noting that studies of commercialisation activities show that these make up a marginal part of Norwegian academics' activities (Thune et al. 2015). Despite this fact, commercialisation, and more specifically technology transfer, has been given disproportionate attention in policy.

Governance of higher education institutions – increased focus on external linkages

There are two alternative governance models in Norwegian state-owned HEIs: one model where the rector is elected and functions as the chairman of the board; and the other model where the rector is appointed, and the chairman of the board is an external representative.

The boards of HEIs have a minimum of eleven members, representing scientific, technical, and administrative staff; students; and external society and working life. The share of external representation has increased over the past two decades, and in 2005 it was established by law that all boards should have four external members. The argument behind this development was to professionalise the boards, as well as to strengthen the links between HEIs and industry and society at large (Stensaker et al. 2013).

The four external board members are as a rule appointed by the Ministry of Education and Research, with the exception of university colleges, where county authorities are responsible for appointing two of the members. The reason for assigning this role to the county authorities has been explicitly to link the institutions closer to regional needs and strengthen their role in regional knowledge-based development.⁸ As part of the Structural reform, the Ministry proposed changes in the current governance structures: the model with an appointed rector and external chairman of the board is to be the rule, and all external board members are to be appointed by the Ministry.

In order to strengthen the interaction between HEIs and industry and the public sector, the Ministry has also initiated the establishment of councils for collaboration with working life (RSA). All HEIs are now obliged to have an RSA with the mandate to ensure relevance in education. This new steering structure and the mandatory external board representation are signs of an increased focus on opening up HEIs, to ensure their relevance and to strengthen their linkages to society.

2.4.2 Funding of higher education

Funding of Higher education institutions in Norway is almost exclusively a central state matter. In total, the public funds 90 per cent of Norwegian HEIs' R&D expenditure. This includes general university grants (GU) allocated from the state budget, which in total make up 75-80 per cent of the HEIs' funding and covers expenses related to e.g. administration, education and research. The GU have two

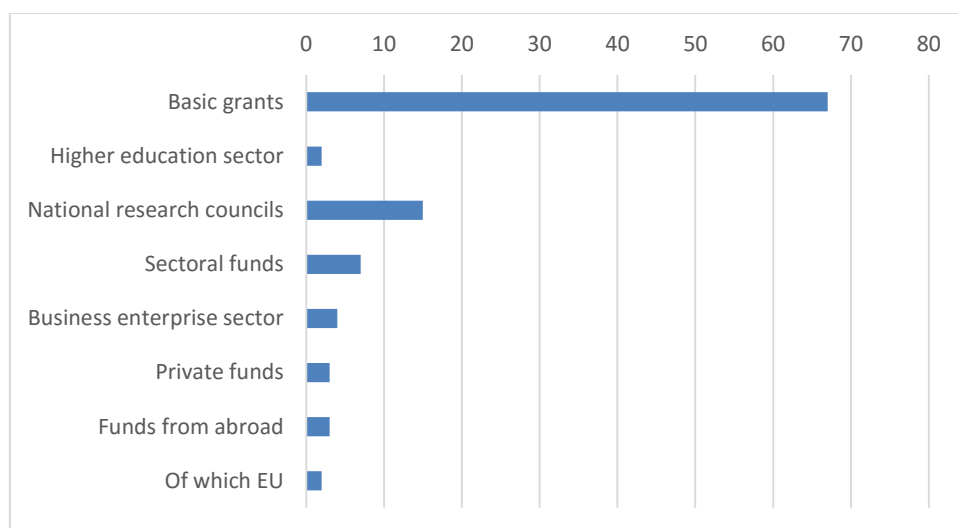
⁸ Meld.St. 18 (2014-2015) *Konsentrasjon for kvalitet – Strukturreformen i universitets- og høyskolesektoren*

components: basic funding in the form of long-term and strategic funds, and performance-based funding. In 2015, basic funding accounted for ca. 70 per cent and performance-based funding for ca. 30 per cent. Performance-based funding is allocated according to a set of indicators – the so-called education and research incentives. There are currently no incentives for innovation-related activities in the funding model, but income from contract research and education will be introduced as a performance indicator from 2017.

The GU comes in the form of block-funding which the HEIs distribute to specific activities. As described above, around 30 per cent is allocated according to a set of performance indicators, but technically the block funding is supposed to be treated as one funding stream. How much each institution dedicates to research and education depends as such upon the institutions' traditions, profile, academic fields and other available funding (Langfeldt et al. 2015).

In terms of total *R&D expenditure* in HEIs, block-funding makes up 67 per cent (see Figure 2). Compared with other Scandinavian countries this is relatively high; Sweden's basic university grants amount to 45 per cent and Denmark's to 57 per cent of the total funding in the HEI sector (Wendt et al. 2015).

Figure 2 Share of higher education R&D expenditure (HERD), by source of funding: 2013 (%)



Source: Wendt et al. 2015

The second most important funding source for HEIs are grants from the RCN, accounting for 15 per cent of total R&D expenditure to HEIs. The figure further shows that few private trusts and foundations fund research, around three per cent of total R&D expenditure of HEIs. This is mostly due to historical reasons. Throughout history, Norway has had fewer wealthy capitalists and large family-run companies with sufficient financial resources to establish funds of a certain size and importance. As the table also shows, the business enterprise sector finances a rather small share of total R&D spending in the higher education sector. Industry funding of higher education institutions has always been rather moderate in Norway, accounting for around 5 per cent of total R&D expenditure in the sector. Despite a general increase in industry funding over the last few years, the share has decreased to 4 per cent. This is a result of public funding of HEIs over the past years having increased more than funding from industry (Spilling et al. 2014). Furthermore, Norwegian HEIs have relatively low levels of funding from abroad, and increased funding from international sources, especially EU, has been on the political agenda for a while. R&D funding from EU sources is thus one of the criteria included in the performance-based funding model.

2.4.3 Interactions between HEIs and other sectors

In this section, we will draw upon available data on the extent to which HEIs collaborate with external organisations (particularly industry), and the extent to which they promote third mission activities, including research commercialisation. As seen above, there is limited industry funding of R&D in the public HEIs, but that does not imply that there is a low level of interaction. There are a range of available data sources on the interaction between HEIs and in Norway, and the below presentation is based on a few selected sources.

The degree of interaction between industry and public higher education institutions

Every second year, Statistics Norway performs the Community Innovation Survey (until 2014 this survey has been combined with the R&D survey). The survey targets all firms with more than 50 employees and a selection of firms with less than 50 employees (down to 10). Results of the survey show that there are fewer firms in 2012 (27.4%) with innovation activity compared to 2008 (35.8%) (Table 6). One potential explanation is the effect of the financial crises.

Table 6 Firms with innovation activity, firms with innovation activity, firms with innovation collaboration and firms with innovation collaboration with HEIs (%)

	2004	2006	2008	2010	2012
Firms with innovation activity	31,0	29,6	35,8	28,4	27,4
Firms with innovation cooperation – share of					
- all firms	10,4	13,1	13,1	8,7	8,2
- firms with innovation activity	33,4	44,3	36,7	30,6	29,9
Firms with innovation cooperation with HEIs – share of					
- all firms	3,7	5,1	4,3	3,5	3,4
- firms with innovation activity	11,9	17,2	11,9	12,2	12,4
- firms with innovation cooperation	35,8	38,7	32,5	40,0	41,6

Source: *Spilling et al. 2015*

However, the share of firms with innovation collaboration with HEIs has been relatively stable in the same period. On average, 3-4 per cent of all firms and 12 per cent of firms with innovation activity (17 in 2006) report cooperation with HEIs. Of firms that report collaboration with other actors on innovation, the share of firms which collaborate with HEIs has increased from 2004 to 2012. Despite the low level of cooperation, HEIs seem to be become a more attractive partner for firms in terms of innovation cooperation.

Data from firms' participation in the R&D tax incentive scheme (SkatteFUNN) confirms this image. The scheme supports business R&D, but also provides an incentive for firms to collaborate with public research organisations on R&D, which increase the total level of tax deduction. Data from 2014 indicate that 28 per cent of all SkatteFUNN projects included cooperation in terms of purchase of external R&D from R&D institutions. Among these "collaborative projects", research institutes stand out as the most frequent partner, accounting for just above 50 per cent of all collaborative projects. Norwegian universities and university colleges are also involved in 30 per cent of the SkatteFUNN projects. This pattern reflects the traditional division of labour in the Norwegian research and innovation system, where technical research institutes have played an important role as R&D partner and knowledge broker for Norwegian industry.

External engagement by Norwegian academics

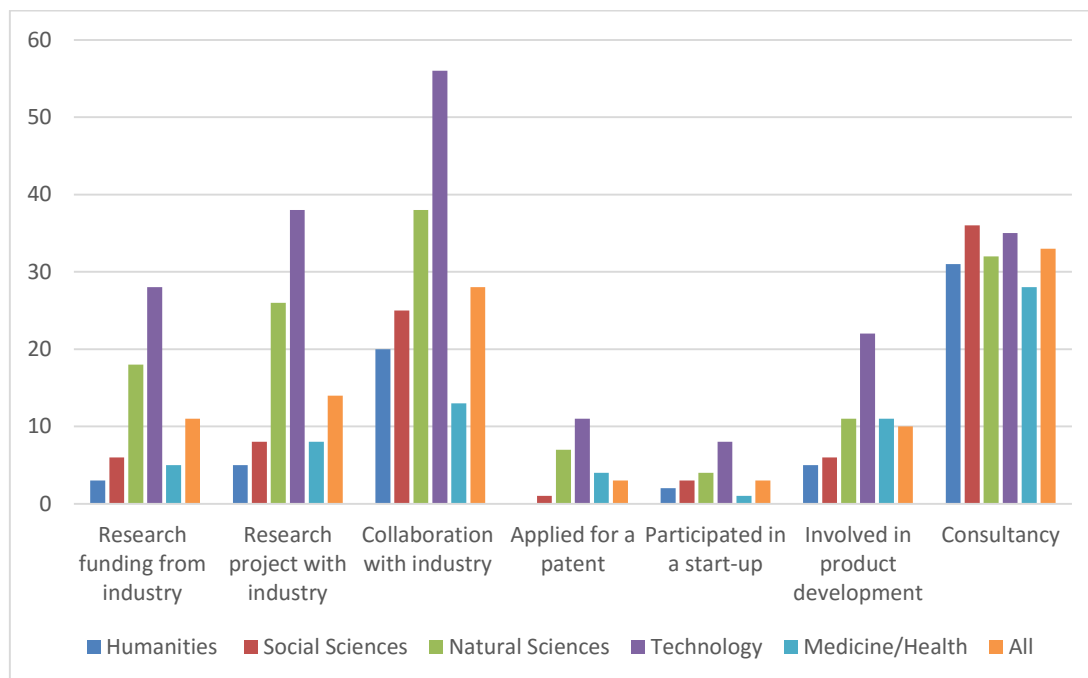
A relatively recent survey among Norwegian scientific staff in all public higher education institutions also confirms the overall pattern described above (Thune et al, 2014).⁹ Only a minority (ca 7-8 per cent) of the staff report research collaboration with private industry. However, approximately 30 per

⁹ The survey was sent out to all scientific staff at Norwegian HEIs and had a response rate of 52.5 per cent

cent report collaboration with the public sector (primarily continuing education) and 17 per cent with health trusts. This underlines the importance of including a broader spectrum of partners when studying collaboration patterns.

Results from the survey further shows that collaboration with industry, commercialisation practices and consultancy varies between disciplinary fields (Figure 3)

Figure 3 Share of researchers in HEIs engaged in collaboration and commercialisation activities the past three years since 2013



Source: Thune et al. 2014

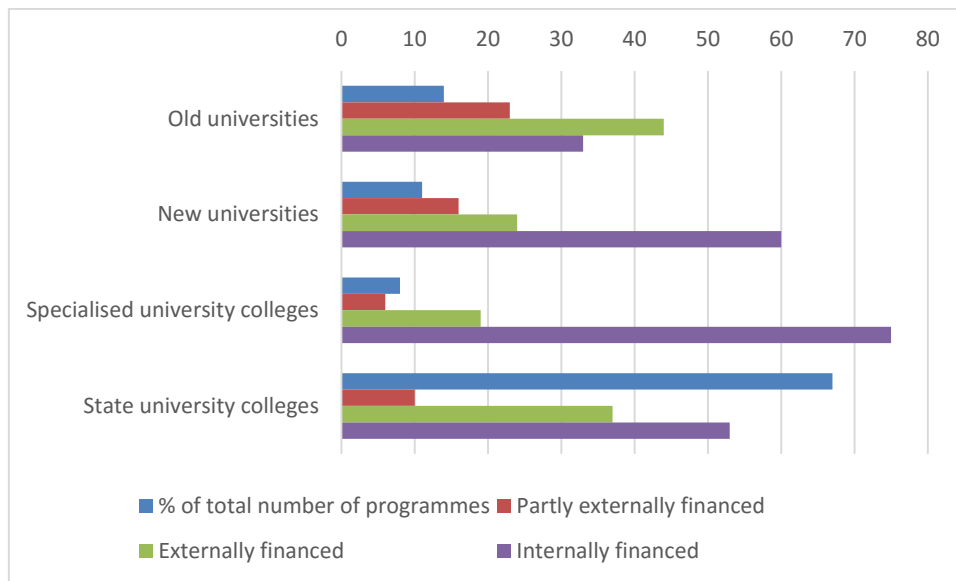
As the figure shows, there is considerable variation between different scientific fields. Researchers in the field of natural sciences and technology have substantially more research collaboration with industry compared with the other disciplines. Note that funding from industry is not included in the category “collaboration with industry”. The table further shows that few researchers report patenting or start-up activities, on average 3 per cent, while 10 per cent and approximately one quarter of the respondents within the field of technology have contributed to product development. In all fields, approximately one third of the respondents have acted as scientific advisors or consultants to external actors.

