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Foreword

The OECD Review of France's Innovation Policy is part of a series of OECD country reviews of innovation policy. It was requested by the French authorities, represented by the General Commission for Investment (CGI), with the support of the Ministry for Higher Education and Research (MESR), and was carried out by the OECD Directorate for Science, Technology and Industry (DSTI) under the auspices of the Committee for Scientific and Technological Policy (CSTP).

The purpose of this review is to obtain a comprehensive understanding of the key elements, relationships and government policies that drive the French research and innovation system (SFRI). The review provides an independent assessment of the performance of the SFRI. It pays special attention to the benchmark year 2010, because it is intended to serve as an initial assessment of the SFRI conducted in the context of "Investments for the Future Programme" (PIA) of the CGI, but updates have been incorporated as necessary. The review formulates recommendations on how to improve the performance of the SFRI.

The study of France's innovation policies covers the same areas as the other reviews in this series: human resources for innovation, public sector research, relations between science and industry, industrial innovation, business innovation and overall governance of the system. However, it will highlight the major diagnostic elements of the SFRI in 2010 by focusing on the system's strengths and weaknesses and analysing how the PIA, as an innovative public policy in terms of scope and methods, seeks to remedy some of them. Thanks to the in-depth diagnostic work, the review will also identify the global context for the PIA, as well as the other public policy elements that could accompany and supplement the actions taken within the PIA, whose purposes are necessarily restricted.

In so doing, the review will identify *ex ante* the changes that a "successful" PIA should reasonably engender, as well as the environment in which it operates and in which other public policies could complement the trend created by the PIA, thereby facilitating assessment work for a future review stemming from this initial exercise.

The first PIA (PIA 1) is a EUR 35 billion (euros) programme launched in 2009 for a period of 10 years, designed to steer France onto a new path of stronger and more sustainable growth based on innovation. This first programme was supplemented by a second tranche of EUR 12 billion, announced in July 2013, which extends and supplements PIA 1 and is also under the aegis of the CGI. In view of this very tight schedule, the review will focus very heavily on PIA 1.

Approximately two-thirds of PIA 1 funding is earmarked for higher education and research. The study commissioned from the OECD will be considered as a "pre-PIA" assessment of the SFRI, reviewing the situation prior to the programme's launch; a "post-PIA" assessment will be performed at the end of the programme to ascertain the change over the intervening period and evaluate its direct and indirect impact. The OECD has also been asked to propose a set of indicators that will allow tracking changes in France's performance in the relevant fields over the coming years, so as to assess the effects of the PIA during its implementation.

Of course, a significant number of new policy initiatives have been taken since 2010, beginning with the PIA itself, which acquired a second tranche. The aim of many of the initiatives is to address shortcomings in the SFRI – discussed in this study – and to adjust previous policy decisions after considering the initial effects of their implementation. Although they were taken after the reference year and are therefore not central to this study, the review will refer to the most notable among them and assess their potential impact on the SFRI in the coming years, although not in the same detail as the earlier measures. These measures' compatibility with the PIA and capacity to increase its effects will be examined in order to identify, where possible, the true effects of the various public policies conducted.

Like the other country surveys carried out by the OECD, the French review draws on interviews with major stakeholders in the national innovation system (see list below), together with a number of recent reports on various aspects of the SFRI – some produced at the request of the Government, others at the instigation of the French Court of Auditors or private sector stakeholders, still others written by academic experts.

A preliminary version of the chapter "Overall assessment and recommendations" was presented to the CSTP in October 2013 and to the OECD Committee on Industry, Innovation and Entrepreneurship in March 2014.

The review was drafted by Dominique Guellec (head of the Country Studies and Outlook Division, DSTI, OECD), Stéphan Vincent-Lancrin, senior analyst, Directorate for Education, OECD, Chapter 3), Patrick Llerena (professor at the University of Strasbourg, Chapter 5) and Philippe Mustar (professor at the École des Mines-ParisTech, Chapter 7), with contributions by Erik Arnold (director, Technopolis Group), Mickaël Benaïm (researcher, University of Strasbourg), Mireille Matt (research director, French National Institute for Agricultural Research) and Giulia Ajmone-Marsan (analyst, Country Studies and Outlook Division, DSTI, OECD). It benefitted from suggestions and comments by Frédérique Sachwald (MESR), Sylviane Gastaldo (director of the public investment evaluation programme, CGI), Vincent Moreau (investments officer, CGI), Grégoire Postel-Vinay (head of strategy at the General Directorate for Competitiveness, Industry and Service, Ministry of the Economy, Productive Recovery and Digital), Jaques Serris (general mining engineer, General Council for the Economy, Industry, Energy and Technologies), Rémi Barré (professor, Conservatoire national des arts et métiers), Jean Guinet (professor, Higher School of Economics [HSE], Moscow), Frieder Meier-Khramer (former State Secretary for research, Germany), Philippe Larédo (professor, Manchester University) and Michael Stampfer (managing director of the Vienna Science and Technology Fund, Austria). A previous version benefitted from comments by CGI, the General Commission for Strategy and Policy Planning, MESR and the Ministry of the Economy.

The review draws on a series of interviews arranged by Beatrice Jeffries (Country Studies and Outlook Division, DSTI, OECD). Grateful acknowledgements go to Romy de Courtay for her editorial work on this report.

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Abbreviations and acronyms

AAP-ANR/AAP-PIA	*Appel à projet de l'Agence nationale de la recherche/du Programme d'Investissements d'Avenir* Call for proposals by the French National Research Agency/The "Investments for the Future Programme"
ADEME	*Agence de l'Environnement et de la Maîtrise de l'Énergie* French Environment and Energy Management Agency
AERES	*Agence d'évaluation de la recherche et de l'enseignement supérieur* Evaluation Agency for Research and Higher Education
AI-Carnot	*Association instituts Carnot* Association of Carnot institutes
AII	*Agence de l'innovation industrielle* Industrial Innovation Agency
ANR	*Agence nationale de la recherche* French National Research Agency
BERD	Business expenditure on research and development
BPI	*Banque publique d'investissement* French Public Investment Bank
CDC	*Caisse des Dépôts et Consignations* Deposits and Consignments Fund
CEA	*Commissariat à l'énergie atomique et aux énergies alternatives* Alternative Energies and Atomic Energy Commission
CGE	*Conférence des Grandes Écoles* Association of French higher education and research institutions
CGEIET	*Conseil général de l'économie, de l'industrie, de l'énergie et des technologies* General Council for the Economy, Industry, Energy and Technologies
CGI	*Commissariat général à l'investissement* General Commission for Investment
CHU	*Centre hospitalo-universitaire* University hospital
CIFRE	*Convention industrielle de formation par la recherche* Industrial agreement on training through research
CIR	*Crédit d'impôt recherche* Research tax credit
CIS	Community Innovation Survey
CNES	*Centre national d'études spatiales* French Space Agency
CNISF	*Conseil national des ingénieurs et scientifiques de France* French National Council of Engineers and Scientists
CNRS	*Centre National de la Recherche Scientifique* National Center for Scientific Research
CSR	*Conseil stratégique de la recherche* Strategic Research Council

DGA	*Direction Générale de l'Armement* French Defence Procurement Agency
DGAC	*Direction générale de l'aviation civile* French Civil Aviation Authority
DGCIS	*Direction générale de la compétitivité, de l'industrie et des services* Directorate General for Competitiveness, Industry and Services
DMTT	*Dispositifs mutualisés de transfert de technologies* Mutualised system of technology transfer
ECTS	European Credit Transfer and Accumulation System
ESA	European Space Agency
EU15, EU27	European Union of 15 Member States, European Union of 27 Member States
EVCA	European Private Equity and Venture Capital Association
FCE	*Fonds de compétitivité des entreprises* Business Competitiveness Fund
FCPI	*Fonds commun de placement dans l'innovation* Innovation mutual fund
FIST	*France Innovation Scientifique et Transfert* France Scientific Innovation and Transfer
FNA	*Fonds national d'amorçage* National Seed Fund
FNS	*Fonds national de la science* National Science Fund
FPRTD	Framework Programme for Research and Technological Development
FUI	*Fonds unique interministériel* Single Interministerial Fund
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
HCERES	*Haut Conseil de l'évaluation de la recherche et de l'enseignement supérieur* High Council for the Evaluation of Research and Higher Education
HCST	*Haut conseil de la science et de la technologie* High Council for Science and Technology
Hegesco	Higher Education as a Generator of Strategic Competences
ICTs	Information and communications technologies
IDEFI	*Initiative d'excellence en formation innovante* Initiative for excellence in innovative training
Idex	*Initiative d'excellence* Initiative of excellence
IEED	*Institut d'excellence sur les énergies décarbonées/ITE* Institute of excellence for carbon-free energy/ITE
Ifremer	*Institut français de recherche pour l'exploitation de la mer* French Research Institute for Exploitation of the Sea
IGAENR	*Inspection générale de l'administration de l'éducation nationale et de la recherche* General Inspectorate of the Administration of National Education and Research

IGF	*Inspection générale des Finances* General Inspectorate of Finance
IHU	*Institut hospitalo-universitaire* University hospital institute
INPI	*Institut national de la propriété industrielle* French National Institute of Industrial Property
INRA	*Institut national de la recherche agronomique* French National Institute for Agricultural Research
INRIA	*Institut national de la recherche en informatique et en automatique* French National Institute for Research in Computer Science and Control
INSEE	*Institut national de la statistique et des études économiques* French National Institute of Statistics and Economic Studies
INSERM	*Institut national de la santé et de la recherche médicale* French National Institute of Health and Medical Research
IP	Intellectual property
IRT	*Institut de recherche technologique* Technological research institute
ISE	Intermediate-sized entreprise
ISI	*Programme Innovation stratégique industrielle* Strategic Industrial Innovation Programme
ITE	*Institut pour la transition énergétique* Energy transition institute
IUT	*Institut universitaire de technologie* University institute of technology
JEI	*Jeune entreprise innovante* Young innovative enterprise
Labex	*Laboratoire d'excellence* Laboratory of excellence
LETI	*Laboratoire d'électronique et de technologie de l'information* Electronics and Information Technology Laboratory
LIST	*Laboratoire d'Intégration de Systèmes et des technologies* Systems and Technologies Integration Laboratory
LITEN	*Laboratoire d'innovation pour les technologies des énergies nouvelles* Laboratory for Innovation in New Energy Technologies
LRU	*Loi relative aux libertés et responsibilités des universités* Law on the Freedoms and Responsibilities of Universities
MEN	*Ministère de l'Éducation nationale* Ministry of National Education
MESR	*Ministère de l'Enseignement supérieur et de la Recherche* Ministry of Higher Education and Research
MIRES	*Mission interministérielle "Recherche et Enseignement supérieur"* Interministerial Mission for Research and Higher Education
MRP	*Ministère du Redressement productif* Ministry of Industrial Recovery
MSTI	Main Science and Technology Indicators

ONERA	*Office national d'études et de recherches aérospatiales* National Aerospace Research Centre
OPI	*Office de promotion des industries et des technologies* Office for the Promotion of Industries and Technologies
OST	*Observatoire des sciences et des techniques* Observatory of Science and Technology
PCT	Patent Cooperation Treaty
PIA	*Programme d'Investissements d'Avenir* Investments for the Future Programme
PFMI	*Plateforme mutualisée d'innovation* Shared innovation platform
PRES	*Pôles de recherche et d'enseignement supérieur* Research and higher education clusters
PRL	*Plan réussite licence* Successful graduation plan
PRO	Public research organisation
R&D	Research and development
REI	Research excellence initiative
RGPP	*Révision générale des politiques publiques* General Review of Public Policies
RRIT	*Réseaux de recherche et d'innovation technologiques* Technological Research and Innovation Networks
SAIC	*Service d'activités industrielles et commerciales* Industrial and commercial activities department
SATT	*Société d'accélération du transfert de technologie* Technology transfer acceleration company
SBA	Small Business Act
SBIR	Small Business Innovation Research
SCR	*Structure commune de recherche public/privé* Joint public/private research structure
SFRI	*Système français de recherche et d'innovation* French research and innovation system
SME	Small or medium-sized enterprise
SNI	*Système national d'innovation* National Innovation System
SNR	*Stratégie nationale de recherche* National Research Strategy
SNRI	*Stratégie nationale de recherche et de l'innovation* National Research and Innovation Strategy
TEPA	*Loi en faveur du travail, de l'emploi et du pouvoir d'achat* Law promoting work, employment and purchasing power
UCITS	Undertaking for Collective Investment in Transferable Securities
WIPO	World Intellectual Property Organisation

Reader's guide

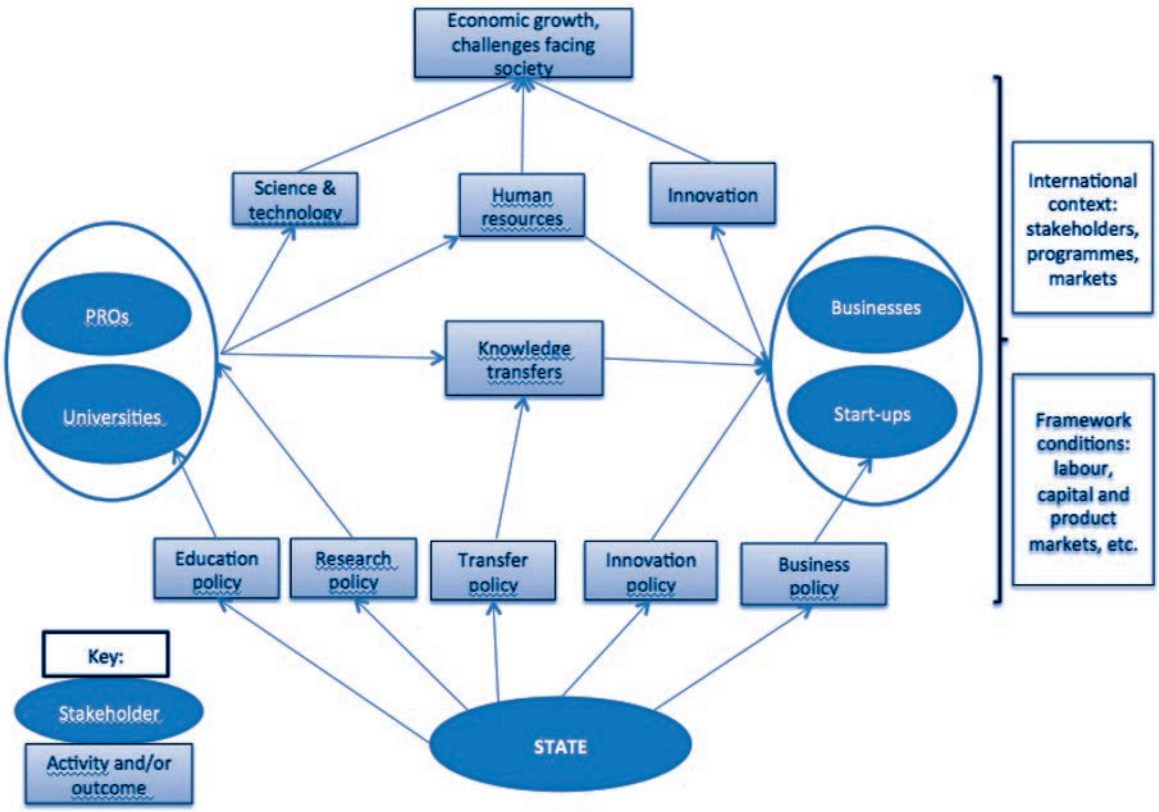
Analytical approach to national innovation systems

It is widely accepted that innovation is central to economic growth and improved well-being. Public institutions and businesses supply new products that increase consumers' standards of living and lead to job creation. To support that process, public authorities seek to maintain a general framework that is conducive to innovation and invest in specific institutions that can facilitate it.

National innovation systems (NIS) theory conceptualises stakeholders, activities and outcomes and their linkages to research and innovation. The complex set of relationships between the various players, activities and outcomes justifies a "system-based"' approach (see Figure 1). The concept of NIS is discussed in detail in OECD and Eurostat (2005). The players are individuals characterised by their skills and motivations, universities, public research organisations (PROs), transfer bodies, businesses, start-ups (a type of business worthy of separate consideration), all aspects of the State (government, agencies, territorial authorities) and foreign stakeholders who exert a strong influence over the national system in an open world. The nature of the interactions between these stakeholders is manifold: knowledge transfers, co-operation to produce new knowledge, various types of commercial transactions, power linkages, etc.

The behaviour of stakeholders – the result of their abilities and the incentives offered to them – and the interactions between these stakeholders determine the global performance of the NIS, i.e. its ability to develop the science, innovation and skills that can serve economic growth and respond to societal challenges. An NIS review therefore consists in analysing the various stakeholders, their capacity and their incentives to perform certain activities, the relationships that bind them and the institutional and policy measures that determine these behaviours, linkages and outcomes. In particular, the review seeks to identify the system bottlenecks or malfunctions that impair its performance, and to consider the political solutions that could improve its efficiency. A similar systematic approach was adopted in recent analyses by the French Government, such as the "New Deal for Innovation" ("*Nouvelle donne pour l'innovation"*) published in November 2013.

