

Engineering and Technical Sciences Committee Opinion Paper



Empowering Researchers to Provide
Societal Value

Towards Innovation Communities that
Leverage Excellence-focused Research

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**SCIENCE
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Empowering Researchers to Provide Societal Value

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Executive Summary

Excellence-focused research organisations and researchers should take a more active role in shaping the debate on the societal value of research. Research-based innovation capacities are crucial for the use of knowledge to foster positive change in industry, governments and civil society.

Research-based innovation is an attempt to introduce new services, products or processes in companies, governments or civil society actors by relying on access to knowledge acquired through conducting research. Research-based innovation creates societal value, notably economic value. It strengthens businesses and is crucial to the appreciation of science by the public. Excellence-focused researchers also benefit from synergies between their work and technological and social developments: they have access to richer data and experiences as well as to better tools. Research-based innovation should be apprehended as a win-win proposition that benefits researchers, businesses and society at large.

The goal of creating a win-win research-based innovation culture is timely; it resonates with current political discussions and responds to a desire by the research community to be empowered when engaging in innovation. Policy makers, including research policy makers, should therefore engage with research-based innovation.

To support research-based innovation capacities, this Opinion Paper recommends focusing on 'innovation communities' that bring together researchers and business persons around a shared goal connected to a societal need. An innovation community is not a specific institutional entity, but rather a model that reflects the dynamics of research-based innovation:

- Researchers explore knowledge; business persons explore market needs.
- The boundary between researchers and business persons should not be blurred in innovation communities. Each brings different skills and requires different support and incentives. Researchers should not be required to become entrepreneurs; similarly, business persons should not be given academic-type funding or contracts.
- Innovation communities are extremely diverse, in terms of, for example, size, duration and structure. Research-based innovation is driven from the bottom up and diversity should be encouraged.
- Innovation communities empower researchers and business persons by promoting a relationship based on trust and knowledge-sharing.

Research-based innovation is not limited to companies and business persons; it also takes place in other 'markets', where 'business persons' may be civil servants or members of civil society.

Summary of Recommendations

To foster a policy environment that is conducive to research-based innovation, this Opinion Paper notes the need for a co-ordinated engagement of all policy actors, notably in research policy, in economic and industrial policy, and in public procurement policy. It recommends that:

1. Policy makers should include the model of innovation communities in their strategic planning.

Further recommendations concern research policy actors, with the assumption that other policy actors would engage in complementary actions. It cannot be the sole responsibility of research to provide innovation capacities to society. Research policy actors should:

2. Recognise research-based innovation as an inherent part of excellence-focused research in all disciplines, and notably in engineering, technical and computer sciences.
3. Focus their actions related to research-based innovation on the capacity of researchers to engage in innovation communities. The institutional form that supports innovation (centres or networks) should be treated as a tool, not a goal.
4. Communicate regarding the place of research-based innovation in their political mandate, and ensure it is understood by researchers, politicians and other institutional actors.
5. Strengthen existing research-based innovation schemes or develop new ones, and evaluate these on the quality of the resulting innovation communities.
6. Ensure that researchers engaged in an innovation community are rewarded fairly and that such engagement will not negatively impact on researchers' careers or their future professional evaluation.
7. Develop capacities and an organisational culture that allows support for researchers involved in research-based innovation.

By publishing this Opinion Paper, the Science Europe Engineering and Technical Sciences Committee wishes to contribute to the current debate on innovation by emphasising important and under-utilised ideas and concepts. It builds on the Committee members' experience as excellence-focused researchers and innovators in engineering and technical and computer sciences.

This document is based on the fact that most researchers, whether in applied or basic research, want the results of their work to be valuable to society, as the Committee's collective experience attests to. Researchers play a crucial role in innovation, not as entrepreneurs or business persons, but as contributors of knowledge. The aim of this Opinion Paper is to emphasise the value of creating a strong interface between research and business, government or civil society. It notes that the contribution of researchers is at its greatest when they are empowered to explore the societal value of their work. The intention is not to underplay the challenges involved, or shy away from pointing out the burden on all actors involved within innovation, including researchers themselves, but rather to support research policy stakeholders in their reflections about their role in innovation, without jeopardising their mission to support excellent curiosity-driven research. This paper does not call for completely new thinking about research-based innovation. The ideas presented are mostly not new. However, the Committee does believe that these ideas have played an insufficient role in the debate so far, and that they can strengthen the discussion and support concrete policy action.

1. What is Research-based Innovation?

The first hurdle that is encountered in this paper is that the word 'innovation' is used by different communities to represent extremely diverse ideas. Some researchers argue that any new knowledge is 'innovation'. Some entrepreneurs argue that innovation is synonymous with entrepreneurship. The Committee will not attempt to propose a definition that can satisfy everyone. Instead, this Paper will focus on a process called 'research-based innovation'.

Definition:

Research-based innovation is an attempt to change something already established by introducing new services, products or processes to companies, governments or civil society actors, relying on knowledge that was not previously used in this area and that has been acquired through conducting research.

Research-based innovation occurs, for example: when a new product is developed using previously unknown properties of a material or chemical, or by relying on previously unknown modelling or simulation techniques; when new chemical, physical or biological processes are used to develop new manufacturing processes; when novel approaches to computation or information management are used to drive a new or improved service or to better control a process; or when novel forms of government actions rely on better models of their effect on the natural, technical or social environment. The essential characteristic of research-based innovation is that it is defined not solely as the creation of a new product, service or process, but also by its relation to the new knowledge that made it possible.

Research-based innovation is notably distinguished from its non-research-based counterpart. It is perfectly legitimate to speak of innovation when it does not build on new knowledge from research. Innovation can take the form of incremental innovation in relation to the cost and characteristics of existing services, products or processes. Innovation happens, for example: when the manufacture of a product or the delivery of a service is streamlined; when two products are combined to develop a more feature-rich product; when new clients for a product or service are identified; or when the rules of an administrative process are changed to make it more accessible to users, or more resilient to fraud. While these non-research-based innovations are valuable, this Paper focuses on research-based innovation for reasons that will be explored in Section 2.

For reasons of convenience throughout the document the term ‘product’ will be used to signify any new service, product or practice resulting from innovation, and the term ‘company’ to mean any company, governmental or civil society actor. While the Committee’s areas of research are often – and rightly – considered as providing great value to industry, it is important to emphasise that research-based innovation is, in the end, a practice that can benefit any societal actor.

2. Leveraging Research-based Innovation

2.1 A Challenge for Europe

Many European states and the European Union have put research and innovation at the centre of their strategy for development and see it as a key competitive advantage internationally¹. Europe’s excellent curiosity-driven research system is a major asset whose potential must not be squandered². At a time when society is becoming increasingly knowledge-driven, the ability of the research system to contribute to innovation capabilities while maintaining or strengthening its scientific excellence must be taken seriously by research policy makers throughout Europe.

Key Argument:

Research systems need robust capabilities for research-based innovation, in order to provide societal value by allowing companies, governments and other societal actors to use breakthrough or cutting-edge innovation backed by excellent research.

As a start, it must be recognised that many good examples of public policies and business practices supportive of research-based innovation exist in Europe. Innovation conferences are filled with individual stories of university spin-offs, industry–academia collaboration, or evidence-based government practices. Many are success stories that built on publicly-funded research to deliver real benefits to society. These are good examples of valuable experiences that can be built upon to strengthen research-based innovation capabilities.

