# Policy Brief

Recommendations from the Research Council of Norway's International Advisory Board **Issue 2** / **October 2019**

# Radical Innovation: Accelerating the transition

**Norway currently faces what the OECD in its recent country review termed a "triple transition imperative": There is a need to shift towards a more diversified and robust economy; move towards a more competitive, effective and efficient innovation system; and achieve these structural transformations while supporting research and innovation that can confront an array of societal challenges and the digital economy possibilities. To achieve this, Norway must improve its ability to foster radical innovation.**

Part of the solution will be a gradual transition of the world class and versatile R&D and business system built around the petroleum sector to new applications and markets. However, if Norway wants to increase the rate of economic restructuring beyond the rather slow rate that is normal, it must:

- Improve the conditions for the emergence of radical ideas by fostering increased R&D-based innovation
- Implement funding and selection procedures that ensure radical ideas receive the requisite financial support
- Diversify the economy through support to diverse partnerships and diverse knowledge combinations

To realise this ambition, private and public sector, higher education institutions, public research institutions, policy makers and funding agencies must cooperate and interact for the mutual purpose of strengthening their impact on the economy. Their challenge is to be both strategic and directive, while at the same time being open to radical ideas, new players, new collaborations and new value chains.

## Fostering radical ideas through R&D-based innovation

Unlike incremental innovations which occur more or less continuously in any industry to improve cost profiles and performance, radical innovations are discontinuous events, which are unevenly distributed over sectors and over time. Such innovations are important as the potential springboard for the growth of new markets and they often necessitate major concurrent changes in products, processes and organizations[1].
In contrast to the conventional wisdom that radical innovations are based less on existing knowledge than non-radical innovations, studies find that they are in fact to a *higher* degree based on existing knowledge, but on different and often *non-related* fields of knowledge or technologies[2]. For example, the Apollo Program, one of USA's most significant instances of government-created innovation, primarily connected diverse strands of fundamental understanding already in place.

The findings pointing to the importance of knowledge diversity for achieving radical innovation is echoed in studies of radical research: Interdisciplinarity is consistently found to be an important element in research breakthroughs[3] – these occur more often among researchers who work within several different fields of research and who internalize significant scientific diversity.[4]

The movement towards open innovation is an expression of the insight that greater breadth of knowledge sources is associated with greater innovation success[5]. Firms are increasingly entering into collaboration and co-creation with customers, suppliers, universities and research institutes. In this way they get access to diverse sources of knowledge and experiences and to talents, test facilities or tacit knowledge not otherwise easily available[6].

However, despite the movement towards increased open innovation, and despite findings that firms which cooperate with external partners are more innovative than firms that rely on their own resources for innovation – internally generated inventions are still the majority[7]. Firms' natural cognitive tendencies are to search narrowly along familiar avenues[8]. Studies[9] have shown that Norwegian firms are particularly prone to do so. They predominantly innovate through cooperation with closely related actors, tending to use a DUI (Doing, Using, Interacting) mode of innovation which involves on-the-job problem-solving based on the exchange of experiences and know-how with customers, suppliers, partners and employees. The other form of innovation – the STI-mode (Science, Technology and Innovation) refers to the use of scientific knowledge in the development of new technologies, products or processes within the firm and involves interaction with universities, research institutes and consultancy firms. The DUI- mode of innovation requires cooperation with partners that share the same practical problems and experiences. In line with the findings that radical innovation if often based on non-related fields of knowledge, the DUI-mode is shown to deliver lower impact than the STI-mode in technological and radical innovation.

Given the tendency towards DUI-based rather than STI-based innovation in Norway, there is a need for incentives that can encourage increased science and technology-based innovation in firms. Norwegian firms which have established links with extra-regional universities, research centres and consultancies have seen their innovation potential increase radically in virtually all types of innovation[9]. Arnold et al. (2019) find that the one area not very well represented in the Norwegian portfolio of innovation support instruments is simple activation instruments for R&D-based innovation, such as innovation vouchers in the form of small grants that fund a company to explore a business opportunity or problem with a university or research institute, graduate placement schemes that subsidise the salary of the first scientist in a company, etc.

