From science to society

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The value of European Collaboration

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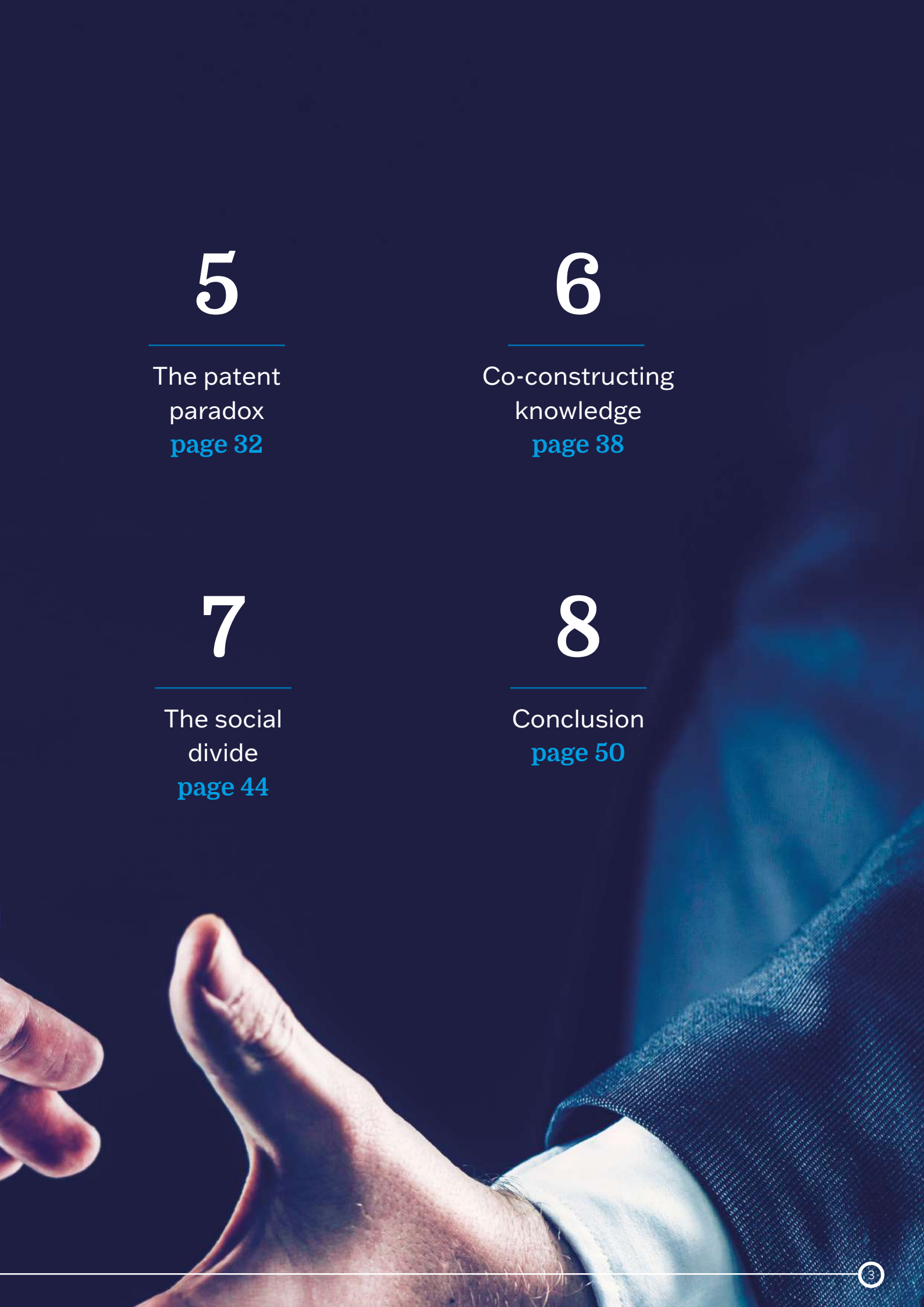
Contents



Foreword

Hervé Amar,
President of Ayming

Antoine Petit,
President of CNRS

Daunting challenges are – to innovators – compelling opportunities.

From climate change to the collapse in biodiversity, and from global food supply to widening socio-economic divides, the stakes today truly are formidable in every sense.

This dual nature of adversity has been epitomised by the last two years. The COVID-19 pandemic has accelerated change and emerging innovations – notably the adoption of digital technologies – while the associated disruption has also had deleterious impacts on industry, as well as public health and society more generally.

Ayming research for our International Innovation Barometer 2022 revealed some of these unsurprising – but no less disquieting – effects on businesses. Companies became more insular in their approach to research and development. Many pulled back from international collaboration. They also relied more on self-funding, losing access or confidence in external sources of finance, both private and state. Meanwhile, businesses also admitted to increased uncertainty about their budgets for R&D.

From its beginning, France's Centre National de la Recherche Scientifique (CNRS) has shown the capacity and dynamism to generate new ideas and solutions based on the best of French science, helping the research community address multiple challenges.

Both our organisations are confident that these latest setbacks can be reversed as the world learns to live with the coronavirus, even as industry and governments must also navigate waves of economic turbulence arising from geo-political conflict, cost inflation and the energy crunch.

Such are the depth and breadth of our global problems that they can be confronted only through collective intelligence. Our combined experience – of more than 100 years, pioneering scientific endeavour and supporting businesses with their innovation strategies and funding – reinforces our belief in the invaluable benefits of collaboration.

For Europe, that means catching up and overtaking North America, for example, where companies are more open to a mixed model of local and international cooperation. Other sectors can learn from the example of biotech and aerospace where the propensity for partnership is greater. And enterprises, research bodies and EU member states alike must make best use of the extraordinary opportunities presented by Horizon Europe.

It is natural therefore, given our collaborative ethos, that Ayming and the CNRS work closely together. We share the same commitment to joint working with industry, and to promoting public-private partnerships in research and investment.

This booklet is another joint effort to promote a fuller understanding of the enablers and obstacles to innovation, and the potential for harnessing science, technology and enterprise more effectively in the cause of economic, social and environmental progress.

We will continue to promote the case for collaboration across industry, public and private sectors, and borders; for a longer-term strategic approach to innovation; and for steady and sustainable funding for R&D.

Pillars of collabo-ration

Building bridges to breakthrough innovation

The bridges built between public research and private enterprise will lead to the breakthrough innovations essential for a successful, sustainable and sovereign Europe, according to Antoine Petit.

The President and CEO of the CNRS (French National Centre for Scientific Research) shares his perspective on Horizon Europe and the R&D landscape, answering questions posed by Ayming across four themes: from public-private collaboration to its societal impact, and Europe's economic sovereignty to France's priorities for its presidency of the EU.

Antoine Petit,
University professor, Chairman and CEO of the CNRS.

Emma Balayre,
Head of Operations R&D Grants at Ayming.

Pillar 1

Public-private / European collaboration

The EU's framework programme for research and innovation – now in its 9th edition – is well established at the heart of the European Research Area. Horizon Europe has significant implications for R&D efforts across both the public and private sectors.

What does the European research strategy mean for your organisation?

The great challenges of the 21st century demand global solutions that, in turn, require research collaborations that cross disciplines and transcend borders. Horizon Europe aims to strengthen the leadership of European research at the global scale, by encouraging industrial investment and collaboration with other research actors. The CNRS has defined its own strategy to facilitate the sharing of research excellence among the best European laboratories, whether they belong to the public or the private sector.

This initiative is meant to harness the potential of our scientists through Horizon Europe's research programmes. The CNRS is the main beneficiary of framework programmes, chiefly, but not only, due to its size. As such, it is the first beneficiary of the European Research Council and wishes to increase the participation of its researchers in the programmes of pillars 2 and 3 – 'Global Challenges and European Industrial Competitiveness' and 'Innovative Europe'.

And what place has public-private collaborative research in your strategy?

It is central. To maintain their competitiveness, French and European companies must increase investment in research and development. With our world-class multidisciplinary research capacity, CNRS can help companies realise their potential to extend and apply scientific knowledge through innovation.

By strengthening our relations with enterprises, we can better understand their challenges, what they need in terms of scientific resources, and the scientific and technological obstacles they encounter. Then it becomes possible to share roadmaps and agree on joint plans of action, leading over time to a growing number of joint research projects.

As we work with enterprises (including large groups and industrial associations), we will pay particular attention to partnerships formally recognised by Horizon Europe. CNRS will continue interacting with French and European enterprises on topics relevant to the continent – in particular, those within Club Europe - Enterprises, which was set up by our Department of Relations with Companies (DRE). The purpose of this Club is to foster synergies with industrial partners engaged in European partnerships.

In this way, we will identify, propose and conduct pre-competitive projects related to different European industrial sectors that will increase the flow of collaborative projects submitted for European funding.

Pillar 2

Societal impact

Competitiveness and innovation are fundamental to the EU's framework programme for R&D. As well as the twin pillars – (II) 'Global Challenges and European Industrial Competitiveness, and (III) 'Innovative Europe' – Horizon Europe also has 'mission areas' that directly address challenges such as cancer, climate neutrality, and smart cities. The CNRS can therefore be expected to have economic, social and cultural impacts on the lives of Europeans.

How will the collaborative research you are promoting impact European society?