However, good examples should not detract from Europe’s weaknesses. In the current innovation-friendly climate, there is a tendency to champion any example of research-based innovation as a success, without much consideration of its societal benefit, its value for the taxpayer, its long-term viability or its impact on the research system. Assessments are hampered by outdated thinking about innovation as a linear process where ideas are transformed into products through a series of successive pre-defined steps. The Committee proposes that policy makers be more demanding of the outcomes of research-based innovation, both in terms of the new knowledge it produces and in terms of its value to the taxpayer. Only then can policies support truly excellent research-based innovation.

The debate on research-based innovation is timely. Notwithstanding many uplifting success stories of innovation, it remains undeniable that, as a whole, research-based innovation in Europe does not meet the expectations of society and of political and economic leaders. It is beyond the scope of this paper to explore whether this is due to changes in the nature of innovation that have rendered old recipes less effective, or whether incremental improvements to old innovation recipes cannot meet the heightening expectations of a knowledge-based society. Nevertheless, the Committee regrets the following situation.

Key Argument:

The transmission between knowledge and societal usage is unreliable. Innovations that should have resulted from available knowledge are overlooked, or their development is delayed. Conversely, too much effort is invested in flawed innovation built on knowledge of little value.

As a result, European companies, governments and civil society do not obtain the full benefit of Europe's excellent research system.

2.2 The Value of Research-based Innovation

- ▶ **Research-based innovation creates societal value from research**, and is crucial to the appreciation of science by the public. It would be foolish to believe that governments would fund a research system if the knowledge it produces cannot be useful to society. It is regrettable that the discussion on the societal value of research is still often reduced to an argument on the amount of funds that should be assigned to long-term 'blue sky' research versus short-term 'applied' research, rather than a debate about the innovation process itself. This can take an even more regrettable form when it leads to efforts being focused on short-term research, creating an inferior and ultimately unsustainable research system, without improving its innovation potential. Only by considering how the whole research system – long-term and short-term – feeds into research-based innovation can its societal value be demonstrated.
- ▶ **Research-based innovation leads to breakthrough technologies.** New knowledge resulting from research holds the promise of breakthrough technologies. Breakthroughs occur when new knowledge allows a sudden and massive acceleration of innovation in an area. For example, in the 1950s, the development of transistors and theoretical models of computing were the basis for the subsequent massive development of computers. Today, various fields of research are seen as potentially supportive of breakthrough technologies: additive manufacturing (incorporating for example 3D printing), sensor networks (leading to smart systems), targeted drug delivery systems, single-layer materials (notably graphene), cryptography (to improve privacy), and so on. It is notable that in all these fields the best research is driven by innovation; ongoing technological breakthroughs and new knowledge reinforce each other.
- ▶ **Research-based innovation supports development at the cutting-edge.** While the focus of politicians and the public is often on breakthrough technologies, much of the value of innovation lies in incremental changes. By feeding new knowledge into an incremental change process, research-based innovation develops cutting-edge methods, services or products. As a result, research is strengthened by the synergies arising from its proximity to societal use.
- ▶ **Research-based innovation has a highly positive economic impact.** The economic benefits of public research are considerable. In a 1991 study, the direct rate of return of public research in terms of sales of new products based on estimates by R&D managers of a sample of US manufacturing firms was found to be 28%³. Subsequent studies have indicated similar or higher rates of return, although recent studies argue that these rates of return are in fact underestimated by not taking into account indirect benefits⁴. Research-based innovation unlocks the high rate of return of research investment.

- ▶ **Research-based innovation provides a competitive advantage for economic, social and political actors.** Europe's excellent research remains a major asset in international comparisons, rivalled in size and quality only by that of the United States⁵. Europe must use this asset to define its place in the world, by ensuring that companies, governments and other societal actors have access to this asset through research-based innovation. Of course, the lack of commitment to reach the Europe 2020 objective of 3% of GDP for R&D expenditures⁶ and the increasing imbalance in research funding between north-western and south-eastern countries is worrying as it could jeopardise the excellence of Europe's research system. The Committee calls upon all governments concerned to ensure that the potential of Europe's research system is not squandered by funding cuts. However, the effort to maintain the research system should not detract from pursuing at the same time a robust strategy for strengthening research-based innovation.

- ▶ **Research-based innovation is a crucial ingredient of smart specialisation strategies⁷.** National R&D policies can use their research-based innovation efforts as a lever to build on their strongest research areas. By integrating research-based innovation activities and smart specialisation strategies, countries can strengthen the link between their strongest research and their strongest industrial and natural capacities.

- ▶ **Ambition in excellence-focused research goes hand in hand with ambition in research-based innovation.** While an excellent research system that consistently produces especially novel and important knowledge offers great potential to foster breakthrough or cutting-edge innovation, it must be supported by excellent research-based innovation practices. Novel and important knowledge in excellence-focused science calls for its use in ambitious societal goals. Ambitious goals require robust and effective research-based innovation capacities.

Key Argument:

A research system is stronger if it can ride the wave of breakthrough technologies and cutting-edge innovation. Research is stronger because it greatly benefits from synergies with breakthrough or cutting-edge actors in industry, government or civil society. Research is also stronger because it can demonstrate societal value, thereby strengthening its case to the public, securing funding for all forms of research, and making research careers more attractive.

2.3 What Role for Policy Makers?

European countries are attempting to advance their policies for research and innovation to make them more conducive to research-based innovation. To do so requires a concerted effort from many sides, which is not always the case. Policy makers and leaders in research, education, business, finance, and many other areas have a role to play in creating the right supportive framework.

There is a concern that Europe's businesses, entrepreneurs, governments and civil society share a culture that is insufficiently open to the exploration of new research knowledge before its societal value or a business case has been definitely identified. European companies in high R&D intensity sectors represent a significantly lower share of the workforce than in the US⁸. The Committee stresses that this is an issue of great concern. No matter how conducive to innovation the research environment is, it cannot deliver societal value without finding a willing

and robust innovation partner in European businesses, governments and civil society. The members therefore call upon all research policy stakeholders to assert, unambiguously and unapologetically, that the perception of a weak research-based innovation capability cannot be laid solely at the door of research organisations.

The mandate of most research organisations is to support excellence in research. The Committee does not call this mandate into question. Nevertheless, research organisations should recognise that they are partners in the story of research-based innovation. They should engage in this area confidently without jeopardising their role of supporting excellence in research. It is not useful to researchers or to society if research organisations provide only perfunctory support to research-based innovation. By focusing their research-based innovation policies on researchers, by being clear about what they can and cannot support within their mandate, and by engaging with other innovation stakeholders, research organisations defend the value of research while taking a positive role in fostering a friendly environment for research-based innovation.

In the members' experience, research organisations have demonstrated that well-designed schemes and policies can motivate researchers to engage with the issue of how their knowledge provides societal value. Many good examples are implemented by research organisations, in universities and in research funding or research performing organisations. There are schemes that help researchers develop their knowledge further (in so-called proof of concept or pre-competitive research) to bring it closer to a point where it can provide societal value and be funded competitively⁹. There are policies that support researchers working on real-life problems with industry or civil society partners in specialised centres¹⁰. There are schemes supporting knowledge transfer, usually by promoting inter-sectoral mobility¹¹.