In addition, there is a need to improve commercialisation activities at universities – a key component in inducing more STI-based innovation. A recent study[10] finds that commercialisation incentives for Norwegian researchers and students are too weak and recommend that these are strengthened. The study finds that incentives provided through FORNY2020 – the support program for commersialising research results – are critical in incentivising researchers to undertake commercialisation work. There could however be a case for supplementing this project-based funding mechanism with a funding mechanism aimed at the individual – particularly young individuals which arguable face stronger disincentives to engage in commercialisation activities. The Swiss Bridge programme is an example of such a funding scheme, providing funding for young researchers who wish to develop an application or service based on their research results.

Commercialisation incentives should be accompanied with wider incentives for universities to open their campus, infrastructure, talents, networks and education programs to firms. Examples of this is offering improved access to test and verification facilities, accelerating open access, experimenting with platforms for co-creating and sharing results and knowledge, etc. An example of the latter is the "company on campus" cooperation model whereby private companies invest resources directly at the university, for example by financing part-time or full-time employees who perform research and teaching at the university, financing research and innovation projects, financing joint laboratories where researchers from the companies and universities interact, etc.

Sector mobility measures are another potential means to stimulate increased university-industry interaction and correspondingly more STI-based innovation in the Norwegian system. A survey from 2014 among 4,400 scientific staff at Norwegian universities and colleges[11] found that those most active in all forms of outward-oriented activities are those who have work experience outside the university sector. Research also shows that highly educated labour is an important determinant for innovative companies. This suggests a stronger emphasis on sector mobility instruments. Established support measures such as industrial PhDs are important in this respect, but new measures aimed at individuals having completed their PhDs should also be considered. The Finnish program PoDoCo is an example in this respect; a matchmaking program that supports the strategic renewal of companies through employment of young doctors in the private sector.

**Drawing on diverse sources of knowledge is conducive to radical innovation, but Norwegian firms tend to cooperate with like-minded partners that share the same problems and experiences. Improving links with universities and research institutes could over time increase firms' innovation potential drastically.**

**IAB recommends that RCN should consider:**

- Induce firms to broaden their knowledge base by offering simple activation instruments for R&D-based innovation such as:
  - innovation vouchers in the form of small grants that fund a company to explore an opportunity or a problem with a university or research institute
  - graduate placement schemes that subsidise the salary of the first scientist in a company
- Improve incentives for university staff to engage with firms by broadening its portfolio of support instruments:
  - Consider complementing the FORNY2020 program with a funding scheme aimed at supporting young researchers in developing an application or service based on their research results
  - Consider complementing the industrial PhD scheme with a sector mobility scheme aimed at individuals having completed their PhDs

**IAB recommends that the government should consider:**

- Improve incentives and support structures to make resources (people, equipment, facilities) at higher education institutions and public research institutions affordable and accessible to firms

**A dedicated funding stream for radical innovation**

It is difficult to select radical ideas and innovations in a competitive funding context. Experience from venture capital, studies of funding processes[12] and evaluations of research centres and cluster organisations indicate that the leading person(s) is critical for success. Studies of research funding processes find that selection procedures focusing on individuals rather than projects are generally more successful in supporting pioneering research. However, a focus on the individual should not be translated into a focus solely on track-record, as this would entail the risk of missing out on ideas from newcomers to the application process, such as young start-ups. Given the tendency of peer review to be risk-averse, and by consequence, prone to selecting candidates with an established and strong track-record, dedicated measures aimed at newcomers should be considered, for example in the form of earmarked funding.

In addition to focusing on the individual(s) rather than the projects in the selection phase, funders should explicitly discourage large and complex teams when aiming to fund radical innovations. As discussed, drawing on diverse sources of knowledge is conducive to radical innovation. However, the advantages associated with collaboration breath diminishes as the number of partners increases; studies indicate radical innovation performance is potentially lower for firms collaborating with five or more partner types within one project than for firms with no collaboration at all[13]. In line with this, a recent study of 65 million papers, patents and software products that span the period 1954–2014, demonstrate that across this period, smaller teams have tended to disrupt science and technology with new ideas and opportunities, whereas larger teams have tended to develop existing ones[14].