By fostering excellence and cutting-edge research, the CNRS is a key actor of the economic world. The purpose of the CNRS is to perform basic research at its best level for the benefit of society. The CNRS has set scientific priorities around the following six societal and environmental challenges: energy transition, 'territories of the future', climate change, educational inequality, artificial intelligence, and health and the environment. We also pay special attention to the United Nations sustainable development goals.

These priorities are consistent with the missions and the cluster policy areas of Horizon Europe's second pillar – 'Global Challenges and European Industrial Competitiveness'. These are also challenges facing enterprises. Moreover, the best science will be needed to address these industrial and economic issues, and to develop solutions.

The disruptive innovations that follow will be essential for conquering new markets, keeping them, and creating value and sustainable jobs within EU member countries.

Interdisciplinarity at the CNRS enables a global approach, so we can deal with the different (scientific, industrial, technical, ethical, social acceptability, etc) dimensions of these breakthrough innovations, and thus, their potential impacts on European society.

How do you work with the private sector to maximise the impact of collaborative research?

Fundamental research is by essence frontier research; it keeps looking beyond, focusing on what might be the next step, whereas an enterprise tends to be more constrained in the scope of its outlook and action. It is in the common interest of the enterprise and of society to encourage and exploit this long-term strategic thinking, as both stand to benefit.

Moreover, as companies' investments in R&D are still too often constrained, it is in their strategic self-interest to build bridges with public research. Meanwhile, by engaging with the business world, public researchers will identify new research subjects and challenges, and try to answer the scientific questions that can unlock companies' innovation.

The strategic partnerships we are establishing with major European groups bring together these different perspectives to design new and potentially valuable scientific programmes.

Pillar 3

European sovereignty in a post-Covid world

The health crisis has highlighted the interdependence of the world's economies, and over-dependence in some areas of the European economy. In this 'post-Covid' world – if we can think as such – the question of European economic sovereignty must be raised and reconciled with Europe's traditional values of openness and humanism.

What is required to achieve greater European sovereignty?

The EU must take a leading role in fostering innovation, particularly breakthrough innovation, in strategic areas such as quantum technologies, artificial intelligence and epidemiology. At the same time, it is important to understand that 21st century challenges such as pandemics and global warming cannot be resolved at the European scale, and the EU needs to lead and/or support wider international action.

Current crises, whether in health or geopolitics (COVID, Ukraine), have far-reaching economic impacts. In response to such shocks, many companies choose to reduce their R&D activities. Part of our mission is to help our private partners support a long-term vision of their R&D activities given that reactive businesses risk being crushed by this 'tyranny of the short term'.

Serious supply chain disruption has highlighted the urgent need for greater economic sovereignty within the European block if not within EU member states. However, repatriating industrial production to national territories while remaining competitive on world markets remains a formidable challenge. This strategy implies more investment in R&D, at both private and public levels, and more synergies between all actors in research and innovation, from low to high levels of technology readiness (TRL). The CNRS runs more than 200 joint labs with industrial partners; these collaborations are strengthening the industrial base of France.

How can research, especially public-private collaboration, contribute to this?

More than ever, it is necessary to strengthen relations between the worlds of industry and academia so that together they can jointly pave the way for breakthrough innovations of tomorrow and the day after tomorrow.

The CNRS has a strong tradition of collaboration with major French industrial groups. For example, over the past 20 years, the CNRS has been involved in the creation of about 1700 innovative young enterprises. Now we must go further. Our partners, for example, can identify Industry 4.0 solutions (additive manufacturing, digital twins, Internet of Things, cloud manufacturing, etc) that will be essential to transform and expand Europe's manufacturing capacity.

We are ready to develop new collaborations, to propose new ideas and directions for research based on the best of French science, and to work with R&D personnel from companies on shared research projects.

Pillar 4

Influence and the French Presidency of the Council of the European Union

On 1 January 2022, France took over the EU presidency. This is generally seen as an opportunity to communicate key messages, launch initiatives, and drive forward developments that are priorities for the host country as well as important for Europe.

What, in terms of European research and innovation, is important to you?

The overriding objective of France's Presidency of the Council of Europe is to develop 'a more united and more sovereign Europe'.

This is an opportunity to share our French perspective and approaches to scientific research and innovation on the European stage through various events. These address open science, scientific and technological sovereignty, the attractiveness of the European area to business, innovation, and science-society links, and bring together representatives of French and European institutions, research organizations, and governments, as well as French and international scientists and companies.

How does public/private research fit in this agenda?

The CNRS is heavily involved at the European level, and has organized multiple events over the six months around various themes – but always exploring this public-private dimension of scientific research, collaboration and innovation across Europe, while also reflecting France's overarching priorities.

For instance, in key European strategic R&D areas such as quantum technologies and AI, during the French presidency we brought multiple stakeholders together in dialogue, including our main public research partners in these domains, but also other key European industrial and innovation actors.

To underline the necessity of more synergies at the European level between public and private research, we have organized a conference dedicated to collaborative research in Brussels.

Amid fierce international competition, the CNRS is committed to collaborative excellence in the European research area, in particular with its industrial partners. We have just celebrated the creation of our 200th joint laboratory – a significant number but still too few European enterprises are committed to such collaboration.

The power of partnering

Industry’s perspective on Horizon

How do participating companies view Europe's research and innovation funding programmes?

Members of Club Europe-Enterprises of CNRS shared their insights into the lessons so far and tips for newcomers to Horizon Europe with Emma Balayre and Pierre Roy.

Emma Balayre,
Head of Operations R&D Grants at Ayming.

Pierre Roy,
Director of Strategic Collaborative Programmes within the CNRS Directorate responsible for relationships with enterprises.

European Framework Programmes for Research and Technological Development have been funding and fostering research since the mid-eighties. The scope and objectives of the multi-year programmes have varied over that time as key priorities shifted. Gradually, industrial involvement has become ever more central to the Horizon Europe vision for delivering competitiveness in technologies and economic growth.

Enterprises are responding individually and collectively to the opportunities Horizon Europe presents, with the support of research bodies such as the CNRS (the French National Centre for Scientific Research). Club Europe-Enterprises is a think tank set up by CNRS in 2020 to bring together its industrial partners and other companies to develop a multilateral approach to Europe's research. The group is developing a strategy to position members not only for current calls for projects and work programmes, but also in anticipation of the second strategic plan expected in 2025.

We took the opportunity to speak to Club Europe-Enterprises members about industry's perspective on Horizon Europe and best practices in engaging with the research framework programmes.

A shared path to higher value

The value for industry from participating in the framework programmes comes in various forms (see Figure 1). From a strategic point of view, the most significant is the potential synergy that can be created by agreeing upon a common European strategy for key technological fields or at project level.

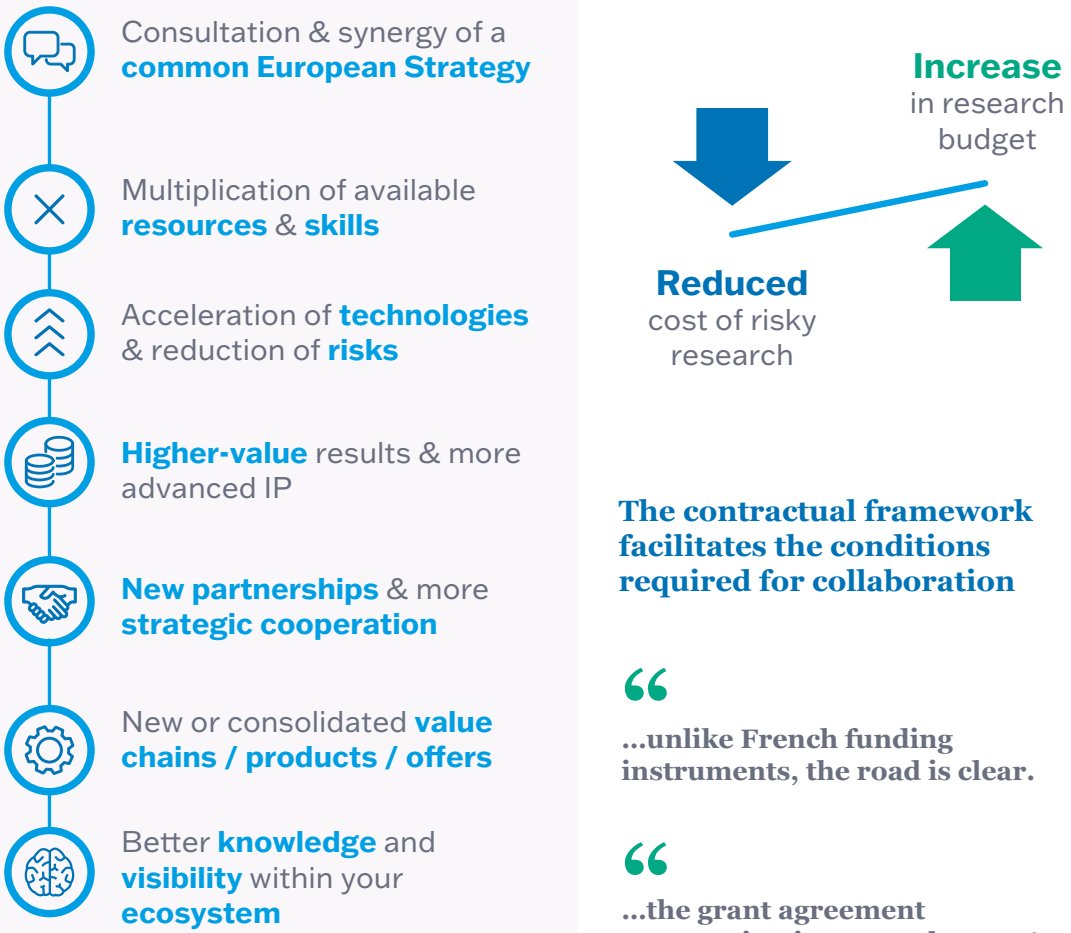


Figure 1
Added value of European Research & Innovation programmes

At this level, accelerating technological development and reducing project risks are of critical importance for industrial partners. In addition, these European projects deliver higher-value results and more advanced IP, and – as in any collaborative project – multiply the available resources and skills, benefiting all parties.