Nevertheless, too many policies for supporting research-based innovation remain poorly designed. Their efficacy is low in terms of successful new products, services or processes. They are plagued by negative incentives, for example on the future academic career prospects of beneficiaries. They focus on researchers without consideration for other research-based innovation actors. As a result, potential innovators in research lack the motivation to engage in long-term innovation activities; notably, they lack the motivation to take part in 'innovation communities', a concept that will be introduced later in this paper. Furthermore, even when good practices are implemented, they are often small, isolated schemes that are insufficiently integrated into a wider research and innovation system.

A robust research-based innovation capacity is a social good in the modern world, as discussed in Section 2.2. It strengthens research capabilities, and it cannot exist without the support of research organisations, as noted above and further analysed in the rest of this Paper. Some research organisations have an explicit mandate to support innovation. Others who may not have such a mandate yet may feel pressure by politicians or the public to engage more with innovation. However, it is the Committee's belief that irrespective of external pressure, it is in the interest of research organisations to engage with research-based innovation, for the benefit of the researchers they support and for the benefit of society.

3. Researchers and Business Persons Working Hand in Hand

In order to engage with research-based innovation, it is important to understand its nature. Research-based innovation is not an abstract concept. It is not a political or institutional construction. At its core, research-based innovation is a team effort; the relationship between individuals and their common work. People with different skills must come together to bring a successful product to the market or implement a novel process in an organisation. They may include development engineers, technicians and marketing and sales professionals. They also include a second layer of people not directly involved in the innovation but supporting it by providing funding and creating an innovation-friendly legal and political landscape: venture capitalists and bankers, 'business angels', regulators, politicians, lawyers, and others.

However, the number of different people involved in a research-based innovation project should not distract policy makers from focusing on the core innovators who drive the process by providing the two ingredients of successful innovation: knowledge and business viability. The Committee believes that, at a policy level, a distinction should be made between two roles: 'researchers' and 'business persons'. For the rest, exactly who is involved is a question that is best considered at the level of a concrete project.

Definition:

Researchers produce new knowledge and have the capacity to comprehend existing knowledge in novel contexts. They also have the capacity to react to new needs exposed by real-world feedback, by refining or extending the knowledge that supports innovation.

Business persons explore market needs and react by developing a product that answers clients' needs and is financially viable. They seek to balance clients' needs, access to capital, development capacities, and pressure from competitors.

Concretely, researchers are often academics, but may also be students or may be employed in private research centres. Business persons may be entrepreneurs, students with an interest in entrepreneurship, established business owners or directors, or product managers in a large company.

Furthermore, it should be clear that this definition is to guide reflection, not an absolute dichotomy between two clearly-identified populations. Some people occupy a grey zone between research and business. However, one must realise that the capacity to conduct research-based innovation stems from the synergy between people strongly focused on knowledge (researchers) and others strongly focused on markets (business person). It is extremely rare that a single person can successfully focus on both of these aspects, especially simultaneously. Some students with an entrepreneurial mind-set may play a business role even though they trained as researchers, but this inter-sectoral mobility tends to be a one-way path. The mind-sets that allow a person to focus on knowledge or on markets are essentially distinct: successful researchers are driven by curiosity, whereas successful business persons are driven by a desire to manage risk and expectation. Successful business persons are focused on bringing a product to market in a timely manner; unforeseen issues are costs, and should be avoided. Successful researchers need time to make sense of their knowledge; unforeseen issues are an open door towards more and better knowledge. As a result, successful researchers usually are not successful entrepreneurs, and vice-versa.

Key Argument:

The central challenge of research-based innovation is that research and business mind-sets are essentially incompatible but must be brought together. It is the interaction between researchers and business persons that fosters the dynamics for research-based innovation.

3.1 A Choice between Two Models?

If one considers for a moment researchers only, their role in research-based innovation is often still essentially conceived as a choice between two flawed models. These are both centred on the assumption that research-based innovation is a linear process with sequential steps, where the subsequent step can only be taken after the previous step has been cleared and the ownership has been passed between their respective owners. In these models, the step from research to product development is particularly clear-cut. The Committee will focus its criticism on two models that can be found in various forms in research-based innovation policies.

In what, for the purposes of this Paper, will be called the **'ivory tower' model**¹², researchers make their new knowledge available to business persons as published papers or, sometimes, as patents, without further involvement in the innovation process. The publication identifies the moment when the research is completed and product development can commence. In this way, researchers ensure that they stay focused on producing the type of knowledge that will allow them to remain competitive when seeking further research funding or promotion. However, without the support of the researcher who developed the new knowledge, other innovation actors will be less likely to understand, take on and develop the research results into products or technologies. For many researchers caught in the 'publish or perish' dynamic, this may appear as the only choice compatible with their research career.

In what, for the purposes of this Paper, will be called the **'entrepreneurship' model**¹³, researchers personally take a leading role in a business venture, developing their research results, for example by founding and running a spin-off company. In this model, the researcher moves the process to the next step by taking a business role. By doing so, knowledge from the original research is brought along the innovation process. In this case, researchers are also more likely to receive a share of any financial benefits. However, their focus on a business venture conflicts with their ability to further conduct excellence-based research. The concerns of running a business draw attention away from the creativity required to conduct research. It is also likely to be detrimental to the researchers' careers in excellence-based research. Because of this, innovation is in practice usually conducted without the continuing enrichment of new research results.

The shortcoming common to both the ivory tower and entrepreneurship models is that neither gives value to the collaboration between researchers and business persons. In the ivory tower model, the interface for collaboration is reduced to the strictest minimum: a scientific publication or a patent. In the entrepreneurship model, the researcher engaged in the process removes or herself from this role to take on that of a business person. This is a critical flaw of linear innovation models that prevents their use as an intellectual foundation for serious research-based innovation policies. They do not take into account the following aspects:

- Excellent research produces knowledge that is complex and requires expertise to understand. At best, researchers will produce a prototype. Without active engagement by researchers to help understand the knowledge, business persons will either be unable to fully exploit the knowledge or else its exploitation will be delayed. In particular, taking into account market and production considerations will typically require significant additional research work on the original prototype; the lack of research expertise can severely impact innovative product development. For example, network analysis software available in research may be used by public transport operators to quickly enable their vehicles to get back to running according to the timetable after delays. However, because of the complex nature of the software involved and the specific needs of public transport operators, it would be a challenge for a typical operator to use these research results without considerable support and guidance by researchers.
- Throughout the innovation process, both the knowledge and the expected product will evolve. Knowledge will continue to be developed by researchers, either independently or in response to requirements linked to the development of the product. The product will likely also change in response to the needs of clients or because of pressure from competitors. If the knowledge available to the innovation process is frozen at the time of its 'completion', for example the publication of a patent, there is a risk that the relationship between knowledge and product will grow apart. In the worst case, this could lead to a situation where the proposed product loses its link to new knowledge. Innovation is no longer research-based, losing its breakthrough or cutting-edge potential. For example, without a link to research, the same public transport operator may not realise that new research has improved the performance of network analysis algorithms to a level such that it becomes possible not only to react to delays, but to predict them in real-time.
- The capacity to produce knowledge is enriched by the development of products or the experience of societal use. Without a robust collaboration between researchers and companies, researchers will not have access to valuable experiences and real-life data for their research. It will also be difficult for researchers to evaluate which research is interesting. For example, researchers working on network analysis algorithms may better focus their research priorities and produce more convincing results if they have access to real-life public transport situations and data.