When funding radical innovation, funders must furthermore be prepared to shoulder a large proportion of failures. As radical innovation projects tend to combine substantially different technology or knowledge with correspondingly uncertain outcomes, they are high-risk. This implies that any portfolio of radical projects will include a long tail of failures, with only a few successes likely to ensure the positive value of the portfolio.

The high-risk nature of radical projects furthermore means that such projects can have a hard time securing funding if competing against more incremental projects. Research on peer review finds that it tends to be conservative and risk-averse, favouring well-established topics within well-established disciplines rather than cross-disciplinary research of a more experimental nature[15]. Diverse teams are significantly less likely to obtain funding[16]. Applications describing projects that are far advanced more often gain funding – even when such decisions are contrary to a program's explicit goal[17]. Radical innovation should consequently be supported through dedicated instruments, excluding projects of a more incremental nature.

Finally, funding schemes aimed at radical innovation should be flexible. As radical innovation processes are highly experimental and unpredictable[18], requiring continuous learning through experimentation[19], there is a need for flexible support programs that allow for adjustments of the project plan and deliverables as the project unfolds. An example of this way of working is the American Defense Advanced Research Projects Agency (DARPA). Radical innovation at DARPA is driven by collaborative and iterative vision development, rather than stage-gate reviews of performance.[20] The benefits of such flexibility is confirmed in studies of radical research programs: Azoulay et al.[21] studied the careers of investigators of the Howard Hughes Medical Institute (HHMI), which tolerates early failure, rewards long-term success, and gives its appointees great freedom to experiment; and grantees from the National Institute of Health, which are subject to short review cycles, pre-defined deliverables, and renewal policies unforgiving of failure. They found that HHMI investigators produced high- impact papers at a much higher rate than the control group of similarly-accomplished NIH-funded scientists. Moreover, the direction of their research changed in ways that suggest the program induced them to take higher risks and explore novel lines of inquiry.

In sum, there is a strong case to be made for establishing a dedicated funding stream for radical innovation. Looking to the international level, the EU is currently in the process of establishing a dedicated funding stream for breakthrough innovation, and the Commission has proposed to dedicate €10 billion to the European Innovation Council under Horizon Europe, the EU research and innovation funding programme for 2021–2027.

**There is a need to establish a dedicated funding stream for radical innovation. Peer review tends to be conservative and risk-averse, biased against diverse teams and biased in favour of incremental projects. As radical innovation projects are high-risk, tending to combine diverse sources of knowledge with correspondingly uncertain outcomes, they are disadvantaged in the funding decision making process.**

**IAB recommends that RCN should consider:**

Establishing a dedicated funding stream for radical innovation which:

- Features a selection procedure that focus on the individuals involved (but avoids a narrow focus on track-record) and the transformative nature of the ideas proposed
- Favours small, rather than large and complex teams
- Is tolerant of risk and failure
- Features flexible follow-up with considerable scope for experimentation and adjustments of the project plan and deliverables as the project unfolds

### Diversifying the economy through diverse partnerships

Industrial development is usually path-dependent in that regions or countries build on past expertise. Innovation policies supporting new industrial activities that are related to current ones are consequently thought to have the highest probability of success[22]. However, the current landscape of rapid technology and market change, globalization and ongoing sustainability transitions, puts a greater demand on also exploring the growth potential of integrating diverse knowledge; essentially radical innovation on a system level. Research suggests that diversifying the economy based on new activities closely related to current ones promotes short-term growth, whereas diversification through unrelated variety is important for economies to keep growing in the long run[23].

For example, discussions on how to restructure the Norwegian economy frequently focus on how competence and resources in the oil sector can be transferred and spur innovation in the closely related sector of renewable energy. However, as the initiative "Pumps and Pipes" illustrates, knowledge in the oil sector also has the potential to spur innovation in largely unrelated sectors. The initiative, which originated in Texas and now has a Norwegian affiliate, provides a platform to transfer knowledge and technology know-how between the fields of petroleum, healthcare and space.