Figure 1. The operation of a national innovation system: Flowchart



The key issues addressed are usually those listed below, although the priority afforded to them varies from one country to another, depending on the bottlenecks in the system:

- Human resources (HR): to what extent do the available HR meet the needs of the existing NIS and the future NIS, such as it should develop in the light of current innovation strategies? Is the current education system, and especially the higher education system, able to produce the HR required by the system now and in the future?
- Public research: do PROs and universities produce excellent research (basic or applied)? To what extent does public research meet the demands of society and the economy? What factors in their organisational structure potentially restrict the quality of the public research produced and how well does it match demand?
- Knowledge transfers between the public sector and business: what volumes of knowledge are transferred through the various existing channels (contractual and collaborative research, intellectual property, mobility of individuals, business creation, etc.)? Is the structure of the transfer system optimal? Does it benefit all actors equally, in keeping with their capacities?
- Corporate innovation: how is the business sector positioned in terms of innovation, and to what extent does innovation contribute to companies' productivity and competitiveness? To what extent do the various public support mechanisms (e.g. the research tax credit, direct funding, public supply contracts) and public bodies contribute to corporate innovation? How closely do government strategies match the current and projected sectoral structure of the economy?

- Innovative entrepreneurship: is the number of innovative companies created high, and how many are experiencing significant growth? Which policy factors (taxes, entrepreneurial policy) or structural factors (e.g. access to finance) foster or deter entrepreneurial activity?
- Overall governance: which principles and strategies guide research and innovation policies? What do the various components of the State (ministries, agencies, local authorities, etc.) contribute to innovation policy and how do they co-ordinate?

This review will consider which actions under the "Investments for the Future Programme" (PIA) aim to intervene on each of these aspects, together with their objectives, methods and breadth. The systematic survey thus carried out will help identify what the PIA can be reasonably expected to achieve within the various components of the French research and innovation system (SFRI), emphasising the existence or absence of multiplier effects and ownership by stakeholders (State, local government, higher education and research institutions, businesses) of the actions and experiments set in motion by the PIA.

The systemic analysis also takes account of the broader national socio-economic context: both as regards goals, since research and innovation seek to improve growth conditions, and environmental and societal issues (e.g. ageing), and as regards determinants, since economic characteristics (e.g. sectoral specialisation) and institutional characteristics (including market organisation) affect France's capacity to produce and use innovations. The dynamics of innovation are based on the interplay between the accumulation of knowledge and the process of "creative destruction" by which new technologies or new business models, and therefore new businesses and new jobs, replace the old. The organisation of the markets must be stable enough to allow factors to accumulate (especially knowledge), but also flexible enough to allow the necessary redistribution of these factors to generate new activities through the process of creative destruction. Together, the institutions that regulate the product, labour and capital markets determine an economy's capacity to optimise these processes, and hence to steer itself onto a growth trajectory driven by innovation.

Review of France

For each of the above topics, the OECD aims to present both a quantitative and political overview of the situation and to identify the stumbling blocks in the system and the public policy options. The analyses are based on thematic work conducted by the OECD in these different areas that capitalise on the experiences of the many participating countries, along with academic literature.

The review of France give equal weight to both of these two objectives: it seeks first and foremost to provide an integrated, fairly comprehensive and consistent overview of the SFRI. In so doing, it identifies stumbling blocks – especially political ones – but the analysis and associated policy recommendations must not take precedence over the diagnostic exercise. Hence, few recommendations are featured in the various chapters that deepen the analysis provided in the chapter called "Overall assessment and recommendations", which formulates detailed recommendations.

A prime feature of the OECD reviews is the systematic use of international comparisons, both for indicators and policies. This makes it possible to provide a better interpretation of the observed outcomes and problems and to envisage various policies that could be introduced to resolve them, since the options have often already been trialled in other countries (these cases must obviously be put in context to serve the analysis).

In the case of France, the comparators used are countries that are closest in terms of size and level of development, or major countries on the global or European scene, or countries whose performance justifies their being used as examples of "good practice" in specific fields. These include, depending on the cases under study, China, Denmark, Finland, Germany, Italy, Japan, Korea, Sweden, Switzerland, the United Kingdom and the United States. These international comparisons will facilitate an in-depth assessment of the main strengths and weaknesses of the SFRI.

Since this review is to act as the *ex ante* assessment of SFRI prior to the introduction of the PIA, a number of special treatments have been applied. One section of Chapter 1 is dedicated to the PIA: it examines its objectives and the indicators for its initial and final assessments. Where possible, all indicators used in the review include information for the year 2010 and the most recent available year. Policies and mechanisms are clearly identified as being in place in 2010 or created subsequently; at this stage, it is not possible to assess the most recent ones in detail.

This is the third full review of the SFRI by the OECD. The first, published in 1985, noted "the persistent weakness of industrial research, insufficient creations of new firms (…) and the chronic difficulty of French industry in making itself felt in leading sectors once it is no longer supported by major government projects" (OECD, 1985). The second, published in 1999, highlighted the difficulties caused by the termination of these major projects and the efforts made to promote entrepreneurship. It noted the need to increase the commercialisation of public research and to simplify and improve the consistency of mechanisms providing publicly funded support for innovation (OECD, 1999). This new report will reveal in this respect a number of historical constants.

References

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Executive summary

The purpose of this study is to assess the French research and innovation system (SFRI). The missions of the SFRI are to mobilise research and innovation in order to support economic growth and help meet the key environmental and social challenges. To do so, it must produce excellence and relevance. The SFRI is the result of a trajectory marked by proven successes since the post-war period, such as the construction of a sophisticated scientific system and a number of technological achievements resulting from major programmes (aeronautics, TGV high-speed train, nuclear energy). That said, conditions have changed, and the SFRI needs to adapt. It started morphing more than a decade ago and must continue on this path. The current climate for research and innovation calls for openness, flexibility and adaptability – all qualities that are not sufficiently developed within the SFRI.

The French economy has experienced a lack of growth for a number of years, linked to weaker price and non-price competitiveness. The framework conditions for economic activity in France are not particularly favourable to innovation: the labour market and the product markets lack openness and flexibility, the taxation of businesses and investments is high and complex. These conditions detract from corporate ability to finance investments and mobilise the human resources (HR) required for innovation. French industry spends less on research and development (R&D) than its main competitors, especially Germany. The direct cause of this is France's sectoral structure, particularly the small size of its manufacturing industry, which has declined steeply over the past 20 years. France is fairly competitive, however, in less R&D-intensive sectors (construction, luxury goods, agri-foods, etc.).

France's HR are characterised by their duality: on the one hand, a minority of very well trained specialist and generalist personnel, able to develop and implement innovations; on the other, a large population segment with little or poor training, distanced from innovation. This stems from the inadequacy of general university training. Improving the quality and relevance of academic studies entails providing appropriate incentives for universities and professors-researchers, as well as rethinking the missions of the various stakeholders and pathways that make up French higher education. The teaching mission must be strengthened, especially in universities that are under-equipped for conducting research. Higher education must also endeavour to develop more specifically attitudes and skills that will promote innovation.

France's international scientific performance (measured by publications, citations or the European Research Council) is quite average: it is better than the performance of countries in southern Europe, but below that of northern Europe, the United Kingdom and Germany. French public sector research centres on public research organisations (PROs), which traditionally undertake the combined roles of strategic management, funding, performance and assessment of research. This model complicates meeting objectives and carrying out the missions entrusted to public research in a new context entailing the excellence and relevance of research to public objectives. The reforms initiated since the end of the 1970s aimed to assign separate functions to different stakeholders: strategic management to the State (national strategies, "Investments for the Future Programme" [PIA]); (project) funding to the French National Research Agency (ANR); assessment to an (independent) specialist agency; and performance of research to universities. To this end, universities have been given greater autonomy and have been encouraged to group together into consortia, the idea being to foster the emergence of a few major, globally competitive research universities. PIA funding, allocated on the basis of excellence and relevance to public objectives, should help accelerate this step change. The French public research system is currently a hybrid of the traditional model based on the PROs (which themselves have evolved) and institutions newly created over the past ten years. This mixed situation is a source of pointless complexity and excessive operating costs, all of which calls for persevering with the reforms.

Knowledge transfers between public research and businesses have been a key theme of French policy for the past 15 years or so. Many measures have been introduced as a result: research partnerships, co-operative research, the commercialisation of intellectual property, business creation, employee mobility. A transfer culture has developed, driven by the growing number of stakeholders and specialist institutions. However, the results are fairly modest, and the rare available indicators do not show major progress over the period. The main barriers to developing transfers are integral to public research itself, which does not offer researchers the necessary incentives to engage in such transfers and choose research fields likely to have social or economic impacts. The policies implemented have lacked overall consistency, adding cumulative measures without always clarifying their respective fields of application. Lastly, the transfer process has often followed an administrative approach (filing patents, entrepreneurship) rather than an economic approach (exploiting patents, expanding businesses).

The State has many measures at its disposal to support corporate research and innovation. The French research tax credit is practically the most generous in the world – yet its positive impact on corporate R&D probably does not match its cost to the State. The multiplicity of programmes and public bodies results in strong public intervention in industrial innovation, with notable success in a number of areas (e.g. the competitiveness clusters). Small businesses on the one hand, and large companies on the other, benefit from these programmes, whereas intermediate-sized enterprises are less well supported. Competitive support methods (based on open calls for tender) are a growing practice. In all, public intervention is very granular, sometimes inconsistent and lacking strategic direction.

Innovative entrepreneurship in France has developed to a level comparable to that of other countries. Businesses have a high survival rate, but few of them grow. Capital funding is abundant in the upstream (growth) phases, but scarcer in the downstream (seed) phases. The plentiful upstream funding stems from public capital and seems linked to the eviction of private capital, which is then invested abroad. Expanding and boosting innovative entrepreneurship has gradually become a central objective of French innovation policy. Public intervention is considerable at every level of the chain (business creation, taxation, funding, etc.) and seems to be making a real impact (e.g. through OSEO grants). This intervention is stronger than in other countries, although France's performance does not appear to reflect the difference, raising the issue of its effectiveness. In particular, the question of the low selectivity – and the duration – of a number of public grants bears asking. A company may carry the "young innovative enterprise" label for seven years, even though its project is not progressing. The excessive survival rate of underperforming businesses detracts from the growth of others, by competing with them for access to funding, skilled labour and contracts.

Governance designates the overall mechanisms ensuring the management and consistency of a country's research and innovation. It implies co-ordination among stakeholders with responsibilities at different levels of the system. Co-ordination among ministries, especially the ministry in charge of research and the ministry in charge of the economy, is necessary to the smooth functioning of the system, including the formulation of research and innovation strategies. Significant progress has been made with vertical co-ordination (management of research bodies by the ministries) and potentially powerful instruments have been established (PIA, ANR). The assessment function, long a weak point of the SFRI, has improved and new mechanisms have been introduced to enable independent assessment of stakeholders and policies; full use should be made of these mechanisms.

Chapter 1

Overall assessment and recommendations

This chapter sets out the strategic issues facing the French research and innovation system today. It tracks its history, marked by the central role played by the State, particularly through the large research organisations, and looks at the effectiveness of this model in the current global and national economic context. It then summarises the main findings of the review in regard to human resources for innovation, the public sector research system, public-private knowledge transfers, corporate innovation policies, innovative entrepreneurship and overall governance of the system. Finally, it looks in more detail at the "Investments for the Future Programme", a ten-year plan launched in 2010 to develop and transform the French research and innovation system.

Strategic challenges facing the French research and innovation system (SFRI)

France, like other high-income countries, needs to strengthen its capacity for growth and respond to the major challenges facing society, such as climate change and an ageing population. It cannot do so without mobilising research and innovation. This message gradually worked its way to the heart of the governmental discourse and became established there once and for all at the end of the 2000s. It follows that it is fundamental to find ways of mobilising the French research and innovation system effectively so that it can play its part in these efforts.

Mobilisation and effectiveness are certainly two related issues, and the successive plans implemented by France, such as the "Investments for the Future Programme" (PIA) launched in 2010, looked at both aspects, seeking both to mobilise and reform the SFRI. This report is an attempt to take stock of the SFRI in 2010 and note the changes that have occurred since that time. In this context, it seeks to evaluate the capacity of the SFRI to respond to economic and social challenges and to identify factors that might act as stumbling blocks.

France is a country with a longstanding scientific and technical tradition, and today it still plays a significant world role in this area. France was at the heart of the scientific revolution in the 17th century, then of the industrial revolutions in the 18th and 19th centuries in Europe. Since that time, it has never stopped playing an active part on the global scientific and technical stage. The SFRI acquired its present structure gradually over the past century, in particular during the decades following the Second World War, the "reconstruction" period. The SFRI has a number of historical features that set France apart from other countries.

A first feature of the SFRI is that the State plays a crucial role. This is a common feature of society and the economy in France (public spending as a proportion of gross domestic product (GDP) was the second highest in the OECD in 2013) and is also the case in science and innovation. The State funded a total of 37% of research and development (R&D) expenditure in 2010 (actually closer to 50% if one includes the research tax credit (CIR), while for countries of comparable size and wealth (Germany, United Kingdom), the figure is about 30%. This share has tended to diminish in the past few decades (it was 50% in the 1980s, while the OECD average was about 40%). Defence spending, which is higher than in other countries (but has been declining for more than 20 years), helps explain this, but only in part, because the State is also closely involved in financing and executing R&D in the civilian sector.

Another distinctive feature is that universities play little part in public research, which is mostly conducted by public research organisations (PROs), including the National Centre for Scientific Research (CNRS) and the Alternative Energies and Atomic Energy Commission (CEA). To a large extent, the PROs steer and fund research themselves, guided by broad objectives they have defined in consultation with the State. These organisations are mainly funded on a recurrent basis and their mandates do not include teaching. For a long time, universities held a marginal position in French public sector research and focused on the task of teaching – except for "elite" teaching, which is carried out in the *grandes écoles*, another specifically French feature.

A third feature (which is not exclusively French, but is particularly pronounced in France) is the proximity of the State and the large enterprises that carry out a major part of R&D, both strategic (the enterprises are involved in public initiatives) and financial (public procurement and State aid). The highest contribution to R&D funding by the State goes to large enterprises (sizeable sums) and to very small businesses (start-ups), although the funds allocated to the latter are fairly small. Medium-sized enterprises receive virtually nothing.

The establishment of this system coincided with France's economic development after the war, and its structure clearly reflects the growth model of the "golden years", the three post-war decades. The SFRI was structured in the 1950s-70s as a predominantly managed system focusing on the State. Its outlets were the large public enterprises, which generally held a monopoly position (public transport, electricity, telecoms, etc.); the PROs managed the technology aspects, while other large public sector companies were responsible for innovation and production. The State determined the strategic choices and allocation of resources, favouring sectors regarded as most important to the country's development, as well as its security and defence, such as energy (especially nuclear), telecommunications, aeronautics, space, etc. Since France was initially situated at some remove from the cutting edge of global technology, the programmes often consisted in adopting and adapting pre-existing techniques, generally originating in the United States. That is how France succeeded in a dynamic process of technological "catch up". That kind of dynamic is consistent with a fairly centralised institutional model, which ensures stability in regard to technological choices, allocates adequate resources and co-ordinates the various stakeholders. It called for a research and innovation system that was closely structured around these major programmes, and for which centralised research organisations may have appeared particularly effective. Accordingly, a number of major programmes were given their own PRO: the CEA for nuclear energy; the French Space Agency (CNES) for space; the National Institute for Research in Computer Science and Control (INRIA) for information technology; the National Centre for Telecommunications Research (CNET) for telecoms. The failure of attempts to transpose this model to sectors that were more competitive or positioned at the cutting edge of technology, such as IT, demonstrated its limitations. The "Plan Calcul" computer plan of the 1960s is often cited as an example of the limitations of the major-programme model. Yet programmes that succeeded technically, such as the Concorde or Minitel, also show that the model was not adequately geared to the more open and competitive global market that prevailed starting in the 1980s.

The properties of this type of administered model have been analysed elsewhere and may have a positive or adverse impact on its effectiveness, depending on the context; in France, the following positive aspects predominated between the 1950s and 1970s:

- Capacity to effectively adopt and adapt the scientific and technical advances achieved abroad and to make incremental innovations, thanks to a hierarchical system that ensures that decisions are consistent ex ante. The downside is a low capacity to achieve radical scientific or technological advances, which require trial and error, a pluralist approach and competition.
- Capacity to conduct very large-scale projects (involving a variety of large stakeholders and major capital injection), with an innovative component and a long-term horizon. The downside of this robustness is low sensitivity to market signals in relation to demand, which is largely captive (telephone, rail, electricity users under a monopolistic national operator, etc.), and no urgent pressure with regard to financial returns, since the funding comes from the State.
- Structural stability, as a result of the administrative nature of the mechanisms in play (budget commitments, status of employees): once a programme has started, it is difficult to stop or re-orient it. This creates a stability horizon that is potentially

beneficial to some projects, but makes it difficult to make the sometimes necessary adjustments, with the result that stability may turn into rigidity. Growth is the source of flexibility, producing resources that grow year by year and can be allocated to new priorities without displacing previous-year resources already tied up in earlier objectives. When growth stops, this source of flexibility disappears.

The context has gradually changed, however, and with it the characteristics that ensure the success of a research and innovation system. The adverse effects of the administered model then became more apparent.