The survey also asked the academics to report on whether they participated in different kinds of external knowledge exchange activities. The survey reveals that almost all academics disseminate their research (78%), and that participating in training and education related events are common forms of transferring knowledge to external audiences (59% of respondents). Participating in research commercialisation and research collaboration funded by industry are the two least frequent forms of interactions with external audiences. This is interesting when considering that these two activities are used as indicators on HEIs’ innovativeness (see below).

Continuing education as a platform for knowledge exchange?

The national survey shows that approximately 44 per cent of all scientific staff report knowledge dissemination through continuing education programmes. Funding of continuing education programmes can also serve as an indicator on HEIs interaction with other sectors. Figure 4 presents an overview of the funding of continued education in the different types of HEIs.

Figure 4 The different HEIs share of and types of funding of continuing education in 2014, percentage



Source: NSD/DBH

As the figure shows, state university colleges are the major sites for continuing education activities, with 67 per cent of all programmes. Of these programmes, 37 per cent were fully funded by external partners.

Continuing education as a mechanism for cooperation between HEIs and working life has received relatively little attention in Norway, and a recent study shows that reporting practices are weak, perhaps due to a conceptual confusion over the term “continuing education” (Tømte et al. 2015). The study also shows that HEIs report that cooperation with the public sector and especially industry sector on the development of continuing education programmes are resource-demanding in terms of time and funding. In addition, cooperation with industry may be subject to market failures and therefore HEIs see cooperation as somewhat risky.

2.4.4 Key observations

The ongoing consolidations in the higher education system, the mandate of HEIs and the attention to developing external linkages in the governance structures, show that the Government has an increased focus on developing KT linkages between HEIs and society.

However, when it comes to funding HEIs, the knowledge triangle is not included. The HEIs have a relatively high level of general university grants and as such a high level of autonomy, but funding from industry and other funding sources are scarce. The performance based part of the general university grants remunerates primarily education and research activities, but from 2017 an indicator on external funding and contract research is included to incentivise increased cooperation between HEIs and the public/industry.

In general, the Norwegian HEI sector shows relatively little direct interaction with industry. On the other hand, cross-sectoral interaction is relatively high between HEIs and the public sector. There is also great variation between scientific fields. In particular, we find considerably more interaction between HEIs and other actors in the fields of science and technology. Data further show that interaction patterns other than industry cooperation and commercialisation are predominant – two examples being continuing education and consultancy. While Norway has considerable data on the research-innovation dimension, less is available concerning the role of education.

2.5 Evaluation and human resource policies in research and higher education – do they support knowledge triangle perspectives?

2.5.1 Evaluation of HEIs by the Ministry of Education and Research

Ownership and reporting structures of HEIs may affect triangle activities. The majority of Norwegian HEIs are state-owned and are subject to the governance of the Ministry of Education and Research (MER). The MER mainly governs HEIs through a well-established system of annual written reports and steering dialogues with the HEIs' boards. The direct communication between MER and HEIs is seen as efficient as there are no other administrative parties involved. The MER calculates the general university grants and sets goals and demands for the grants for each institution. Each year the MER develops a "state report" based on data collected from HEI reports to the official database for higher education. Together with the HEIs' annual reports, these data constitute the background material for the annual steering meetings.

The HEIs report on four general sector level goals: 1) high quality in education and research; 2) Research and education for welfare, value creation and development; 3) Good access to education; and 4) An efficient, manifold and solid higher education and research system. Number two points especially to KT activities. Overall, the sector goals of 2016 show an increased focus on quality and relevance of education programmes, thus indicating a change towards qualitative measures alongside the traditional quantitative ones (number of students etc.).

The reporting includes indicators on the quality of research and education, internationalisation, and on commercialisation and cooperation with industry/the public sector. Only a few of these indicators and reports are included in the performance-based funding model, and these emphasise primarily education and research. Although the KT perspective is underlined as an important aspect in current policies, we find so far little evidence that this has been implemented in the reporting and funding system.

However, the institutions give a qualitative description of their cooperation with industry and the society at large in their annual reports, and this is also addressed in the steering dialogue. As such, this is also an important part of the reporting but is not yet incentivised financially.

A recent Norwegian Official Report (Gjerdrem et al. 2016) states that Norwegian HEIs have a high level of autonomy when it comes to dimension (student number etc.), programmes and scientific content, but a low level of autonomy when it comes to economy and personnel management. The latter is, amongst others, due to regulations concerning civil servants, public administration act and restrictions regarding HEIs' access to private loans for financing large investments in infrastructure etc. The regulations are seen as limiting the institutions' opportunities to develop attractive career paths and make long term investments. Nevertheless, concrete suggestions of changing the legal status of HEIs to private entities have been strongly rejected by the academic community, notably through the relatively massive opposition against a proposition forwarded by the so-called Ryssdal committee in 2003 (NOU 2003:25).

2.5.2 Quality assurance practices in HEIs

"Triangle-approaches" to education of bachelor's, master's and PhDs are further evident in the Norwegian qualifications framework for lifelong learning (NQF), administrated by NOKUT. The framework describes what the students should have learned. Although most qualifications included in the framework relate to academic and methodological skills, a cluster of more generic skills is included, hereof communication and dissemination skills as well as one qualification directly related to "new thinking and innovation processes".

This means that the qualification framework in principle includes criteria that are relevant to triangle policies. The question is however how this framework will be used and followed up in practice, both at the national and the institutional level. The Ministry of Education and Research is now in the process of adopting the NQF into Norwegian law as a regulation. At a later stage, the NQF is to be used as a transparency tool for comparison of Norwegian qualifications with qualifications from other countries.

2.5.3 The Research Council's evaluation practices

Currently there are tendencies towards increased coordination between the intermediary agencies when it comes to evaluating disciplinary or subject specific research. As part of its mandate, RCN is responsible for carrying out evaluations of Norwegian research, with a focus on institutions, programmes and mechanisms and research disciplines. The latter category is mainly based on peer review by international panels of experts, and have traditionally been focused on research quality. National evaluation practices are changing and increasingly including assessments of knowledge triangle interaction, both between research and society and between research and education. For instance, in the ongoing evaluation of the humanities – which started up the autumn of 2015 – it is a central objective to develop and test new methods for documenting and assessing the impact of research within this field.

The humanities evaluation is also the first to assess the interplay between education and research in higher education institutions, and NOKUT and the RCN are currently cooperating on developing an evaluation model that combines education and research.

2.5.4 Recruitment and career policies for academic staff

Academic career systems may have positive and negative impacts on the realisation of triangle policies. MER has established a set of national criteria for appointment and promotion to teaching and research posts in the higher education sector.¹⁰ In order to incentivise the institutions to develop career strategies and policies, MER has since 2015 given the institutions greater freedom to define and add other criteria for individual positions.

The national appointment and promotion criteria are centred on traditional academic qualifications, and appointment to the posts of professor and associated professor are based on scientific merit and documented competence in teaching theory and practice. Only for the post of “dosent”, an education-oriented professor post that is most common in university colleges and the new universities, do the appointment criteria include “third mission” activities. In addition to experience from education and research, which is a requirement, extensive education and research cooperation with industry and civil society, or professional experience from these fields may qualify for appointment

In general, academic staff at Norwegian universities and university colleges are expected to engage in R&D activities, education as well as dissemination and innovation. The balance between these missions may, however, vary between individual researchers, academic positions and the different phases of each academic career. Although Norwegian doctorate holders seem to maintain a very high rate of employment (99%), a number of career challenges are under consideration, some of which are directly related to triangle policies:

- Despite a strong increase in the number of doctorate holders during the last decades, the mobility of Norwegian researchers between institutions and in particular between sectors seems relatively low (Forskningsbarometeret, 2014). At the same time, recent research demonstrates that researchers with work experience from outside academia have a high propensity to engage in external relations and attract third party funding (Thune et al., 2014). Increasing the cross-sectoral mobility of researchers is therefore an issue.

¹⁰ Regulations concerning appointment to teaching and research posts, URL: https://www.regjeringen.no/globalassets/upload/kd/vedlegg/uh/forskrifter/regulation_concerning_appointment_promotion_teaching_research_posts.pdf

- The Norwegian PhD education received a rather positive evaluation in 2012, but the evaluation also addressed the need to strengthen the generic parts of the education and consider measures to better prepare future PhD candidates to careers outside academia, especially if the expansion of doctorate holders continues (Thune et al., 2012). A more recent report from the Norwegian Association of Higher Education Institutions (UHR) also raised a worry that PhD candidates following research intensive three-year tracks may risk getting too little experience with education (UHR, 2015).
- Another issue raised in the same UHR-report concerns the lacking engagement in education in post.doc and other “intermediary positions” qualifying for fixed term employment. As qualification to permanent academic positions is mainly based on academic achievements, post.docs tend to be little engaged in activities other than their own research (UHR, 2015).

In general, there seems to be a need for better career systems and traditions for rewarding achievements related to education and external relations/innovation. The report from UHR emphasises that they see the need for career clear strategies for recruiting and rewarding researchers that are able to combine both R&D, education and innovation. Among the existing initiatives are:

- Establishment and strengthening of the Industry PhD and Public sector PhD schemes (see above).
- Since 2008, a national scheme for so-called researcher schools has been in place. The scheme is administered by the Research Council. The aim is to promote recruitment of PhDs, improve the completion of degrees and enhance the internationalisation of researcher training. The schools also provide an opportunity to better integrate the triangle perspective in researcher training. At present 15 schools are active.

The government is currently working on a white paper on quality in higher education, to be presented in 2017. This process will provide an opportunity to integrate these and other initiatives in official policy processes.

2.5.5 Key observations

State-owned HEIs are subject to the governance of the Ministry of Education and Research. They are evaluated on a broad spectrum of goals and indicators concerning education, research, internationalisation and interaction with society. However, only accountable activities related to education and research are incentivised through performance-based funding. There is, nevertheless, development towards increased emphasis on the quality and the relevance of the education programmes. There is also more attention on HEIs’ broader social role and impact.

New evaluation practices of scientific fields are under development and they include, apart from traditional academic quality criteria, the impact of research and the interplay between research and education. There is an increased emphasis on developing assessments of scientific fields which capture knowledge triangle interactions.

Developing recruitment and career policies that include education and innovation is also on the agenda.

2.6 Conclusion

The above shows that at the policy level, there are many initiatives to develop interlinkages between education, research and innovation, but while the intentions are good, there is a considerable gap between the intentions and the current system. Below we summarise the findings from this chapter in a figure pointing out the strengths and weaknesses concerning knowledge triangle initiatives and activities on the national level.