Integrating knowledge from diverse sources is thought to increase with the availability and improved accessibility to general-purpose technologies, such as ICT – including AI, as well as biotech tools and applications, nanotech and new materials. Upgrading the level of knowledge of new, key enabling technologies among innovating organizations and individuals could therefore be one potentially effective tool in promoting diversification based on unrelated knowledge combinations.[24] An example is the Swedish competence centre program, which supported 28 centres over a period of ten years in order to build capacity in generic technologies – with commitment of financial and human resources from both university and industry[25].

Furthermore, for new firms with radical innovations based on unrelated knowledge combinations to "stick" and grow, they must be integrated in well-functioning national/regional innovation systems which provides support for global knowledge sourcing and links.[26] A common pitfall is that businesses who build on new combinations of knowledge and skills encounter difficulties in recruiting qualified personnel and finding relevant collaborators locally, and therefore exit the economy.

If Norway wants to increase its rate of restructuring beyond the rather slow rate that is normal, a dedicated restructuring programme could be warranted. Such a programme could on the one hand provide funding aimed at accelerating promising diversification paths evident in the project portfolio of existing bottom-up funding schemes. Funding should be aimed at addressing missing links in relevant ecosystems through a wide and flexible set of instruments such as public purchasing, infrastructure support, facilitation of industry-university cooperation, international cooperation, etc. However, given that Norwegian firms are particularly prone to innovate through cooperation with closely related actors[27], such an approach is likely to result in economic diversification predominantly based on combining related knowledge sources. It could consequently be coupled with explicit incentives to encourage economic diversification based on unrelated knowledge sources. This could take the form of bottom-up calls open to all themes, but limited to projects aimed at combining unrelated knowledge/technology.

An alternative or complement to such a bottom-up funding strategy is to support firms' exploration and exploitation capacity in prioritized domains (mission-oriented policies). Thematic multi-actor, multi-measure programmes are commonly used in this respect, but significant restructuring will also need measures outside traditional R&I policy. An obvious analogy is the wide range of R&I, regulatory, educational and infrastructural measures that was needed to enable Norway's adventure in oil and gas. Tehcnopolis in their recent analysis of Norwegian innovation funding instruments[28] points out that in this respect, it may well be necessary to work at the level of just one or two national missions, selected through broad consultation spanning citizens, business, the state and the research community.

**There is a need to explore the diversification and growth potential of industrial development based on integration of knowledge from diverse sources and actors; essentially radical innovation on a system level.**

**IAB recommends that the Government and RCN should consider:**

- Assessing the need for additional measures to strengthen innovating organizations' and individuals' level of knowledge of new, enabling technologies such as ICT; unrelated knowledge combinations are thought to increase with the availability and improved accessibility to such general-purpose technologies

- Devoting funding to a national diversification programme consisting of two funding streams:

  - Funds aimed at building well-functioning innovation ecosystems around promising paths to diversify the economy. Call themes could be selected based on portfolio analysis of existing bottom-up funding schemes. Funding should be aimed at addressing missing links in relevant ecosystems through a wide and flexible set of instruments.

  - Bottom-up calls open to all themes, but limited to projects which aim to combine unrelated knowledge/technology

- Devoting funding to a mission-oriented programme that dedicate resources to a limited number of missions aimed at restructuring the economy – imposed top-down, but selected through broad consultation

## References


1) **Freeman C. and Perez C. (1988):** Structural crises of adjustment, business cycles and investment behaviour, in Dosi G., Freeman C., Nelson R., Silverberg G. and Soete L. (eds) Technical change and economic theory, Pinter, London, pp. 38–66.

2) **Schoenmakers, W. & Duysters, G. (2010):** The technological origins of radical inventions. Research Policy, 39, pp. 1051–1059.

3) **Research Council of Norway's International Advisory Board (2019):** Interdisciplinary research: Constructing a level playing field. IAB Policy Brief no. 1.

4) **Hollingsworth, J. R. (2007):** High Cognitive Complexity and the Making of Major Scientific Discoveries, in Sales, A., Fournier M (ed.): Knowledge, Communication, and Creativity, Sage Publications, pp. 129–155.

5) **Garriga, H., Krogh, G., Spaeth, S. (2013):** How Constraints and Knowledge Impact Open Innovation. Strategic Management Journal 36, pp. 1134–1144.