First of all, simply as a result of its successful model, France has managed to catch up. Its productivity is now among the highest in the world (productivity per hour of work). French research and French industry are at the forefront of global knowledge in the sectors where they have a presence. This position has a variety of implications for the research and innovation system. At the cutting edge, "the future is not yet written"; one must certainly look at what others are doing, but everyone must make their own way. This means taking a flexible approach, by trial and error, and having the ability to change one's choices and reallocate one's resources rapidly in response to scientific and technical opportunities or demand. It also means that the challenge of productivity, which is always crucial to growth and competitiveness, takes on a new form: there is a need for young, innovative companies as pioneers of innovation, alongside the large groups. The central position of entrepreneurship in the innovation process was reinforced by the role acquired by information and communications technologies (ICTs), in particular software, as the main pathway towards the emergence and distribution of the new products. ICTs have also driven the new innovation processes: open innovation (structured co-operation among enterprises or with public research bodies), innovation by consumers, non-technological innovation often linked to the web. A position at the cutting edge is in fact important not only to science and technology, but also to the organisation and provision of services, the capacity to follow the changing tastes of the consumer, etc. This is especially significant in economies where the service sectors are more important, and the manufacturing sector less important, than in the past. When that happens, innovation in services becomes a priority.

Secondly, the world has become more diverse and interconnected than before. The rapid development of Asia – particularly Korea and then China – and of the other BRICS (Brazil, Russia, India, China and South Africa) countries over the past decades has sped up global growth at the very time that growth was perceptibly slowing in the developed countries, including France. France's share of global GDP (in purchasing power parity) fell from nearly 4% in 1970 to a little over 2.5% in 2010, a decline also seen in other countries such as the United Kingdom and Germany. The world has also become more interconnected: flows of goods, services and capital, as well as of information and knowledge, are now far more dense and multidirectional. Production has become increasingly segmented at the global level, in "global value chains" where each country tries to acquire a favourable position and thus depends on multinationals' choices and market dynamics. Furthermore, France joined the European Union, with the effect of not only tightening its economic links with the other Member States, but creating a body of rules that are binding within France as well. Within that context, market competition has become stronger and there are few public monopolies left that can impose their technologies of choice on captive consumers; the evolution of telephony is the clearest illustration of this change. Moreover, international treaties and the EU institutions now give Member States less margin for manoeuvre; for example, there are strict ceilings to enterprise subsidies. In the same context, any technological strategy must from the outset obey international rules and be conceived in terms of global demand, which is not captive, instead of national demand, which could be.

Thirdly, the major collective challenges the State is attempting to address, in particular through innovation, have changed. Earlier on, during the Cold War period, defence was the biggest challenge. It mobilised substantial resources, with large amounts channelled towards research and innovation. It was hoped that these investments would have a spillover effect on civilian markets. Yet it appears that these spillovers, however significant, never met the level of spending allocated to other ends. By its very nature, defence research is secret and is not likely to have a trickle-down effect. It is also very national, given that international defence co-operation is limited and regulated. The SFRI was well prepared for operating procedures of this kind, and France was in fact one of the top OECD countries in terms of defence R&D. Over the past two decades, new collective challenges have replaced defence, such as the environment (including energy transition) and the ageing population. Governments are carrying out significant research programmes linked to these challenges, but they differ from the military programmes. First, the approach is more open, since secrecy is no longer a vital requirement; this means that a diverse range of stakeholders, such as small businesses and universities, which would have been excluded in the past can now be included. Second, they are drawing on a more diverse range of knowledge from every scientific and technical field; the research therefore needs to be multidisciplinary and laboratories or enterprises in very different fields have to work together. Finally, since these challenges are common to the whole of mankind, international co-operation is the natural operating procedure, even if reality is not always equal to the opportunities.

The new context that has gradually emerged calls for the research and innovation system of countries at the cutting edge of science and technology to show new qualities, against which the SFRI and PIA measures can legitimately be evaluated. The system needs to be:

- *Flexible*, capable of rapidly reallocating resources: this applies to the State, which must therefore develop project funding (whose orientation can be readjusted very rapidly) alongside recurrent funding and draw on universities, which are more flexible than PROs in terms of resource allocation because of their multiple missions; and to industry, which requires a more dynamic demography (renewal of the corporate population, entrepreneurship).

- *Competitive and co-operative*, less compartmentalised: the stakeholders, both public and private, must not adopt a "silo" mentality and must interact closely; this particularly applies to the relationship between public research and businesses.

- *Open to society and the market:* able to respond to the demand of a multitude of consumers, a demand that can change rapidly or shift to other providers. Currently, public demand is directing innovation towards the major economic, environmental and social challenges. That means that the State must manage public research strategically (see below) and encourage interdisciplinary action. This is necessary when research is led by demand, since most of the real issues it is tackling go beyond disciplinary boundaries; it also presupposes flexible and decentralised organisational structures.

- *Entrepreneurial:* new businesses often drive new technologies, especially in the ICT sector, software, the web and biotechnology.

- Attach more importance to *non-technological innovation* and the *service sectors*: innovation is omnipresent and is no longer confined to a few “high-tech” sectors. Design and marketing form an integral part of innovation activities.
- *Internationalised:* actively included in global knowledge networks, able to tap and exploit the most recent knowledge.
- Such that *higher education* can offer a solid training to large numbers of young people in order to increase the economy’s capacity for innovation and provide future researchers, engineers and entrepreneurs with the capacity for initiative and innovation required by the new dynamic.
- *Managed strategically* but flexible in its implementation. In this diversified and changing environment, the State can no longer apply a command and control model, but must accept a certain amount of flexibility and autonomy on the part of agents; it must also put in place adequate incentives to guide them in their work. This more complex form of governance brings with it a greater need for transparency and evaluation.

The entities responsible for research and innovation in France have certainly realised this and the model has changed significantly over the past two decades, gradually moving away from its initial state – but without fully embracing the new model.

The chosen direction has been to adapt increasingly to the new context described above, with repeated attempts to meet the criteria set out earlier. This led to waves of reforms: the Fillon Act promoting public-private transfers in 1994; the Allègre Act on transfers and Daniel Strauss-Kahn measures to finance entrepreneurship in 1998/99; the “competitiveness cluster” policy in 2004; the creation of the National Research Agency (ANR) for project funding and Evaluation Agency for Research and Higher Education (AERES) in 2006; the Law on Responsibility and Autonomy of Universities (LRU) in 2008; the National Research and Innovation Strategy (SNRI), placing the major social and environmental challenges at the heart of research policy, in 2009; the PIA (about EUR 20 billion spent on research and innovation, excellence, transfers and entrepreneurship, allocated mainly on a competitive basis) in 2010.

The PROs themselves, a legacy of the old model, changed. They forged closer ties with the universities by creating “joint research units” from the 1990s onward and sought to respond, going beyond their supervisory authority, to socio-economic demand (from which they must draw part of their income). Over the same period, public funding of research fell as a share of GDP as a result not only of the decline in military spending, but also of reduced support for businesses; this lasted at least until the reform of the CIR in 2008, which radically reversed the trend by introducing very high State transfers to R&D enterprises. Support for innovative entrepreneurship also became a central concern of many public policy measures.

The SFRI emerged from these successive reforms and policy re-orientations considerably transformed. Yet the changes are only partial, and the current system can be described as mixed – a hybrid between the old administered model and the new open model. This mix is unsatisfactory in many respects, because the friction and segmentation it creates makes the system less effective overall. Looking back to the earlier criteria, the main features of the SFRI can be summarised as follows:

- *Flexibility:* public research funding is allocated in a very rigid manner because of the statutory management of human resources in the PROs and the mechanical allocation of recurrent resources. Hence, public research is not well placed to respond to sudden changes in opportunities and requirements; it is, in fact, the most rigid in the world in terms of thematic orientation.
- *Competition and co-operation:* the higher education and research establishments have little strategic, academic, educational or financial autonomy, making them less able to interact and the system less able to generate the few large research universities that France needs. The joint research units have encouraged closer interaction between PRO teams and with the universities; some progress has been made here, but more remains to be done (the joint research units answer to multiple supervisory authorities within their member bodies) and as a result, running costs remain too high. If the host universities moved to a single management system, this evolution could be completed. Higher education is also segmented, because of the split between universities and grandes écoles, which is damaging to both education and research.
- *Openness to society and the market:* public-private transfers are still not measured properly, but appear to have increased slightly in volume since the late 2000s, despite the great variety of reforms and measures put in place; this probably reflects strong systemic obstacles, in particular the lack of incentive for laboratories and researchers to co-operate with enterprises.
- *Entrepreneurship:* public aid chiefly goes towards large firms, while many intermediate-sized enterprises (ISEs) remain untouched by public sector measures. The entrepreneurship policy is certainly generous, but it sometimes resembles patronage rather than venture capital in the sense that it offers almost unconditional protection to a number of young businesses without necessarily giving them either the incentives or the means to achieve growth.
- Attaches more importance to *non-technological innovation* and the *service sectors*: public sector innovation policies now attach more importance to these new areas of innovation, but there is still room for improvement.
- *Internationalised:* French public research is certainly internationalised, yet France is not attractive enough to foreign R&D and researchers because of the difficult environment (taxation, etc.) overall and a research system that is neither very transparent nor open.
- *Higher education* is finding it hard to produce the large quotas of students needed for an overall more innovative economy; it is, however, increasingly open to entrepreneurial approaches.
- *Managed strategically:* modern public research management means separating the planning and implementing functions (as well as funding and evaluation) in order to align planning more closely with collective needs. In France, however, the PROs are in charge of planning public research, which therefore reflects the direct interests of the teams conducting the research – hence the difficulty in commercialising the research and the thematic rigidity emphasised above. Despite progress in project funding, recurrent funding is still largely predominant (about 90% of public research funding is recurrent), restricting the State's capacity to steer research in some organisations.

The SFRI has embarked on an incomplete process of transformation by trial and error. In the light of the above analyses, the main weaknesses of the SFRI may serve as a guide for political action, which will be described in detail later in this chapter. A similar kind of diagnosis led to the creation of the PIA, which is intended not only as a programme for investment directed at new growth but also as an instrument for transforming the SFRI.

The various plans and strategies published in recent years set out the major objectives of current research and innovation policy in France in a fairly coherent manner. They are consistent with the analysis made earlier and relate to corporate competitiveness on the one hand, and environmental and social challenges on the other.

France has become far less competitive over the past decade. Its share of the export market has fallen, growth has slowed significantly and the number of manufacturing companies with more than ten employees has shrunk by one-quarter. Although this is mainly due to macroeconomic and structural factors (a decline in price and non-price competitiveness), the situation has been exacerbated by the positioning of French industry at the medium rather than the high end of the market and the weakness of its innovative offer. If it wants to restore competitiveness, it will have to speed up its productivity growth. The high-tech sectors where France has made major investments (aeronautics, nuclear, etc.) have not made up for the overall decline.

The first strategic challenge facing the SFRI can be defined as follows: how to help make the French economy more competitive again. That means identifying promising sectors where France has great potential, channelling the necessary human and financial resources towards them and using these resources as efficiently as possible. This has to be done within a new context marked by a globalised, service-oriented and competitive economy for which the SFRI is not necessarily prepared. Given the stakes, the identified sectors must have a strong impact on employment, either directly (e.g. (tourism, luxury goods, agri-food) or indirectly through their various ripple effects (high-tech, web, health, etc.).

The second challenge for the SFRI relates to the social and environmental aspect. Energy transition, climate change, greenhouse gas emissions, air and water management, urbanisation, ageing, the development of social inequality: faced with these sometimes radical changes, societies must bring into play all the tools at their disposal, including technological and social innovation. Many countries, like France, have become aware of the issues, which are also economic, since those problems also create opportunities for developing new activities that create value-added and employment. The question that arises specifically in France concerns its research and innovation model: how to mobilise and channel the resources needed to respond effectively to the major social and environmental challenges? What adjustments need to be made to the resource allocation mechanisms to facilitate this mobilisation and allow these resources to be used more effectively?

These two challenges are clearly recognised and reflected in the rationale of the PIA (Juppé and Rocard, 2009), which argues that France should aim for stronger and more sustainable knowledge-based growth.

It is also reflected in the “France Europe 2020” strategic agenda published by the Ministry of Higher Education and Research (MESR) in 2013.

This survey will assess the SFRI in the light of these two challenges, and of the conditions required for France to tackle them. France will have to answer a number of questions in this context: what is the right balance between efforts to maintain France's position in its "traditional" high-tech sectors (aeronautics, space, nuclear, etc.) and efforts to strengthen the high-tech sectors (ICTs, software, biotechnology) and boost innovation in sectors where France is already competitive (luxury goods, agri-food, tourism, value-added services)? How can France strengthen its position in the global value chain and attract more foreign R&D investment? How can the powerful public research sector be made to rally around these objectives? What political instruments could be used to influence innovation in enterprises that are more heterogeneous and less tied to the State than its partner enterprises during the preceding period? What conditions should be provided to boost the growth of young innovative businesses? If these issues of innovation policy are to be resolved adequately and the solutions implemented, France must pursue the structural changes initiated by the SFRI.

This survey will examine all these challenges. It will endeavour to position France within these different dimensions, both in 2010 (the reference year for the PIA) and in more recent years (the difference between the two is generally negligible): how has France performed? What are its strong points and its weaknesses? How well have past and recent policies worked? What improvements could be made in the light of international experience?

Performance of the SFRI

Box 1.1. France in the Innovation Union Scoreboard

The European Commission's annual "Innovation Union Scoreboard" (EU 2014), a reference for many observers in Europe, places France in the category of "innovation followers", countries that are close to the EU average for the composite indicator of innovation. France ranks 11th out of the 27 EU Member States for this indicator, very close to the EU average. The "innovation leaders" in this classification are the northern European countries and Germany. The followers include, along with France, the Netherlands, Belgium and the United Kingdom. France scores better for human resources (7th), scientific performance measured chiefly by publications (8th) and public sector financing and venture capital (8th), but far less well when it comes to corporate investment (14th), entrepreneurship and linkages between enterprises (14th) and innovators, notably small to medium enterprises (SMEs) (14th). The heterogeneous nature of the composite indicators may mask a number of specific realities, which can be analysed only by examining individual indicators. In terms of higher education and research, for instance, France's good ranking is the result of a high degree of internationalisation (as seen in the number of foreign doctoral students), by contrast to its share of most frequently cited scientific publications, which is lower than the EU average. France scores fairly well in terms of venture capital investment (in relation to GDP), but distinctly less so for corporate innovation; it also scores well in terms of applications for European Community trademarks, drawings and models (design), thanks to the SMEs introducing new products or processes, and in knowledge-intensive exports. Over and above the heterogeneous nature of these various indicators, France appears to score somewhat better (without, however, ranking among the leaders) in terms of higher education, research and funding, and innovation indicators.

Table 1.1. SWOT (strengths, weakness, opportunities, threats) of the French research and innovation system

Strengths	Weaknesses
• France offers top-quality, multi-skilled and innovative engineers for industry. • A significant number of researchers are internationally recognised for their excellence, although the overall quality of French fundamental research is average. • Some top-quality PROs operate in fields such as health and ICTs. • France has a growing population of imaginative and skilled entrepreneurs. • The country easy conditions for business creation and effective policies encouraging the creation of young innovative firms. • There are various government support schemes for innovation, offering businesses a wide range and allowing them to experiment in order to choose the most effective schemes.	• Major segments of the population have poor educational performance. • France has a low incidence of PhDs. • The labour market is segmented and rigid, which does not encourage labour force mobility. • The public research system is segmented, with some rigid components that are unaffected by evaluations and not reactive to social and economic demand. • PROs combine the roles of planning, funding, executing and evaluating research, while universities remain minimally involved. • The system of public-private knowledge transfers is rather ineffective. • The system of public aid for businesses is excessively complex. • The tax system does little to encourage investing in businesses, although conditions have been adjusted for young innovative companies. • Framework conditions (particularly taxation and social thresholds) hinder business expansion. • Government aid for industry is not selective enough, keeping businesses with weak growth potential afloat.

Opportunities	Threats
• Industries where France is strong (agri-foods, luxury goods, tourism, value-added services) are becoming globalised and require a great deal of innovation. • New sectors are emerging (nano, bio, software, etc.) where France could establish a position. • The early phases of project funding and independent evaluation have been a learning curve and now need to be extended and systematised. • The high levels of public procurement could be put to better use by encouraging innovation ("demand-side policies"). • Local authorities' strong interest in innovation could lead them to increase their investment in fully autonomous universities to support local development. • The reform package implemented over the past 15 years to open up the system and make it more flexible has led to the creation of mechanisms with a high potential: for instance, university autonomy could foster the establishment of large research universities. • The PIA offers significant funding and a long-term horizon (ten years) and needs to be co-ordinated with the other measures.	• Any decline in project funding or independent evaluation could make public research less open to society and the economy. • A proliferation of separate strategies on the part of different public stakeholders would reduce overall co-ordination of efforts and make them less transparent and effective. • A further decline in framework conditions for enterprises (taxation, flexibility of markets) could undermine efforts to foster innovation. • The fragile financial situation of the business sector is reducing its ability to invest.