Figure 5 Strengths and weaknesses concerning the knowledge triangle on the national level

Strengths	Weaknesses
Interaction between key actors	
<ul style="list-style-type: none"> • Strong vertical coordination between Ministries and implementing agencies • RCN has a broad mandate that includes innovation and research • RCN coordinate across sectors 	<ul style="list-style-type: none"> • Weak horizontal coordination on the level of the Ministries • Too many provisions on funding from the Ministries to the implementing agencies
Strategies and policies	
<ul style="list-style-type: none"> • Recently increased attention on KT activities, especially the link between education and research/innovation • Integrated approach to KT activities in sector strategies (e.g. health) 	<ul style="list-style-type: none"> • Has been a focus on developing the linkage between research and innovation, primarily on formal industry-HEI research cooperation and commercialisation of research – activities performed by relatively few of the scientific staff • Few strategies for broader types of knowledge and technology transfer
Funding of HEIs and funding programmes	
<ul style="list-style-type: none"> • Many programmes, administrated by the implementing agencies, support the link between research and innovation, increased tendency to include education 	<ul style="list-style-type: none"> • Performance-based share of general university funding rewards primarily education and research • Low funding from other sources, i.e. industry, private funds, international funding
Structure, mandate, governance and interaction patterns	
<ul style="list-style-type: none"> • Consolidations in the system between universities and university colleges, a focus on increased quality in research, education and innovation • New governance structures for strengthening external linkages between HEIs and society • Relatively high interaction between HEIs and the public sector (including health) • Manifold channels of interactions between HEIs and society, these are however understudied and few data are available – especially on education 	<ul style="list-style-type: none"> • Low research cooperation between HEIs and industry • Low participation of scientific staff in commercialisation activities, however many do consultancy
Evaluation and human resource policies	
<ul style="list-style-type: none"> • Recently increased attention on quality and relevance of research and education, previously performance mainly measured • Tendencies to explore new criteria for recruitment and career tracks • Development of new practices for evaluating scientific fields, inclusion of the interplay between research and education and the impact of research 	<ul style="list-style-type: none"> • HEIs' reporting to the Ministry includes few indicators on innovation, primarily focus on external funding and commercialisation activities. • Criteria for recruitment and career tracks focus primarily on academic qualifications

3 The knowledge triangle: institutional case studies

In the following, we present the three institutional case studies:

- The comprehensive university: University of Tromsø (UiT) - The Arctic University of Norway, located in the Northern Norway
- The technical university: The Norwegian University of Science and Technology (NTNU), located in Mid Norway
- The regional university college: Buskerud and Vestfold University College, located in the South of Norway

The three institutions vary in terms of R&D expenditure and size. In order to provide a picture of the differences between them, table 7 gives an overview.

Table 7 General university grants, R&D Expenditure sources, 2013 (MNOK), academic staff and students (2013)

Institution	General university grants*	Total R&D expenditure	Block funding (% of total R&D)	External sources	Academic staff	Students
UiT	2,024	1,221	67.5	32.5	1,493	10,398
NTNU	3,676	2,876	51	49	3,046	22,935
HBV	769	157	62	38	507	9,103

Source: NIFU R&D statistics and Ministry of Education and Research

*2015

As seen above, the technical university NTNU is by far larger than the two others, and in particular the university college HBV. NTNU also have the highest share of external sources of R&D expenditure, while UiT has in general high public funding.

We will first present each case study, then summarise the main findings and conclude.

3.1 Case study of a comprehensive university: UiT The Arctic University of Norway

3.1.1 Central level

Institutional profile

UiT The Arctic University of Norway is a state-owned comprehensive university located in Northern Norway. The institution was established as the University of Tromsø (UiT) in 1968, with an explicit political mandate to contribute to education and access to a qualified workforce in the Northern region of Norway. The region makes up around one third of the country, and is characterised by a relatively sparse population and industry based on natural resources.

In 2009, the University of Tromsø merged with the University College of Tromsø and was renamed UiT The Arctic University of Norway. Subsequently, mergers with three other university colleges in the region have taken place,¹¹ making UiT a multi-campus university located in all the three Northern counties of Nordland, Troms and Finnmark.

UiT is a comprehensive university covering the major academic disciplines. With the mergers with university colleges, there has been a strengthening of profession-oriented areas of study such as technology, health, social care and welfare.

The adoption of the name “The Arctic University of Norway” in 2009 highlights the central role the location in the High North plays in shaping UiT’s academic profile, and key research areas include the polar environment, climate research, indigenous people, telemedicine, space physics, fishery science, and marine bioprospecting.¹² The university is the largest institution for education and research in Northern Norway, and has from the time of establishment had close ties to the public sector in the region and contributed to the development of public health and welfare services. Ties to local and regional industry are less strong, reflecting for a large part that the industrial sector is characterised by small companies with low R&D intensity.

UiT is governed by a Board with five¹³ external members, and has an elected rector serving as the chairman of the board. In addition to the rector, the rectorate is made up of two pro-rectors, for education and research and development respectively, and one vice-rector for regional development.

Knowledge triangle policies and instruments

The central strategy of UiT¹⁴ covers all three areas of education, research, and innovation, and has a clear focus on developing and strengthening links between the areas, but it does not explicitly refer to KT. UiT defines itself as a research university committed to developing knowledge and human capital that will contribute to economic, cultural and social development in the High North. This involves offering research-based and innovative education of relevance to industry and working life; engaging in commercialisation and research and innovation collaboration with applied research institutes and industry; and carrying out research in areas of relevance to the region. The thematic priorities range from areas that are highly relevant for regional business development, such as energy production and the sustainable use of marine resources, to areas of key importance for developing and improving public health and welfare services.

¹¹ UiT merged with the University College of Finnmark in August 2013, and with the university colleges of Narvik and Harstad on January 1st 2016.

¹² UiT web pages, URL: https://en.uit.no/om/art?p_document_id=343547&dim=179040

¹³ As of January 1st 2016.

¹⁴ Strategic plan for UiT The Arctic University of Norway 2014-2020, URL: https://en.uit.no/om/art?p_document_id=377752&dim=179033

Cooperation with industry and working life

Several initiatives have been made to strengthen cooperation with industry and working life. UiT has developed a separate strategy within this area, and established a Council for cooperation with working life (RSA). However, according to our informants, the Council has little practical significance for the faculties. A main criticism is that it as a central level unit is not able to effectively deal with the great variety in collaborative partners and types of interaction across different faculties and disciplinary fields. This suggests that it may be more effective to have strategic cooperative bodies with industry and working life at lower levels in the organisation.

A Centre for career and working life was established in 2013 as a central support and coordinating unit. Profession-oriented educational programmes that involve practical training have long traditions for cooperating closely with working life, and the Centre aims to strengthen cooperation also in other fields of education, e.g. through internship agreements, industry involvement in bachelor's and master's theses, and continuing education.¹⁵ In 2015, UiT established an annual seminar – the P.F. Hjort seminar, named after the first rector who was a strong proponent of the university's responsibility for engaging with the community and promoting societal development. The seminar is an arena for discussion of how linkages between UiT and industry and working life can be strengthened and contribute further to value creation in Northern Norway.

Another relatively new initiative to strengthen interaction with industry is the “Industry professor”, which is an adjunct position dedicated to persons from industry that can contribute in education (lectures, supervision). The industry professors do not need academic qualifications. UiT administers the professoriates, and the Research Council's programme VRI (Regional innovation)¹⁶ finances the positions. Currently UiT has nine industry professors. The same programme also supports student mobility, i.e. they cover travel and stay expenses for students that cooperate with industry.

Innovation infrastructure

Norinova Technology Transfer (NTT) is the TTO for UiT and the University Hospital of Northern Norway (UNN). The TTO also offers incubation services, and is located in the Research Park not far from the university main campus. Our informants expressed great contentment with the services provided by Norinova, and the support structures for commercialisation. Marine biotechnology is a central area for commercialisation of research, and the counties of Nordland and Troms, together with the Ministry of Trade, Industry and Fisheries, support the MABIT programme, which finances R&D projects with commercial potential.

In collaboration with Norinova and other actors involved in promoting innovation in the region, UiT runs a web portal for information about innovation support.¹⁷ The portal is a resource for actors within research, industry and policy, and was created as part of a broader effort to strengthen industry-oriented R&D in Northern Norway through cross-sectoral cooperation.¹⁸

Entrepreneurship and innovation in education

Entrepreneurship education is offered through the master's programme Business Creation and Entrepreneurship at the School of Business and Economics. The programme is open for students holding a bachelor's degree within several different subjects and disciplines, and includes teaching from academic staff and business sector representatives, as well as practical training in developing entrepreneurial ideas or innovation projects. The students can choose to work with research results that have been reported to and evaluated by Norinova, and the TTO will assist them in the process.¹⁹

¹⁵ *UiT Annual report 2014-2015*

¹⁶ <http://www.tromsfylke.no/Tjenester/Næringsutvikling/Tilskuddsordninger/VRI-TROMS/Personmobilitet>

¹⁷ <http://www.aksjonsprogrammet.no/>

¹⁸ *UiT Annual report 2014-2015*

¹⁹ *UiT Annual report 2014-2015*; the web pages of the master programme: https://en.uit.no/utdanning/program?p_document_id=270730

3.1.2 The Faculty of Health Sciences

The institutional level

The Faculty of Health Sciences (FHS) is the largest faculty at UiT in terms of staff, and the second largest in terms of students.²⁰ When UiT and the University College of Tromsø merged in 2009, FHS was established as the first integrated health science faculty in Norway, covering the traditional academic areas of medicine, dentistry, pharmacy, and psychology, as well as the shorter educational programmes within nursing, physiotherapy etc. that traditionally have been offered by the university colleges. The faculty has eight departments, which includes RKBU North – a regional centre for education and research within child welfare and mental health funded directly by two government directorates.

FHS is strongly embedded in the public health sector in Northern Norway, and has close ties to the primary and specialist healthcare services and the dental care services in the region. Interaction with the public hospitals governed by the regional health authority *Helse Nord* is especially strong, and there is a high degree of integration between the faculty and the University Hospital in Northern Norway (UNN), which is located on the university campus. *Helse Nord* is furthermore an important source of research funding for FHS. Local and regional industry plays a limited role as collaborative partner and funding source, and with the exception of funding from *Helse Nord*, national research funding seems to be more important than regional funding.

Of total R&D expenditure at FHS in 2013, 58.9 per cent was basic government funding. Other public sources, which includes funding from *Helse Nord*, accounted for 23.8 per cent. 8.6 per cent was funding from the Research Council, 1.1 per cent EU funding, and only 0.7 per cent funding from industry.²¹

Knowledge triangle policies and instruments

The strategic plan for FHS covering the period 2014-2020²² is mainly focused on education and research both in terms of overall goals and proposed strategic initiatives. Innovation is included as a thematic priority, and the faculty aims to contribute to innovation in health education as well as in healthcare services. Practice-oriented research and cooperation with the healthcare services, users, and industry aimed at product and service development, are key elements in this respect.

According to our informants, the faculty lacks a well-developed policy for innovation, but the strong focus on innovation in Horizon 2020, and increasingly also in national research programmes, has increased awareness of the need for competence and strategic initiatives in this area. At the same time, it is pointed out that there is no common understanding of what is meant by innovation at the faculty, and that the term is typically defined narrowly as commercialisation or the development of industrial technology. If a broader definition is used, which includes contributing to improvements in professional practice through interaction with the healthcare services, innovation is perceived to be at the core of what the faculty is doing. Strengthening linkages between education, research and professional practice is moreover a consistent theme in the strategic plan, however without an explicit reference to KT.

Cooperation with industry and working life

The national system for interaction between HEIs and the specialist healthcare services provides an important platform for education, research, and innovation cooperation between FHS and the public hospitals in Northern Norway. The cooperative body with *Helse Nord* which allocates the research funding the regional health authority receives from the Ministry of Health and Care Services, is said to play a major role in developing interlinkages between the faculty and the hospitals.

²⁰ based on figures for 2015, Database for Statistics on Higher Education, Norwegian Social Science Data Services

²¹ National R&D statistics, NIFU

²² The strategic plan for the Faculty of Health Sciences for the period 2014-2020 (*Helsefak 2020*)

Cooperative bodies are in place at the level of individual hospitals too, and FHS has worked systematically to develop the institutional basis for interaction with UNN. The two institutions have joint leadership meetings and joint education and research committees, which function as important arenas for regular strategic dialogue and joint initiatives.

There is furthermore extensive use of dual affiliations, through which hospital staff work at FHS and academic staff at the faculty work in the hospitals. FHS currently employs more than 300 people with main positions in the specialist healthcare services, who are said to contribute significantly to quality and relevance in the educational programmes. Dual affiliations have traditionally been most common within medicine, and FHS is working to increase the number across all health sciences/professions. The faculty has – as the pioneering faculty in Norway and in cooperation with UNN – established 30 dual affiliations for both hospital and university staff within areas other than medicine. It is an ambition to extend the initiative to the municipal primary healthcare services. However, the municipalities' lack of tradition, explicit mandate and earmarked funding for active involvement in education and research poses a challenge, both for the establishment of dual affiliations and for systematic interaction between education, research, and professional practice in the primary healthcare services more generally.

The Council for cooperation with working life (RSA) at UiT is not considered to be very visible or relevant at the faculty level – it is perceived as an advisory body mainly for the central university leadership, and to lack specific knowledge of the field of medicine and health. However, there is a regional council for health education in Northern Norway, where FHS and other health faculties in the region come together with representatives for the specialist and primary healthcare services to discuss strategic matters relating to the capacity and contents of the educational programmes.