Participants also point out that these programmes present opportunities to set up new partnerships that can lead in the longer term to strategic cooperation.

The role of public-private partnerships

Public-private partnerships between the European Commission and industry are seen as an excellent means to establishing common European strategies in specific fields. The advantages that flow from these contractual arrangements are gained on both a strategic and an operational level (see Figure 2).

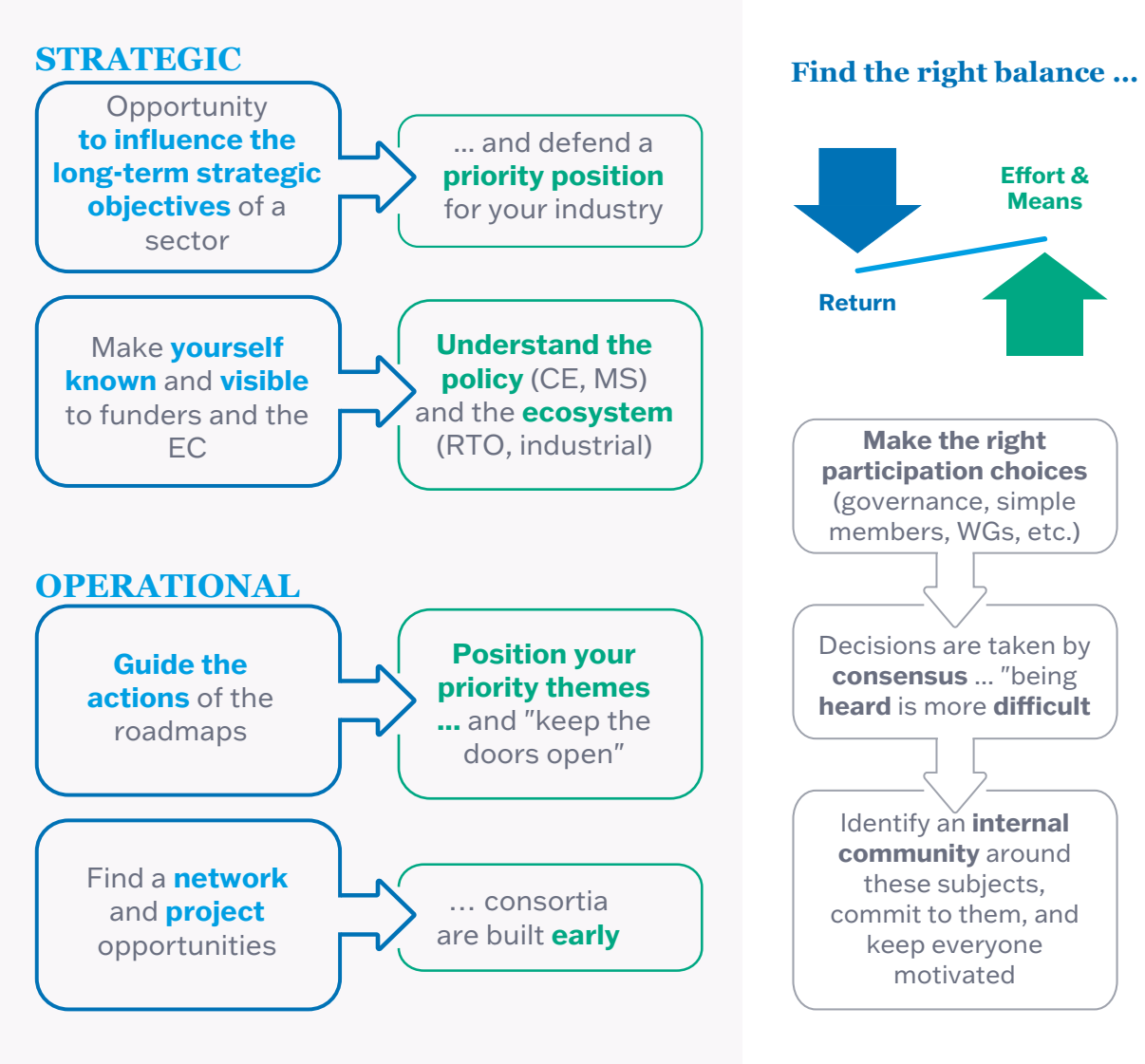


Figure 2
The advantage of participating in partnerships between the EU and industry, such as joint undertakings (JU), European Technology Platforms (ETPs) or contractual public-private partnerships (cPPPs)

As partners, industrial companies can influence the long-term strategic objectives within a sector, and when necessary, defend a strategic position based on various prerogatives such as market, competitiveness, R&D or other strategies, including more political or national concerns.

> *Public-private partnerships give us the opportunity to initiate the actions of our technological roadmaps and to position our priority themes. Among the strategic projects in which we participate, some contribute directly to the implementation of the scientific programmes of our joint laboratories.*
>
> Florence de Launet, Naval group

Participation in these initiatives brings with it a better understanding of policy, whether at EU or member-state level. There is the opportunity too to become better known and more visible to funders and the Commission, while also networking within the innovation eco-system network (research and technology organisations, industry).

> *As a member of public-private partnerships we have access to a great network and project opportunities; this is greatly appreciated since consortia need to be built early.*
>
> Anna Rossi, Faurecia

However, to maximize these benefits, members must make choices with regards to their participation, commitment and activity, and navigate the system and its multiple levels – from governance, through working groups, to individual members. Teaming up with other partners, especially from other member states, is of utmost importance, as decisions are taken by consensus.

> *As a member, it is crucial to establish an internal community around the definition of the Strategic Research Agenda and make sure to appoint the right technical expert for each SRA sub-topic representation. Managing to achieve that is the best way to transform project ideas into concrete long-term actions.*
>
> Guilherme Siepierski, Solvay

Strengthening the science-technology link

Most industrial and leading technology companies have very strong links with scientific groups from academia or research centres through joint laboratories or framework agreements.

These agreements are made to develop partnerships that are strategic (via framework agreements) and/or long-term (via joint laboratories) and to carry out joint research, often relatively upstream (low TRL or discovery-oriented), by sharing objectives, means and results. Thus, the respective teams get to know each other, to work together, to trust each other.

Technological challenges may be translated into scientific questions and arouse the interest of researchers.

Quite naturally, joint participation in European collaborative programmes and the setting up of consortiums must be based on a solid foundation.

> *"We are frequently involving academia or research labs in our projects; often first collaborations are made within national funding schemes, then we decide to bring it up to a European scale.*
>
> Jerome Peyard, Renault

In addition, funding opportunities at European level are unique in terms of amount and skill offer. It is therefore essential to establish transnational partnerships bringing together the best of science and the best of technology and to act at European level. This is particularly true for companies that are European (and global) players, having R&D centres but also production centres across Europe.

We must not forget the local relationships that are built on trust. This trust allows partners to share their respective networks and therefore to expand them.

> *"Working with scientific groups on a national level is rather difficult since funding conditions are less attractive and collaboration with industry is not natural. However, we do have very strong links with scientific groups outside of our national borders; we would appreciate having the same within France.*
>
> Dominique Defossez, NXP

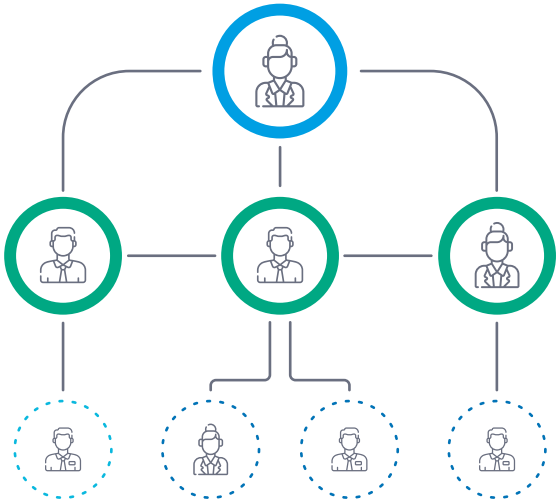
Best practices for accessing funding

If companies are to make effective use of funding programmes they must mobilize and raise awareness within their organizations, making sure they reach all stakeholders, from decision-makers to project leaders (see Figure 3).

There are various ways of achieving high awareness, such as a very centralized approach where dedicated working groups are set up to guide and follow up actions, or targeting divisions through regular presentation meetings or training. Whatever the choice, the challenge is about matching the opportunities of the calls for proposals with the company's internal technological roadmap, and whenever possible, involving the most appropriate experts in working groups and key events.