Overall performance in research and innovation

The performance of the SFRI is shown in detail in the thematic chapters that examine its various dimensions. The salient points of this analysis have not varied since 2010 and are as follows. In regard to human resources, France appears to have a highly skilled elite (e.g. engineers of globally recognised competence), although it is too small (a significant portion of the labour force is not sufficiently skilled to support innovation). France also trains a smaller number of doctoral students than countries that are leaders in the field of research and innovation. In the field of scientific production, France comes behind Germany and the United Kingdom, but ahead of Italy and Spain. It has some internationally respected researchers, but not enough to raise its overall performance to the highest level. In the field of knowledge transfer between the public and corporate sector, France has essentially remained at a modest level for the past ten years, like many other countries in fact. In the field of corporate innovation, France has also posted average performance. France's R&D intensity is distinctly lower than that of Germany, because of the small size of its manufacturing industry. France also has fewer very large research enterprises, because its strength tends to lie more in areas where innovation relies very little on R&D: luxury goods, tourism, agri-food, etc. In innovative entrepreneurship, France scores quite well for business start-ups and venture capital investment, but less well for the growth of these businesses (which remain small in scale). Overall, as reflected in the Innovation Union Scoreboard (see Box 1.1), France is close to the European average, behind the Scandinavian countries, Germany, the Netherlands and the United Kingdom, but ahead of southern Europe and central and eastern Europe.

A SWOT analysis (Table 1.1), showing the strengths and weaknesses of the system and the opportunities and threats facing it, gives a more qualitative picture of the SFRI.

Human resources

In 2010, France's human resources were marked by duality, as confirmed by the Programme for International Student Assessment and Programme for the International Assessment of Adult Competencies tests and the evidence from companies. On the one hand, there was a minority of well-trained specialists or generalists who were able to develop and implement innovations and were internationally recognised, and many of them were employed in large enterprises or PROs (a growing but still tiny number turned to entrepreneurship); on the other hand, a large section of the population had little or poor training and played no part in innovation. That reflects a system of higher education that performs well in terms of training elites (*grandes écoles*, selective advanced training in universities), while general or vocational university training does not produce enough graduates to broaden the human capital base in the French innovation system. This is because vocational training through university institutes of technology (IUTs), advanced technician certificates (BTSs), and specialised master's degrees) was too small-scale, and non-selective general training was often poor, with a high failure rate.

Human resource requirements depend on the characteristics and trend of the innovation system. The dual structure of human resources described above reflects a situation where the SFRI was indeed based on large high-tech businesses and projects, but chiefly with a view to catching up with cutting-edge technology. In a context where France needs to position itself at the cutting edge and on a broader sectoral base, the issue for the educational system is how to produce both pools of excellence to manage the cutting-edge sectors, together with a larger number of highly qualified specialists and generalists to permeate all the sectors and drive a form of innovation that is less radical, but nonetheless necessary to achieve competitiveness in many areas of activity. This can be done first, through pursuing educational excellence policies and strengthening the links with research by promoting a limited number of research universities and other initiatives of excellence (Idex) supported by the PIA and second, by improving the quality and relevance of general or vocational university training for more students. This means creating the right incentives for universities and teacher-researchers (currently, the quality of the teaching delivered has little impact on the institutions or individuals responsible for delivering it) and reviewing the specific tasks and complementarities of the various players and courses of study that make up higher education in France. While research must be guided by criteria of excellence and, hence, be concentrated in the universities that have the necessary capacities, more emphasis must be placed on teaching in other universities, in response to needs that are felt directly at the regional level in particular; this does not preclude these universities from taking part in innovation activities linked to local needs (particularly those of SMEs) – supported, where possible, by "niches of excellence" in research. The historical separation between *grandes écoles* and universities has now become counterproductive: the *grandes écoles* need research in order to improve their graduates' capacity to innovate, while the universities need to be selective and link up with industry; France needs to pursue the various forms of co-ordination that have been tried out over the past decade. Higher education must also focus more openly on developing student attitudes and competences that are conducive to innovation and entrepreneurship. In the light of international experience, this means, in particular, attaching more importance to individual and group work during training.

Some of these changes must begin as early as the school level, which produces too many (and more and more) poorly educated pupils, as shown by France's mediocre results in the Programme for International Student Assessment (PISA) tests. Specifically, school education should emphasise training in skills that are key to innovation and entrepreneurship, such as self-confidence, initiative and group work.

Recommendations:

- Pursue the policy of promoting excellence in teaching linked to research, while also placing more emphasis on teaching in the vast majority of universities, which are not involved in international-level research but may find real comparative advantages in their specific (scientific or economic) assets.
- Support the development of vocational university training and the improvement of the quality and relevance (in relation to social and economic demand) of general university training, including in the humanities and social sciences.
- Place more emphasis in universities on teaching activities likely to make students become more innovative and entrepreneurial (individual or, even more importantly, group work).
- Make the institutions more autonomous at every level (full responsibility for the management of teaching and non-teaching staff, freedom to recruit students, capacity to collect own resources, greater autonomy in the definition and award of diplomas, etc.) and continue to emphasise assessment at all levels.

Public research

According to various quantitative indicators, France scores lower in science than the leading countries and is near the European average. While there is a category of internationally excellent researchers – such as European Research Council (ERC) grant winners – the overall level, as measured by the impact of scientific publications, lies below that of the United Kingdom, Germany and northern Europe, for example, but above that of southern Europe and Asia. French research also seems to be among the most inert in the world in terms of specialisation; the thematic distribution of publications has changed less than in the other countries since the early 2000s. These two features show how difficult the French public research system finds it to reallocate resources (by subject areas, but more broadly among research units, etc.) and – in direct correlation with that – to focus on excellence.

Public research centres on the PROs. The largest of these, the CNRS, is mainly responsible for basic research. The others focus more on applied research, in areas where the State plays a major role for either strategic or economic reasons: nuclear (CEA), cutting-edge industrial technologies (CEA), health (Institut national de la santé et de la recherche médicale, French National Institute of Health and Medical Research), information technology (INRIA), agronomy (Institut national de la recherche agronomique*,* French National Institute for Agricultural Research, INRA), etc. In terms of scientific publications (not the primary objective of all PROs), these organisations generally appear to do well or very well at the European level, except for the CNRS which ranks at the middle or lower end of the European classification system in some fields. This is an average figure; a number of CNRS researchers may well be carrying out internationally recognised research. The French PROs are exceptionally strong compared with those of other countries: they combine the planning, financing, execution and evaluation of research. Most other countries abandoned this model some time ago – if indeed they ever adopted it – because it affects the way the system works, making it very difficult for the political authorities to supervise – meaning they cannot pursue their own priorities, for example in terms of research themes or orienting it research towards transfers to enterprises and society.

A few large research universities (Université Pierre et Marie Curie, Paris-Orsay, etc.) have emerged alongside the PROs, thanks in particular to the 2007 LRU law on the responsibilities and autonomy of universities, but they remain weaker than the PROs or comparable establishments abroad. Moreover, much of their research is conducted by joint research units, some of which are controlled by the CNRS and other PROs, leading to complex working procedures. The "site policy" now promoted by the MESR could eventually simplify this cumbersome system of governance by placing the joint research units under the sole control of the universities.

Project funding was traditionally limited in France, where recurrent funding allocated to the PROs were the norm. The French Parliament allocated the resources among PROs, after which the organisations allocated their resources within themselves, based on their own priorities as discussed with their ministerial authorities. The creation of the ANR in 2006 started a trend that was boosted by the establishment of the PIA in 2010. Project funding now accounts for over 10% of public research budgets (far less than in other countries). This gives the State a potentially powerful lever for promoting excellence and relevance in research. The coexistence of project funding – which is by its very nature limited in time – and the stable status of many public sector researchers proved difficult: some laboratories had to create temporary jobs because they had the funding but not the statutory manpower, while others had to reduce their effective activity because they had the statutory manpower but not the funding. This emphasises the need for a change of status, so as not to hinder gearing human resource allocations to research needs.

Excellent and relevant public research calls for independent, competent and effective evaluation. The AERES was created in 2006 to meet that need. Overall, the Agency has done well in that respect and has, in particular, helped universities manage their research teams. Some PROs also rely on AERES evaluations when they allocate resources among their own research teams. Now that the AERES no longer awards an overall mark to research units, it seems to have become less useful, since it is no longer allows identifying research units that are having difficulties and are therefore candidates for restructuring.

Recommendations:

- The MESR site policy, which puts universities of excellence at the core of research, must be pursued and deepened. In particular, the joint research units need to be fully integrated in the sites concerned and the universities given sole management responsibility (a decision that was taken in the early 2000s and virtually not applied). Following the example of the PIA, research spending must be concentrated on excellence, which would allow other researchers to contribute directly to the quality of university education.
- Project funding should be more widespread, as it is a particularly good lever for promoting excellence; in particular, there is a need for more thematic (rather than open) calls for tender so that research can effectively be attuned to national priorities. Consideration should be given to adjusting the status of staff in PROs where the funding allocated is no longer consistent with the staff allocated.
- Evaluation of public research should continue on a regular basis and be rendered more effective, e.g. by introducing a reporting obligation for the organisations evaluated by the AERES – now the High Council for the Evaluation of Research and Higher Education (HCERES); it should be extended to teacher-researchers.

Knowledge transfers

Knowledge transfers between public research and businesses have been a major objective of French policy for the past 15 years or so, as is the case in other countries. A wide variety of measures have been taken to that end: commercialisation units within the universities in 1998, ANR transfer programmes, Carnot Institute label (which promotes research contracts), doubling the CIR for R&D outsourced to public laboratories, etc. Partnership research, collaborative research, commercialisation of intellectual property, business start-ups and staff mobility are the main instruments that have been put into play for this purpose. A transfer culture has developed, driven by an increased number of stakeholders and specialised institutions. Yet the results since 2010 remain modest. The few available indicators, covering staff mobility, income from intellectual property and partnership research, do not point to any significant progress over the past 15 years or so.

The main obstacles to the development of knowledge transfers are to be found within public research itself, in that it does not offer researchers enough incentives to transfer knowledge and choose research that is likely to have a social and economic ripple effect. Overall, the policies pursued have not been consistent enough, and multiple measures have been adopted without the respective fields of application always being clarified. This has resulted in a very complex overall system that is costly and not very transparent to its users (in particular SMEs) and is ultimately less effective. The PIA itself has created new stakeholders, notably in the form of technological research institutes (IRTs), energy transition institutes (ITEs) and technology transfer acceleration companies (SATTs), although the way they tie in with the existing system of operators has still not been completely clarified. Finally, in France, as in the other countries, transfers have often been based on an administrative approach (*filing* patents and *creating* businesses are administrative measures) rather than economic measures (*commercialising* patents and *encouraging business growth* are industrial, market activities).

Recommendations:

- Offer more incentives to universities and PROs so that researchers will turn towards commercialisation rather than confine themselves solely to scientific publications. This means including transfer indicators in researchers' career files.
- Seek to clarify and harmonise the body of transfer mechanisms, by carefully evaluating the scope and impact in each case, consolidating or removing the least effective mechanisms, and clarifying the advantages of each mechanism. In that light, industrial property management poses particular challenges. A single management mandate must certainly be implemented (including the right to transfer a patent), but the respective roles and rights of the various stakeholders, such as SATTs and IRTs, also need clarifying.
- Professionalise and offer adequate incentives to the institutions and staff in charge of commercialisation: these are market activities that require stakeholders to have the relevant qualifications and experience and to do their best to respond to the signals received, especially from the market. From that point of view, the creation of SATTs is a step forward that should be built on.

R&D and business innovation

Businesses in France spend less on R&D than private sector businesses in Germany or other leading countries in the field of innovation. The difference can be explained by France's sectoral structure, particularly the small size of its manufacturing sector. French businesses tend to be more competitive in sectors that are less R&D-intensive (luxury articles, agri-food, tourism, value-added services, etc.). Furthermore, French industry has shrunk perceptibly since the early 2000s because it has become far less competitive. It is made up of small firms that are relatively more numerous and more R&D-intensive than their German (or British) equivalents and of large businesses that are smaller and less R&D-intensive than their German counterparts. The sectoral distribution is partly to blame, but this difference in size is clearly reflected within individual sectors (e.g. the automotive industry). In terms of innovation (as measured by innovation patents or surveys) and science, France occupies an intermediate international position, behind northern Europe, Germany and the United States, but ahead of southern Europe. In terms of internationalisation, it would appear that France as a country does not much attract the R&D of foreign firms, whereas French firms tend to locate a significant share of their R&D in the United States.

The CIR tax credit is among the most generous in the world. In itself, the CIR is a good measure – which is one of the reasons most OECD countries, and other countries, have adopted it. It has a positive impact on corporate R&D, although this probably does not match its cost to the State. Cost is, in fact, only one of the determinants of R&D, and lower cost would not entirely remove the other obstacles to R&D growth (i.e. enterprise capacity, demand, industrialisation costs, etc.) Rather, the real impact of the CIR seems to be in helping firms that do R&D to survive better than those that do not. Its generosity is justified largely by a tax environment (corporate tax, etc.) that is difficult and complex for enterprises, but with limited adverse effects on R&D firms.

A wide variety of public programmes and organisations ensure strong public intervention in innovation, with some considerable successes in a number of areas: competitiveness clusters, refundable advances from the French innovation agency OSEO, sectoral aid programmes, etc. The main beneficiaries are small businesses on the one hand and large businesses on the other, while ISEs receive less support. Competitive support measures (based on open invitations to tender) are becoming increasingly common. Overall, however, public intervention is very fragmented, not always consistent and does not follow a clear and single strategy.

Recommendations:

- Make the higher education and research "sites" and the competitiveness clusters more consistent among themselves, by adjusting their total number in keeping with this need for consistence.
- In the context of future tax changes, make the CIR less generous, especially for large companies, and reduce the corporate tax rate; this would make the CIR less likely to have a distorting effect on sectors where innovation rests relatively little on R&D.
- Given that national schemes to support innovation in France do not fully take into account France's sectoral structure and services, schemes that could benefit businesses in sectors such as agri-food and tourism should be developed.

Entrepreneurship

Judging by the available statistics, innovative entrepreneurship in France has grown to a level comparable to that of other countries. While the rate of business survival is high, few businesses are growing in size. Examples of successful growth (such as Criteo's listing on Nasdaq in 2013) remain rare. That is France's main issue in this area.

Venture capital funding is reputedly inadequate in France, as in other European countries. In terms of absolute amounts, it is higher in the downstream (expansion) stages than in the upstream (seed funds) stages, which admittedly require far less investment. Yet stakeholders report that it is difficult for French start-up businesses that have succeeded in the initial stages to complete the "third round", which generally requires higher funding (several tens of millions of euros). In fact, more venture capital is collected than invested in France, with a difference of about EUR 100 million per year since 2008. The reasons for this net export of capital remain to be identified. The level of capital injection is higher in France than anywhere else in Europe, but it goes hand in hand with this net export of capital and the persistent difficulty encountered during the third round. An in-depth analysis of these conditions is needed to optimise public intervention and target market segments with the highest demand while avoiding any crowding-out effects, such as private capital moving abroad in search of better projects while leaving the least profitable French projects to the State.

Greater and more dynamic innovative entrepreneurship has gradually become a central objective of French innovation policy. Public intervention is extremely thick on the ground in this field, with the State intervening at all levels of the chain (training, business start-up, taxation and social security contributions, funding, etc.), which seems to be making a real impact on the number of young innovative enterprises and their capacity to recruit researchers. Nevertheless, the far higher level of public intervention compared with other countries does not seem to be reflected in these businesses' growth and performance – which raises the question of the intervention's overall effectiveness.

What factors restrict the creation and, above all, the growth of innovative businesses in France? Lack of capital is often cited to justify the injection of large amounts of public funding into venture capital through funds of funds. The impact of the lack of capital is all the stronger in the absence of a stock market for growth companies, which would provide them with an additional source of funds, together with the exit capital needed by private investors.

A second limiting factor is the range of framework conditions that encourage businesses not to grow beyond a certain size, and especially the effects of the established thresholds (e.g. in terms of social legislation, taxation, access to public support) in relation to size.

A third factor is that some public support measures are not selective enough and last too long. A company can accumulate a variety of public support measures for years, even though its project is making no progress. The prolonged and artificial survival of poorly performing businesses inhibits the growth of other businesses by making them compete against one another for public and private funding, as well as access to skilled labour and the market.

Recommendations:

- Examine the actual venture capital requirements in France sector by sector, at a time when the much-cited shortage of venture capital does not seem to be general, and adjust the amounts the State allocates to the corresponding funds and funds of hedge funds.
- Examine the fiscal and legal conditions that give small businesses, in particular innovative start-ups, less incentive to grow.
- Make the strategy to encourage the creation of innovative enterprises by means of taxation and public sector support more selective. Following the methods used by venture capital professionals or by Small Business Innovation Research in the United States, funding granted to each young business could be reviewed on a regular basis in the light of its prospects of success, with those passing the test successfully entitled to higher funding in line with their growth needs.

Governance

Governance refers to all the mechanisms involved in managing and co-ordinating a country's research and innovation policies. It implies co-ordination among stakeholders with responsibilities at different levels of the system. In France, the highest level (strategic, interministerial) is the President of the Republic and the Prime Minister, usually advised by a "High Council" made up of major figures in research and innovation. In the past, High Councils of this kind never worked well in France, because their responsibilities were limited and unclear and because they did not have enough legitimacy in the eyes of some stakeholders who were not involved in their appointment and operations.

The ministries, especially those in charge of research and industry, must co-ordinate if the system is to work properly, including in formulating research and innovation strategies. This has not always been the case in the past. The recent (2013) creation of an interministerial body in charge of innovation policy should improve matters.

The situation was complicated by the creation of the General Commission for Investment (CGI), which developed its own strategy – derived from the "Juppé-Rocard report" and endorsed by the President of the Republic – on the basis of which it allocated significant funds to the PIA without creating any organic link with the ministries in the affected areas of competence. This resulted in systemic friction between old and new institutions with overlapping missions and different operating methods.