Entrepreneurship and innovation in education

FHS has a strategic focus on innovation in education, and more specifically on developing new forms of education to meet the competence needs of the healthcare services. As an integrated health faculty, FHS places strong emphasis on so-called “cross-professional learning” in the educational programmes, and has introduced joint courses for all students with the objective to teach them how to interact and cooperate across healthcare professions. The faculty is also in the process of developing joint arenas for practical training through various pilot projects carried out in close collaboration with the healthcare services. The projects have been initiated by dedicated faculty staff as well as by actors in the healthcare services, and embedded at the faculty level. This is seen as an example of innovation in education that has been directly motivated by the needs for new types of competence in the healthcare sector following from the major national health reform, the Coordination Reform.

Governance and leadership

The close ties between FHS and the healthcare services in Northern Norway is reflected in the composition of the Faculty Board, where both UNN and a municipality in Troms County are represented. There are no industry representatives on the Board. The external representation is said to be important by bringing in stakeholder perspectives and giving broader societal legitimacy to strategic decisions. Experiences with external representation on boards at the department level are positive too, whereas the external members of the central University Board are felt to play a less important role in facilitating interaction with working life and society.

The faculty has dedicated leadership positions for education and research, but not for innovation or “third mission” activities.

Human resource policies and evaluation

FHS does not seem to have human resource policies or assessment and evaluation systems that systematically support knowledge triangle activities. Recruitment and promotion of academic staff is based primarily on academic criteria, although experience from clinical practice is considered important in professions-oriented subject areas, and industry experience is valued in areas such as pharmacy. The formal systems for internal reporting is based on the indicators in the national reporting

system of the Ministry of Education and Research, and there is no systematic collection of data on innovation activities. Yet, our informants point out that innovation-related activities and results are discussed as part of the day-to-day dialogue between the institutional leadership and academic staff.

Examples of knowledge triangle practices

Integrated education, research, and innovation cooperation with the specialist healthcare services in Northern Norway is the most prominent example of knowledge triangle practice at FHS. It includes practical training of students in the hospitals, contributions from hospital staff in teaching and supervision at the faculty, and joint research and innovation projects aimed at improving professional practice.

FHS cooperates extensively with the dental care and primary healthcare services as well, but mainly in the area of practical training, and there is less integrated knowledge triangle interaction. RKBU North engages in integrated education, research, and service development cooperation with providers of public services within the area of children's mental health and welfare, based on a direct government mandate and earmarked funding.

While cooperation with the public health and care services is the main arena for knowledge triangle activity, FHS is also engaged in commercialisation and innovation collaboration with industry, mainly in the areas of medical biology and pharmacy. FHS is the faculty at UiT with the highest number of DOFs, according to our informants, and there have been two spin-offs: the biotech company Lytix Biopharma, and D'liver which was established as a collaboration between a medical professor and a group of students in the master's programme in Business Creation and Entrepreneurship.²³ Collaborative projects with industry include a Centre for Research-based Innovation, MabCent – Marine bioactivities and drug discovery (2007-2015), and two Industrial Ph.D projects at the Department of Pharmacy. Within the area of pharmacy, innovation is closely integrated in education at both bachelor's and master's level, and the Department is actively developing master's projects with direct industrial relevance.

FHS is furthermore involved in the development of health technology in collaboration with *Helse Nord* and the Faculty of Natural Sciences and Technology at UiT, and cross-disciplinarity is generally considered to be important for innovation.

3.1.3 The Faculty of Science and Technology

Institutional profile

The Faculty of Science and Technology (FST) covers both discipline-oriented fields such as physics, chemistry and mathematics, and profession-oriented and applied fields such as informatics, technology, engineering and geology. In 2014, the faculty had 254 scientific staff and 1312 students,²⁴ and ranges as number four out of seven faculties in size. In terms of total R&D expenditure, FST accounted for 18.3 per cent of UiT's total R&D expenditure, and of this the main sources except block-funding were the RCN and industry, making up respectively 24 and 6 per cent, which are considerably more than UiT central.

The industrial structure in Northern Norway is characterised by small and medium sized enterprises, and our informants perceive it as a great challenge that local and regional industry do not have the means to finance research or educational programmes at the university. There are some larger regional and national firms in the region, and here the informants mentioned Troms Kraft (electricity company), Sparebank 1 Nord Norge (finances) and the Kongsberg Group as important cooperation partners.

²³ For more information about D'Liver (in English), see: <http://www.dliver.com/>

²⁴ www.uit.no

Troms County is a central funding source, and of particular significance is the RDA fund (Regional differentiated employer's contribution) which is a regional political instrument to increase employment in areas characterised by geographically dispersed and small industry. In 2014, the fund amounted to 127.2m NOK (ca €14m). As we will see below, the fund has contributed to establishing important infrastructure.

One informant expressed a concern regarding the Government's announcement of a reduction in regional funding. In his view, it is important to have a combination of national competitive funding and funding adjusted to the characteristic of the regions. The NORDSATSING initiative of the RCN is seen as an important programme that offered the possibility to create clusters.

Knowledge triangle policies and instruments

In its strategic plan the Faculty²⁵ emphasises innovation, education and research, and thematically it focuses on the Northern areas, including the Arctic. However, in the clarification of goals and strategies, research and development and education is described thoroughly, while innovation has received less attention. The plan pays as such little attention to the interaction between the three vertices of the triangle. This corresponds with the informants' perception that the university and the faculty perceived education and research as their main tasks.

Cooperation with industry and working life

FST and the Department of Geology has an industry-sponsored chair from Statoil, which lasts for five years, and after that UiT continues the professorship. Within the same and nearby fields FTS has 4 industry professors, and their main role is to link the research groups to industry, but also to participate in education.

Innovation infrastructure

RDA funding has, among other things, contributed to develop the Barents Bio Lab – which offers access to modern laboratories with advanced equipment for biotechnology companies, research communities and educational institutions.²⁶ The lab is located in the Research Park.

Governance and leadership

The FST has a faculty board where both the chairman of the board and the vice chairman are external representatives from respectively the research institute IRIS and Statoil. They are seen as important to ensure relevance in education and research. All of the departments also have a board, but only the Department of Informatics has external representatives. One informant was critical of the role and the authority of these boards without external representatives. The departments already report to the dean and the faculty board and thus the department boards are seen as an extra reporting layer without real authority.

The FST has one vice-dean respectively for research and education.

Human resource policies and evaluation

As FHS, FST does not seem to have human resource policies or assessment and evaluation systems that systematically support knowledge triangle activities. Recruitment and promotion of academic staff is based primarily on scientific criteria.

Examples of knowledge triangle practices

Regional funding has been important for developing KT practices. The RDA was important in the first phases of establishing the Research Centre for Arctic Petroleum Exploration,²⁷ hosted by the Department of Geology at UiT. The centre aims to create new knowledge about petroleum resources in the Arctic and to provide essential knowledge and methodology for eco-safe exploration. It will

²⁵ Faculty for science and technology (2015) Naturvitenskap og teknologi i Nord. Strategi mot 2020

²⁶ www.barents-biocentre.com

²⁷ <http://www.arcex.no/>

recruit ca 30 Ph.D and postdoctoral fellows, and has developed a master's programme in petroleum geosciences in cooperation with industrial partners.

All informants emphasised the importance of the cluster schemes, and in particular the Arena programme (early-stage clusters) which currently funds the "Mineral cluster Norway" – a cooperation between several mining companies, research institutes, and HEIs. The participants cooperate on Ph.D education, data and education. One industry professor is very central in creating the network.

The informants represented chemistry – a disciplinary field, and informatics – an applied subject, and there were rather great differences in KT practices. According to the informants, the link between innovation and education weak is especially weak in chemistry. There is considerable interaction between research and innovation, and the staff participate in collaborative funding programmes and in commercialisation – half of the department is even located in the Research Park to achieve synergies with other actors, but the field has no tradition for including the students in these activities.

In informatics, on the other hand, the KT is seen as important. The aim is to be in the international research and innovation frontier, and thus the staff, and especially the informant, has close collaboration with large international firms such as Microsoft, in addition to regional firms. One of the regional firms is a start-up from UiT, currently employing 60 people, and is a branch of Microsoft Development Centre. Given the characteristics of the field, it is seen as important to have an up-to-date education in contact with industry's research problems. However, KT practices are not institutionalised, and depend to a large extent upon the initiatives, personal engagement and networks of individual staff members.

The Centre for Research-based Innovation was underlined as an important instrument for integrating education, research and innovation, and the informant had participated in a centre led by Microsoft. In this centre, the industry provided research problems for the master's students. Although this seemed like a good practice, there were challenges related to issues such as industry's lack of understanding of the nature of the master's degrees. The informant experienced that some master's students ended up doing development for the companies instead of their master's thesis, reducing the trade-off this linkage may represent, and increasing the workload on the supervisors. Here we see that there is a certain risk in realising KT activities in terms of sometimes contradictory goals between the cooperating actors.

3.2 Case study of a technical university: NTNU

3.2.1 Central level

Institutional profile

NTNU is a state-owned university with a main profile in science and technology. The university is located in Mid-Norway. It is one of the "old" universities and is the second largest university in Norway²⁸ with 22,935 students and 3,046 academic staff (2013). Although NTNU specialises in S&T, it includes all the major academic disciplines and has currently seven faculties. A majority of the staff, 38 per cent, are in the field of engineering and technology, 15 per cent are in the field of natural sciences, 17 per cent in the field of medicine/health while 12 and 18 per cent are in the fields of respectively humanities and social sciences.

In terms of R&D expenditure, 2013 figures show that the major contributors were the block funding accounting for 51 per cent of the expenditure, RCN accounted for 22.5 per cent and industry for 11.5 per cent. Compared with other state-owned HEIs, industry funding accounted for a relatively large part of NTNU's expenditure.

²⁸ By 01.01.2016 it is the largest university in Norway after a merger with three university colleges.

NTNU is governed by a Board with four external members, and the chairman of the board is the CEO of one of Norway's largest industrial companies, Hydro. NTNU was the first state-owned university to have an appointed rector, and it is the only university that has a pro-rector for Innovation in addition to a pro-rector for research and a pro-rector for education. By having a pro-rector for innovation, the university has anchored the responsibility for innovation and entrepreneurship.

Knowledge triangle policies and instruments

The central strategy of NTNU emphasises a strong interaction between research, education and innovation, and NTNU sees KT as a natural part of its mission. Cooperation with industry on education and research has always been a key issue at NTNU. NTNU has strong ties to SINTEF, a large technical research institute, which is primarily co-located with NTNU. The cooperation between SINTEF, NTNU and industry has been called the triangle cooperation – mostly because of the different actors but also because of their different roles in education, research and innovation. In this cooperation, NTNU's role has primarily focused on education and more fundamental research while SINTEF has been close to industry. Changing framework conditions, among other things, have however contributed to push NTNU towards increased and integrated cooperation with industry especially concerning research, thus taking the role traditionally held by SINTEF (Borlaug et al. 2015).

NTNU has developed relatively many instruments for knowledge triangle interaction, and we provide an overview in table 8, before we describe some of the instruments in more detail.

Table 8 Instruments for cooperation, commercialisation and education at NTNU

Type of interaction	Instrument
Cooperation councils/initiatives	Council for cooperation with working-life, "Industry rings", Partners for Innovation, NTNU Bridge
Conferences, awards	Technoport, Top-management conference, Innovator
Innovation infrastructure	NTNU TTO, NTNU Discovery, Innovation centre Gløshaugen, NTNU Accel
Entrepreneurship	School of Entrepreneurship, CERN cooperation, Take-Off, Experts in Team, Venture Cup, AppLab, Spark NTNU, Start NTNU

Cooperation with industry and working life

Cooperation with working life and industry is institutionalised at NTNU. Rector and management team have meetings with firms and public agencies and contribute to anchoring the cooperation among the academic staff and in the firms.

At the central level, NTNU has a Council for cooperation with working life (RSA), but according to the informants the Council has more a symbolic function than practical significance for the faculties, as they have their own cooperation structures adapted to the needs and practices of different fields. One such structure is the so-called cooperation forums, which is cooperation on educational programmes with industry.²⁹ It started in 1999 with the construction industry which experienced a decrease in the number and the quality of engineering candidates, and thus established a collaboration with NTNU to ensure quality and relevance of the study programmes. 60 firms in the construction industry are members, together with a central student union. The industry ring has been successful and the collaboration structure has spread to other fields; currently NTNU has 10 industry rings.

Together with regional firms and the research institute SINTEF, NTNU runs Technoport, a cooperation project which aims to generate meeting arenas for industry, researchers, students, investors and entrepreneurs. Some of the same partners and the county of Sør-Trøndelag cooperate in "Partners for

²⁹ <http://www.naringslivsringen.no/om-nlr/hisotire/>

Innovation” which arrange a conference for leaders in academia and industry, a conference for young leaders and the innovation award “Innovator”.³⁰ NTNU has recently established NTNU Bridge, a web page which aims to generate relevant student theses in cooperation between working life, students and research environment.