Mobilize and raise awareness

- Evangelize decision-makers
- Identify opportunities related to your roadmaps
- Internal promotion for all stakeholders
- Regular presentation meeting (R&D Board, Business Units …)
- Participation of experts in PPP / JU working groups
- Internal working groups to prepare the response to calls for projects
- Training on good practices



> *We almost always collaborate with a French public research actor within these programmes; this is not a barrier.*

Figure 3
Best practices for raising awareness and mobilization within your organisation

For us it is very important to put the project leader in the spotlight. Therefore, the bigger projects that we are involved in are committed at the very highest level of our company.

Emmanuel Custodero, Michelin

Such commitment has a cost. Facilitating these internal initiatives usually has a direct financial impact on the budget and bottom line of the division (see Figure 4).

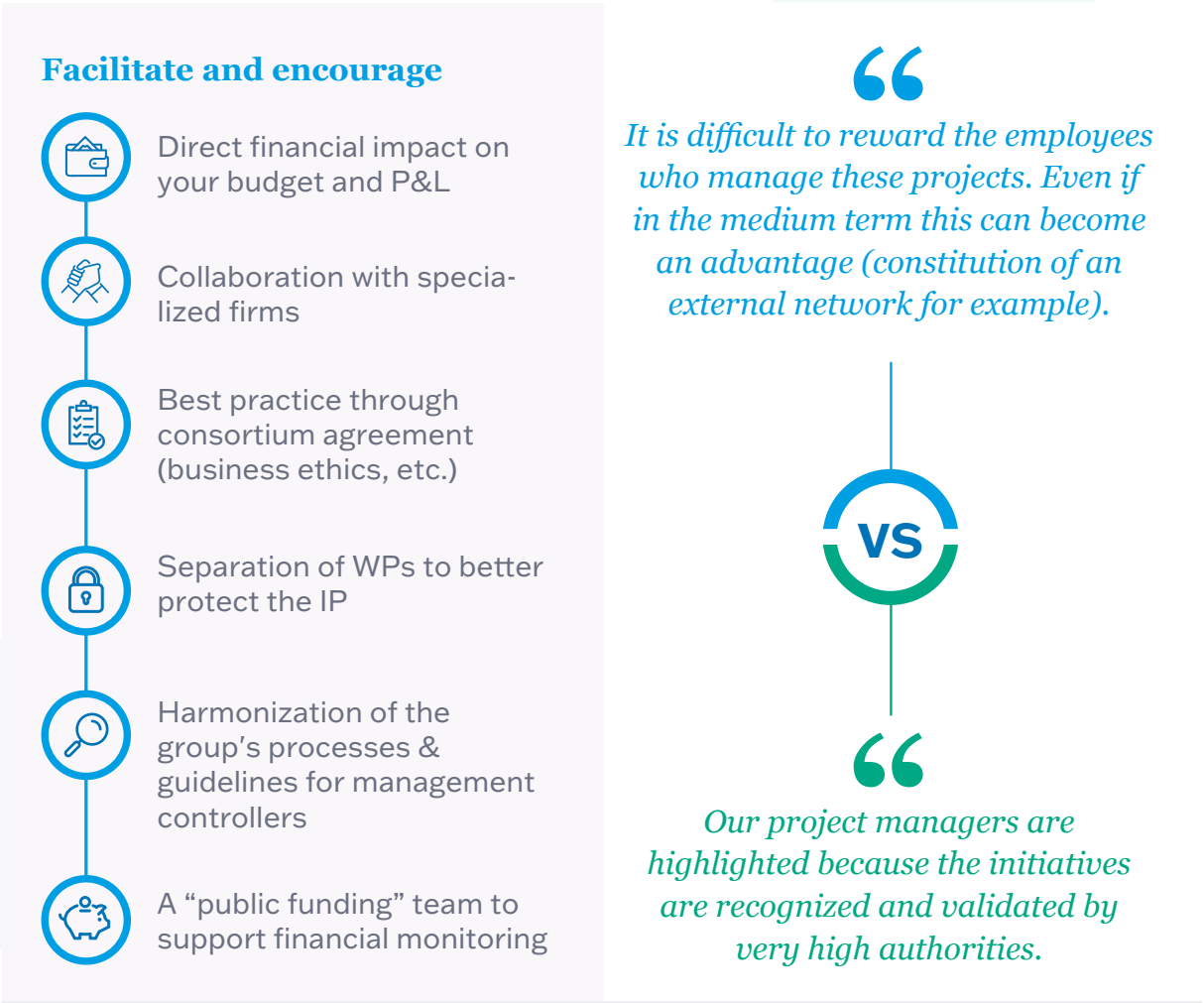


Figure 4
Best practices for facilitating your participation

Some organizations go further when managing and administering these initiatives by working with specialized consulting firms or setting up dedicated teams to support their collaborators. Group processes are harmonized, and guidelines are set in some cases to follow best practices that have been developed for aspects of consortium agreements.

It is crucial to protect the background knowledge and know-how well and isolate work packages, if necessary, to better protect the foreground results. When it comes to settling contractual rules within the consortium, one must say that the model consortium agreements are very efficient and highly regarded.

Olivier Esmilaire, TotalEnergies

Return on investment

Often companies find it hard to quantify the actual value of their participation because the product that results from a project is realised in the long term and the returns are diluted within the overall performance of the business.

However, most are clear that they have participated in projects that helped their company become established and recognized in certain fields. Some led to strategic collaborations within the value chain. And some cite their European project in discussions with clients to highlight their capacity to develop and adapt important technologies.

QUALITATIVE GAINS

- **Emblematic projects** that positioned you as a key player on certain themes
- **Strategic cooperation** following your project

QUANTITATIVE MONITORING

- **Technical progress** measurement (Technology Readiness Level) or IP
- Projects with a **high internal rate of return** on investment
- **Level of funding**

> *We could do better ... we are not taking enough advantage.*

> *We focus on quality and alignment with our strategy and invest in it.*

> *We promote our projects / technologies developed at European level during discussions with our customers.*

Figure 5
Measures used to assess return of investment

The economic value added is material, even if hard to quantify. Project results provide the basis for new or consolidated value chains, products and offerings. New partnerships are made or existing ones strengthened to achieve more strategic cooperation. And, for small and medium-sized companies in particular, higher visibility and wider knowledge of their capabilities across their eco-system is a potentially valuable by-product.

Advice for first-time partners

Members of the Club Europe-Enterprises think tank of CNRS have, collectively, accumulated profound experience of European research programmes. By developing best practices, they put this bank of knowledge at the service not just of their partners and CNRS, but also new participants.

> *"As a very active participant, we consider that it is also our role to promote the programme so that newcomers have the opportunity to join and develop their potential.*
>
> Emmanuel Remy de Cournon, STMicroelectronics

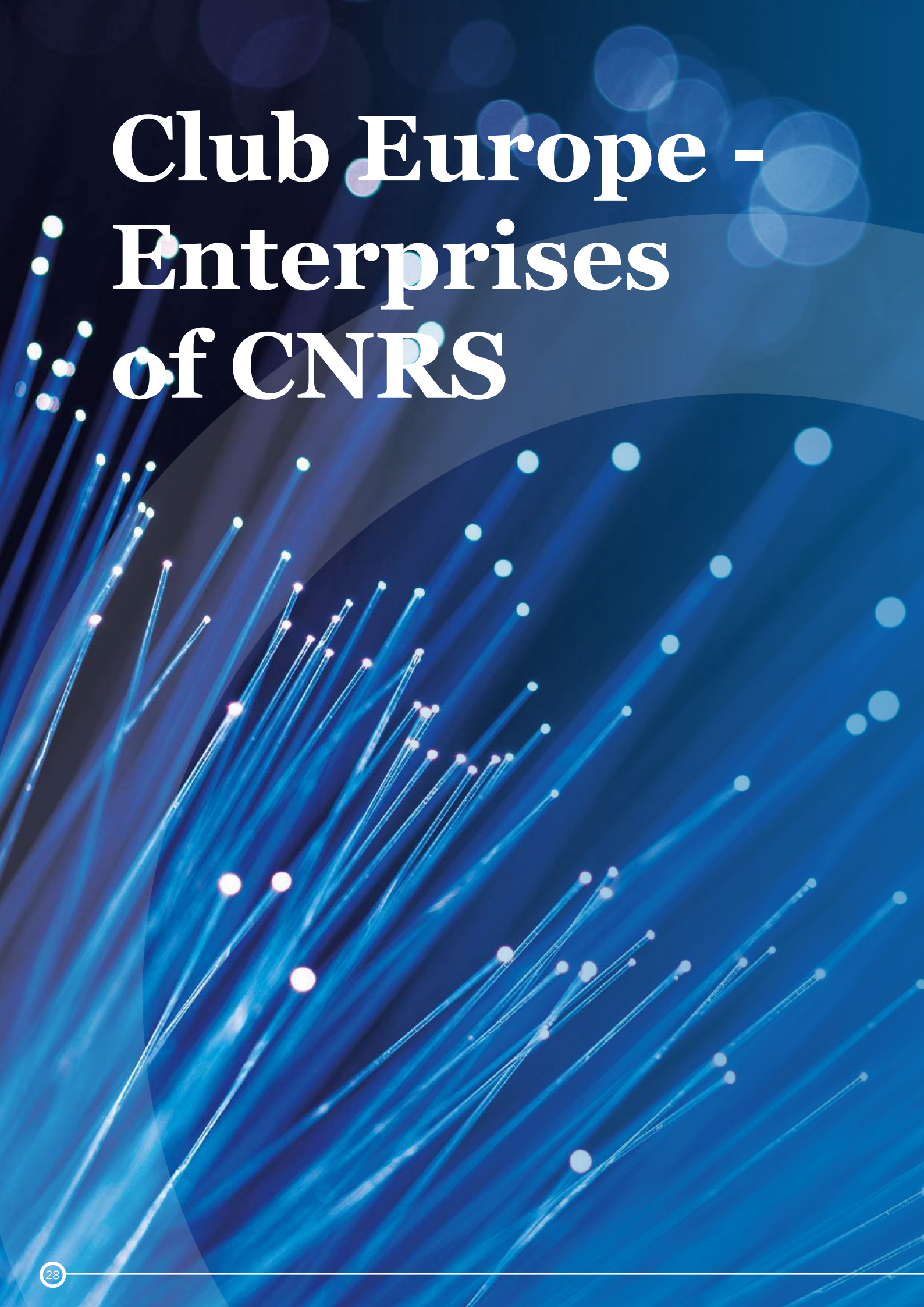
Where to go?
Setting your direction:

- Decide on your strategy at senior management level, ensuring a strong and enduring commitment to areas of research that have a long-term perspective
- Be clear about your strategic R&D axes and the goals of the organization so you are able to define your strengths and the resources you bring to projects
- Select opportunities according to your long-term technology roadmap
- Choose your research topic and approach actors who know the ins and outs of collaborative projects

How to get there?
Approach and guidance:

- Make the most of the facilitators, such as innovation networks/clusters, professional federations and other specialists
- Reach out to your ecosystem and form a core group through brokerage events or industry partnerships
- Accept that your initial attempts at collaboration may be complicated, so do not be discouraged, and learn from any failures
- Get assistance from professionals; setting up a European project proposal requires real know-how. Specialist consultants can provide valuable insights, and free you to concentrate on the technical aspects of your strategy or tender

Club Europe - Enterprises of CNRS



Founded in 2020 by the Business relations department of CNRS (DRE), Club Europe-Enterprises is a think tank dedicated to the future Horizon Europe research framework programme. It is supported by more than 20 industrial partners, including large groups and sector associations representing SMEs.

Members, who meet each quarter, aim to promote collaborative projects at European level, while also anticipating and preparing for future Horizon work programmes.

The CNRS adds value through its interdisciplinarity and ability to bring together companies from different sectors, based on mutual trust. Adapting its working methods to develop new relationships with enterprise, the CNRS is responsible for coordinating rather than managing the Club.

Private members add value by sharing their experience of collaborative research, European strategy and organisation, and of R&D consortium building, as well as their partnership networks.

Some companies joined to develop their own R&D programmes. Others are specialized, and need partners to diversify. Another motivation – notable among companies in electronics and space who are used to collaborative projects – is to allow other members to benefit from their experience.

The meetings are first and foremost an opportunity for members to discuss best practices on European projects. Another priority is the setting up of consortiums to respond to European calls for projects

It is also a possibility to share our actions and our contacts within European Partnerships of Horizon Europe.

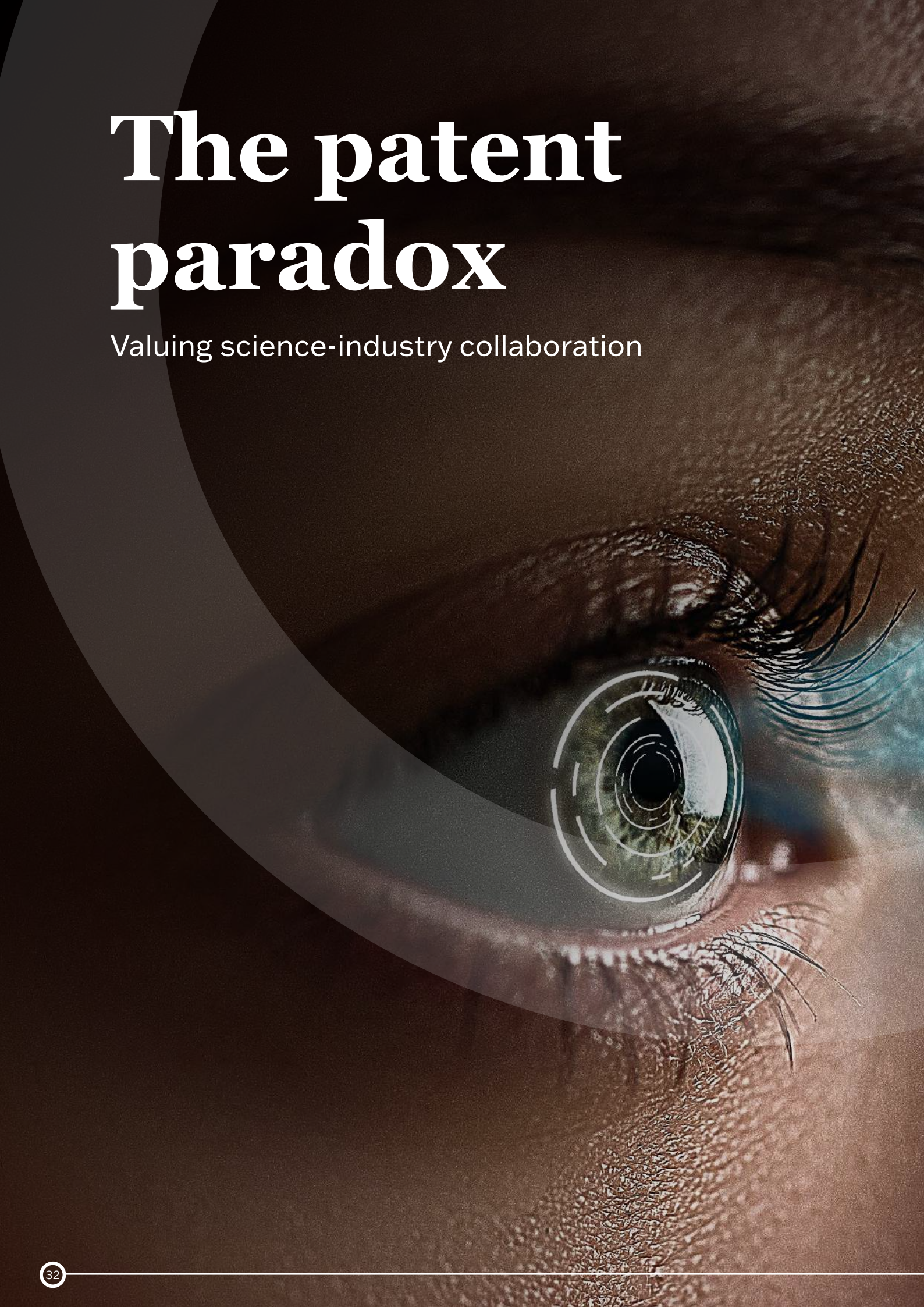
Two departments within the CNRS are involved in the Club.

DERCI — the European Research and International Cooperation Department – implements the CNRS's international and European policy. Whether for French or foreign institutional partners, it is the gateway for operations conducted both within the European Research Area and throughout the world.

DRE — the Directorate for Enterprise Relationships – implements the institution's enterprise relationship strategy, working closely with its Institutes, regional offices, and CNRS Innovation. The DRE is committed to providing personalised support to all strategic sectors, and helping companies achieve their scientific, technological, societal, and environmental objectives.

The patent paradox

Valuing science-industry collaboration



Drawing on his own research into patenting activity, Valerio Sterzi considers what changes may be required to strengthen collaboration between business and academia for the sake of future innovation.

Valerio Sterzi,
Associate Professor of Economics at Bordeaux School of Economics, University of Bordeaux and researcher at Bordeaux Sciences Economiques, a CNRS-University of Bordeaux research unit.

An apparent paradox has characterized the relationship between science and innovation over the last 30 years or so: on the one hand, corporate investment in basic research has either stagnated or declined[1]; on the other, the importance of science as a direct source of new products and processes has continued to increase – witness the rise of biotechnology and information and communications technology (ICT)[2].

This paradox is explained by the changing role of universities and public research organizations, which have found themselves uniquely well-positioned for producing prototypes and proofs of concepts derived directly from basic research, but with clear applications for product and process innovation[3]. As a result, companies (especially large businesses) have increasingly been able to replace or couple vertically integrated R&D strategies with open innovation and collaboration with academic scientists – not only for hunting new prototypes and proofs of concept, but also for developing them.

In view of these facts, I set out to analyse the contribution and value of science-industry collaborations to the overall patenting activity of industrial firms.

A collaborative patent is defined as a patent with more than one applicant. Science-industry collaborations are thus defined as collaborative patents involving at least one firm and one academic institution (university or public research centre), while industry-industry collaborations are patents gained jointly by two different firms.

This analysis covered patents filed in the years 1978-2015 (and granted up to 2020) at the European Patent Office (EPO) by industrial firms[4] based in four large European countries (Germany, France, Italy and the UK) and in the US.

About 93.9% of the industry patents analysed were sought by one firm only (non-collaborative patents)[5], 5.4% were co-applications by two or more firms (collaborative: industry-industry)[6], and 0.7% involved a joint application by firms and universities or public research centres (collaborative: science-industry).