Vertical co-ordination relates to the steering/supervision of research organisations and operators (e.g. OSEO) by ministers. Basically, the PROs decide on their plans themselves, without any *ex ante* guarantees of overall consistency or compliance with the policy priorities. Potentially powerful instruments have been put in place (PIA, ANR) to remedy this. It is now time to make full use of them.

Positive developments have recently taken place in regard to the evaluation function, which has long been a weak point in France; new mechanisms have been established to ensure the independent evaluation of players and policies, in the form of the AERES, the CGI (for PIA investments), the increased powers of the French Court of Auditors in the field of research and innovation, and the creation, in 2014, of a policy evaluation committee under the General Commission for Strategy and Foresight.

Recommendations:

- The High Council that is being created under the Law of July 2013 should be given real operational independence in relation to the SFRI stakeholders, in particular the PROs.
- Specific procedures should be put in place to promote regular co-operation among the key SFRI ministries, so as to align the various strategies with the corresponding political measures. That calls for interministerial co-ordination.
- The ministries that supervise the PROs, particularly the MESR, will have the capacity to orient their strategies, by setting goals aligned with national strategy and implementing them through multiannual plans signed with the PROs for achieving those objectives.
- Independent evaluation should continue and be developed, and the prerogatives of the AERES should be confirmed in the new HCERES. Evaluation should become more effective and have a direct influence on the subsequent orientation of the evaluated policies and measures.

The PIA

Genesis and content of the PIA

The PIA was established in 2009, on the initiative of President Sarkozy, following the Juppé-Rocard report and as an immediate follow-up to the SNRI. The PIA covers the period 2010-20.

The aim of the programme is to prepare France for the challenges of tomorrow (competitiveness, environment, health, etc.) and increase its growth potential by investing up to EUR 35 billion in higher education and training, research, industry and SMEs, sustainable development and digitisation. All in all, assuming it has the desired multiplier effect on other funding, and especially on private sector co-financing, the target investment programme will be worth between EUR 60 billion and EUR 65 billion, to be spent as follows:

- research (EUR 7.1 billion)
- higher education and training (EUR 11.0 billion)
- digitisation (EUR 4.5 billion)
- sustainable development (EUR 5.1 billion)
- industry and SMEs (EUR 6.5 billion)

Each of these fields includes a number of different programmes, combining various methods of funding (loans, own resources, subsidies) and different approaches per sector, per object (creation of new objects, such as the SATTs, ITEs, IRTs) and per technology linked to a target issue (e.g. car of the future). The PIA is piloted and co-ordinated by the CGI. The bodies responsible for disbursing the funds under special programmes are existing entities, which as a result now have additional responsibilities. Chief among these are the ANR, the Deposits and Consignment Fund (CDC), the Environment and Energy Management Agency (ADEME) and OSEO.

Part of the allocated funding is paid outright to the beneficiaries ("consumable funds"), but another part is given in the form of an endowment, with beneficiaries receiving only the interest on the investment, namely an annuity amount to about 3.5% of the endowment. Some programmes may definitively receive the investment capital after ten years, when the programme comes to an end, under terms that remain to be defined.

The PIA stands out among public policies relating to research and innovation in terms of both its objectives and methods.

The PIA sets thematic objectives. The main target is research and innovation, which absorbs more than half of the funding. The PIA also pursues excellence and allocates funding to stakeholders and projects that it considers the most able to produce value.

The method for pursuing these objectives is based on openness and selectivity. Most of the funds are allocated on the basis of open tenders, arbitrated by expert juries (which include foreigners) who base their decision on the expected value of each tender submitted. Selectivity means that there is a restricted number of beneficiaries, to avoid scattering funding, effectively rendering it inoperative. This method deliberately disregards institutional barriers, such as PROs/universities or universities/*grandes écoles*. The PIA has created new entities to drive certain projects, e.g. Idex, SATTs, IRTs, etc. In line with its selective and transparent approach, the PIA also gives pride of place to evaluation, which is included at all planning levels (individual projects, programmes, operators, overall level).

Table 1.2. PIA: Programmes and activities

Programme	Amount	Content, operator
Centres of excellence (EUR 12 billion)		
Equipment of excellence	EUR 850 million	Approx. 100 pieces of research equipment
Laboratories of excellence	EUR 1.94 billion of which EUR 1.8 billion in capital	Managed by ANR
Initiatives of excellence (Idex)	EUR 7.1 billion of which EUR 6.9 billion in capital	Aim: create 5-10 interdisciplinary clusters of global excellence Managed by ANR
Plateau de Saclay	EUR 1 billion consumable	Establishment of a research cluster of excellence comprising about 14 schools and universities Managed by the ANR
Plan Campus	EUR 1.3 billion	Supplement to the EUR 3.7 billion from Plan Campus to renovate university buildings across ten French campuses; the PIA contributes in two instances (Paris and Saclay)
Heath and biotechnologies (EUR 2.45 billion)		
Health and biotechnologies	EUR 1.55 billion	Fund the most advanced research in these fields
University hospital institutes (IHUs)	EUR 0.9 billion in capital	Fund five clusters of excellence in research, education and commercialisation
Commercialisation of research (EUR 3.5 billion)		
Carnot Institutes	EUR 500 million in capital	Public-private partnership research
IRTs	EUR 2 billion, of which 75% in capital, plus estimated EUR 1 billion in multiplier funds	Create a dynamic of public-private co-operation
SATTs	EUR 950 million in own funds	Technology transfers, commercialisation
France Brevets (patents)	EUR 50 million (plus EUR 50 million from the CDC)	Patent funds
Energy and circular economy (EUR 3.15 billion)		
Institutes of excellence for carbon-free energy, now ITEs	EUR 1 billion, of which 75% in capital	Associate the public and private sectors
Energy and green chemistry demonstrators	EUR 1.2 billion	Managed by ADEME
Circular economy	EUR 200 million	Innovation and deployment
Nuclear	EUR 800 million	R&D
"Green tech" investment fund	EUR 150 million	Investment in innovative "green" enterprises
Transport (EUR 3 billion)		
Aeronautics	EUR 1.5 billion	R&D
Automotive, maritime, rail, space	EUR 1.5 billion	R&D
Employment, equal opportunities (including boarding schools of excellence, co-operatives, etc.) EUR 1.1 billion		
Urban planning, housing (EUR 1.5 billion)		
City of tomorrow	EUR 850 million	Demonstrators for planning, energy, transport, etc.
Digital industry (EUR 4.5 billion)		
Support for new digital services and uses	EUR 2.25 billion	Support for research and innovation in ITCs
Support to enterprises (EUR 3.1 billion)		
National seed capital fund	EUR 600 million	CDC
Competitive clusters	EUR 300 million	OSEO
Other support for innovative SMEs	EUR 1.4 billion	OSEO

Source: http://investissement-avenir.gouvernement.fr/content/action-projets/les-programmes/centres-dexcellence.

In July 2013, the government replenished the PIA with EUR 12 billion. This study does not discuss what is known as “PIA 2”.

The PIA combines two kinds of instrument to address the issues of creating a larger, more specialised pool of human capital geared more closely to innovation:

1. The “Idex” scheme has committed EUR 7 billion in non-consumable endowments to create between 5 and 10 world-class multidisciplinary clusters of excellence in higher education and research. This scheme, which began in 2011, led to the selection of eight projects that could spawn fully-fledged research universities by combining on a given site the forces of excellence of all the stakeholders.

   With the launch of the second PIA scheme in 2013, Idex was completed by a new tender for projects designed to support sites which, while they cannot pretend to achieve a high overall position in the scientific disciplines, have some strong points that are closely linked to the economic actors in the field.

   With these two instruments, which together account for more than EUR 10 billion in funding, the PIA encourages:

   – structuring: through closer governance of shared strategic projects, taking into account global competition

   – differentiation: by distinguishing between universities and schools on the basis of the assets of the respective sites, recognising these strengths by awarding selective labels, and encouraging them to focus more directly on the economic activities of their territory

   – decompartmentalising: between universities, grandes écoles, organisations and enterprises, which are often co-founders of new projects for unified universities

   – openness: by opening up to global competition, thanks to a policy of attracting researchers and establishing partnerships with top foreign institutions.

   For projects already selected, this “championship” policy includes a policy of excellence in research-based training; it also often features an in-depth reform of undergraduate education. The PIA provides substantial long-term funding, in exchange for governance and a strategic project based on excellence that ensure proper use of the resources. The PIA thus reflects a systemic ambition.

2. The PIA has also embarked on several experimental projects designed to test and, where appropriate, demonstrate the viability of innovative pedagogical models.

   With its “scientific and technical culture”, “boarding schools of excellence” (for middle and high school students) and “initiatives for excellence in innovative training” (IDEFI) projects, the PIA has created more modest but highly innovative instruments; some time will be needed to assess how far they have succeeded in each case and whether they can be reproduced on a larger scale.

   Small as they are, the IDEFIs could still serve as an important breeding ground for innovation on which the MESR could capitalise in years to come. This kind of large-scale support is the only means of exerting a lasting influence on higher education training.

   The PIA has also funded measures related to apprenticeship.

Conditions for a successful PIA

Within the research and innovation landscape in France as described above, the PIA is the strong but natural follow-up to the reforms initiated some 15 years ago. Its objectives – thematic research orientation, pursuit of excellence, public-private links for innovation and development of entrepreneurship – reflect all the reforms initiated at the time. Yet the PIA ushers in two new dimensions. First, as something that has been created from nothing, it effectively sets up all the institutional mechanisms required for this agenda. Second, it draws on a substantial budget, which potentially gives it a more direct impact on the SFRI than the earlier reforms. The amounts involved certainly need to be considered in relative terms: a large part of the approximately EUR 20 billion allocated to research and innovation is made up of allocated capital, meaning that the amount actually available per year is about EUR 1 billion – some 5% of the public budget allocated to this area. However, it will offer considerable financial leverage, since these funds will mobilise existing resources (researchers, infrastructure) financed under existing budgets. In particular, concentrating funding on "excellent" stakeholders not only boosts their chances of success but may also promote change within the SFRI culture, for even those not initially selected will have an incentive to improve their performance. In this way, the PIA could not only speed up France's convergence towards a new growth path, but also contribute to reforming the SFRI beyond its own scope of action.

Even though the PIA has clear direction and all the necessary resources, its success is not guaranteed. Two major and closely connected difficulties need to be overcome first: the complexity of the mechanism itself and its role in combination with the other components of the SFRI. The PIA has created new programmes and new entities (Idex, etc.). Although the tasks and objectives of each have been clearly identified, the way in which they are co-ordinated is not always properly defined *ex ante*. For example, the tasks of the SATTs and the IRTs overlap to some extent and will prove rather difficult to co-ordinate. An additional issue is that the PIA is actually an addition to the system, rather than a replacement for it; it has created new programmes and new players alongside the existing mechanisms. This means that the efforts of the PIA to simplify the situation will only have an impact if the State and the establishments concerned agree to adjust or remove structures that the projects funded by the PIA are intended gradually to replace (e.g. SATTs vs. transfer services in place) or whose rapprochement it is meant to accelerate (e.g. the Idex initiative of excellence, which is aimed at bringing together certain educational establishments). Otherwise, the PIA will simply be adding to the prevailing complexity and segmentation – especially in relation to the mechanisms established and operated by the PROs – whereas in fact one aspect of the SFRI that the PIA seeks to correct is this segmentation of structures, which creates a kind of "silo" system.

If the PIA is to have its full impact, the reforms initiated must therefore continue: university autonomy at all levels (research and training policy, including during the first cycle, management of human and financial resources); transfer of the management of joint research units to the universities; specific measures to strengthen research universities; groups of universities and *grandes écoles* – these reforms must be taken further so that the recipients of PIA funds can use them to the fullest extent and produce the expected excellence. It is also clear that the programmes designed for businesses at start-up, commercialisation or partnership research stages rely on the French economy becoming increasingly globalised at both the macroeconomic (tax burden on businesses) and microeconomic (obstacles to business growth, labour market) levels. From that point of view, measures such as the "competitiveness agreement" and the "responsibility agreement" are extremely important.

The French research agenda also needs to be clearly defined, which means that the various agendas currently in place or in preparation (the PIA and National Research Strategy (SNR) in particular) must be closely aligned, since the dispersal of resources would remain a problem otherwise. The State cannot afford to pursue several strategies in parallel if they are not properly co-ordinated.

If the PIA is to succeed, further changes will therefore have to be made to the system in order to reform and simplify it. This will require major strategic choices upstream to ensure that the juxtaposition of similar mechanisms does not detract from their overall success. At every stage, existing institutional forms, operations and entities – whether or not linked to the PIA – will need to be assessed and measures taken in line with their performance so as to strengthen those that meet their objectives and re-orient or restructure those that do not.

Failing that, resources will continue to be dispersed and the system will remain complex, rendering the PIA far less effective – hence the importance of both evaluating the system and implementing the findings, which calls for strong political commitment. The importance attached by the CGI to evaluation is a step in the right direction. Co-operation could be established with the HCERES, which evaluates the PROs and the universities implementing the PIA.

Assessing the success of the PIA

The PIA seeks to steer research and innovation in France towards specific objectives and to promote excellence in those fields; it is also an instrument aimed at transforming the SFRI in order to render it more capable of achieving its objectives. In the light of that definition, the success of the PIA is indissociable from the progress of the SFRI, and will therefore be assessed both in terms of direct objectives (thematic successes, global excellence, public-private links, entrepreneurship) and of the indirect objective (transforming the SFRI).

Provided the PIA achieves its objectives, the main features of the SFRI in 2020 could be as follows:

- Research and higher education: the balance between recurrent funding and project funding has shifted towards the latter, with projects selected in an open and competitive manner; recurrent funding is concentrated on a few institutions of excellence and on the research infrastructure; France has improved its ranking in excellence (higher impact index, higher number of ERC grant winners, larger share of European funding); France has become more attractive and welcomes many high-level foreign researchers; France has several (five to ten) large, world-class research universities providing an education that meets the highest international standards; the other universities focus on quality education that meets economic and social needs, on research focused on several quality subject areas, and on developing close partnerships within the economic and social fabric.
- Transfers: partnership research has become a standard activity of universities and laboratories, whose choices of research areas are guided chiefly by the State (SNR, ANR) and by socio-economic stakeholders, including businesses; intellectual property is commercialised so as to optimise the economic value created; the joint entities (IRTs, ITEs, etc.) make breakthroughs which are then implemented by the participating enterprises.

- Innovation: French industry retains its position in high-tech sectors such as aeronautics and space; new sectors based on environmental innovation emerge. The most technology-intensive sectors (automotive, etc.) regain their position by moving upmarket. French industry becomes more R&D-intensive as a result of its restored competitiveness in certain industries (e.g. automotive). The sectors where France currently has the strongest presence (agri-food, services, luxury goods, etc.) broaden their (technological or not) innovation base, making them more competitive. (Although the PIA does not target them directly, improved innovation conditions in France and in particular, relations between universities and business should have an impact on these sectors, which are economically strong and potentially heavy users of innovation).
- Innovative entrepreneurship: because capital is more widely available and framework conditions have improved, a greater number of innovative firms – particularly many web-based businesses – experience growth.

The alternative – a failure of the PIA and an end to the reforms – would mean that France maintains at best an intermediate position in research and innovation. This position would most likely worsen gradually, since currently less well-positioned countries – especially emerging countries, like China, which are dynamically catching up with more advanced countries – are carrying out the necessary reforms. The decline would probably be slow, because France has considerable available (human, scientific, technological) capital and a number of institutions are already obeying or moving closer to the new logic, but it would be a decline nonetheless.

Conclusion

With the implementation over the past 15 or so years of a number of major reforms and the formulation of a plan – the PIA – with significant financial clout to back those reforms, the SFRI has clearly improved its capacity to meet the economic and social challenges of today's new technological and global landscape. The system has become more open and flexible. Yet it has come up against some limitations that became increasingly obvious as the French economy became less competitive in the 2000s. When the PIA was established in 2010, the SFRI had already embarked on a change process. However, the fact that the reforms were incomplete and sometimes inconsistent and were not adequately funded tended to reduce the system's capacity to meet its objectives, i.e. to produce radical innovation in cutting-edge fields, together with incremental innovation in other fields – not necessarily based on high technology – where France has a tradition of excellence.

The challenge for 2020 is to finalise the changes to the SFRI, by selecting from among the measures in place those that make the system more open and flexible while removing or re-orienting the others in a bid to simplify France's research and innovation policies and make them more coherent. The pursuit of these objectives under the PIA should effectively accompany the broader economic measures (reduction of public deficits and less tax pressure, establishment of a more flexible and open product market and labour market) that are being taken to make businesses more competitive. That will create the conditions for economic stakeholders to invest more in innovation activities, for new innovative firms to renew the French productive fabric, and for innovation to help satisfy social and environmental needs. The PIA must play its part in providing the necessary policy models and financial base for pursuing this agenda. Conversely, a return to the "old-style" SFRI would ultimately make public investment in research and innovation unproductive, with a direct impact on France's competitive position in 2020.