Innovation infrastructure

NTNU has a well-developed eco-system for technology transfer, has actively engaged in building the system, and also has equity interest in several of the actors. In the system, NTNU Technology transfer (TTO) is a central actor and serves both NTNU and the university hospital St. Olav’s. Personnel from the TTO contribute to education, and lecture in IPR and commercialisation at master’s level and on Ph.D courses. The informants report great satisfaction with the TTO’s services: their competence and ability to find funding. To support commercialisation and entrepreneurship, NTNU has established the pre-seed funding NTNU Discovery, and this is perceived as an important initiative that lowers the threshold for students and staff to participate in commercialisation. Other important actors in the system are the Innovation centre at Gløshaugen with incubator facilities, and the newly established NTNU Accel which provides support to knowledge-based start-ups.

Entrepreneurship and innovation in education

NTNU has several offers to support entrepreneurship in education. The School of Entrepreneurship offers a master’s programme in entrepreneurship, and students may take on the task of commercialising research ideas from academic staff. Informants report that they have very good experiences in developing their ideas together with the students. Moreover, the TTO has two internship positions where the students participate in the commercialisation of academic research results. Students also have the possibility to develop ideas from the well-known research institution CERN or to aid in the development of the ideas from external entrepreneurs through the programme Take-Off.

All graduates participate in the programme Experts in Team. Here they collaborate with students from other fields on industry and working-life assignments. Each year 2,000 students participate under the guidance of 80 staff. Large organisations such as the public agency NAV, the public agency for the railroad Jernbaneverket, Statoil and Microsoft contribute with assignments.

On the initiative of NTNU TTO, NTNU has established AppLab. AppLab offers students the opportunity to develop their app idea into a prototype. Both NTNU staff and representatives from industry lecture on the six-month programme. NTNU offers also the study programme Venture Cup, which focuses on developing business plans.

Other initiatives to stimulate entrepreneurship among students are Spark NTNU, a collaboration project between NTNU and the regional firm Trønder Energi, which provides mentoring, networks and meeting arenas for students with a business idea, and Start NTNU, a voluntary student organisation for entrepreneurship.

In the Annual Report 2014-2015 NTNU underlines that the university lacks good structural incentives, such as career opportunities, for stimulating innovation and commercialisation among staff. However, to strengthen education, NTNU has together with the University of Tromsø, initiated the project Top-Education. The goal is to develop criteria for promoting staff with pedagogic competence and lifting education as an attractive career track given equal status as a researcher career.

3.2.2 The Faculty of Medicine

Institutional profile

The Faculty of Medicine (FM) at NTNU is a classical medical faculty offering a medical doctor programme as well as bachelor’s, master’s and Ph.D programmes in several medical and health

³⁰ NTNU Annual Report 2014-2015

related areas, including a master's programme in pharmacy. The faculty is organised in seven departments, and hosts several research centres. Main areas of research include translational research, medical technology and health surveys and biobanking.

As a medical faculty, FM is strongly embedded in the regional healthcare services, with particularly close ties to the regional health authority *Helse Midt-Norge* and its subordinate hospitals. The faculty is fully integrated with St. Olav's Hospital, and the two institutions make up the Integrated University Hospital in Trondheim. There is extensive collaboration with industry as well, but mainly at the national level.

If we look at funding sources, basic government funding accounted for 34.4 per cent of total R&D expenditure in 2013. 23.7 per cent was Research Council funding, and 30.2 per cent funding from other public sources. The high share of funding from other public sources reflects the importance of research funding from *Helse Midt-Norge*, which makes up around 50 per cent of external funding at the faculty. Industry accounted for a small share of total R&D expenditure in 2013 – 1.6 per cent, and funding from the EU, 2.7 per cent.³¹

Knowledge triangle policies and instruments

According to the faculty's strategic plan,³² the mission of FM is to educate skilled healthcare professionals and conduct research that contributes to the development of health and welfare, nationally and internationally. Innovation is a priority along with education and research, and strategic goals for integration between the three priority areas include intensifying cooperation with the NTNU TTO; strengthening teaching about innovation, patenting and business establishments; and utilising the Integrated University Hospital as an arena for innovation.

While commercialisation and entrepreneurship are central focus areas in the strategic plan, our informants stress that innovation is understood broadly at the faculty. In addition to the development of medical technology, it includes improvements in healthcare services and "in ways of doing things" more generally.

Cooperation with industry and working life

The national system for cooperation between the specialist healthcare services and medical faculties means that FM has close institutionalised ties to *Helse Midt-Norge*. The system is an important platform for interaction between education, research, and innovation, and the integration of FM and St. Olav's Hospital in the Integrated University Hospital is explicitly based on the idea of the knowledge triangle. In practical terms, the two institutions function as one organisation – they are co-located and represented on each other's boards, and have joint leadership meetings, cooperating bodies for education and research, and a high number of bridging positions.

The central Council for cooperation with working life (RSA) at NTNU does not have any practical significance for cooperation at the faculty level.

Entrepreneurship and innovation in education

There has not been any systematic integration of innovation in the educational programmes at the faculty, but the newly established master's programme in pharmacy includes a mandatory course in innovation. The objective is to give the students an introduction to the drug development process "from idea to final product", and the course draws on expertise in the TTO.

Another initiative is earmarked funding for Ph.D positions in innovation projects. The faculty funded three Ph.D positions in innovation projects in 2014/15, and another two positions in 2016.

³¹ National R&D statistics, NIFU

³² *Health for a Better World. Strategic Plan 2011-2020*, Faculty of Medicine, NTNU, URL: http://www.ntnu.no/documents/10268/7960844/DMFstrategi_brosjyreA5_kortversjon_engelsk_LR-1.pdf

Governance and leadership

The public healthcare services are represented on the faculty board, by the director of St. Olav's Hospital, who is the chairman, and the municipal director in Trondheim. This is considered important for institutional backing of collaborative initiatives.

There are no formal management functions for knowledge triangle interaction at the faculty level. However, management sees education, research, and innovation as strongly related activities, and has recently appointed an innovation advisor in the Research Division to strengthen the strategic and administrative support for innovation.

Human resource policies and evaluation

The formal criteria for recruitment and promotion of academic staff at FM do not include knowledge triangle activity, but industry collaboration, patenting, etc. is seen as relevant within some scientific fields, e.g. ultrasound.

Internal reporting is based on the national reporting system for HEIs. Patents are used as assessment criteria in some internal calls for funding and evaluations, but not consistently. Our interviewees find it challenging that contributions to improve healthcare services, such as patenting, are not covered by internal reporting and assessment practices.

Examples of knowledge triangle practices

Integrated education, research and innovation cooperation with the specialist healthcare services, and particularly St. Olav's Hospital, is an essential part of the faculty's activity. Cooperation with the primary healthcare services is considered to be important, but underdeveloped because it is not institutionalised in the same way as cooperation with the specialist healthcare services.

FM has long traditions for close research and innovation collaboration with the technology departments at NTNU, e.g. within the area of ultrasound, where it has resulted in a spin-off company which is now part of GE Vingmed Ultrasound. Still, there is potential for stronger cross-disciplinary cooperation, according to our informants.

Industry collaboration is widespread, and takes many different forms. FM has a cooperative agreement with GE Vingmed Ultrasound, and the company rents offices in the Integrated University Hospital, funds Ph.D and postdoctoral positions, and is involved in education and research at the faculty through part-time positions.

The faculty has hosted two Centres for Research-based Innovation in recent years, both within medical imaging and with GE Vingmed Ultrasound as industrial partner: Medical Imaging Laboratory, MI Lab (2007-2015), and the Centre for Innovative Ultrasound Solutions, CIUS, which was started up in 2015. CIUS is a collaboration with researchers from St. Olav's Hospital and technology departments at NTNU and around ten national and regional industrial partners. There are several master's students associated to the Centre, but our informants point out that IPR issues prevent direct student involvement in research cooperation with the industrial partners.

Interaction with industry also takes the form of consultancy services offered by academic staff, and one of our informants has established his own consultancy firm based on previous work experience in the medical industry.

FM is engaged in commercialisation, and makes active use of the university support system for innovation, including NTNU Discovery and the TTO. One example, where researchers at NTNU and St. Olav's Hospital have collaborated closely with the TTO, is the development of a method and surgical navigation device for treatment of severe headache, called MultiGuide.

Whereas cooperation with the specialist healthcare services is institutionalised, cooperation with industry and commercialisation is for a large part dependent on individual interest and drive, according

to our informants. Another point they make is that education in many cases is the responsibility of the members of academic staff who are least active as researchers, while those who engage in research and innovation do not take part in education. This may have a bearing on the interest in research and innovation among students, and good role models for knowledge triangle practice are considered to be important.

3.2.3 The Faculty of Natural Science and Technology

Institutional profile

The Faculty of Natural Science and Technology (FNST) has six departments and covers the academic fields of biology, biotechnology, physics, chemistry, chemical process technology and material technology.

Of the total R&D expenditure³³ of the faculty, basic funding accounted for 46.7 per cent, the RCN for 38.8 per cent and industry for 9.4 per cent. Compared with the whole university, the FNST has considerable more funding from the RCN (NTNU 22.2 per cent), and rather less from industry (NTNU 11.4 per cent).³⁴ The Faculty has more funding from the EU than the whole of NTNU (3.5/2.9 per cent). Hence, the faculty performs well in the national and to a certain extent in the international competitive funding arena.

The faculty has relations primarily to national and international industry and working life, but cooperate with regional firms on particular initiatives for stimulating to entrepreneurship. Regional place-based policies have little significance for the activities of the faculty.

Knowledge triangle policies and instruments

In the strategic plan (2011-2020), FNST states that its core missions are education, research, innovation and dissemination, and the plan emphasises the importance of relevance in research and education.

Cooperation with industry and working life

The faculty has a cooperation forum which includes 12 national firms. The forum cooperates on levelling the attractiveness of science subjects and to ensure relevance and quality in education. Additionally, according to the dean, the faculty has 10-15 councils for study programmes, in which industry is represented and where one cooperates on the contents of the programmes. Thus, FNST has several institutional cooperation structures for ensuring the relevance of education. However, informants underline that these structures are resource-demanding, and some councils therefore cover relatively similar programmes.

The various departments have different degrees of institutionalised relations with industry. The informants in the project represented the applied fields of biotechnology and material technology, and here cooperation seems to be institutionalised. In fact, the Institute of biotechnology was a result of a large research project together with industry in the end of the 1980s. All the informants have broad experiences in running research projects in cooperation with industry.

Entrepreneurship and innovation in education

Education at master's level is research-based and including master's students in research projects is seen as important in order to give them a perspective of relevance. Previously, it was common for students to do their thesis in a firm, but this practice has been reduced due to, among other things, perceived cooperation challenges concerning the supervision of the master's students. The informants claim that the challenges are greater than the trade-offs of this type of KT practice, as it involves

³³ NIFU R&D Statistics 2013

³⁴ The Faculty of engineering science and technology has relatively high R&D Expenditure from industry

considerably more work for the supervisors, and because firms may exploit the work of the graduate rather than contributing to the work with the thesis. UiT had similar experiences.

Human resources policies and evaluation

Despite the range of instruments for supporting entrepreneurship and commercialisation, the FNST does not seem to have human resource policies or formalised assessment and evaluation procedures that systematically support these activities. Recruitment and promotion of staff is based primarily on academic criteria, but innovation and commercialisation are valued as a positive asset in recruitment procedures. Innovation may also be emphasised in promotion but there are no common criteria and practices seem to differ between institutes.

The formal system for internal reporting is based on the indicators in the national reporting system of the Ministry of Education and Research, and there is no systematic collection of data on innovation activities. Currently FNST staff report on ideas, patents and start-ups and there is an ongoing debate on how one may operationalise indicators for innovation in collaborative projects with industry. The informants report that scientific publication is seen as the main currency at the management level, and that this is prioritised in internal distribution of funding and in performance appraisals. Although innovation and commercialisation are important activities there are few structural incentives for staff to engage in these, and especially commercialisation such as spin-offs and licensing become activities which the staff perform on the side.

Governance and leadership

The Faculty Board has four external representatives, including the chairman of the board. They represent large national industrial companies and research institutes, herein SINTEF. All the departments have boards too, but with two external representatives. The external representation is said to be important by bringing in stakeholder perspectives and by providing input to the faculty/department leadership. Furthermore, the faculty has a pro-dean for education and a pro-dean for research and innovation, and the inclusion of the responsibility for innovation reflects, according to an informant, that the faculty has strong ties to industry.