1. Participation in scientific research by large American companies diminished over the period 1980-2006 – a decline particularly evident in high-quality publications. See Arora, A., Belenzon, S. and A. Patacconi, (2015), 'Killing the Golden Goose? – The decline of science in corporate R&D.' National Bureau of Economic Research, Working Paper No. 20902.
2. Ahmadpoor, M., and Jones, B. F. 'The Dual Frontier – Patented inventions and prior scientific advance.' Science, 357.6351(2017), 583-587.
3. Baba, Yasunori, Naohiro Shichijo, and Silvia Rita Sedita. 'How do Collaborations with Universities Affect Firms' Innovative Performance? – The role of "Pasteur scientists" in the advanced materials field.' Research Policy 38.5 (2009): 756-764.
4. To identify the type of applicant we performed an automatic search in the applicant's name: I used business entities code to distinguish private enterprises, and keywords – in different languages – to identify universities or public research laboratories.
5. Some of these patents may, however, derive from collaborations between a university and firm: this happens whenever a university professor transfers the invention autonomously to the private sector, or in the case of consultancy activities (Carayol and Sterzi, 2021).
6. Industry-industry collaborative patents could include both joint ventures and collaborations involving subsidiaries belonging to the same group.

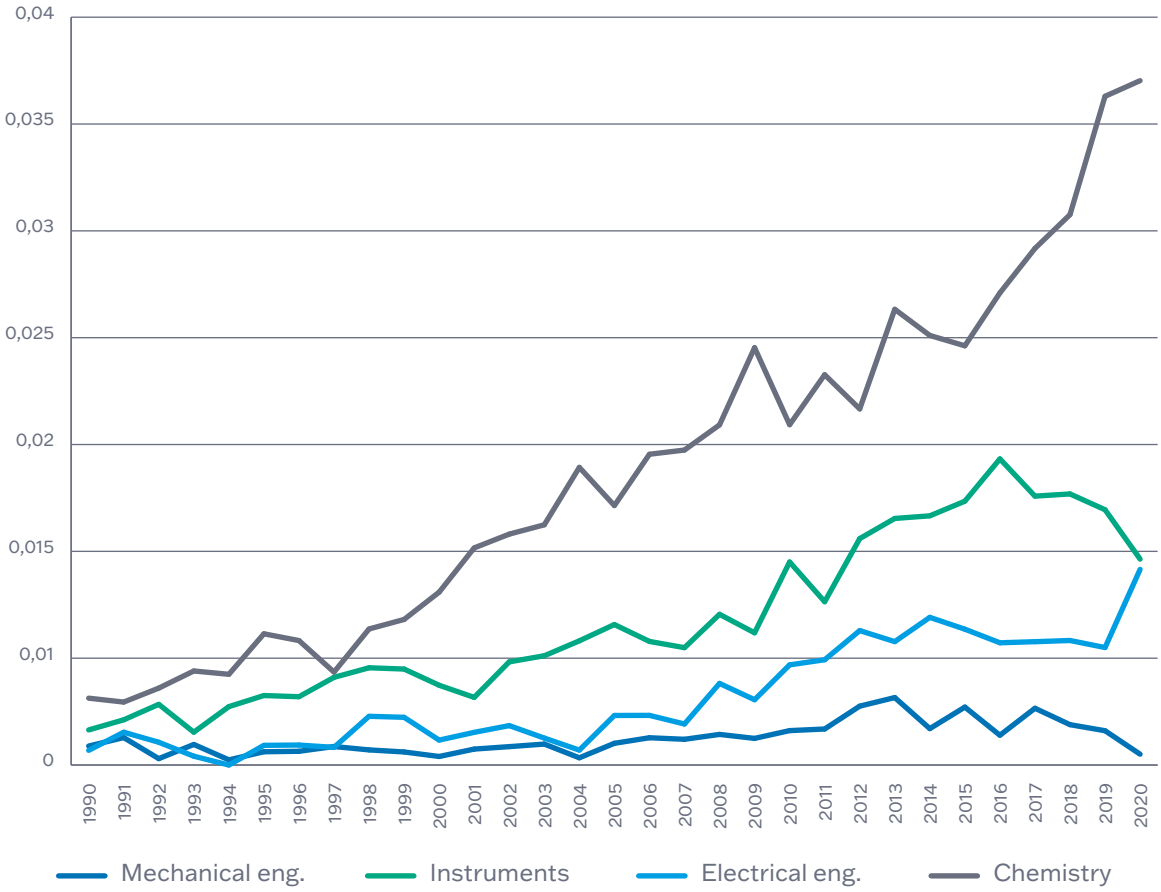


Figure 1
Share of collaborative science-industry patents by technological fields

Note: EPO patents filed in the years 1978-2015 by industrial firms in four European countries (Germany, France, Italy and the UK) and the US. Technological fields are defined according to WIPO 2011.

Three notable facts emerge from this analysis. First, the share of science-industry collaborative patents has increased continuously over the last 30 years, from less than 0.5% of the total number of industrial patents during the 1990s to almost 1.5% in 2020. Meanwhile, the share of industry-industry collaborations has been stable.

Second, the trend has been stronger in science-based technologies in general, and the increase is greatest for Chemistry (see Figure 1). The fields with the largest share of industry-science collaborative patents are Biotechnology, Micro-structural and Nanotechnology, and Pharmaceuticals – where between 4% and 5% of industry patents are co-assigned to academic institutions.

Third, the share of science-industry collaborative patents varies significantly across the countries considered in the analysis, with France showing the largest share (2%).

I then assessed the value of science-industry collaborative patents compared with non-collaborative or industry-industry collaborative patents. Two dimensions of patent value were considered: the technological importance (quality) of the underlying invention, and the economic value of the patent.

Technological importance mainly captures the contribution of the patent to follow-on innovation, based on the number of forward citations and the patent's originality. Economic value reflects the ability of the patent holder to exploit the invention protected by the patent commercially, as indicated by the number of patent renewals and family size.

When technological quality of the underlying invention is taken as the proxy of patent value, science-industry collaborative patents are slightly higher quality than industry-industry collaborative patents[1], and significantly higher in quality than non-collaborative patents (their value is on average between 0.059 and 0.074 standard deviations greater).

In terms of economic value, by contrast, the premium of science-industry collaborations disappears, suggesting that, on average, industry patents derived from collaborations with academic institutions are not particularly valuable to the private sector.

How can we interpret this result?

First of all, the peculiar use of patents from science-industry collaborations may reflect a greater need to clarify IP ownership and facilitate knowledge transfer, rather than exploit the underlying invention[2].

Second, the decision to patent a science-industry invention is influenced relatively more often by universities (than companies) seeking economic returns from public agencies that view patents as a performance indicator, rather than by a desire to protect an invention[3].

Third, it may be that firms do not generally collaborate with universities for core strategic projects. Where the collaboration is more exploratory and long-term in outlook, fewer patents will be renewed (and extended in fewer countries), because they open new lines of research and lead to subsequent patenting but not to protection of inventions in the market.

1 The premium is only marginally lower than the one found for science-industry collaborative patents (and the difference is not statistically significant).
2. Hellmann, Thomas. 'The role of Patents for Bridging the Science to Market Gap.' Journal of Economic Behavior & Organization 63.4 (2007): 624-647.
3. Sterzi, Valerio, Michele Pezzoni, and Francesco Lissoni. 'Patent Management by Universities – Evidence from Italian academic inventions.' Industrial and Corporate Change 28.2 (2019): 309-330.

Last, to be effective, science-industry collaborations require strong investment from both firms and academic institutions. Firms need to invest in absorptive capability (for example, by hiring managers whose role is to interact with academia) and communicate the firm's technological needs. For academic institutions, investments should include promoting their discoveries, making them more accessible to non-scientists, and transferring tacit knowledge (know-how) in the development process. Even when these investments are made, they are not always effective, especially when inventions are in an embryonic state and require the inventors' cooperation in the commercialization process[4].

Depending on which of these interpretations prevails, the results of this analysis raise some potential concerns about the future of innovation. Research conducted by universities may be an imperfect substitute for research performed by larger firms, especially when coordination and transaction costs (and eventually, conflicting interests) are relevant factors.

I hope that future research will explore the plausibility of these different interpretations.

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4. Jensen, Richard, and Marie Thursby. 'Proofs and Prototypes For Sale – The licensing of university inventions.' American Economic Review 91.1 (2001): 240-259

Co-constructing knowledge

How labs and firms create value from science

Jean-Alain Héraud challenges conventional thinking about 'technology transfer' and calls for a better understanding of how science and innovation interact within a complex knowledge ecosystem.

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For at least half a century, developed countries have pursued policies and built institutions with the purpose of creating value from science. Often called – in our opinion incorrectly – 'technology transfer', the valorisation of science is the process of exploiting scientific knowledge for economic or societal gain in the form of products, services or related applications.

To facilitate this process, each country has set up in its own structures, known generically as TTOs (Technology Transfer Offices). In France, the SATTs (Sociétés d'Accélération du Transfert de Technologie) – generally located near major university sites – perform this role within the national system of innovation. Large research organisations like CNRS (French National Centre for Scientific Research), INRAE (National Research Institute for Agriculture, Food and the Environment) or CEA (Atomic Energy Commission) also have valorisation structures of their own, centrally situated and/or spread over the territory.