As can be seen, the inter-dependence between knowledge and product is at the heart of research-based innovation. This is why it is important to emphasise that any model used to reason about research-based innovation must give a central role to the collaboration between researchers and business persons.

The Committee does not argue that the ivory tower or entrepreneurship models have no place in policy thinking. There is no doubt that taking the wealth of knowledge shared in publications or patents and making it more accessible to innovators is a worthwhile goal for policy action. The promotion of entrepreneurship and societal outreach skills amongst students is doubtlessly a sound investment that will benefit the student and the economy alike. However, because neither model focuses on the core issue of personal collaboration between researchers and business persons, they cannot be relied upon to provide the deep, systemic changes to research-based innovation capabilities that society should aim for.

The Committee members are, of course, aware that non-linear innovation models are now commonly discussed in innovation policy circles. However, as mentioned in Section 2.3, their impact on research organisations remains underwhelming. This may be due to the fact that existing non-linear innovation models may be difficult to use by research policy actors. The language that is used and the manner in which concepts are framed is that of business. These models also tend to describe innovation at a macro (systemic) level, without much focus on specific individuals. However, despite these shortcomings, this change in discourse is welcomed, and in Section 4.2 the role that non-linear macro models, notably the ‘helix’ models, can play in innovation policies will be discussed.

3.2 Innovation Communities

The Committee believes that innovators as individuals and their relationships must be at the heart of a model for research-based innovation. The previous section discussed how traditional linear models fall short in that regard. Instead, policy actors could develop research-based innovation policies using a model that:

- Recognises that researchers must be **engaged throughout the innovation process**, which is not the case for the ‘ivory tower’ model;
- Emphasises that researchers are **skilled professionals in their own right**, and that they should be supported, incentivised and recognised as such when engaging in research-based innovation, which is not the case for the ‘entrepreneurship’ model.

To achieve the above, it is proposed that the concept of ‘innovation communities’ is used.

Definition:

Innovation communities are groups of researchers and business persons developing a new product and new knowledge, where the co-ordinated developments of the product and of knowledge are mutually reinforcing.

This term has been chosen for the emphasis that ‘community’ puts on notions such as common interests and goals, joint ownership and liabilities, sharing, interpersonal contacts and the interdependency of participants. The term ‘innovation community’ or ‘community of innovation’ is also used in the R&D policy literature for ideas in relation to the model being discussed. A seminal paper by Coakes and Smith¹⁴ discusses communities of innovation as a form of communities of practice and identifies the role of ‘special people’ who play the role of innovation champions. The term has been knowingly chosen to provide a stepping stone into an area of the scientific literature that, the Committee believes, can enrich the debate, without necessarily endorsing it – the term is used to refer to a variety of ideas including some that would not be called research-based innovation.

The preferred model to reason about research-based innovation considers it an ever-changing constellation of innovation communities. The capacity for research-based innovation is directly linked to the ability of innovation communities to form and to flourish. In this context, some communities are large and long-lived, allowing innovation to mature on a large scale. Others exist for just an instant, around a table in a coffee lounge. All create a space where researchers and business persons meet around a shared goal, and where product and knowledge co-evolve in response to new needs. Section 4 will discuss what distinguishes a worthwhile innovation community. Section 5 will discuss actionable implications of this model for policy makers in general and research organisations in particular.

3.3 The Diverse Landscape of Innovation Communities

The definition of innovation communities is broad. The innovation communities model is a framework that can be used to reason about a variety of realities and to analyse policy actions. Some of the axes that structure the diversity of an innovation community are discussed below.

▶ **Product-oriented communities or long-term collaboration:**

- Innovation communities can be based on the introduction of a single product or service in a short time frame. Researchers and business persons have a common, concrete goal, with no *a priori* intention to pursue a longer-term relationship. This model, which is typical for university spin-offs, has the advantage of being able to react quickly to research developments or market needs. However, the limited scope in time of these innovation communities may restrict the synergies between researchers and business persons to simple knowledge transfer. Effective actions supporting these communities take into account their time-sensitive nature; long delays in obtaining support can break them at an early stage.
- Long-term collaboration between researchers and business persons better equips them to engage in more ambitious innovation, for example in exploring a new area of breakthrough technology. It is also more likely to provide long-term benefit for researchers in terms of returns of user experience and data. However, for researchers and business persons to participate in a long-term community, a level of pre-existing shared trust and goodwill is required. In that regard, innovation communities targeted to a single product can be a foundation for longer-term, more ambitious communities. Effective actions supporting these communities take into account their long-term nature; it is not uncommon in engineering disciplines that innovation communities require ten years or more to be able to produce societal value, half of that time for pre-competitive research and development (proof of concept), the other half for industrial development (proof of production capacity) and marketisation.

▶ **Early-stage or late-stage innovation communities:**

- Innovation communities can form at an early stage of the innovation process. In this case, business persons are present when research questions are being formulated or with research still at relatively low technology readiness levels (TRL). Early-stage innovation communities are often found in areas of applied research, but may also exist with more basic types of research when business persons have a long-term interest in developing a research field or promoting breakthrough technologies. Early-stage innovation communities have the advantage of testing the societal value of research at an early stage, which can inform research priorities and makes it more likely for the community to yield an innovative product. They also put knowledge at the centre from the start, ensuring that the innovation community remains research-based. Finally, it offers additional space to build trust between researchers and business persons and to develop a win-win mind-set.
- Often, though, knowledge has been developed to a relatively high TRL by researchers. They may have used dedicated schemes such as proof-of-concept grants, or knowledge that they developed as part of their own research efforts may end up having a potential for societal value. In this case, the innovation community forms at a later stage of the innovation process.

▶ Meeting of minds or institutional structures:

- Large innovation communities are typically shaped by their institutional structures. Consortia that comprise universities and companies can help researchers and business persons to engage in a shared community. Institutional agreements, often cemented by additional public or private funding, define the modalities of the collaboration, allowing researchers and business persons to focus on their collaboration without afterthought about their role in the larger structure. Because of their scope, they offer considerable potential to explore ambitious breakthrough technologies over long periods of time. These institutionally-driven communities are often the first to be considered in innovation policies, because their structure makes them amenable to policy intervention. Many instances of institutionally-driven communities can be found in Europe, such as the European Institute of Innovation and Technology's Knowledge and Innovation Communities¹⁵, the Graphene FET (Future and Emerging Technologies) Flagship of the European Union¹⁶, or the Instituts Carnots in France¹⁷, to give some examples of different structures. However, there is a risk with large institutionally-driven communities that institutional considerations override the innovation challenges. These may frustrate the ability of researchers and business persons to explore the most valuable synergies through a bottom-up approach. And when their success is measured in terms of institutional collaboration rather than in terms of research-based innovation dynamics at the level of individual participants, they can become little more than public relations vehicles.
- At the opposite end of the spectrum, innovation communities can be composed of a single researcher and a single business person with a plan to work together. Because of the small numbers of individuals involved and their bottom-up development, one-to-one communities or other small communities play a crucial role in innovation. Although they are small, they are not limited to short-term innovation. In fact, they can benefit from strong interpersonal links to develop long-term collaborations that can be highly rewarding to both parties. For example, a researcher in electron microscopy may develop close links with their microscope manufacturer. The business person benefits from access to knowledge, giving the business the capacity to put cutting-edge microscopes on the market. The researcher benefits from buying microscopes that are built specifically for the techniques that he or she is studying. However, even though one-to-one communities are essentially built around interpersonal relationships, they cannot thrive without policy frameworks that consistently support each partner's distinct role over time.
- Finally, innovation communities need not be framed in a strict contractual form. An increasingly popular model, commonly called 'open innovation' communities, is where a number of innovation actors reach a mutual understanding that their common interest is best served by exchanging knowledge and experiences openly. In this model, researchers and business persons are brought together not within a shared legal structure or through an institutional co-operation agreement, but by personal links and mutual values. Examples of open innovation can be found in open source software. For example, the Linux kernel (a program that controls a computer's electronic hardware on behalf of other programs) led to an ecosystem of researchers and businesses that commonly develop the system without a formal collaboration agreement, in a community that has been highly beneficial to both parties. Researchers in computer science benefit from the millions of Linux users who can provide data and accounts of their experience. Companies have successfully developed profitable business models from the freely available Linux kernel. Open innovation is not limited to software; an experiment in open innovation recently started in the electric car industry after Tesla motors made a number of their patents freely available, shortly followed by other actors in the industry.