Examples of knowledge triangle practices

At FNST the interviews revealed four types of KT practices. The first involves external funded projects from the RCN. In the applied fields of biotechnology and material technology, KT practices are institutionalised as the staff have strong and integrated cooperation with industry. Including master's students in cooperation projects with industry and working-life is common in the RCN project knowledge-building projects for industry (KPN), centre programmes, and large programmes, like Biotek 2021. These provide long-term funding and the opportunity to plan the activities. It seems, however, uncommon to include master's students in EU projects.

The second concerns commercialisation and entrepreneurship. One of the informants contributed an idea that was developed into a commercial project by students of the School of Entrepreneurship and he has good experiences of this process. These types of KT practices are driven primarily by the personal interest of academic staff and are not institutionalised. However, according to the informants there is interest among staff to contribute ideas.

The third includes involving students in projects where the ideas of the industry and academic staff need some further exploitation before the project may achieve funding from the RCN. This requires, according to the informants, small and easily accessible funding, which per se does not exist.

A fourth type involves the development of a field. In nanotechnology, there is a tight integration between research and education, and students and academic staff cooperate on attracting relevant industrial partners. Here, NTNU provides infrastructure, and may as such be an attractive partner for industry.

3.3 Institutional case study of a regional university college: Buskerud and Vestfold University College

3.3.1 Central level

Institutional profile

Buskerud and Vestfold University College (HBV) was established on January 1st 2014 through a merger between the state-owned university colleges in Buskerud (HiBu) and Vestfold (HiVe). On January 1st 2016, HBV merged with a third HEI to become the University College of Southeast Norway, but since the information presented here relates to the period before the most recent merger, the name HBV is used consistently.

The merger in 2014 made HBV the third largest state-owned university college in Norway in terms of students, and a regional HEI with four campuses in the two counties of Buskerud and Vestfold. The two counties are located in the densely populated and industry-intensive South-Eastern region of Norway, and both have knowledge-based industry. The large international technology corporation KONGSBERG, which specialises in defence, maritime, and oil and gas technology, is headquartered in Buskerud and has production units in both counties.

Reflecting the historical mandate of the state-owned university colleges, HBV has a professions- and working life-oriented profile, and specialises in the areas of health, technology, teacher education, economics and administration, and humanities and social sciences. Shorter professional education has traditionally been the core activity, but research has been systematically strengthened over time, and the institution currently offers four Ph.D programmes.

The regional embeddedness of HBV is strong, and the institution has close ties to both the private and the public sectors. We lack official statistics on institutional R&D expenditure after the merger in 2014, but in 2013, total expenditure for R&D at HiBu and HiVe taken together was approximately €16m (157m NOK, cf. table 9). Basic government funding accounted for 62 per cent, RCN funding 24 per cent, and funding from industry 8 per cent.³⁵

Before the most recent merger, HBV was governed by a board with four external members representing industry and county authorities in Buskerud and Vestfold. Our informants are generally of the opinion that the external members on the central University College Board are interested in knowledge triangle activity, and contribute to a stronger institutional focus on the role HBV plays in regional development. The board was chaired by the elected rector, and the institution had two prorectors – one for education, and one for research, development and innovation.

Knowledge triangle policies and instruments

The main strategic objective for HBV is to create value for industry, the public sector and society in general through education and research.³⁶ Innovation, defined broadly, is given high priority by the leadership, and developing interlinkages between education, research and innovation is part of the institutional policy.

As a professions-oriented university college, HBV has a strong focus on offering education that meets the needs of working life and industry. This includes the education of new candidates, as well as continuing education of professional practitioners. All education should be research-based, and developed and carried out in collaboration with societal stakeholders.

Research should, according to overall institutional goals, be closely linked to profession practice, and R&D and innovation cooperation with the public sector and working life is a priority. The main strategic

³⁵ National R&D statistics, NIFU

³⁶ *Annual report 2014-2015*, HBV

partners include municipalities and counties, technology firms, and local and regional public health services.

Cooperation with industry and working life

Due to the merger processes in recent years, HBV does not currently have a Council for cooperation with working life (RSA), but the institution is working to develop suitable structures for strategic dialogue with societal stakeholders. Based on previous experiences, our informants believe that cooperative bodies should be established on faculty rather than central level in order to be relevant and tailored to discipline and subject-specific collaborative patterns. Advisory boards and Ph.D programme boards with external representation are mentioned as possible organisational forms.

Each faculty has a “contract leader” in an administrative position. He/she facilitates interaction with industry and the public sector in terms of commissioned research and education.

Innovation infrastructure

The HBV campus in Drammen, Buskerud is part of *Papirbredden Knowledge Park*, where the university college is co-located with knowledge-based companies, innovation support agencies, and the regional innovation company *Papirbredden Innovation* which was established with HBV as one of the initiating partners. The company is a collaboration with municipalities, private industry, and SIVA, and engages in innovation projects, commercialisation, and business development within regional priority areas.

The HBV campus in Horten, Vestfold is co-located with Vestfold Innovation Park. The building was a result of collaboration between HBV, NCE Micro- and Nano Technology (MNT) and local industry. It offers offices, lecture rooms, laboratories and incubator services through the Silicia Technology Incubator.³⁷

Entrepreneurship and innovation in education

Innovation Camp is an annual event at HBV aimed at promoting interest in research and innovation among the students. It is an “idea competition” organised in collaboration with the organisation *Young Entrepreneurship* and local industry and working life, where students compete in solving a practical problem defined by a private firm or public enterprise.

3.3.2 The Faculty of Health Sciences

Institutional profile

The Faculty of Health Sciences (FHS) specialises in four areas of study – nursing, optometry, radiography and health technology, and health promotion, and offers bachelor’s and master’s programmes within these areas, as well as a cross-disciplinary Ph.D programme in person-centred healthcare. The educational programmes target students who have just finished secondary education, as well as professional healthcare practitioners.

The faculty is organised in five departments located in three campuses, with Drammen, Buskerud, as the main campus. As a professions-oriented health faculty, FHS has strong links to the local and regional public healthcare services and especially to the primary healthcare services in the municipalities. Links to local industry are well developed, too, and the faculty is part of a health technology cluster in Drammen that was developed through funding from the national Arena cluster programme. In addition to the Arena programme, the faculty has received funding from several other support schemes for regional R&D and innovation, including the Research Council’s VRI programme, the Regional Research Funds, and innovation funding from the county councils.

³⁷ Vestfold Innovation Park URL <http://www.hbv.no/om-hbv/studiesteder/vestfold/forskningsparken/>

If we look at overall R&D expenditure, figures for the health faculties at HiBu and HiVe in 2013 show that for both faculties taken together, 63.7 per cent was basic government funding. RCN funding accounted for 25.9 per cent and funding from industry 3.8 per cent.³⁸

Knowledge triangle policies and instruments

According to the strategic plan for FHS,³⁹ the faculty's main objective is to promote health and welfare in the population, primarily by educating competent health professionals, but also by conducting research that addresses the health challenges of the future.

At the same time, there is strong strategic focus on engaging in innovation, and developing interlinkages between education, research and innovation is an explicit goal. The way our informants see it, knowledge triangle interaction is an inherent part of the activities of a health faculty offering professional education in close cooperation with the healthcare services. A key point in this context is that innovation is understood broadly, as something that includes incremental improvements in healthcare services based on continuous exchange of knowledge between students, academic staff, and healthcare professionals.

Cooperation with industry and working life

FHS has been actively involved in developing a health innovation cluster in *Papirbredden Knowledge Park*. In close cooperation with *Papirbredden Innovation*, the faculty initiated a process around 2007 to establish a cluster of local technology firms specialising in the development of health and welfare technology, primarily for the municipal primary healthcare services. The cluster, which has received funding from the Arena programme, is an important platform for enhancing systematic innovation collaboration between FHS, municipalities and private industry.

In 2012, FHS opened a centre for testing and demonstration of the technology developed by the health innovation cluster.⁴⁰ The centre brings together students and staff at the faculty, the technology firms, and municipalities and other users of health and welfare technology. FHS uses the centre actively for educational purposes, and the students are introduced to the new technologies through simulation training and lectures from the technology producers and from users in the municipal healthcare services.

HBV is the only HEI offering optometry education in Norway, and FHS has established a national centre for competence development, R&D and innovation within optometry, vision and eye health.⁴¹ The centre has collaborative partners from the public healthcare sector as well as national and international institutions for education and research, and has in recent years worked actively to strengthen cooperation with private industry. This has resulted in private donations to the centre for upgrading of clinical and laboratory facilities.⁴²

Innovation infrastructure

The innovation company *Papirbredden Innovation*, where HBV is co-owner, has health and welfare technology as a priority area. The university college is also represented on the board of *Driv Incubator*, a SIVA incubator which specialises in health-related commercialisation and start-ups, and is co-located with HBV in *Papirbredden Knowledge Park*.

Entrepreneurship and innovation in education

FHS has worked strategically to integrate innovation in education on all levels, including the Ph.D programme and continuing education. An Innovation Camp focusing on health was organised in 2015,

³⁸ National R&D statistics, NIFU

³⁹ *Bedre helse – personen i sentrum. Strategiplan for helsevitenskap mot 2020*, 2014

⁴⁰ *Vitensenteret helse og teknologi*, URL: <http://vitensenteret.hbv.no/>

⁴¹ *Nasjonalt senter for optikk, syn og øyehelse*, URL: <http://optikkogsyn.hbv.no/>

⁴² *Annual report 2014-2015*, HBV

where students competed in developing solutions to a practical problem defined by an international healthcare company, which is co-located with HBV in Papirbredden Knowledge Park.

Governance and leadership

There is no faculty level board at FHS. The faculty leadership is said to have a strong focus on integrating education, research and innovation. This is not reflected in the formal leadership functions, however, which in addition to the dean include two pro-deans for education and research respectively.

Human resources policies and evaluation

Knowledge triangle activity is, according to our informants, not supported by faculty HR policies or evaluation systems. Recruitment and promotion is based on academic qualifications, and internal reporting follows the national reporting system for HEIs developed by the Ministry of Education and Research.

Examples of knowledge triangle practices

FHS has close cooperation with the local and regional health sector, and primarily the municipal primary healthcare services, when it comes to education, both through practical training for students and continuing education for professional practitioners. Practical training is an important mechanism for systematic interaction and knowledge exchange between the faculty and the healthcare services, and contributes to quality and relevance in education as well as continuous and incremental improvements in professional practice. Continued education too plays a central role in health service development, and FHS has an extensive portfolio of courses commissioned by actors in industry and working life and tailored to their competence needs.

Innovation in education is a central area of activity that includes the development of innovative educational designs, as well as teaching students about innovation. The faculty has, for example, worked systematically to integrate the innovation concept and innovation thinking in all bachelor's-level programmes through a project with funding from the Government's "Entrepreneurship in Education" initiative.⁴³

FHS has extensive project-based innovation collaboration with industry and working life. The innovation projects are mainly in the area of health service innovation, with municipalities and technology firms as central partners. Many projects are collaborations between the partners in the health innovation cluster, and aimed at developing, testing and implementing health and welfare technology. The faculty is also involved in projects aimed at facilitating organisational development and innovation in the healthcare services through competence building among students, staff and professional practitioners. One example is a cross-disciplinary project where FHS collaborated with the engineering department and business school at HBV, in addition to external partners, to apply principles from systems engineering and lean methodology to the area of health.⁴⁴

The role FHS plays in innovation projects is primarily that of facilitator of innovation processes in the healthcare services, e.g. through scientific consultancy, competence development, and formative research. Commercialisation of research results is not a central activity at the faculty.

Research at FHS is practice-oriented, and the faculty has received project funding from the Research Council's programme for practice-oriented R&D in health and welfare services.⁴⁵ The projects link research, education, and professional practice, with the aim to strengthen the knowledge base and thereby improve the quality of the health professions education and the healthcare services.

⁴³ For more information (in Norwegian), see: <https://norgesuniversitetet.no/soknad/innovasjon-entreprenorskap-utdanning-av>

⁴⁴ For more information (in Norwegian), see: <https://norgesuniversitetet.no/prosjekt/brukerorientert-helseinnovasjon-og>

⁴⁵ PRAKSISVEL, the predecessor of the current HELSEVEL programme.

3.3.3 The Faculty of Technology and Maritime Sciences

Institutional profile

The Faculty of Technology and Maritime Sciences (TekMar) covers the relatively applied areas of engineering, maritime sciences, micro and nanotechnology and systems engineering. TekMar has currently seven departments and the main campus is in Horten, Vestfold. It has approximately 1,600 students and 150 FTE staff⁴⁶ and offers 10 bachelor's and master's programmes and a Ph.D in micro and nanotechnology accredited in 2010. 2013 figures for R&D expenditure show that for HiBU and HiVE, with both faculties of technology taken together, 47 per cent was block-funding, 40.3 per cent funding from the RCN and 9.2 from industry.