All these structures fulfil the mission of linking public research actors with innovative firms of various size. Their interactions have usually been studied through a technology transfer lens, where knowledge is transferred in a unilateral way from the academic to the economic world. However, other interactions exist – and they are increasing with the complexification of innovation worldwide.

Technology transfer is non-linear

The common understanding is that public research activity is mainly devoted to basic science, and private organizations are in charge of applied research leading to commercial innovation. But the reality is quite more complex since part of the public research is also applied, intentionally or sometimes by serendipity.

The reality of the valorisation process for scientific activities is also more complex than the preconceived view in another sense. While 'technology transfer' suggests that this process is linear, in practice the creative interaction between basic research actors and those responsible for innovative projects in the economy or society involves an iterative co-construction in many cases.

Researchers in innovation studies have been aware of this reality since the 1980s (following the seminal work of Nathan Rosenberg [1]), but many policymakers have not completely understood the extent to which the global innovation model is interactive and organized in knowledge loops. Basic research, applied research and industrial development (or service design) are definitely distinct activities. However, this does not mean that they happen one after another in the process of innovation.

1 Kline, S. & Rosenberg, N. (1986): 'An overview of innovation', in Landau, R. & Rosenberg, N., The Positive Sum Strategy: Harnessing technology for economic growth, Washington D.C.: National Academy Press (275-305).

Valorisation of science is not one-way

Given its iterative nature, the valorisation of science must be considered as a creative relationship among actors through the process of research, not just after the production of scientific results. One must clearly distinguish between science in the making and science done. The valorisation of science concerns both the use of stabilized scientific knowledge (science done) and the co-construction of knowledge (science in the making).

The recent success of messenger RNA-based vaccines is a good illustration of the value of innovation processes interacting very early with basic research – not just waiting for sound stabilized science. Of course, such a strategy is risky and sometimes costly, but is there innovation without uncertainty? The problem with financial partners and policymakers is that they accept computable risk but not absolute uncertainty – yet this is the hallmark of any innovative activity.

The valorisation of science – not only through more or less radical innovation but also simple economic and social improvements – is a co-construction of different sorts of knowledge among several organizations and knowledge communities. There are pieces of pure scientific knowledge (the sort that leads to scientific publications), but also individual competences and know-how.

Private and public researchers contribute through hybridization and translation of such knowledge, but they are not the only ones. Sometimes technicians in public labs have a valuable applied knowledge from working on specialized research instruments that could be used in industrial contexts. Scientists can bring expertise, which is not the same as scientific knowledge. Science and expertise can also be injected into firms' innovation projects by specialized B2B actors like KIBS (Knowledge Intensive Business Services). They are good knowledge brokers, sometimes called Knowledge Angels [2]. PhD students can also play the latter role when working as trainees – and especially under CIFRE contracts (Industrial Agreements for Training through Research).

2 Doloreux, D., Freel, M. & Shearmur, R. (2010): Knowledge-Intensive Business Services. Geography and innovation. Farnham, Surrey: Ashgate. See in particular Muller, Zenker, Héraud (chapter 10) on Knowledge Angels.

The context is not neutral

As we can see, the TTOs are not the only ones to fulfil the role of linking science to the socio-economic world. The actors of valorisation function in different ways depending on national systems of innovation. For instance, the CIFRE system works very well in France but does not exist in Germany and is unimaginable in Japan.

In contrast, inviting scientists onto the supervisory boards of large firms is much more usual in Germany than in France, for at least one good reason: German groups have their Aufsichtsräte, whereas in France such conseils de surveillance are an exception.

Some issues are cultural as well as institutional. For instance, it has always been accepted in Germany that a university professor may work for a private firm, alongside his/her public job in education. In such a context, there is less need of public incentives to connect public labs with economic actors. In contrast, joint labs (laboratoires mixtes) between university teams and public research organizations or even firms are a specifically French phenomenon; and probably impossible to replicate within the German system, although it is an effective way of connecting knowledge communities.

The other important feature of the German national system from a valorisation point of view is its nationwide network of Fraunhofer institutes located in areas with important universities, research centres and firms. These institutes occupy the niche of adapting science and technology to firms' innovation needs through contract research (80% of their revenue). Nothing like that exists in other countries. The Carnot institutes in France are, by comparison, a very modest approach to the same mission, with a completely different institutional setting.

International comparisons and policy benchmarking are difficult because institutions as well as cultural traditions are so different. Behind identical words, the realities are not the same. For instance: in France a university is a public institution that derives most of its income from the state; in the UK, universities act like private companies and some of the leading ones have considerable assets (even land); in Germany, they are public institutions but the post-war federal constitution provides that they are paid by the Länder, and – in the spirit of von Humboldt's nineteenth-century reform – protects the autonomous status of research, making it very difficult for public authorities to steer university policy.

Knowledge is co-constructed

Beyond national distinctions, valorisation has universal aspects too – in particular, the complexity arising from the multiple roles of each actor. Basic research opens new avenues for disruptive discoveries – possibly giving rise to disruptive innovation – but also contributes to incremental innovation, for instance through the development of scientific instrumentation. Applied research can open up, in a non-programmed way, new scientific questions leading to valuable basic research agendas.

Industrial activity works sometimes like a large-scale laboratory that raises fundamental questions – that fundamentalist researchers did not have on their agenda. Basic and applied research are often interwoven in the case of breakthrough discoveries as well as breakthrough innovations[3]. Spintronics (spin electronics) and the discovery of giant magnetoresistance by Albert Fert (and independently, Peter Grünberg) is a typical example of the complex co-construction process involving research agendas and commercial technology development.

Policymakers and finance officers should stop thinking they have to choose between science and innovation. Both are part of a complex creative ecosystem of knowledge.

3 See chapter 2 in Héraud, J-A., Popiolek, N. (2021), L'organisation et la valorisation de la recherche. Problématique européenne et étude comparée de la France et de l'Allemagne, Bruxelles : Peter Lang.

The social divide

Time to integrate soft sciences with innovation

To solve the transitional crises facing society, innovators must end the exclusion of the humanities and social sciences if new technologies are to save us from the effects of the old, argues Pascal Taranto.

Pascal Taranto,
Professor of Philosophy of the Enlightenment, and Director of the Center Gilles Gaston Granger, CNRS – Aix-Marseille University research unit, specializing in history of philosophy, history of the sciences, and epistemology.

Europe is the cradle of the humanities and social sciences. European research programmes tend to forget this, as they too often consign these areas of knowledge to categories such as culture, gender, governance, ethics or whatever. However, the humanities and social sciences (HSS) form a pool of creativity and innovation from which all calls for proposals can and should draw, even the most technologically oriented. The complexity of our possible futures demands a broader synthesis and multidisciplinary perspective on the sciences and technology.

Collaboration for utopia

The various crises we are currently experiencing (climate, energy, health, economic, political, and so on) are unique in that they are transitional crises. The return to the norm (a pacified society confident in its future) will not be simply a restoration of the previous state with the help of more or less incremental innovations (electric cars, new vaccines, new types of EPR nuclear reactors or local economic organizations). It will consist in the redefinition of the norm itself, under the constraint of historical circumstances: what kind of society do we want, and what do we need to do to get close to it?

Reflection on the role of innovation in our societies thus immediately touches on political utopia, on the reinvention of a model of social organization likely – for our liberal democracies – to counter the proposals of illiberal democracies and non-democratic countries that widen the gap between the people and the 'elites'. Liberal democracies must, in contrast, move towards greater socio-political integration, based on a community of interests and the desires of citizens.

A new social pact is expected. It is a question of committing all forces (the citizen community, the socio-economic fabric, the academic world and political structures) to participate and reflect on a vision for a way out of the crisis (utopian moment), to identify the problems that need to be addressed in order to get closer to this vision (the moment of collaboration between science, the economic world, politicians and civil society), to invent the most acceptable technical and socio-economic solutions (innovation moment).

Participation, collaboration, integration, and transparency: participatory science and democracy go hand in hand. The method must be collaborative, and the ethics those of transparency and openness.

Innovation and social progress

From my point of view, the role of HSS in this mutation of our societies, their articulation with technical progress, will be decisive. What we need is to detach the concept of 'innovation' from that of 'technical progress'. Indeed, the latter nowadays bears, often unjustly, the opprobrium of having been the motto of scientism and technoscience, and the emblem of a capitalism held responsible for our situation.

The gap has widened between citizen and scientists, and technology no longer makes us dream. The question of the acceptability of new techniques has become crucial. It is thus necessary today to re-tame technology if, in a Schumpeterian perspective and its concept of 'creative destruction', one assumes that only new technologies will save us from the effects of previous technologies and bring us new possibilities.

Thus, the HSS constitute an impressive reservoir of creativity and innovation for reconciling technology and society. For several years, many projects led by laboratories of the Institute of Human and Social Sciences of the CNRS (inHSS) have combined fundamental research work and industrial or commercial development by and with businesses. For instance, the SMILE project, currently in development at Aix-Marseille University (AMU), brings together two CNRS units (one of them purely HSS), a microelectronics company and a data science company to nudge citizens into responsible environmental behaviour prompted by air pollution sensor data displayed on an innovative collaborative platform.