► **Physical communities or virtual communities:**

- Many innovation communities are based on people in close geographic proximity. Researchers and business persons occupying the same building present a powerful driver for fostering innovation communities. Proximity favours interpersonal relations, trust and regular exchanges. For example, university technology parks are designed to create this closeness, although it must be emphasised that creating proximity is not in itself a research-based innovation policy. Furthermore, attaching an innovation community to a geographic location can restrict access to the people present at that location, reducing diversity and thereby constraining innovation capabilities.
- Innovation communities working on intangible services or software have long attempted to break the barrier of geographic proximity. The example of the Linux kernel community noted above involved people from around the world. Even world-class centres of research and business are limited in their capability to explore breakthrough technologies; virtual communities can open up innovation communities to the most relevant people irrespective of their location. Virtual innovation communities at a European scale, such as the European Union's Human Brain Project FET Flagship¹⁸, are exploring how data-driven science and innovation can target ambitious societal goals. The challenge of virtual communities is to overcome the original barrier of bringing people from across the globe into one innovation community. Bottom-up capabilities to create international communities, including in countries with less research and business capabilities, are therefore key to the success of research-based innovation policies focusing on virtual communities. In our experience, these capabilities remain limited.

► **Convergence communities or expert meetings:**

- People involved in an innovation community exploring a product based on a well-defined technology or method usually share similar vocabularies and work methods and may have done similar studies. The cultural gap between researchers and business people must still be bridged, but the common technological or methodological culture reinforces the community.
- However, the Committee emphasises the need to pay particular attention when innovation communities arise that involve people from different backgrounds. For breakthrough innovation to take place expertise from researchers and business persons from different backgrounds is required. Reflections on the convergence of disciplines, explored in a workshop organised by the Science Europe Physical, Chemical and Mathematical Sciences Committee¹⁹, should be taken into account when exploring heterogeneous innovation communities. In particular, the convergence between engineering and social approaches appears to be of great value. For example, innovation related to social networks is based on the exploitation of knowledge of both a technical and social nature, requiring a mix of researchers and business persons comfortable with these distinct aspects. It is noted that innovation communities may also be used as a policy to drive scientific inter-disciplinarity by bringing together researchers from different disciplines around a common societal goal, which the Committee believes to be more productive than inter-disciplinarity conducted for its own sake.

The diversity of forms that innovation communities can take may appear daunting when considering policy actions. This is, however, a challenge that policy makers aspiring to strengthen research-based innovation capabilities cannot overlook. Innovation communities should be supported using a policy framework that is flexible and that allows bottom-up exploration.

At the same time, considering innovation communities through a disciplinary lens may help to focus actions. As suggested above, differences in the form of innovation communities have some relation with the field of research being considered. A typical innovation community active in the area of online currencies, for example, will be notably different from one in automotive engineering. To give an example that is highly relevant, albeit outside the Committee's area of concern, biomedical research is well known to have particular innovation practices, notably linked to university hospitals. While it is beyond the scope of this Paper to explore how the form of an innovation community is influenced by its research field and industrial area, the members believe that collecting additional data to understand this relationship could help develop policy actions for research-based innovation.

In conclusion of this overview of innovation communities, it must be emphasised that this model does not describe a new concept. In fact, the Committee believes that innovation taking place in communities where researchers and business persons work together on a basis of trust and with a shared societal goal have been the hallmark of much successful research-based innovation in the past. Engineering and technical sciences have a long history of developing important and novel knowledge by relying on a deep understanding of societal needs and proximity with companies and governments. It is the aim of the Committee to alert policy makers to the success of this model, both in terms of researchers' ability to conduct excellent science and in terms of creating societal value. The members call upon research organisations to recognise innovation communities as a positive concept that they can embrace without jeopardising their role of supporting excellent research.

4. Towards Integrative Research-based Innovation

The previous two sections defined and demonstrated the value of innovation communities in implementing research-based innovation, and the shape that the diverse forms that these communities can take. If policy makers are to successfully support innovation communities and research-based innovation, they must focus on two aspects:

1. Ensuring that the incentives framework enables both researchers and business persons to engage actively and in a way appropriate to their capacities in innovation communities.
2. Establishing an environment conducive to the creation of innovation communities that have a common tangible goal with a strong sense of shared ownership.

This section envisions the implementation of research-based innovation communities from the global perspective. Section 5 will focus more specifically on the role that policy makers in the research system can play to support their researchers.

4.1 Engineering Innovation Communities that are Attractive to Researchers and Business Persons

For an innovation community to be created and to be maintained for a sufficient duration, all actors must benefit from being part of it from the start and for as long as necessary. Because public funding plays an important role in research-based innovation, any benefits will be highly

dependent on the framework conditions set by policy makers, such as funding opportunities, career paths of researchers, or intellectual property licensing practices. The term, 'incentives', will be used to describe all such framework conditions that can impact on the real or perceived benefit of participants in innovation communities. Using this word does not imply that researchers should be coerced to participate in innovation communities by aggressive incentives. It is also noted that negative incentives are often of greater concern than the lack of positive ones, for example in terms of decreased career prospects for researchers engaged in innovation.

Researchers and business persons do not play the same role and do not respond to the same incentives:

- Researchers provide knowledge. They are incentivised through strengthening their research career prospects by ensuring recognition of their contribution or being rewarded with funds that they can use to better plan their research. Incentives must aim at long-term effects, giving researchers the visibility in their own career that they require to embark on ambitious research projects.
- Business persons implement a business case. Their incentives are based on the risk they take. Incentives are short-term, allowing business persons to focus on the needs of clients and the development of a tangible product, and balancing capital flows and needs. Business persons are incentivised to move the innovation process forward. If it appears that the innovation is not delivering on its promise or that capital is not available, their incentives should favour early failure, thereby limiting losses.