Chapter 2

France's economic performance and innovation

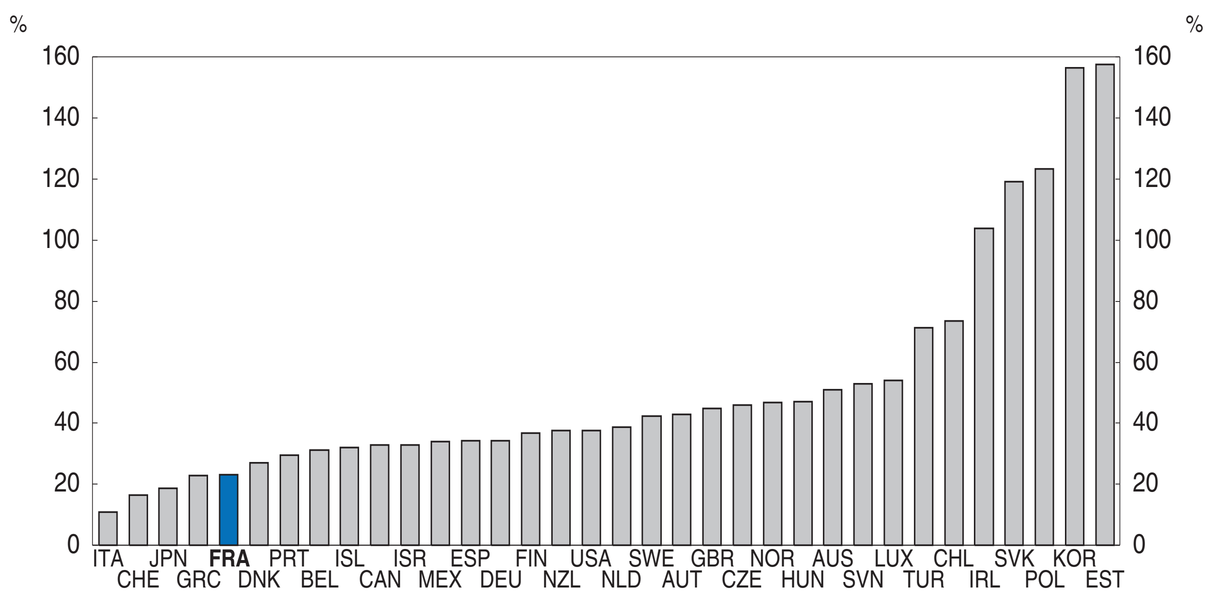
This chapter presents France's performance in terms of growth, competitiveness and innovation. It examines the factors of the shortfall in the country's balance of trade and growth slowdown, and especially its declining price competitiveness. It reviews the structural conditions for economic activity – in other words, the labour market and the market for goods and services – as well as taxation and public deficits. The second part of the chapter focuses on France's performance in the realm of innovation, as measured by expenditure on research and development, patents and the share of new products in total sales, and as reflected in France's attractiveness for international investments in innovation. It compares France with its main partners, particularly Germany.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

France is the second-largest economy in the euro area in terms of its gross domestic product (GDP). It is among the Organisation for Economic Co-operation and Development (OECD) countries with the highest hourly labour productivity rates and one of the few countries in the OECD in which inequalities have not increased perceptibly over the past two decades (OECD, 2011).

France's economic performance in recent decades, however, has been very average. The level of GDP per capita has grown far more slowly than in most other OECD countries (at 0.4% between 2000 and 2010, compared with an OECD average of 1%). This sluggish GDP growth translates into a pronounced (0.6%) drop in the number of hours worked, barely cancelled out by a gain in hourly productivity (1%) that is lower than the OECD average (1.3%). If we consider a longer time span – since 1990 – the performance level is identical (Figure 2.1), putting France among the OECD countries registering the lowest per capita growth rates.

Figure 2.1. Per capita growth, 1990-2012, annual average in %



Source: Boulhol and Sicari (2013), "The Declining Competitiveness of French Firms Reflects a Generalised Supply-Side Problem", *OECD Economics Department Working Papers*, doi: 10.1787/5k4c0dldmgr2-en; "OECD Economic Outlook No. 92", *OECD Economic Outlook: Statistics and Projections* (database), doi: 10.1787/data-00646-en.

This growth deficit worsened in the middle of the last decade. France had been experiencing a slowdown even before the 2008 crisis, followed – as with other OECD countries – by a recession in 2009. Though less seriously affected than others in the first phase of the crisis, France has also made a less dynamic recovery. It is not alone in this respect and has actually come off lightly compared with the countries of southern Europe. Nevertheless, the feeling that France, historically a pillar of Europe and the euro, was in danger of becoming "detached" from northern Europe was a source of great concern to some observers.

Diminished competitiveness

France's growth problems have been analysed elsewhere (OECD, 2013). They are intimately linked with its declining competitiveness. This is reflected in lost export market shares and an increase in the country's external deficit, especially with regard to manufactured goods. As for France's export growth, it was 20% lower than that of the euro area between 2000 and 2010.

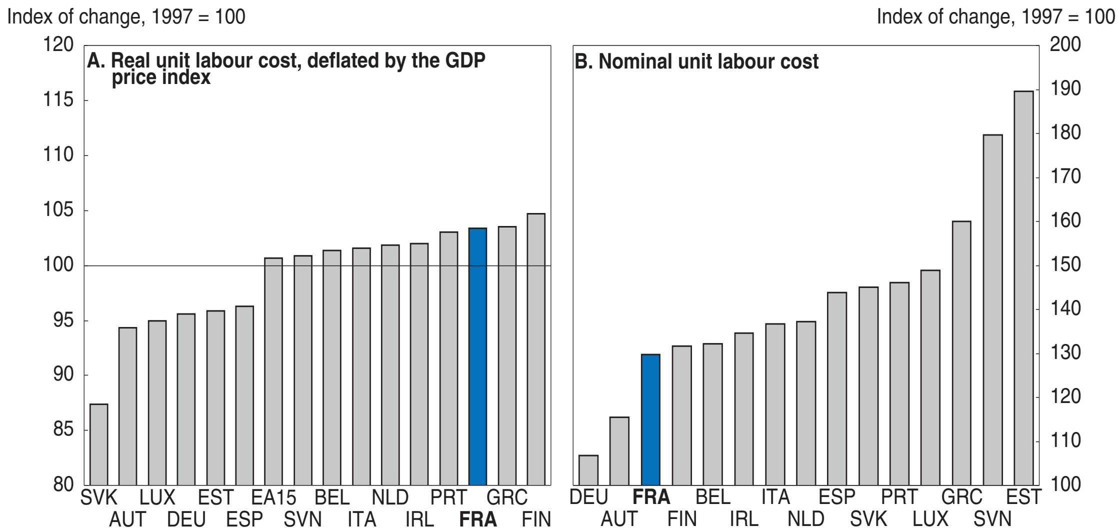
France has seen its balance of payments deteriorate over the past ten years, even incurring deficits (from 2004), particularly as a result of shortfalls in the balance of trade in goods. The balance of trade in manufactured goods went from a surplus of EUR 25.5 billion (euros) in 2002 to a deficit of EUR 26 billion in 2011. This deterioration has occurred in virtually all areas of manufacturing – intermediate, consumer and capital goods – but capital goods have registered the heaviest slump.

France's share of global export trade has been contracting since the turn of the century. Between 2000 and 2011, it declined at an annual rate of almost 2.8%. While this shift was chiefly attributable to the emerging economies, it hit France harder than any other country in the euro area, except for Greece, Italy and Finland. Germany's market share rose by 1% a year over the same period.

This lack of competitiveness is symptomatic of underlying structural weaknesses. Not only does it affect France's export capacity, it also has a more general impact on the country's productive capacity and hence its growth potential. Two dimensions of competitiveness need to be examined, namely the price dimension and the "non-price" dimension. These two dimensions must not be seen as alternatives; on the contrary, they complement each other greatly in advanced economies. Companies that compete well on price can earn profit margins that enable them to invest in innovation and quality, thereby enhancing their non-price competitiveness in a virtuous circle of the sort that Germany has experienced since the turn of the century. Conversely, companies that are highly competitive in non-price factors allows them to pay higher wages, thereby boosting the motivation and hence productivity of the workforce.

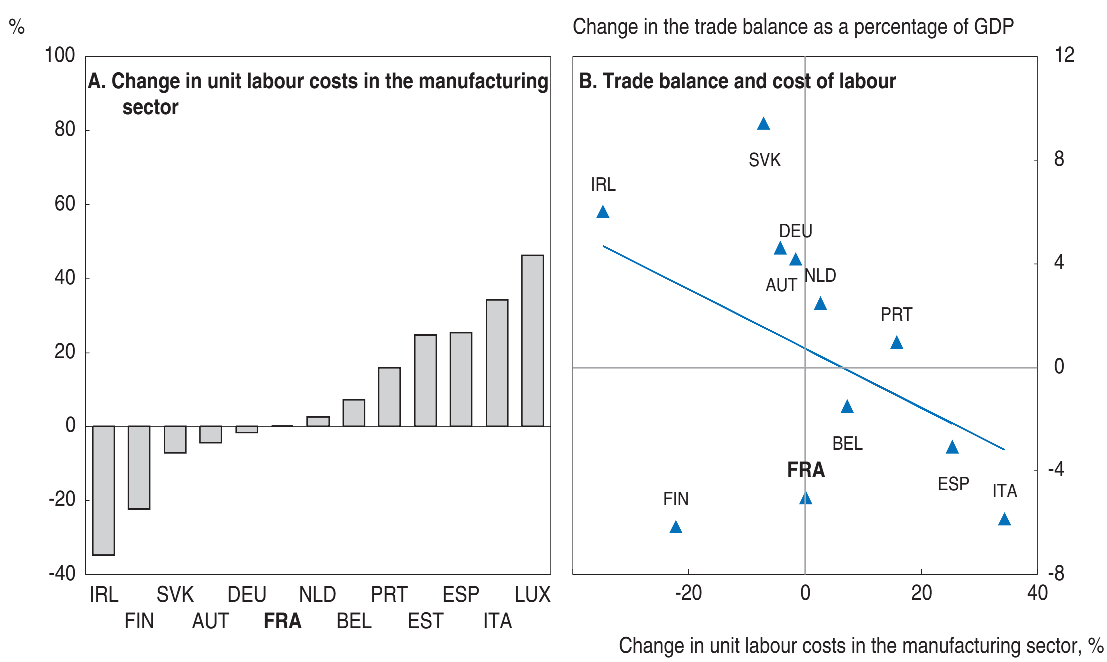
One of the key factors in the decline of French competitiveness has been the rise in unit labour costs, calculated as the total cost of labour per unit of output. This increase reflects the fact that pay levels have risen faster than productivity since the late 1990s. Between 1997 and 2010, France had the third-largest increase in real labour costs (deflated by the GDP price index) in the euro area, after Finland and Greece. The increase amounted to 4% over the period, compared with 2% for Italy, 1% for the euro area as a whole and 5% for Germany (Figure 2.2). Labour productivity grew faster in France than the average in the euro area, but that was not enough to cancel out the increase in labour costs.

Figure 2.2. Cost competitiveness of the whole of the French economy, 1997-2010: Real (left chart) and nominal unit labour cost (right chart); 1997 = 100



Source: Boulhol and Sicari (2013), "The Declining Competitiveness of French Firms Reflects a Generalised Supply-Side Problem", *OECD Economics Department Working Papers*, doi: 10.1787/5k4c0dldmgr2-en; "OECD Economic Outlook No. 92", *OECD Economic Outlook: Statistics and Projections* (database), doi: 10.1787/data-00646-en; OECD, STAN database.

Figure 2.3. Cost competitiveness (unit labour cost) and trade balance in the manufacturing sector, 1997-2010

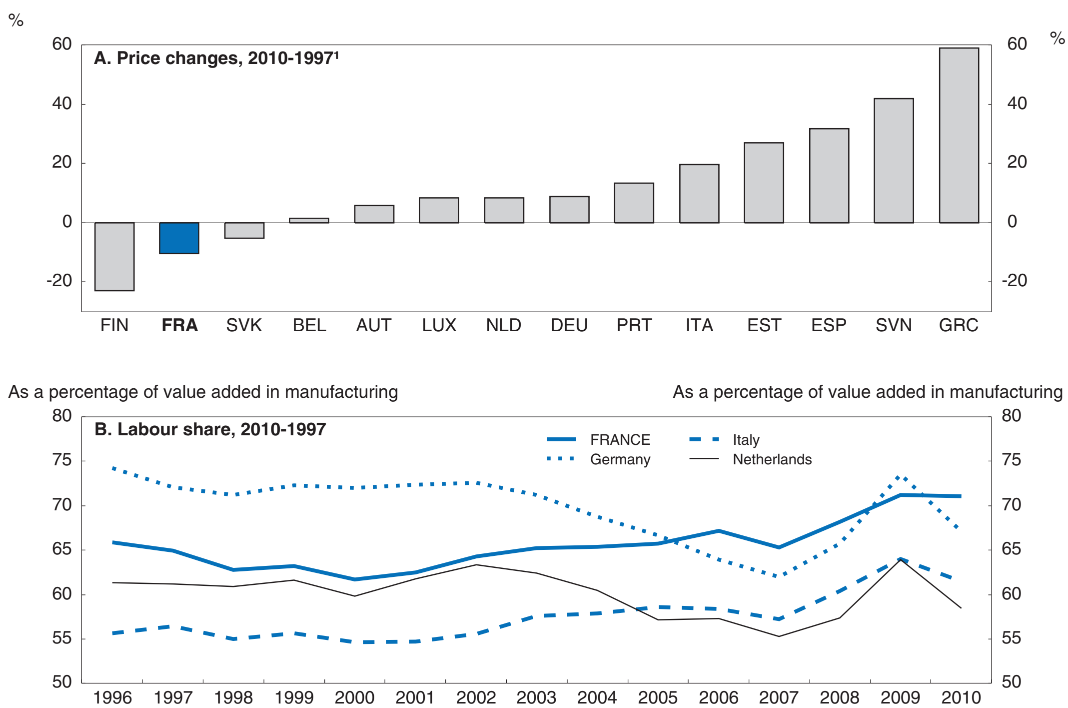


Source: Boulhol and Sicari (2013), "The Declining Competitiveness of French Firms Reflects a Generalised Supply-Side Problem", *OECD Economics Department Working Papers*, doi: 10.1787/5k4c0dldmgr2-en; "OECD Economic Outlook No. 92", *OECD Economic Outlook: Statistics and Projections* (database), doi: 10.1787/data-00646-en.

Manufacturing and service sectors: Differing trends

In the manufacturing industry, on the other hand, France did not experience any shift in its unit labour costs, remaining more or less on a par with Germany from 1997 to 2010 and comfortably out-performing the countries of southern Europe (Figure 2.3). In fact, producer prices in the manufacturing sector fell by almost 8% during that period (Figure 2.4); only Finland recorded a comparable decrease (-20%) over the period (probably as a result of price trends in the electronics industry, which accounts for a large share of Finnish exports). This reflects France's position in markets for mid-range products, where competition intensified during the period, particularly from the BRICS countries (Brazil, Russia, India, China and South Africa), putting considerable pressure on prices. In these conditions, manufacturers cannot raise their prices; an increase in costs leads first of all to tighter margins, with a resulting impact on investment (and thus on non-price competitiveness), ultimately leading to the disappearance of the firms concerned (with the result that the average unit labour cost does not increase *ex post*). Thus, a gradual erosion of France's industrial base was observed during this period.

Figure 2.4. Price changes and labour cost as a percentage of value-added in manufacturing, 1997-2010



1. Change in real prices from 1997 to 2009 for Belgium, Estonia, Greece, Luxembourg, Slovakia, Slovenia and Spain and from 1997 to 2006 for Portugal.

Source: Boulhol and Sicari (2013), "The Declining Competitiveness of French Firms Reflects a Generalised Supply-Side Problem", *OECD Economics Department Working Papers*, doi: 10.1787/5k4c0dldmgr2-en; "OECD Economic Outlook No. 92", *OECD Economic Outlook: Statistics and Projections* (database), doi: 10.1787/data-00646-en; OECD, STAN database.

By contrast with manufacturing, the service sector saw a more significant rise in its unit labour costs than other countries of the euro area. Since service firms supply the manufacturing industry, this relative cost increase fed through to manufacturing. Service productivity progressed less in France than elsewhere. This limited productivity growth may be attributed to some of the inherent characteristics of service activities that are not conducive to effective allocation and use of productive resources (see below). Accordingly, the problem of price competitiveness in France may be seen as stemming from an imbalance in the division of earnings between an "exposed" sector in which companies – chiefly manufacturers – face international competition and a "protected" sector, comprising mainly service providers (General Commission for Strategy and Forecasting, 2013).

Cost pressure and the need to maintain world market price levels have put a squeeze on corporate profit margins. Corporate profit margins in France (gross operating surplus/value-added) amounted to less than 29% in 2011, the lowest in Europe (Eurostat). The European Union (EU) average was 38%, with Germany posting 41% and the United Kingdom 34%.

Depressed corporate finances also drove down capital spending – including investment in research and development (R&D), quality and sales networks – which was a major factor in the declining non-price competitiveness of French industry during the first decade of the 21st century. In 2010, French companies' R&D expenditure represented only 1.4% of GDP. Even though this rate was higher than in 2008, it remained below those of Finnish (2.7%), Swedish (2.3%) and German firms (1.9%) over the same period. This gap, however, is not due to relaxed efforts on the part of French companies, but rather to the shrinking the industrial base. There are fewer companies – the number of businesses with 10 or more employees fell from 41 800 in 2003 to 31 400 in 2010 – and total output is not growing, despite the persistent efforts of the survivors. Moreover, the companies that disappeared mostly had no R&D activities, which means that their demise has increased the average R&D contribution of the surviving population. Since the size of that population has dwindled, however, its continuing vigorous efforts have not been enough to maintain the overall level of innovation.