Another instance is the Mapping Autistic Cognitive Abilities (MACA) research programme conducted at the Centre de Mathématiques Sociales (EHESS, Paris), which aims to systematically assess the remarkable abilities of autistic people. MACA is an experimental psychology platform dedicated to research on atypical intelligence, and it paves the way for career inclusion pathways based on the strengths and talents of people with autism, rather than focusing on their shortcomings. It has become a start-up collaborating with IBM.

Boosting collaboration with humanities and social sciences

We can put forward a few ideas for boosting innovation in connection with the human and social sciences in the medium term.

The situation – A general survey on HSS participation must be done and updated. How many HSS submissions, interdisciplinary projects with HSS coordination, or strong participation (as work package leader), the rates of successes, the thematic fields, and the outcomes: books, articles, trainings, patents? The names, contacts and thematic fields of the people involved in these application files, successful or not, should be put into a database accessible to every interdisciplinary project leader and fully searchable with Boolean filter all over Europe, following the Horizon programme's research tools. Such a database should address companies' needs for R&D collaboration.

Method – Build a European network of committed HSS referents from all disciplines capable of structuring projects with scientists and engineers, and value this mentoring role. To avoid simply adding a superficial 'HSS layer' to 'interdisciplinary' projects – which will be useless to some and frustrating to others – the HSS should be integrated from the project definition stage with a view to overall structuring (coherent articulation of technical and societal/cultural aspects). Mixed working groups should be asked in advance to reflect broadly on this articulation: no innovation project nowadays is to be considered as 'purely technical' anymore. For companies, this is important, so they communicate about the social value of their innovations.

Simplification and support – It is also necessary to simplify the identification of pertinent calls for proposals, and ensure follow-up at earlier stages of the project. Efforts have been made with various portals, but the idea is to engage people that are reluctant. Therefore, it is necessary to drastically increase the support functions (specialized engineers, development units, SATTs, etc) so as to identify/guide potential HSS project leaders by helping them to find their way through the jungle of calls for proposals, and help them on managerial/budget issues and with many basic skills. Companies should be involved in training researchers in commercial and administrative aspects of a start-up project.

Unleashing energies – 'Pure HSS' should be valued more. We need to review how funding in calls for proposals is apportioned for the HSS; this has been reduced for years to the model of the hard sciences. For the latter, the expenditure on equipment and manpower is necessary and considerable, and management is heavy and complicated. However, most purely HSS projects can be financed with a very small fraction of such funding (€20-50,000). If 'lighter' calls for proposals that include innovation as a secondary item show a better rate of success, researchers could be encouraged to think of their projects in terms of possible prototyping and further exploitation, with the help of support structures and mentors. Companies should consider how to fund light HSS project through sponsorship and communicate about it.

Committed committees – A 'cultural revolution' is also needed at the level of Steering Committees (COPIL), the bodies making the final decision on many innovation funding applications. In general, risk-taking should be increased and HSS participation should not be a handicap. The composition of committees should include HSS mentors. European companies should be less reluctant to employ HSS researchers.

New tools and concepts – Massive development of digital collaborative tools for joint projects is essential to integrate researchers, engineers, the private sector, and the R&D departments of large companies. One must create communities via virtual third places / living labs, where one can freely ask for advice, share the benefits of one's experience, question the community of innovators, and open the science to citizens. Collective intelligence is the key. The LABΩ programme – a digital collaborative platform designed for research, currently being developed at AMU – will be available in mid-2022 and will offer such a tool. It is another instance of a fruitful collaboration between a HSS lab, the SATT, and two digital businesses.

In conclusion, innovation must become an integral part of the culture of the humanities and social sciences, as companies and funding programmes increasingly consider them a strength. For this to happen, institutions must give concrete proof of their confidence, calls for projects must be rethought to enhance the value of the HSS contribution, and companies must treat this largely untapped pool of skills and expertise as an asset.

Conclusion

The premium on innovation has never been higher – for business, society, Europe and the world.

This booklet comes at a pivotal point for the ambitions of Horizon Europe – not least its goal of fostering competitive industries and sustainable economies in member states that will help solve the global challenges facing humanity.

As our contributors observe, Europe has a vibrant ecosystem of innovation, but all actors will need to be fully engaged if we are to achieve the full potential of the framework programme's almost €100 billion investment to 2027.

Companies do value their involvement in the EU's framework programmes, as members of Club Europe - Enterprises attest. The benefits are varied and significant, and range from the financial to the wider synergies that can only be generated by such international partnerships.

However, to deliver the breakthrough innovations essential for a successful, sustainable and sovereign Europe, more and stronger bridges need to be built between public research and private enterprise. Both sides stand to benefit. Businesses increase their investment in R&D, which is still too often constrained, and by engaging with the business world, public researchers can identify new research subjects and challenges that unlocks companies' innovation and inspire long-term strategic thinking. The research revealed here into the value of patents resulting from such joint efforts indicates that further work may be needed to optimize these collaborative arrangements.

Our brief survey of the innovation landscape also points to other lessons for policymakers, researchers and business leaders alike. We can all do more to close the gaps between science and innovation on one hand, and science and society on the other.

The process of translating new scientific knowledge into action, commercial or societal, is more complex that many are willing to credit. With the right commitment, resources and expertise we can manage the co-construction of knowledge and technology transfer more effectively.

Nor can we afford to downplay the social and environmental dimensions of innovation. The existential threats we now face demand new technologies and solutions – often to problems arising from the misuse of past industrial advances; (for example, greenhouse gas emissions, microplastic pollution and antibiotic resistance). Full account must be taken of ethical implications from the outset of research projects to produce

technological solutions with acceptable socio-economic and environmental consequences.

This calls for a new social pact, committing all forces (the citizen community, business leaders, the academic world and political structures) to participate, and contribute to a shared vision for the progressive change that will lead us out of crisis.

The Horizon Europe programme provides a well-established framework for the research and innovation needed to deliver on the EU's ambitious goals, across sectors, disciplines and borders.

Collaboration will be central to this work. For more than 30 years, Ayming has facilitated European R&D partnerships while helping companies optimize their innovation strategies and funding. The CNRS too is engaged in intense dialogue with industry, listening attentively to companies and contributing to their scientific resourcing through its internationally recognised expertise.

We are clear that it is through such collaboration that we will build the capabilities of the continent's research and industrial base so as to maximize the benefits to European economies, the environment and society.

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Head of Operations R&D Grants
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Biographies

Hervé Amar is President of business performance consulting group Ayming. He started his career at F-Initiatives, where he became the Managing Director in 1998. After the acquisition of the company by Alma CG, he joined the position Director of the Innovation Cluster in 2001, later taking up the role of Managing Director in 2008.

After his studies in Economic Science at the Université Paris Nanterre he obtained a Master of Advanced Studies from the Université Paris Dauphine.

Hervé also wrote a book called "The balanced Business" where, backed by his own experience, he deconstructs the mechanisms that enable companies to safeguard their business models, accelerate innovation policy and anticipate market shifts. In his book he also underlines the importance of time and employee motivation, encouraging decision makers to rely on openness, common sense and invest in the well-being of their teams.

He is passionate about Digital, Innovation and Change Management, constantly evangelizing about the importance of the human side of business and how it allows Ayming to stand out.

Hervé also founded in 2018 the Ayming Institute, the think tank of the Ayming Group which brings together all the value-added knowledge produced by experts to think about tomorrow's business performance.

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Emma Balayre is Head of Operations of R&D grants within Ayming. Following a year's research in nanotribology at the Fraunhofer IZFP Institute and Ohio State University, she joined Ayming in 1999. Emma has implemented numerous collaborative projects in fields such as Energy, Transport, Materials and Processes, and Environment. Emma has also acted as Expert Evaluator within European R&D funding programmes and, for three years, chaired the 'Collaborative Projects think tank' within the French professional Association of Innovation Consultancies (ACI).

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Antoine Petit, university professor, was appointed Chairman and CEO of the CNRS on January 24, 2018. With a degree in mathematics and a doctorate in computer science from the University of Paris Diderot, Antoine specializes in formal methods, mainly based on transition systems, for the specification and verification of parallel systems in real time. A teacher-researcher from 1984 to 2004, he was associate professor at the University of Orléans, lecturer at the University of Paris-Sud, then professor at the Ecole Normale Supérieure de Cachan in 1994. From 2001 to 2003, Antoine Petit was Deputy Director of the Research Department of the Ministry of Research, in charge of mathematics, information and communication sciences, and the technologies sector. In 2004 he was seconded to the CNRS, first as scientific director of the Information and Communication Sciences and Technologies department, and then as South-West interregional director. In 2006, he joined Inria to manage the Paris-Rocquencourt research centre, before being appointed Deputy Managing Director then Chairman and Managing Director in 2014.

Pierre Roy is Director of Strategic Collaborative Programmes within the CNRS Directorate responsible for relationships with enterprises. An engineer, he worked for nearly 20 years in the chemical industry before returning in 2006 to CNRS, where he had been a researcher early in his career. Prior to his current role, Pierre was responsible for managing CNRS involvement in French innovation ecosystems, and later, the Focus Transfert programme for breakthrough innovations.

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Pascal Taranto is Professor of Philosophy of the Enlightenment, and Director of the Centre Gilles Gaston Granger in Aix-Marseille University, a unit specializing in history of philosophy, history of the sciences, and epistemology. Within this unit he is developing collaborative platforms and tools for the digital transition of higher education and research.

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