The incentives that researchers and business persons are looking for when engaging in research-based innovation are incompatible. Innovation policies that incentivise business persons in the same way as researchers, or *vice versa*, are perverse. This is often the result of inappropriate linear thinking in research-based innovation:

- In linear innovation models, the early 'research and development' phase is supported by researcher-friendly incentives. Business persons are either not incentivised at all, so that the development of a business plan is delayed or is defined by researchers who may not have the skills to do so, or business persons are involved, but are not induced to focus on a tangible, realistic goal, leading to unfocused business plans, no focus on clients' needs, or overly ambitious goals. In both cases, the innovation is more likely to eventually fail because the early development of the business case is weak.
- In linear innovation models, the late 'development and commercialisation' phase is supported by business-friendly incentives (such as the provision of risk capital). Researchers are either not incentivised at all because their share in the company is too small, or they focus on the development of the product to respond to the incentives, effectively forcing them to play the role of business persons. In both cases, the innovation community loses the connection with active research; unforeseen technological or competitive challenges are harder to overcome without the ability to respond by referring to new knowledge. This creates additional risks for the company and is one component of the so-called 'valley of death' encountered by start-ups²⁰.

Policy makers should avoid linear thinking and recognise that effective innovation requires the creation of communities of researchers and business persons working with a common purpose but with different roles (see Section 3).

Key Argument:

Researchers and business persons need to be **incentivised (and evaluated) separately** at all stages of the innovation process. At the same time, they need to be integrated in **the same community**, which is also evaluated as a whole.

This creates specific challenges for policy makers. Organisations that support researchers (such as research funding and performing organisations and universities) and those that support or employ business persons (existing companies, innovation promotion agencies, incubators, venture capital firms, and banks) are institutionally distinct. However, an eco-system that is supportive of research-based innovation requires institutions of both kinds to collaborate. Section 5 will demonstrate that research funding and performing organisations cannot overlook the role they play in making such ecosystems viable, and possible actions to strengthen their role will be discussed.

4.2 Making Sense of Innovation Communities by Defining Societal Value

For a community to exist, its participants must benefit from being part of it, but it must also have a purpose, a structuring force that focuses the community.

Not only must innovation communities be beneficial to all actors, they must also provide a shared purpose for researchers and business persons that can build trust and drive the community forward.

- Researchers aim to obtain validation that the research they are conducting can be put in the context of a usage that provides societal value. For example, researchers in biotechnology may contextualise their knowledge in terms of developing useful wood-based biofuels, which in turn resonates with the societal challenge of developing low-carbon energy sources. Successfully engaging in an innovation community with a clear mandate gives researchers reassurance that their knowledge is valuable to the community and can be put forward as a genuine, credible part of the researchers' track record, for the benefit of their career.
- Business persons aim to ensure that the tangible goals of the innovation community support a viable business plan, so that they minimise the risk of failure in the process and maximise the return on their investment.

Tangible goals related to societal value are therefore at the centre of successful innovation communities: they allow researchers and business persons to share a common aim and to build a shared understanding of the purpose of their collaboration.

Key Argument:

Innovation communities are attractive to researchers and business persons alike if they are built on a **tangible goal** that is defined in terms of providing **societal value**. This is the foundation that allows researchers to evaluate the relevance of their knowledge to the community, and allows business persons to evaluate whether the community can support a viable business plan.

A 'tangible goal' is relatively clear in the context of innovation: it relates to a new service, product or practice. The 'societal value' provides a context for the tangible goal and allows potential actors to join together even before a tangible goal has been defined. It can take the form of specific challenges involving just one research group and one company, for example multi-frequency damping for earthquake protection. It can relate to breakthrough challenges, involving whole communities of researchers and multiple companies, such as in the Graphene FET Flagship project. It is noted that very broad areas of societal value, such as the 'societal challenges' defined by the European Commission and used in Horizon 2020²¹, are unlikely to foster innovation communities: no single, tangible goal can be defined in terms of 'health, demographic change and wellbeing'.

4.3 Creating Institutions that Support Innovation Communities

Policy makers should build their actions on the understanding that researchers and business persons are keen to develop innovation communities, if they have the capacities to do so:

- Researchers naturally relate their research to the societal value that it can produce. In many fields of engineering, where a strong start-up culture exists, researchers are actively trying to create innovation communities.
- Companies are looking towards universities for knowledge that supports the development of research-based breakthroughs or cutting-edge innovation. Larger companies in particular are looking to engage with universities or research groups in longer-term innovation communities²².

Creating an environment that is supportive of motivated individuals developing innovation communities is central to creating a capacity for research-based innovation.

However, bottom-up efforts are often frustrated by the fact that the actors are not supported when attempting to break away from either the 'ivory tower' or 'entrepreneurship' model. Researchers may shy away from engaging in start-ups created by their own students because they fear that this may be detrimental to the researchers' careers. Companies often end up licensing a patent from a university's technology transfer office without engaging with the research group that developed the underlying knowledge because no model is available for a more collaborative engagement. Contrary to current practice, such outcomes should in general not be considered as successes.

Policies for research-based innovation should attempt to remove negative incentives for the bottom-up creation of innovation communities. More effort needs to be made by policy makers to improve the framework conditions that would allow naturally-occurring research-based innovation.

However, there is also a place for more strategic routes focusing on institutional issues. The triple-helix model, in particular, may complement the model of innovation communities by considering the institutional structures that are likely to foster research-based innovation. The triple-helix model of innovation recognises that research institutions and companies collaborate throughout the innovation process; they represent the two first strands of the intertwined helix. The model then adds a third strand: public authorities, who support the other actors by linking the innovation to areas of societal value and by providing funds accordingly. For example, the city of Copenhagen and the Technical University of Denmark have long been collaborating as the third strand in a triple-helix innovation model, contextualising research in terms of the city's societal challenges and facilitating its access by companies.

Innovation communities can thrive within a variety of structures. It goes beyond the scope of this paper to explore all institutional forms that can support innovation communities. However, to give some examples, innovation communities have successfully developed within networks of research labs and companies, innovation centres within universities, research-driven companies such as university spin-offs, or in connection with certain types of research infrastructures such as pilot plants.

However, the Committee wishes to emphasise that merely creating a network, centre, or spin-off does not ensure that an innovation community will develop. In fact, most fail in that regard. Many such structures are broad and impersonal, so that individual participants do not feel any responsibility towards the intended community; indeed, there is no sense of community. University-based structures often do not have enough business persons involved or, when they do, are not appropriate for the type of research being conducted. Structures in the form of a company may only be able to host researchers as employees, which might be detrimental to the researchers' ability to conduct research or to their academic career. Whatever the structure, it must guarantee that all actors find a meaningful place in it.

Research-based innovation policies should therefore not be evaluated on the institutional structures they create, but on whether innovation communities flourish within these structures.

Key Argument:

Whatever institutional form an innovation community takes, it must ensure that:

- It is appealing to researchers and business persons from the start, so that the community can actually form;
- Its duration is sufficient to allow the innovation community to mature and reach its goals;
- Researchers receive reasonable support throughout the process, on a similar basis as they would when conducting research outside of an innovation community;
- Business persons find an environment that is viable from a business perspective, including at the beginning (which does not preclude them taking risks and contributing financially);
- All parties are recognised and rewarded for their contribution (albeit with different engagement at different times); and
- Its structure facilitates the flow of knowledge and experience between all actors, notably by fostering trust.

In conclusion of this section, the Committee emphasises that while the institutional set-up supporting an innovation community is important and that research organisations can play an important role in supporting it, the attention of research-based innovation policies should not be distracted from the researchers and business persons themselves and from the community they form. Notably, inflexible institutional set-ups can hinder the formation of innovation communities that require a great amount of diversity, as described in Section 3.3.