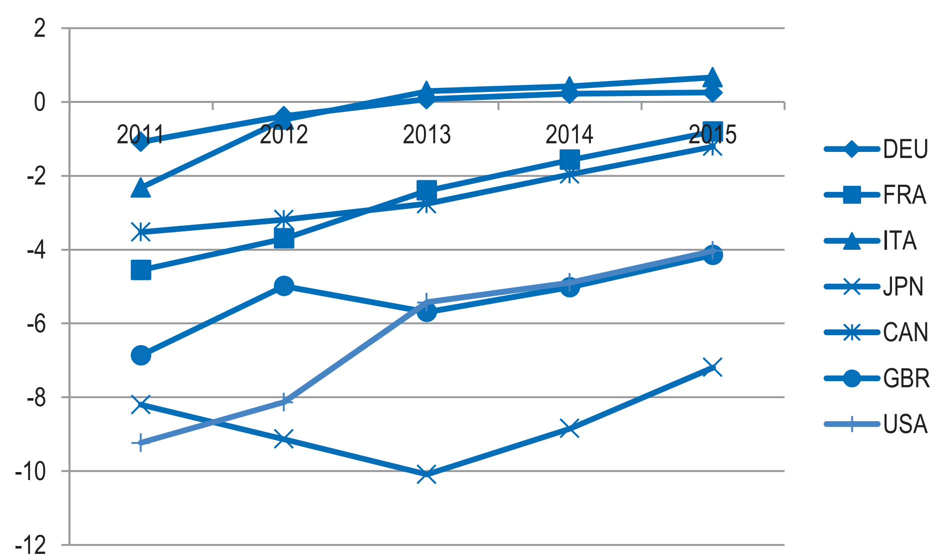
Thus, the decline of the French productive system is not due to a lack of innovation – which has merely compounded other factors (see the following section). Whereas the manufacturing sector lost 25% of its businesses with 10 or more employees between 2003 and 2010, the percentage of firms engaging in R&D rose from 7.4% to 16.6% (see the following section). The erosion of the industrial base, weakened by rising costs, has not been halted by this purely relative growth in innovation, which was not always able to make its mark in a world of increased competition.

The positioning of French industry in the middle rather than the top of the market and at an innovation level below that of northern European countries and Germany is rooted in historical factors. French industry as it was shaped in the period of the post-World War II reconstruction was tightly administered; it was structured around industries that were overseen or regulated by the State, served (often protected) internal markets, etc. The exposure of the French economy to international competition in the context of European integration and globalisation led to the gradual disappearance of the least competitive industries. Established industries – such as aeronautics – were able to preserve or increase their competitiveness, while others – such as the agri-food industry (which became less competitive in the context of the general downturn, but still possesses unique growth potential), luxury goods, tourism and some service industries with high value-added – held their own globally. These new successes, however, have not compensated fully for the loss of traditional industries, chiefly because there has been insufficient redeployment of productive resources into these new engines of growth. This also applies to research and innovation, which have not sufficiently focused on these sectors.

The increase in government deficits

As growth has slowed and public expenditure has risen at a faster clip, the State's financial position has gradually worsened and government debt has risen. The currently very low interest rates have served to limit the impact of the debt on the deficit, but rising interest rates in the wake of economic recovery might make the situation more difficult in the future. This means that there will be limited scope for public capital expenditure in the coming years. The State will have less money to spend on R&D in particular and on financial support for corporate innovation.

Figure 2.5. Government budgetary surplus or deficit as a % of GDP



Source: *OECD Economic Outlook No. 94* (database), 2013; the positions plotted for 2013 to 2015 are estimates or forecasts.

Insufficiently innovation-friendly general conditions

France's successes and failures with regard to economic growth and innovation can partly be attributed to the general operating conditions for companies, namely the labour market and the regulatory and fiscal frameworks. Recent OECD studies have identified some unfavourable general conditions for growth and innovation in France.

The labour market

In the labour market, the segmentation of employment contracts into permanent contracts (which are heavily regulated) and fixed-term contracts (which are far less so) restricts the capacity of the French economy to adapt to unforeseen events by redeploying the workforce from activities or firms that are declining to those that are expanding. Innovation entails a process of "creative destruction", in which old jobs disappear and new jobs emerge, particularly in connection with technological transformations. Any hiccups in this redeployment process will not only delay innovation – and hence productivity –

but will also generate unemployment, as the disappearance of established jobs under the pressure of international competition will not be balanced by the creation of new jobs. The national inter-professional agreements on "secure career paths" concluded among social partners in January 2013 represents a significant advance in this respect. Job segmentation also deters investment in training staff on short-term contracts, since the time frame is not long enough to justify the expense, whether on the part of the company or the employee.

The centralised nature of collective bargaining (at the level of an entire industry) does not allow taking into account the specific features of individual businesses – which are all the more significant and variable in the realm of innovation.

Innovation requires changes in skill profiles; the vocational training system should normally help employees to adapt and companies to train their workforce. Although a great deal of money is spent on vocational training in France – EUR 32 billion in 2012 – the system does not seem fully up to this task. For example, access to vocational training is uneven (the rate of access to continuing vocational training for the 20-29 age bracket is three times higher for university graduates than for young people without degrees). A lack of basic training is also a major problem for some sections of the population (OECD, 2013b). All in all, the shortcomings of the vocational training system, both initial and continuing, are a source of labour shortages in some specialities and unemployment in others (see also the chapter on human resources in this study). The observed decrease of 8% in the number of apprentices in 2013 gives is in this respect worrisome, despite plans to increase the present number of apprentices to 500 000 by 2017, compared with a little over 400 000 today.

The high level of compulsory levies (particularly contributions to welfare schemes and the generalised social contribution/CSG) and the inflexible rules governing wages and salaries (including a very high statutory minimum wage in relation to average earnings) weigh heavily on supply and demand in the labour market. The compulsory levies have created a "fiscal wedge" that increases the cost of labour for enterprises and reduces employees' take-home pay. France has opted for one of the highest minimum wage rates in the OECD, and the countries where the minimum wage is higher, namely Australia and the Netherlands, have special provisions for young people giving them easier access to employment. This high minimum wage is one factor that has helped stem the growth in inequality in France compared to other countries. The minimum wage, however, is not the most effective means to this end; on the contrary, it has a significant exclusionary effect on more vulnerable sections of the population, such as young people and the unskilled.

Government expenditure and taxation levels

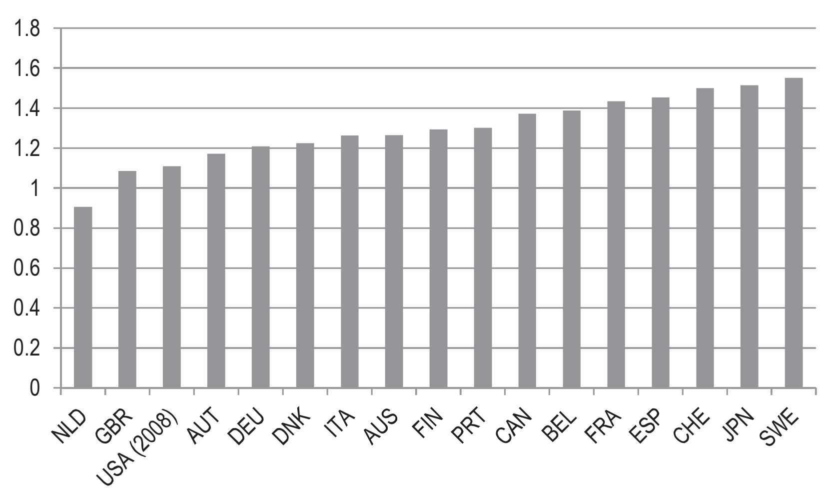
Next to Denmark, France is the OECD country with the highest ratio of public spending to GDP (55.9% in 2011). Accordingly, the public sector itself will need to make efforts to remedy this situation so that net productivity gains may be achieved in the French economy. Numerous sources of inefficiency and inefficacy have been identified in public administration, such as the multi-tiered structure of regional and local government and the way in which health care is administered. The review of public expenditure (the comprehensive public policy review and the government civil service modernisation scheme since 2012) launched in the early 2000s is a key component in the effort to reduce public spending.

Corporate tax rates are very high, but the tax base is often narrow, and is rendered opaque by a multiplicity of “niches”. France’s 33.3% corporate income tax rate is among the highest in Europe, alongside Austria, Belgium and Spain. Despite the many exemptions businesses can claim, this situation is a source of uncertainty and distortion and thus does not foster investment. A number of initiatives have been taken in 2013 and 2014 (especially in the wake of the “Gallois report”) to rectify this situation. These include the “Competitiveness Pact” (which includes a tax credit for competitiveness and employment), the taxation review launched by the Prime Minister in 2013 and the “Responsibility Pact” under negotiation in 2014.

Overregulated markets in goods and services

Some service industries are subject to particularly tight regulation and therefore experience a lesser degree of competition (Figure 2.6), which is a source of production inefficiency and (sometimes) slower adoption of innovations. The most highly regulated services are also those in which productivity growth has been the slowest. Foremost among these are retailing, rail transport, energy, regulated professions and health care. Some regulations, particularly those relating to safety or environmental protection, can foster innovation by imposing new objectives on companies that can only be met through innovation. But the barriers to entry and restrictions on competition that are imposed in a number of cases reduce players’ capacity and incentive to innovate, ensnaring them in a web of restrictions that make innovation a riskier proposition (by increasing the chance of infringing an established rule) and curbing their ability to capitalise on it (by setting demand conditions). A company whose position is safeguarded by legislation (e.g. a public monopoly) has little incentive to innovate, while a company that knows itself to be excluded offhand from a market it would otherwise happily enter will obviously have no reason to innovate for that market

Figure 2.6. Barriers to competition in the market for goods and services, 2013



Source: OECD, Indicators of Product Market Regulation, www.oecd.org/economy/growth/indicatorsofproductmarketregulationhomepage.htm.

General conditions and innovation

These general conditions diminish the ability of the French economy to redeploy its human and financial resources from less competitive to more competitive businesses and to come up with the resources required for private and public investment to breathe new life into the productive fabric. Thus, they have a direct impact on France's performance in research and innovation.

The role of innovation in the decline of French industry

French economic growth has been sluggish for the past 15 years, coinciding with the country's waning competitiveness. This section examines the role of innovation in this decline. How has innovation developed in France over the past few decades? How does French industry compare in this respect with its counterparts in other countries?

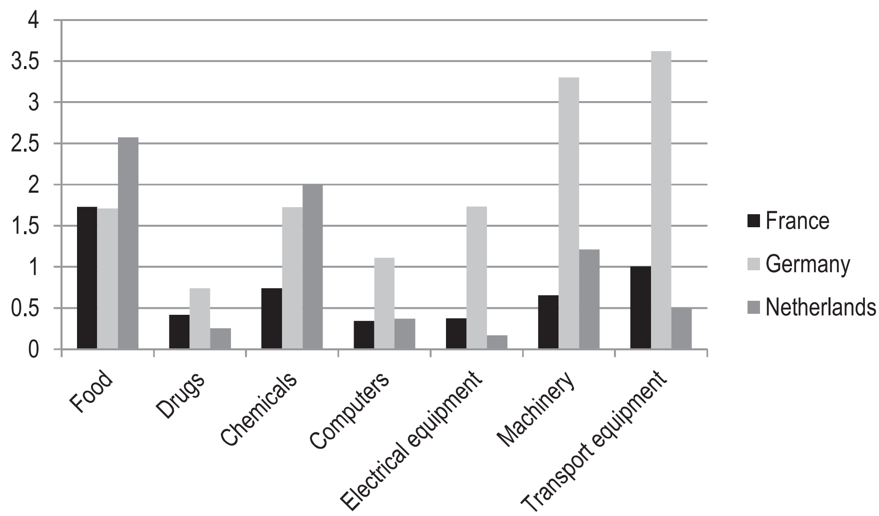
One of the characteristics of industrial R&D in France is its low level of investment compared with French government spending on R&D – and that of comparable countries, notably Germany. The following analysis shows that French industry's low R&D input compared with other countries (such as Germany) is essentially due to its sectoral and size structure. The fact that French companies spend less on R&D is not of itself a handicap; it reflects a focus on other sources of competitiveness besides R&D, including innovation, design and quality. A review of innovation indicators other than R&D shows that French companies' performance compares favourably with the OECD average in a number of sectors and dimensions. While innovation is crucial to the growth of French industry, it is not the main reason for the decline observed over of the past decade. That decline had more general causes, namely the unfavourable conditions for entrepreneurial activity in France in terms of the market for labour and goods and the tax system (see previous section).

R&D expenditure and the sectoral structure

In 2011, businesses in France spent EUR 28.8 billion – 1.44% of GDP – on R&D; the corresponding figures for Germany were EUR 50.3 billion – 1.94% of GDP. The percentage of GDP invested in R&D by businesses in 2011 averaged 1.59% in the OECD and 1.20% in the 27 EU Member States (e.g. 2.34% in Sweden, 1.09% in the United Kingdom and 0.68% in Italy). France therefore ranks above the average in the European Union and some major countries, but below Germany and northern Europe. Businesses account for 63.9% of all R&D in France, compared with 67.3% in Germany and 67.0% in the OECD as a whole: thus their share of R&D compared with the State's is smaller than in most other countries. A review of how R&D is funded rather than who carries it out shows that the gap is even greater, since the government contributes more funding to R&D carried out by businesses in France than in many other countries by virtue of military and civil public contracts and government subsidies. In 2011, R&D funded by businesses totalled EUR 24.8 billion in France, compared with EUR 49.6 billion – more than twice as much – in Germany; businesses funded 55% of the R&D carried out in France in 2011, compared with 65.6% in Germany and 59.9% in the OECD as a whole.

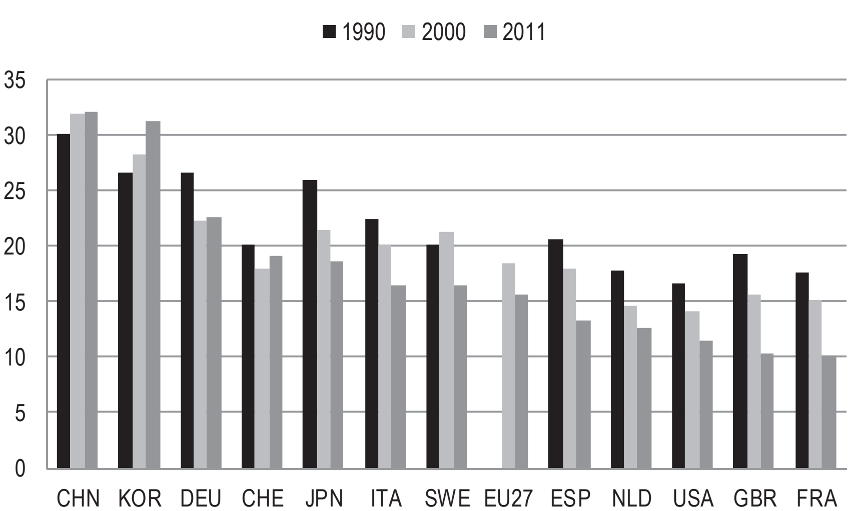
The main reason why France has a lower level of business R&D than Germany and the rest of the OECD is the sectoral nature of its industry. France tends to specialise in industries (services, construction, materials, luxury goods, energy and distribution) where R&D is not the main source of competitiveness in terms of quality or innovation, while companies in the more R&D-intensive – essentially manufacturing (notably automotive, chemical, pharmaceutical and electronics) – industries play a less prominent economic role than in Germany (Figure 2.7). The manufacturing industry contributed about 10% of France's GDP in 2011, compared to nearly 22% in Germany (Figure 2.8). The medium-high technology sectors contribute 10.4% to market value-added in Germany, compared with 3.0% in France. Sectoral levels of R&D intensity, that is to say R&D spending as a proportion of value-added, do not differ hugely between the two countries: they are slightly higher in France for aerospace and pharmaceuticals (5.3%) and slightly lower for the motor industry sector (4.4%). The main difference lies in the contribution of these industries to total value-added in the two countries.

Figure 2.7. Share of GDP of leading industries, 2010



Source: OECD, STAN database.

Figure 2.8. Share of manufacturing industries in GDP (1990, 2000 and 2011)



Sources: OECD National Accounts, STAN database; National Bureau of Standards and OECD estimates for China.

R&D expenditure in the services sector is very high in France. In 2010, it reached EUR 4.9 billion (Table 2.1) – 18% of domestic business expenditure on R&D (BERD). Information technology and management come fourth in the research league, after the automotive, pharmaceutical and aerospace industries.

Table 2.1. BERD by industry, 2010

Main research areas	BERD by businesses		
	In EUR billions	As a % of the total	Growth of expenditure volume, 2009/10, in %
Manufacturing industries	**22.465**	**82.0**	**0.1**
Automotive industry	4 .202	15.3	-2.8
Manufacture of IT, electronic and optical products	3.777	13.8	-3.3
Pharmaceutical industry	3.269	11.9	-4.6
Aerospace industry	2.959	10.8	15.0
Chemical industry	1.463	5.3	-0.3
Machinery and equipment n.e.c.	0.930	3.4	0.5
Other manufacturing industries	5.864	21.4	0.5
Service industries	**4.938**	**18.0**	**15.6**
IT activities and information services	1.633	6.0	11.1
Telecommunications	0.793	2.9	-2.0
Other service industries	2.512	9.2	26.1
Total	**27.403**	**100.0**	**2.6**

* Data concerning government subsidies for the production of communications equipment are subject to statistical confidentiality, which means that the source data underestimate the actual figures.