The profile of the faculty has changed over the past ten years, from being primarily a professions-oriented faculty, to one that also emphasises research and innovation. The faculty has increased and strengthened the research competence together with regional industry; the number of scientific publications has increased significantly, and educational programmes are developed in cooperation with industry. Thus, nearly all activities at TekMar are characterised by KT practices and thinking and the faculty embeds, so to speak, the knowledge triangle.

The increase in research and innovation activities is much due to the establishment of two Norwegian Clusters of Expertise (NCE); NCE in Micro and Nanotechnology located in the Research Park in Vestfold, and NCE Systems Engineering located in Kongsberg Technology Park in Buskerud; both have been drivers in building up research environments and educational programmes at TekMar. This will be further described below.

Policies and instruments

TekMar has a strategy of prioritising four areas: systems engineering, micro and nanotechnology, maritime technology and human factors, and concentrates resources onto these. It has worked strategically with internal priorities and with external relations in order to be the preferred and an important partner in providing competence and knowledge for the NCEs and other clusters in the region. Hence, to build research capacity and competence and educational programmes in collaboration with industry lies at the core of the faculty. A goal is to increase the faculty's participation in programmes like Centres for Research-based Innovation and Horizon 2020.

Cooperation with industry and working life

The establishment of the two mentioned NCEs has been important for development of infrastructure for cooperation between HBV and industry. The management of the NCEs is located in nearby or co-located research parks, and has been a central facilitator in establishing cooperation arenas. The arenas are manifold, and in fact two of the departments at TekMar, the Department of micro and nanosystem technology and the Norwegian Institute for System Engineering, have been developed or established in cooperation with industry in the clusters. The industry together with the cluster management have as such had a decisive role for establishing KT practices.

Recently, the faculty established a new advisor/adjunct position called R&DI Expert (research, development and innovation).⁴⁷ A R&DI Expert works in regional industry and holds a 20 per cent position at HBV, and knowledge of industry is seen as more important than academic qualifications. The aim is to increase the number of cooperation projects between HBV and regional industry and to develop HBV as a research and education actor. The basic idea is that the R&DI Experts have intrinsic knowledge of the firms' activities, technology and strategic priorities and may thus identify important research questions and areas for cooperation projects between HBV and the respective firms. Currently, one R&DI Expert is in post, and the goal is to have six.

⁴⁶ Presentation from Dean 2015: Status og plan, Fakultetseminar.

⁴⁷ For more information (in Norwegian), see: <http://www.hbv.no/fou-i-eksperter/category26400.html>

TekMar holds five industry-sponsored chairs from regional industry and the county of Buskerud, and the county of Vestfold finances a postdoc. The chairs are instruments to develop R&D capacity in specific fields, and the positions financed by the regional counties are within maritime science, a field that has received considerable attention in the past five years. According to the informants, the counties have generally limited funding, but they have an explicit strategy for industry development, and perceive HBV as a central actor in the regional innovation system.

Entrepreneurship and innovation in education

One department, the Norwegian Institute of Systems Engineering (NISE), offers an industry master's. This is a three-year master's programme where the students also hold a 50 per cent position in industry. The master's programme was initiated by the system engineering industry in 2006, and developed in collaboration with the Stevens Institute of Technology in New Jersey, US. The students spend one semester at Stevens Institute. In 2009, the master's programme obtained accreditation from NOKUT.

According to the informants, the master's thesis in all fields is seen as an important contribution to innovation and value creation. The informants sketched out three alternative ways of including master's students in research and innovation: 1) to include them in existing research projects (most common); 2) to use them to explore ideas; and 3) work on research questions from industry. The informants claim that the master's theses hold high scientific quality, and several are published in peer-reviewed journals. They are also of great value to industry. Here we see a different type of experience and collaboration pattern than at UiT and NTNU. The interactions are institutionalised and also valued as positive contributions to research.

Governance and leadership

TekMar has no faculty board, it has a dean, and a pro-dean with strong focus on education. The faculty leadership emphasise cooperation with industry and the needs of the industry partners.

Human resources policies and evaluation

In recruitment processes both academic qualifications and industrial experience are considered as important. However, to recruit candidates with both qualifications is seen as challenging due to the specificity of the fields and that in general there are few, at least nationally, who have both qualifications. Thus, a majority of new staff have an international background. Promotion practices, on the other hand, follow standards issued by the National council for the field of science and technology, and emphasis primarily academic qualifications.

Internal reporting follows the national reporting system for HEIs developed by the Ministry of Education and Research. The informants report that they would prefer reporting on cooperation with industry to render the activity visible, this could be granted cooperative projects, cooperation with industry/public sector on master's theses etc.

Examples of knowledge triangle practices

The informants represented three different departments, two of them characterised by institutionalised KT practices and one on the way to develop KT practices. At the beginning of the 2000s, HBV provided generic engineering studies and had relatively little interaction with the local industry.⁴⁸ The local microelectronics industry in Horton requested HBV to develop and tailor studies to their field. This did not happen overnight, but after a while, a professor in the field was hired and he was granted strategic funding to establish a group of Ph.Ds and new study programmes at bachelor's and master's levels was developed. In 2006, the microelectronic industry was awarded NCE status and funding. This became very important for the development of the department, as the NCE funded six to seven academic positions. Of these, four are now permanent positions. The department still receives funding from NCE for participating in NCE activities, and some of it funds a professor who is responsible for a

⁴⁸ All text in the paragraph is based on information from the informants

working group in the NCE. In 2010 the Department of Micro and Nano Technology was accredited a Ph.D programme. The activity has generally been concentrated on developing educational programmes, but in some phases of the NCE period building research capacity has also been a priority. Currently the department participates in a Centre for Research based Innovation (CRI) together with amongst others NTNU and UiO, which may be said to signal quality in research. Taken together, we see that the development of the department is a result of a strong interaction between education, innovation and research.

The Norwegian Institute of Systems Engineering (NISE) was established in 2006 by the industry and facilitated by a NCE grant. Currently the institute numbers 12 staff, and industry finances half of the institute. The institute offers the “industry master’s” described above and has developed other courses in, among other things, lean management, in cooperation with industry. To coordinate and to ensure cooperation the institute has an industrial advisory board. As in the case above, developing research capacity seems to be a priority and the institute applied recently together with industry partners for a CRI. The application did not go through, but the research programme achieved a relatively high score. A CRI is still a goal and one works strategically to achieve this, and NISE is one of the prime movers in the network. The same network also aims at Horizon 2020. The close ties between the institute and industry in developing educational programmes and increasing research capacity witness strong integration of KT.

A third example of KT practices is the development of the Department of maritime technology operations and innovation. Here HBV has been a prime mover to establish the field, and has worked strategically, in collaboration with three other university colleges and universities,⁴⁹ to obtain funding from ministries and other public funding bodies to develop education and research competence. The industry has also contributed through amongst other two industry-sponsored chairs, as has the regional county. The industry has also moved their training simulators to HBV. As such, the development of the field includes the three main actors of “the triple helix” (Etzkowitz and Leydesdorff, 1997), all pulling towards the same goal. One central objective to increase the research capacity in the field is to get accreditation of a Ph.D programme. It seems that this is on its way, together with funding from the Government for 16 Ph.D positions, of which four are dedicated to HBV. This resembles the development of the field Nanotechnology at NTNU.

The three examples of KT practices show different development patterns. While industry initiated the cooperation in the two first examples and HBV actively responded to the invitation by dedicating resources and prioritising the fields, the last example shows that HBV took the initiative and developed the field together with industry and the public sector.

3.4 Main findings

The case studies show that UiT, NTNU and HBV have policies, strategies and practices that integrate education, research and innovation, but in various ways and degrees. Below, we will first discuss the main differences between the three institutions at the central level and thereafter differences at the level of faculties. We will then describe what informants see as the main challenges and barriers to develop KT practices.

3.4.1 Central level

UiT, NTNU and HBV have relatively different profiles. UiT can be characterised as a comprehensive university with a mixed model, which includes elements typical of an academic institution and of a professionally-oriented institution set up to serve local needs. NTNU can be characterised as an entrepreneurial university with a strong emphasis on technical and multidisciplinary research, and HBV is a university college oriented towards the needs of the local industry and labour market.

⁴⁹The project is called Markom2020 and financed by the Government

All three institutions have strategies that emphasise interaction between education, research and innovation. The institutions vary as to whether they see themselves as a regional or national and even international institution. Both UiT and HBV have clear strategic priorities concerning the characteristics of the region and regional industry and the public sector. NTNU's strategy, on the other hand, centres around national and international arenas, emphasising the role and mandate of being *the only* technical university in Norway.

Governance/leadership

All three institutions have boards with external representatives from industry and the public sector. External representation is seen to be important by bringing in stakeholder perspectives and giving broader social legitimacy to strategic decisions. This is also mandatory by law. All three institutions also have a pro-rector for respectively education and research, but they have formalised the responsibility for innovation in the leadership differently. NTNU has a dedicated pro-rector for innovation and UiT has a vice-rector for regional development. HBV's pro-rector for research also has the responsibility for development and innovation.

We further see that all three institutions have developed infrastructure for cooperation with industry and working life more generally. A Council for cooperation with working life (Råd for samarbeid med arbeidslivet, RSA) is in place at NTNU and UiT. However, the informants at both were generally sceptical about the RSA, and a main criticism is that they, as a central-level units, are unable to deal effectively with the great variety in cooperation partners and types of interaction across faculties and scientific fields. To have strategic cooperative bodies at lower levels in the organisation is seen as more relevant.

Infrastructure for cooperation, commercialisation of research results and entrepreneurship education

The institutions have taken different roles in setting up and facilitating cooperation with external constituencies, and this seems to relate to their profile, size and location. As the technical university, NTNU has established several cooperation arenas with national and regional industry and public sector. At the department level, several councils for close interaction with industry on matters of technical and engineering education has been established. In comparison, UiT has relatively few arenas for cooperation, and this may relate to it being a comprehensive university with an academic profile. At HBV, on the other hand, the arenas for cooperation have been developed by the faculties and departments together with regional industry and the public sector, especially through the NCE cluster schemes. This reflects the applied profile of HBV.

All three institutions have industry-sponsored chairs⁵⁰ and HBV also from the counties. This arrangement underlines the cooperation on developing education, research and innovation in the region. For strengthening the ties and cooperation with industry, UiT and HBV have also developed new categories of adjunct positions. The Faculty of Health Sciences at UiT has expanded the traditional use of dual affiliations in medicine to include other professions in healthcare. At HBV, The Faculty of Technology and Maritime Science has recently introduced the new adjunct position "R&DI Experts" for industry employees, in which industrial experience and networks are more important than academic qualifications.

As the technical university, NTNU has been a prime mover in the development of an ecosystem for commercialisation of research and entrepreneurship – involving both staff and students. In fact, NTNU has developed a system for KT practice with a specific emphasis on entrepreneurship. In comparison, UiT has an infrastructure for the commercialisation of research results, but few other services, and HBV has another type of support structure. At HBV, three of four campuses are located in a research/innovation park which of two have incubator services. HBV's applied profile also means that new technologies, products and services are commercialised by the cooperating firms.

⁵⁰ Five years professoriate externally financed and then continued by the HEIs

Career policies and evaluation systems

Although the institutions emphasise KT in their policies, we see that in general, all three institutions emphasis primarily academic qualifications in hiring and promotion of scientific staff.

Commercialisation and industrial experience seem to be perceived as a positive asset, but not a necessary qualification. One exception to this is the Faculty of TechMar at HBV, which primarily hires staff with academic qualifications *as well as* industrial experience. The informants at UiT and NTNU report that academic qualifications i.e. scientific publications, seem to be even more important now than previously in both hiring and promotion processes. Experience from industrial cooperation and success in commercialisation of research results is seen as less important in itself, even though quite many of the academic employees have such career experiences as well. At NTNU in particular, there is thus a tension between the emphasis on innovation and commercialisation in strategies and instruments on the one hand, and the lack of incentive structures for academic staff on the other.

Despite that the institutions report on both quantitative and qualitative indicators to the Ministry of Education and Research, both deans and researchers at all three institutions claimed that the formal system for internal reporting and evaluation is primarily based on the indicators for education and research which give financial incentives. Again, we observe a tension between the policies and the strategies of both the Government and the institutions and the institutions' behaviour.