5. A Research System that is Supportive of Innovation...

In this Opinion Paper, the Committee emphasises the equal role of researchers and business persons in research-based innovation and within innovation communities. Therefore, research-focused organisations, such as ministries of research, research funding organisations, research performing organisations and universities, cannot overlook research-based innovation. In fact, such organisations are amongst the main partners in making research-based innovation possible.

Key Argument:

Research policy actors – including research funding and performing organisations – should **include in their policy-making process** the impact of their policies on the ability of researchers to engage in **innovation communities**. They should **engage with industrial policy actors** – notably innovation funding agencies – to co-ordinate their practices to be supportive of innovation communities.

This opinion paper does not seek to offer ready-made policy solutions, but rather aims to drive a discussion on possible actions. The rest of this section will build upon four questions that underlie the capacity and willingness of research policy actors to envision concrete action:

1. Are basic and applied knowledge comparable?
2. Can researchers engaged in an innovation community be excellent?
3. What support do researchers need when engaging in an innovation community?
4. Who are the other actors that research funders and performers must engage with?

5.1 ... Values Knowledge for its Use both Inside and Outside the Research System

Research results should be valued on the basis of how novel and important they are.

Novelty should relate to the amount of new ideas or new data underlying any new knowledge. Knowledge that pertains to basic notions is not intrinsically more novel than that pertaining to applied problems. Understanding a new fabrication process for a chemical compound may require as many new ideas and new data as the discovery of a new chemical compound.

Similarly, the importance of research results should relate to the number of persons that will be impacted by the results. Importance is still often reduced to the importance that new knowledge has to the members of a specific research community. It is obvious that the importance of knowledge is partially related to the contribution it makes to a community's ability to advance its research agenda, and perhaps to eventually produce breakthrough research. However, this should not distract from recognising the importance that knowledge may have for other research communities or, indeed, for society at large. A research system that is based on a narrow definition of the importance of knowledge is not conducive to interdisciplinary research and to research-based innovation.

In particular, applied research conducted in support of research-based innovation is not intrinsically less novel or important than other forms of research. Neither is it more important and novel. It should be evaluated on its merit and fairly. Often, however, evaluation practices and other incentives do not allow this form of applied research to be compared with other research results. For example, a researcher whose career was in industry may have produced extremely novel and important knowledge, but will find that it often will not be evaluated on its merits, if at all, because it has not been published in academic journals. A proposal to develop a new service or product should be recognised as a valid or important milestone in a research project proposal.

Research policy makers should strive to ensure that they can offer balanced evaluation of research conducted within an innovation community.

5.2 ... Recognises Researchers' Engagement in an Innovation Community

When researchers engage with an innovation community, they are taking time that could be used for traditional research activities, such as publishing papers. In a context of 'publish or perish' academic careers, this is seen as a major disincentive for engaging in innovation. Only if researchers feel that their engagement in an innovation community is valued in their career can they fully engage in.

The evaluation practices of research organisations and universities are therefore the foundation for facilitating research-based innovation from the side of researchers. The current debate on evaluation and peer-review practices should aim to extend their capacity to take into account a broad array of research practices and paint a better picture of a researcher's contribution to the research system and to society. This may include concrete factors such as:

- Knowledge that has not been published in peer-reviewed journals, but is described in technical reports or patents;
- Prototypes and software;
- Data;
- Training of students and young researchers; and
- Access to research infrastructures and other research capacities.

It should also aim to engage with more abstract factors that are representative of the importance of a researcher's contribution in an innovation community:

- The importance of the researcher's knowledge in reaching the expected societal goal of an innovation community.
- The importance of the researcher's knowledge in permitting the development of a viable business plan.
- The importance and novelty of real-life experiences and data obtained through the innovation community.

Of course, the evaluation of researchers involved in research-based innovation must also take into account the quality of the innovation community they engage with. Researchers should not be incentivised to engage with innovation communities that are unlikely to lead to successful innovation outcomes, or for which the expected societal goal is of little importance.

However, there are instances where the business case developed by the business persons in an innovation community is flawed, and the community must be shut down, but where the research being conducted is of high value. This may for example occur if an innovation turns out to be too ambitious and the development of the product fails. The experience gained may nevertheless be of high value for the development of better, more refined knowledge in the field. To ensure that important research is not put at additional risk by being linked to an innovation community, research organisations should be prepared to continue supporting such research on the basis of an evaluation independent of its place in the innovation community.

Defining good evaluation procedures for researchers is one of the greatest challenges of supporting research-based innovation and innovation communities. Novel models of peer-based and other reviewing practices should be explored. The Committee does, however, emphasise that evaluation by peers must continue to play a central role, including evaluation of innovation communities. Finally, it is noted that any change in evaluation must be made with a clear and confident commitment on future practices, so that researchers have the trust to make decisions about their career. Only then can changes to evaluation practices actually impact on the research system.

5.3 ... Supports Researchers when Working with Business Persons

Most researchers are not professional innovators, and should not be expected to be. When engaging in an innovation community, researchers should receive institutional backing. Working with business persons can be challenging for researchers, and vice versa. Without a strong supportive framework that ensures a place for researchers and a clear attribution of funding that is linked to the excellence of the knowledge produced in the innovation community, researchers may find that they have no choice but to accept that the innovation community is driven by business needs. In that case, no matter how good the incentives for researchers may be, the community cannot be balanced, and cooperation will not be fostered.

Therefore, research funding and performing organisations should either provide directly, or support universities in providing:

- A legal and contractual framework for various forms of innovation communities that is meaningful both to researchers and business persons. It should facilitate and clarify decisions relating to such questions as intellectual property rights, capital ownership and dilution, the

development of the company, sharing of risks, responsibilities, and so on. The research organisation should aim at being an ‘honest broker’, smoothing the relationship between the various actors in the innovation community. The US National Science Foundation, for example, has a policy of using its brand identity and institutional weight to serve as guarantor in academia–industry relations. Novel forms of legal entities should be explored to provide researchers with a platform to engage with business persons. Similar legal and contractual frameworks should be available for innovation communities built with ‘business persons from the public sector or civil society.

- Management of intellectual property rights originating from research conducted with public funds, for the benefit of the whole innovation community and in support of its societal goal. Royalties arising from the use of intellectual property developed by researchers in the innovation community should always be collected; some of these royalties should directly benefit those researchers involved. Business persons should be able to easily gain exclusive rights to key intellectual property for the purpose of reaching the shared goal of the innovation community. In general, they should not automatically have access to exclusive rights to intellectual property for uses other than those envisioned by the innovation community. For example, if the innovation community’s goal is to develop damper elements to mitigate earthquake effects on buildings, the business persons involved should not automatically be able to claim exclusive rights for the use of that knowledge when applied to automotive suspension systems.
- Coaching of researchers prior to engaging in an innovation community, and subsequently all participants in an innovation community.
- Clear guidelines for access to public infrastructures by companies working in an innovation community.
- Appropriate long-term financial rewards based on the profits of the company for all researchers involved, including young researchers pursuing a PhD. If a new company is created, this can take the form of a share in the company. These rewards should at least include additional funding to be made available to the research group.
- Support for reaching out to business persons or researchers in other communities to engage in innovation communities.