6) **Laursen, K. and Salter, A. (2006):** Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. Strategic Management Journal 27, pp. 131–150.

7) **Walsh, J.P., Lee Y.N., Nagaoka, S. (2016):** Openness and innovation in the US: Collaboration form, idea generation and implementation. Research Policy 45, pp. 1660–1671.

8) **Leiponen, A., Helfat, C.E. (2010):** Innovation objectives, knowledge sources, and the benefits of breadth Strategic Management Journal 31, pp. 224–236.

9) **Fitjar, R. D., Rodríguez-Pose, A. (2013):** Firm collaboration and modes of innovation in Norway. Research Policy 42, pp. 128–138.

10) **Grünfeld, L.A., Teie, M. G., Hvide, H., Spilling, O., Borlaug, S. (2018):** Insentiver for kommersialisering av forskning. MENON-Publikasjon nr. 9/2018.

11) **Thune, T.M., Aamodt, P.O., Gulbrandsen, M. (2014):** Noder i kunnskapsnettverket. NIFU-rapport 2014:23.

12) **National Science Board (2007):** Enhancing support of transformative research at the National Science Foundation. Arlington VA: National Science Foundation.

13) **Kobarga, S., Stumpf-Wollersheim, J., Welpea, I. M. (2019):** More is not always better: Effects of collaboration breadth and depth on radical and incremental innovation performance at the project level. Research Policy 48, pp. 1–400.

14) **Lingfei Wu, Dashun Wang & James A. Evans (2019):** Large teams develop and small teams disrupt science and technology. Nature 566, pp. 378–382.

15) **Langfeldt, L. (2006):** The policy challenges of peer review: managing bias, conflict of interest and interdisciplinary assessments. Research Evaluation 15, pp. 31–41.

16) **Banal-Estañolnés, A., Macho-Stadler, I., Pérez-Castrillo, D. (2019):** Evaluation in research funding agencies: Are structurally diverse teams biased against? Research Policy 48, pp. 1823–1840.

17) **Lamont, M., Mallard, G., Guetzkow, J. (2006):** Beyond blind faith: Overcoming the obstacles to interdisciplinary evaluation. Research evaluation 15, pp. 1–13.

18) **Veryzer, R.W., (1998):** Discontinuous Innovation and the New Product Development Process. Journal of Product Innovation Management 15, pp. 304–32.

19) **Lynn, G.S., Morone, J.G. & Paulson, A.S. (1996):** Marketing and Discontinuous Innovation: The Probe and Learn Process. California Management Review 38, pp. 8–37.

20) **Sen, A (2013):** Totally radical: From trans-formative research to transformative innovation. Science and Public Policy 41, pp. 344–358.

21) **Azoulay, P., Graff Zivin, J. S., Manso, G. (2009):** Incentives and creativity: Evidence from the academic life sciences. National Bureau of Economic Research working paper 15466.

22) **Boschma R. (2016):** Smart specialisation and regional innovation policy. Welch Economic Review 24.

23) **Saviotti P. P. and Frenken K. (2008):** Export variety and the economic performance of countries. Journal of Evolutionary Economics 18, pp. 201–218.

24) **Asheim, B.T., Herstad, S.J. (2019):** Regional innovation strategy for new industrial path development in the era of the forth industrial revolution: Evolutionary theoretical perspectives on innovation policy. Paper presented at International Symposium on 'Regional Innovation Strategy and Inclusive Regional Development in the Fourth Industrial Revolution Era'.

25) **Asheim B.T., Moodysson J. (2017):** Innovation policy for economic resilience: The case of Sweden. CIRCLE papers in innovation studies 2017/5.

26) **Boschma, R. (2017):** Relatedness as driver of regional diversification: a research agenda. Regional studies 51, pp. 351–364.

27) **Fitjar, R. D., Rodríguez-Pose, A. (2013):** Firm collaboration and modes of innovation in Norway. Research Policy 42, pp. 128–138.

28) **Arnold, E., Åström, T., Andréasson, H., Nielsen, K., Wain, M., Tofteng, M., Røtnes, R. (2019):** Raising the Ambition Level in Norwegian Innovation Policy. Technopolis report.

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Design and layout: Burson Cohn & Wolfe AS