3.4.2 The Faculties of medicine/health

A central feature of the faculties of medicine/health is that they are professions-oriented institutions with a clear mission to contribute to high-quality healthcare services in close cooperation the public healthcare sector. At the same time, the three faculties have different academic profiles. Whereas the Faculty of Medicine at NTNU is a classical medical faculty, the Faculty of Health Sciences at HBV is a faculty for shorter health professions education, mainly in nursing, radiography, and optometry. The Faculty of Health Sciences at UiT is an integrated health faculty that covers classical medical sciences as well as shorter health professions education in a broad range of areas, including nursing, radiography, and physiotherapy. These differences give different conditions for KT practices.

Strategies

All of the faculties have education, research, and innovation as strategic priorities, and goals for strengthening interlinkages between the three areas. Innovation is understood broadly to include improvements in healthcare services as well as the development of health technology – and in the cases of UiT and HBV, innovative education. The strategic plan for FM-NTNU has a relatively stronger focus on medical technology, commercialisation, and entrepreneurship, whereas the strategies of UiT and HBV are more oriented towards practice-oriented research, development, and innovation in the healthcare services.

Governance and leadership

At the two universities, UiT and NTNU, the medical/health faculties have boards with external representation from key actors in the specialist and municipal healthcare services. This is seen as “obvious” since the public healthcare sector is their most important collaborative partner, and important for strategic dialogue and joint initiatives. The faculty at HBV, which is a smaller institution, has a unitary governance model with the dean as the highest authority.

None of the three faculties has formal leadership functions for knowledge triangle activity, but according to the deans, education, research, and innovation are seen as interrelated areas by the leadership.

KT practices

The differences in academic profile between the three faculties have a bearing on what types of KT activities they engage in. As faculties for medical sciences, NTNU and UiT have strong integrated education, research, and innovation cooperation with the specialist healthcare services, and especially the university hospitals in their respective regions. These KT practices are intrinsically linked to the

national system for interaction between the university hospitals and medical faculties, where the hospitals have a legal responsibility – and receive dedicated government funding – for engaging in education and research. There are strategic cooperative bodies in place based on government regulations. The system is also characterised by extensive use of dual affiliations, and close physical integration between the medical faculties and the university hospital.

For the two faculties that offer shorter health professions education, UiT and HBV, cooperation with the municipal primary healthcare services is an important arena for KT practices. This relates mainly to practical training for students and continuing education for healthcare professionals, which contribute to competence-development based on the needs of the healthcare services and thereby improvements in professional practice. However, there is less systematic and integrated KT interaction than with the specialist healthcare services – for several reasons. First, the primary healthcare services do not have the same explicit mandate to contribute to the education of healthcare personnel, and do not receive government funding for engaging in practical training of students. Second, this is an area where education traditionally has not been based on research, and the healthcare services engage in research to a very limited extent.

However, the health faculty at HBV collaborates with technology firms and municipalities in a local health innovation cluster focused on developing and implementing health and welfare technologies in the primary healthcare services. Innovation collaboration with industry at NTNU and UiT takes different forms than at HBV, reflecting the more research-intensive nature of the medical sciences. Both faculties are involved in Centres for Research-based Innovation, as well as commercialisation and entrepreneurship activities.

Cross-disciplinary cooperation with technological fields of science is an aspect of knowledge triangle practices at all three faculties. However, there seems to be potential for stronger innovation collaboration between the faculties of health and technology.

3.4.3 The Faculties of science and technology

There are three faculties of science and technology in the study. Two of them; the Faculty of Science and Technology at UiT and Faculty of Natural Sciences and Technology at NTNU, have rather similar academic profiles covering the traditional natural sciences and related applied fields, while the Faculty of Technology and Maritime Sciences at HBV has an applied academic profile.

Strategies

A comparison of the three faculties of science and technology (FST)⁵¹ shows that all have strategies that emphasise the linkages between education, research and innovation, but that they emphasise different aspects of the linkages. The strategy of FST-UiT has few explicit goals and formulations concerning innovation, but clear goals on education and research and development, perhaps reflecting that the region has a relative small and fragmented industry sector. The strategic plan for FST-NTNU emphasises, in addition to synergies between education, research and innovation in cooperation projects with industry, commercialisation of research results and entrepreneurship. The strategy of FST-HBV underlines the importance of the close interaction between industry and FST-HBV, and the priorities are directed towards developing education and research in close cooperation with industry.

Governance and leadership

The specific profile and size of the faculties seem to affect governance and leadership structures. The FST-NTNU is the largest of the three in terms of staff, students and R&D expenditures, and the faculty and the individual departments have all boards with external representatives. This reflects the close ties the faculty has with industry. Additionally, the faculty has a pro-dean for research and innovation, thus anchoring the responsibility. In comparison, the FST-UiT has a board with external

⁵¹ To simplify, all faculties name are abbreviated as FST

representatives, while at the level of department the main rule seems to be boards with only internal representatives. The FST-UiT has one pro-dean for respectively research and education. The FST-HBV is a smaller institution and the dean is responsible for all missions.

KT practices

In general, the academic profile of the field, i.e. whether it is discipline-oriented or applied, seems to affect KT practices. Applied fields are closer to industry, and the case studies show that some of these fields, e.g. biotechnology, micro and nanotechnology have been established and developed in close cooperation with industry. While cooperation with industry may also be common in discipline-oriented fields such as chemistry and physics, the basic character of the educational programme may not necessitate interaction with industry and thus integrating master students in research projects may not be seen as relevant.

The case studies further show that KT practices in the fields of science and technology are primarily results of a bottom-up initiated development of cooperation between HEIs and industry. We may delineate four different development patterns. First, the cluster schemes have had a central role in facilitating institutionalisation of KT practices by providing relatively long-term funding for such activities. Furthermore, research parks, innovation centres and the like seem to have an important role in administering the funding and acting as the node in the cooperation by bringing the different actors together. In the clusters, the industry has been a prime mover in strengthening the other two corners of the triangle, i.e. research and education. This pattern is seen particularly at HBV.

A second pattern of KT practices is characterised by a strong interaction between innovation and research, and to a lesser extent education. We find this pattern in projects supported by relatively large funding programmes with long time-horizon in the Research Council. Whether education is tightly integrated or only loosely coupled to research and innovation seems to depend upon the characteristics of the scientific field, the ties between academic staff and firms and the interests of the individual academic staff.⁵²

The third pattern shows that the institutions themselves are prime movers in developing KT practices. One example is HBV, which, together with other HEIs, took the initiative to strengthen education and research in maritime technology operations, a field with relatively large industry, but limited educational programmes and research. Another example is the master's programme in nanotechnology at NTNU, where students and academic staff together establish cooperation with industry partners.

We find a fourth and rather different pattern of KT practice at NTNU. Here entrepreneurship students are involved in commercialising product ideas from scientific staff. Yet, this type of KT practice seems to be driven by the individual interests of the staff, and as such is not an institutionalised practice.

3.4.4 Perceived challenges and barriers to knowledge triangle practices

The study reveals several challenges and barriers to KT practices, both at the institutional and system level. At the institutional level, one barrier is the tradition and culture of the scientific staff to focus on education and research. Some are even opposed to cooperation with industry in principle, according to our informants. Nevertheless, compared with a decade ago, attitudes towards external cooperation and commercialisation are increasingly positive.

A second barrier or challenge concerns time and division of labour. Due to time constraints, education may become the responsibility of those who are least active as researchers, while those who engage in innovation and research do not take part in education, at least at the undergraduate level. This observation means that it may be challenging to realise the ambition of a "whole of career approach" (UHR, 2015) where academic staff combine research, education and innovation. At least, it is not suitable for everyone, but needs perhaps local and personal adjustments. However, the main criterion

⁵² See also Borlaug et al (2015)

for recruitment and promotion of academic staff per se is primarily academic qualifications, and systematic practices or formal criteria for incentivising staff for cooperation with industry and commercialisation have not been developed. This is also a challenge for developing KT practices.

A third barrier is that of limited flexibility in the funding system for acting on opportunities for short-term collaboration with industry or public sector to explore the viability of an idea. Bureaucratic funding procedures mean that there is a time lag from an interesting opportunity occurs until funding has been secured, and funding is moreover allocated mainly to longer-term projects. Thus, our informants call for more flexible small-scale funding that can be mobilised at short notice.

A final barrier is the weak incentives for integrating the knowledge triangle in evaluation systems. Innovation activities are not incentivised in the Ministry of Education and Research's current reporting system, and HEIs have as such to a little extent systemised cooperation and commercialisation in their internal reporting and evaluation systems.

3.5 Conclusion

This report includes the case studies of three Norwegian HEIs: A comprehensive university – the University of Tromsø (UiT) – the Arctic University of Norway, a technical university – Norwegian University of Science and Technology (NTNU), and a regional institution – the University College of Buskerud and Vestfold (HBV). At each institution, we looked for KT practices at two faculties; the Faculty of Health/Medicine and Faculty of Natural Sciences and Technology. The three institutions have different contexts for KT practices as they differ in terms of profile, size and regional conditions, and we see that this affects the degree and type of KT practices.

Main institutional differences

The comprehensive university, UiT, has a strong regional mandate and covers all the major academic fields. It appears as a university with a mixed model – on the one hand it is an academic university and on the other, a locally embedded institution. The ties to the public health sector are particularly strong, but the regional industry is generally small and geographically dispersed – thus challenging cooperation with regional industry. There are well-developed KT practices in professionally-oriented fields, while these are less developed in science and technology.

As the national technical university, NTNU has a clear national mandate and strong ties to industry and the public sector. Cooperation arenas are manifold and well-developed, and KT practices are an integrated part of the activities. NTNU has anchored the responsibility for innovation in the rectorate, and has invested in developing infrastructure for commercialisation of research and entrepreneurship education. Compared with the two other institutions, NTNU researchers focus considerably more on commercialisation and entrepreneurship.

HBV is located in a region characterised by technology-intensive industries. The university college has integrated ties with industry and the public sector, and all cooperate on strengthening education, research and innovation. HBV has systematically developed research capacity and educational programmes relevant to regional industry and the public sector, and has taken a leading role in developing the region.

The study points to two different sets of knowledge triangle practices. On the one hand, we find a set of practices based on a narrow definition of innovation as commercialisation or entrepreneurship. On the other hand, there are practices which include a broader definition of innovation as improvements in industrial and professional practices more generally.

Main differences between scientific fields

The case studies show that there is a great variety of KT practices at the institutions, but also that the premise and context for KT practices differs between the fields of health, on the one hand, and science and technology on the other. Health sciences are characterised by professions-oriented education and they have a clear mission to contribute to high-quality healthcare services in close cooperation the public healthcare sector. KT practices are integrated in the specialist healthcare services through the national system for interaction between the university hospitals and medical faculties. Hence, the interaction between HEIs and hospitals is governed and funded by the Ministry of Health and Care, through amongst others strategic cooperative bodies and dual affiliations, and KT practices are institutionalised by top-down mechanisms.

The faculties that also offer education for shorter healthcare professions cooperate mainly with the municipal primary healthcare on education. These fields have relatively weaker traditions for research, and innovation is related to development of health services and welfare technologies.

KT practices in science and technology, on the other hand, are generally characterised by bottom-up initiated cooperation between HEIs, industry and the public sector. Both regional funding and national competitive funding schemes, and especially cluster schemes, have been important mechanisms for developing cooperation and KT-practices. The development of new fields also generates KT practices.

In both fields, we find tendencies towards an emphasis on including education; it is a tendency towards systematically including education in research, and towards including innovation in education. In the latter sense, the focus has been on entrepreneurship education at all levels. This might reflect the tendencies in policies at the national level.

Main challenges

As pointed out above, the HEIs experience a tension between policies and demands from the Ministry of Education and Research on the one hand, and the financial incentives in the system, on the other. First, the financial incentives concentrate on education and research, which influences the institutions' internal reporting systems. Second, the national and international emphasis on academic qualifications comes at the expense of acknowledging other competencies in the institutions' recruitment and promotion practices. Together, these two factors contribute to the institutions having few structural means for incentivising cooperation activities and commercialisation of research among staff.

Drivers for knowledge triangle practices

The study points to several drivers for KT practices, and we will here highlight four:

- Long-term funding is important for developing and institutionalising cooperation structures between HEIs and public/private actors. It offers the opportunity to work strategically to strengthen interaction between education, innovation and research.
- A strong policy environment, and especially a sector ministry, facilitates the development and institutionalisation of KT practices
- The availability of local flexible funding, characterised by short-term application and decision processes, may offer an opportunity for researchers to explore potential innovative ideas together with industry or the public sector, which may further develop into larger KT projects.
- New types of adjunct positions and expanding the use of dual affiliations can enhance knowledge exchange and facilitate KT practices.
- Academic career systems can be used to incentivise KT practices, by including innovation and education as promotion criteria.
- Flexibility should be ensured in academic positions for research, participation in education and engagement with public and private sectors. The share of time to the different tasks may be individually negotiated.

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