Another important aspect that research institutions should clarify with companies is the latter’s engagement in the innovation project. As a general rule, innovation communities should be co-financed by the companies involved, to ensure the companies’ genuine commitment to the community’s success as well as providing taxpayer value.

5.4 ... Integrates with the Rest of Society

In the same way that the ‘ivory tower’ model is flawed for researchers engaging in research-based innovation, research policy makers must seek to collaborate with other governmental and non-governmental actors to support research-based innovation.

Research organisations have the capacities and the trust from researchers to provide researcher-friendly incentives in an innovation community. They may have neither as a provider

of business-friendly incentives, which should either be offered by innovation organisations or private actors such as incubators, venture capital firms or banks. Research-based innovation that is not structured around the restrictive linear model of innovation does not allow for the defining of a 'hand-over time' where the responsibility for the innovation process goes from the research organisation to the innovation organisation. Instead, it requires that both work together to jointly support innovation communities in a complementary manner, tailored to the needs of researchers and business persons respectively. Of course, the ratio of financial support given to researchers and business persons will vary:

- At the beginning of the innovation process, research organisations should ensure that new knowledge can be developed rapidly, producing prototypes. Innovation organisations should ensure that business persons can explore the business potential within the innovation community, and start defining the needs of clients, assessing the competition, and so forth.
- At the end of the process, business persons need significant capital to ensure that the product can be brought to market. Research organisations should ensure that researchers still find a place in the innovation community at this stage, and can utilise the experience and data in the community to enrich their knowledge, and either contribute to solving new research-based challenges or create new knowledge that is important and novel by itself.

Conclusion and Main Recommendations

The Committee calls upon policy makers to continue expanding Europe's research-based innovation capacities.

General Recommendation

A debate with all stakeholders is needed to reinforce a common understanding of research-based innovation by taking into account the notion of 'innovation communities'. The following recommendation is of interest to all stakeholders:

1. Policy makers and administrators concerned with research-based innovation should include the notion of 'innovation communities' in their strategic planning.

They should ensure that their focus is on enabling the development of personal relationships between researchers and business persons and on creating communities based on trust, fair rewards and common societal goals. Institutional concerns – the creation of centres or networks – should be treated as a tool in support of innovation communities, not as a goal in itself.

Recommendations for Research Organisations

This Opinion Paper builds on the understanding that researchers and research organisations have a positive role to play in research-based innovation, and that it should not be considered as being in conflict with excellence-focused research. The following recommendations are intended for research organisations, including research funding and performing organisations. They assume that other policy actors would engage in complementary actions; it cannot be the sole responsibility of research to provide innovation capacities to society. The Committee recognises that these recommendations will need to be tailored to the individual organisations, as these are diverse in nature. However, the Committee believes that they provide a framework to inform policy action:

2. Research organisations should ensure they advertise their role in supporting research-based innovation with respect to their political mandate.

They should include this role in their institutional strategy, notably for their engagement with other national and international actors. All European stakeholders should work together to ensure that innovation communities are strengthened at the level of the European Research Area. Research funding and performing organisations should request appropriate public funding to support researchers engaged in innovation communities.

At the same time, they should promote the understanding that the public research system alone cannot strengthen research-based innovation capacities. To do so requires robust commitment from the business community and civil society as well as innovation-friendly public procurement practices.

3. Research organisations should strengthen their tools for supporting research-based innovation as an integral part of their mission to support research.

They should evaluate their existing research-based innovation schemes or develop new pilot schemes on the basis of their capacity to support the creation of innovation communities, notably taking into account:

- a. Whether they attract researchers and business persons around a common societal goal;
- b. Whether their duration is sufficient to allow communities to form and reach their goal;
- c. Whether their contractual and legal structure fosters trust and supports the sharing of knowledge and experience between the innovation community's actors;
- d. Whether researchers are supported for the duration of their engagement in innovation communities, with no financial or career penalty in comparison with other schemes;
- e. Whether they define contractual and financial conditions that are viable from a business perspective; and
- f. Whether selection, evaluation and incentivisation practices recognise and reward fairly all actors for their contribution.

4. Research organisations should strengthen their ability to understand and encourage the production of societal value by the researchers they support.

They should review the financial and non-financial incentives they offer over the whole duration of a researcher's career to discover and remove negative incentives that penalise researchers engaging in research-based innovation or who have worked for industry. Notably, they should:

- a. Develop capacities to recognise when researchers have been involved in innovation communities, and evaluate their internal dynamics and their societal value;
- b. Review practices of scientific track-record evaluation (including peer review) to better take into account knowledge produced in non-traditional forms, such as patents, prototypes, data, software, and other relevant knowledge;
- c. Develop operational capacities and institutional cultures that allow for the provision of practical support for researchers who wish to engage in innovation communities; and
- d. Develop institutional links with public and private organisations supporting business persons in innovation communities to better understand each other's role and co-ordinate responsibilities and actions.

▶ Notes

1. See for example the OECD's report: "[Innovation and Growth: Rationale for an Innovation Strategy](#)" which discusses national innovation roadmaps and explores their innovation potential.
2. See for example publications and citation data in the Royal Society report "[Knowledge, Networks and Nations](#)".
3. E. Mansfield: *Academic research and industrial innovation*; Research Policy, 20, pp. 1–12, 1991.
4. A Scott et al.: *The Economic Returns to Basic Research and the Benefits of University–Industry Relationships*; Science and Technology Policy Research (SPRU) report for the Office of Science and Technology, 2001.
5. As an example of this, the [Leiden ranking of world universities](#) by number of publications amongst the 10% most cited (a relatively robust indicator of scientific excellence), remains topped by American and European universities.
6. An overview of targets and of current R&D expenditures in EU countries can be found in: '[Europe 2020 Targets: Research and Development](#)', EU Commission, undated (data from 2012).
7. The concept of smart specialisation is [used by the European Commission](#) to promote innovation strategies that focus regional public investment in sectors where the region already has existing strengths.
8. Source: [2014 EU Industrial R&D Investment Scoreboard](#), report EUR 26903, p 8.
9. An example of such a scheme is the [European Research Council's 'Proof of Concept' funding](#).
10. An example is Norway's [Centres for Research-based Innovation](#) scheme.
11. An example is France's [CIFRE scholarship](#) scheme (*Conventions Industrielles de Formation par la REcherche*).
12. The term 'ivory tower' is commonly used to criticise the work of intellectuals, notably academics, who engage in pursuits that are disconnected from the practical concerns of everyday life.
13. The term of 'entrepreneurship' does not have a negative connotation. However, it is used here in reference to its indiscriminate application to researchers involved in innovation.
14. E. Coakes and P.A.C. Smith: *Developing communities of innovation by identifying innovation champions*; The Learning Organization, 14(1), pp. 77–85, 2007.
15. <http://eit.europa.eu/>
16. <http://graphene-flagship.eu/>
17. <http://www.instituts-carnot.eu/>
18. <https://www.humanbrainproject.eu/>
19. See the report on the Science Europe workshop on 'Convergence of Disciplines'.
20. The 'valley of death' is usually defined in terms of a lack of funds. However, the reasons why a start-up finds itself without sufficient funding are.
21. <http://ec.europa.eu/programmes/horizon2020/>
22. As an example of this, one can note the longstanding relationship between Philips and TU/Eindhoven, which has led to numerous joint programmes and strategic alliances.

This Opinion Paper has been produced by the Science Europe Scientific Committee for Engineering Sciences

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