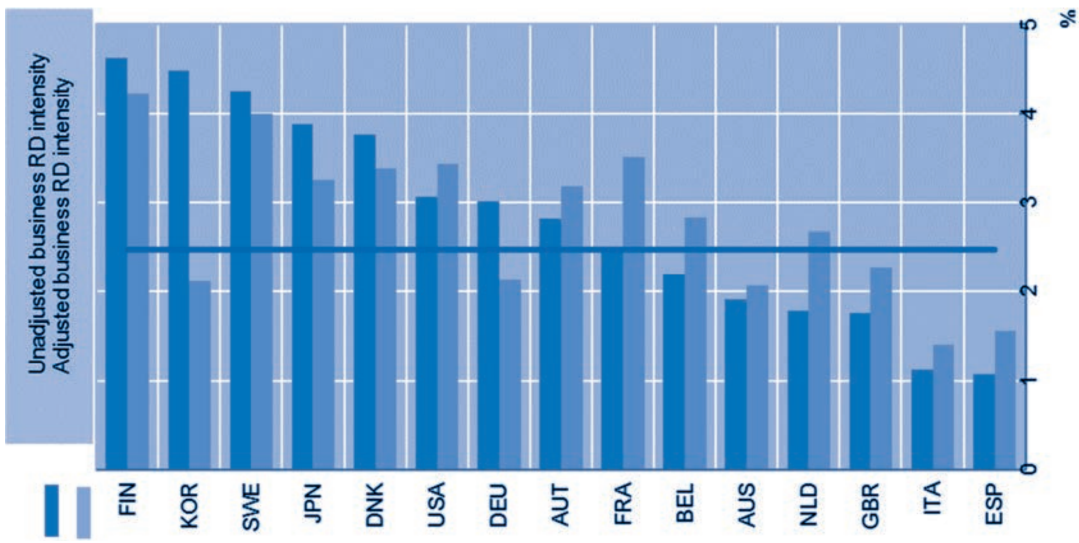
** Indirect aid received by businesses' exemptions from welfare contributions or research tax credits) are not included.

Sources: Research Unit of the Sub-directorate for Information Systems and Statistical Studies (SIES) at the Ministry of Higher Education and Research (MESR); French National Institute of Statistics and Economic Studies (INSEE), PLF, 2013, p. 173.

The impact of both the sectoral structure and intra-sectoral R&D on overall differences in R&D intensity can also be quantified. To that end, the total industrial R&D expenditure of each country is estimated by maintaining its intra-sectoral R&D intensity and applying the industrial structure of the other country or a common industrial structure against it. This is tantamount to neutralising the role of the sectoral structure and serves, by comparison with the observed level of R&D intensity, to quantify the effect of the structure itself.

In the OECD context, the average sectoral structure of the area is applied to various countries (Figure 2.9). France, whose gross R&D intensity is lower than that of northern Europe, Germany, the United States and Korea, comes out ahead of these countrie,s and only behind Finland and Sweden, once the figures have been adjusted. An identical diagnosis emerged from a comparison with Germany alone in a study conducted by the MESR (2012). By applying the German levels of sectoral R&D intensity to the French industrial structure, the study identified virtually matching levels of net R&D intensity in both countries, differing by only EUR 0.1 billion. If the French economy had the same sectoral structure as in Germany, with its own intra-sectoral intensity rates, it would have a total R&D intensity of 2.75% of GDP. Thus, the lesser role of industry explains the difference in total R&D intensity between the two countries, pointing to the possibility that the relatively modest performance of French industry in terms of innovation is due to the size of its industrial sector – itself dependent on wider structural factors – rather than to its innovation methods as such.

Figure 2.9. BERD as a share of commercial GDP, adjusted for the economic structure, 2011



Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

R&D expenditure and industrial structure by business size

A second factor affecting R&D intensity is the structure of industry by business size. The propensity of businesses to engage in R&D varies according to their size. More very large businesses do R&D than medium-sized enterprises – let alone small companies. Even though the small businesses that do engage in R&D invest more in it relative to their turnover than large companies, the overall average rate of R&D intensity increases with company size. Yet French companies are on average smaller than their German or British counterparts. Businesses with over 250 employees create 42% of value-added in France, compared with 48% in Germany and 50% in the United Kingdom, whereas businesses with 1 to 9 employees account for 26% of total value-added (compared with 18% in Germany and the United Kingdom). Businesses with fewer than 50 employees account for 43% of value-added in France, 32% in Germany and 34% in the United Kingdom (OECD, 2013a).

Small and medium-sized enterprises in France

This difference in the size structures of the economies is directly reflected in the structure of R&D (Table 2.2), more of which is carried out by small and medium-sized enterprises in France, where businesses with fewer than 1 000 employees accounted for EUR 10.1 billion of R&D investment in 2009, than in Germany, where the corresponding figure was EUR 9.9 billion. The gap between the two countries is far wider in the category of mid-tier and large businesses with 1 000 to 5 000 employees, whose R&D expenditure amounted to EUR 5.9 in France but EUR 10 billion in Germany, while for those with more than 5 000 employees the figures were EUR 10.3 billion in France and EUR 25.4 billion in

Germany. Within each size category, however, R&D intensity, i.e. the ratio of R&D spending to total value-added, is similar for French and German businesses. Small French enterprises (fewer than 50 employees) are actually more R&D-intensive than small German businesses, whereas medium-sized and large enterprises (50 employees and over) are slightly less so (Table 2.3). The higher level of R&D intensity among small French businesses suggests there may be some untapped growth potential in this category, given the fiscal and legal climate that is currently stifling growth. This issue will be addressed in the chapter devoted to entrepreneurship.

Table 2.2. Share of BERD by business size (%), 2009

<table>
<tr><th>Size (number of employees)</th><th>France</th><th>Germany</th><th>United Kingdom</th></tr>
<tr><td>1 to 49</td><td>9.3</td><td>3.6</td><td>4.6</td></tr>
<tr><td>50 to 499</td><td>20.1</td><td>12.7</td><td>24.0</td></tr>
<tr><td>500 to 999</td><td>9.0</td><td>5.6</td><td rowspan="3">71.4</td></tr>
<tr><td>1 000 to 4 999</td><td>22.4</td><td>22.1</td></tr>
<tr><td>5 000 or more</td><td>39.2</td><td>56.1</td></tr>
<tr><td>Total</td><td>100</td><td>100</td><td>100</td></tr>
</table>

Source: OECD, Research and Development Statistics (RDS).

Table 2.3. R&D intensity (R&D/value-added) of businesses by size category (%), 2009

	Under 50 employees	50 or more employees	Total
France	0.53	3.88	2.44
Germany	0.35	4.42	3.12
United Kingdom	0.24	2.47	1.72

Source: OECD, Research and Development Statistics (RDS).

France has focused its attentions for a number of years on ISEs. An ISE is defined as a business with between 250 and 4 999 employees and either a turnover of no more than EUR 1.5 billion or a total balance sheet not exceeding EUR 2 billion. This definition is set out in the 2008 *Loi de modernisation de l'économie* (Modernisation of the Economy Act), which aimed among others to create more favourable operating conditions for ISEs, which are considered particularly weak in France, especially compared with Germany's *Mittelstand* (see Box 2.1). France numbered 4 600 ISEs in 2008, accounting for 23% of industrial jobs. France numbers fewer ISEs than Germany (12 000) or the United Kingdom (8 000). The ISE category is relatively volatile: ever year between 2003 and 2011, 18% of ISEs entered the category and 18% left, mainly because they changed their status to that of SME. ISEs tend to be smallish; over half of them have fewer than 500 employees. The ones that have persisted as ISEs are medium-sized, with an average of 650 employees. Since the ISE status was created in 2008, the number of ISEs has remained fairly stable. It should be noted, however, that the R&D expenditure gap between France and Germany (see Table 2.2 above) does not stem primarily from ISEs, whose BERD is similar in both countries, but from large enterprises with more than 5 000 employees, which account for 39% of BERD in France, against 56% in Germany.

Box 2.1. The German *Mittelstand*

The German *Mittelstand* does not fit in any particular statistical category (Hénard, 2012). According to the Bonn-based Institute for Research on the *Mittelstand*, this category encompasses family businesses with a turnover of up to EUR 50 million and fewer than 500 employees. The leading industrial small and medium-sized enterprises (SME) in Germany reportedly include 4 400 family businesses with a turnover between EUR 50 million and EUR 3 billion. These businesses export 40% of their production and have created 1 million jobs since the 1990s (Wettmann, 2012). According to Hermann and Guinchard (2012), the "hidden champions" are major SMEs that are market leaders, have a turnover under EUR 3 billion a year and have a fairly low public profile. Germanynumbers 1 500 companies that are global leaders; 70% of them are family businesses and 50% are managed by engineers. Their leadership is chiefly due to their international focus, their capacity to innovate and their ability to offer products with backup services. The *Mittelstand* is a continuum, from SMEs through intermediate-sized enterprises (ISEs) to large enterprises. For example, the company EBM-PAPST, which specialises in industrial fans, employs 11 000 people and has an annual turnover of EUR 1.5 billion, but regards itself as part of the *Mittelstand* for two reasons: it is owned by three people, has no shares and no annual general meeting and comprises several small units operating autonomously (Bpifrance, 2012).

Wettmann (2012) says the economic power of the *Mittelstand* can be explained by Germany's economic and political history. The competitive model of the German *Mittelstand* is not easily copied, even within Germany in *Länder* (states or regions) where there are few SMEs, such as the Ruhr or the former German Democratic Republic. France can draw inspiration from this model, but needs to develop an economic and political framework that takes into account the specific characteristics of its own regions. The following points are particularly important:

- At a very early stage, the existence of small German states led to the creation of small, highly competitive manufacturing businesses and hence to a decentralised economic structure. Since their domestic markets were small, SMEs were compelled to export.
- The federal system of government enables each *Land* to develop an appropriate regional policy to support SMEs and enables SMEs to defend their interests locally.
- The model is difficult to adapt in countries where there are different governmental structures. The dual system of apprenticeship-based vocational training is another success factor. SMEs train apprentices to meet 80% of their demand for highly skilled workers. Some *Länder* have created tertiary technical colleges with sandwich courses to train students with highly prized practical experience. This dual training model is difficult to export into contexts that do not feature a dense network of of SMEs.
- Another major asset is the proximity of SMEs to local banks, which hold a significant share of the market and make it easier for local businesses to access funding sources.
- In many cases, SMEs have formed associations in order to work together to capture a share of the global market.
- Lastly, the large German groups give SMEs the opportunity to cover world markets and employ them as subcontractors within the framework of their technological innovation strategies.

Large enterprises

France has almost as many very large enterprises as Germany (29 French businesses had a global turnover in excess of EUR 10 billion in 2011, compared with 34 in Germany; the French companies' aggregate turnover was EUR 1.017 trillion, compared with EUR 1.384 trillion for German companies). However, France numbers fewer very large RD-intensive companies (36 French companies spent more than EUR 100 million a year on R&D, compared with 61 in Germany; their aggregate R&D expenditure was EUR 24.5 billion, compared with EUR 48.2 billion in Germany). More so than in Germany, France's major enterprises operate in sectors – such as construction, materials, energy, distribution or luxury goods – that are less technology-intensive than those in which most major German companies operate – namely the automotive, electronics and chemical industries.

The performance of French businesses beyond the realm of R&D

Given the significance of the industries that do not feature R&D expenditure at the heart of their activity, it is important to perform a more thorough diagnosis of innovation – including non-technological innovation – beyond the realm of R&D.

Innovation

Between 2008 and 2010, 53.5% of French businesses are classed as innovative. France is very close to the European average of 53% (Community Innovation Survey, CIS), far behind Germany (79%), Sweden and Italy, but ahead of the United Kingdom, the Netherlands and Spain. In 2010, 40% of French businesses engaged in both product and process innovation, below both the European average and Germany's rate of over 60%.

The 2008 CIS found a higher number of innovative companies in manufacturing than in services in most EU-27 countries. Knowledge-intensive business services (KIBS), on the other hand – which include IT services, consultancy, etc. – tend to be more innovation-intensive than manufacturing. From 2008 to 2010, the innovation rate was 56.1% in manufacturing, 51.5% in the services sector and 64.8% in KIBS. In Germany, the innovation rate was 83% in manufacturing, 76.7% in services and 86.5% in KIBS.

Patents

In terms of patent applications by EU27 member countries to the European Patent Office, Germany applied for 21 880 patents, followed by France (8 751) and the United Kingdom (4 795). In France, patent applications increased by 0.9% on average every year from 2005 to 2010, whereas they fell by 1.8% in Germany and by 3.1% in the United Kingdom. French businesses thus showed an increased propensity to apply for patents compared with other European countries over the 2000s. France's share within the European Union of applications under both the Patent Cooperation Treaty (PCT) and triadic patents (patents taken out all at once in Europe, the United States and Japan) has grown significantly (Table 2.4).

Table 2.4. Share of total patents taken out by inventors located in the European Union (PCT, by priority year, %)

Technology	All technologies		Information and communication technologies	
Year	2000	2010	2000	2010
France	12.68	14.93	11.96	16.22
Germany	35.95	36.95	31.60	31.99
United Kingdom	15.69	11.62	17.33	13.38
Italy	4.92	6.48	2.60	4.37
European Union	100.00	100.00	100.00	100.00

Source: OECD Main Science and Technology Indicators, www.oecd.org/sti/msti.htm.

External trade and competitiveness

An analysis of the external trade figures[1] reveals key areas of specialisation in France that accrue trade surpluses. The first area covers a range of high-tech industries – aerospace (EUR 20.3 billion surplus in 2012), pharmaceuticals (EUR 3 billion) and automotive equipment (EUR 2.5 billion). Another set comprises activities relating toFr ance's brand image – farm and agri-food products (EUR 11.5 billion surplus), luxury goods (sales of perfumes and cosmetics alone post EUR 8.5 billion surplus) and tourism (EUR 7 billion). These are sectors in which non-technological innovation – particularly business, design and organisational innovation often linked to ICTs – has a consistently stronger impact on business competitiveness than technological innovation. France has one of the largest service sectors of any European country and is a leading global player in areas such as the environment, construction, energy, the media, hotels and restaurants, distribution and transport.

Internationalisation and attractiveness

Internationalisation

Patent indicators show that French companies – including their foreign subsidiaries – are slightly more inventive than their German counterparts at the international level (Table 2.5). The difference probably has more to do with the respective size of the two innovation systems than with any real structural differences – all other things being equal, a smaller system is more likely to be open to the outside. It may also stem from the greater propensity of German companies to patent their inventions, in which case the diagnosis based on the R&D statistics would apply here too. The difference appears more significant, however, for patents on products invented abroad that are owned by a national entity. French companies invent more abroad – particularly in the United States – than German companies; this is especially noticeable in the pharmaceuticals industry.

Table 2.5. Internationalisation of French industry measured by patents

Joint inventions by partners located in two or more countries (% of all patented inventions)

	Total	Partner: Japan	Partner: United States
France	18.8	0.5	5.2
Germany	15.6	0.6	4.2
United Kingdom	26.5	1.1	11.4
Inventions made in the country but patented by foreign entities			
France	23.7	0.4	5.6
Germany	17.2	0.4	4.7
United Kingdom	41.3	1.8	15.4
Inventions patented by national entities as a percentage of inventions made abroad			
France	25.0	0.8	10.4
Germany	18.3	0.7	4.0
United Kingdom	19.4	0.4	6.4

Source: OECD Main Science and Technology Indicators, www.oecd.org/sti/msti.htm.

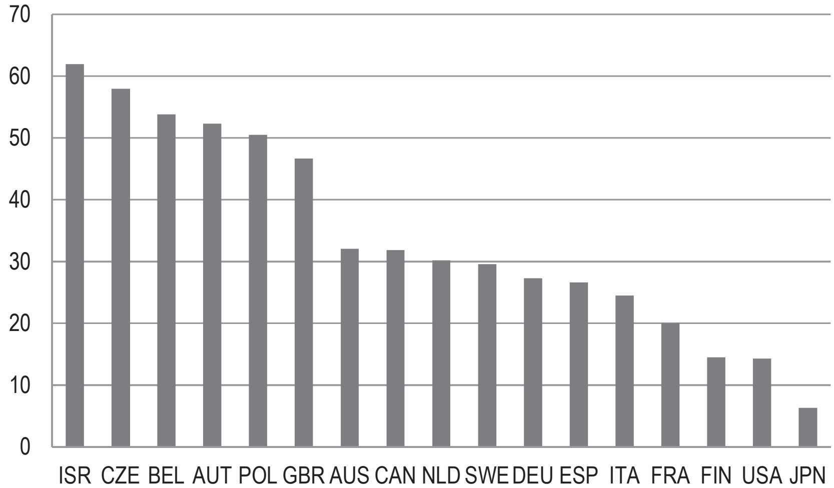
Attractiveness: R&D activity of foreign subsidiaries in France

In 2010, subsidiaries of foreign companies were responsible for 20% of corporate R&D activity in France, according to new estimates released by the MESR.[2] The corresponding figures for other countries are 27.3% for Germany, 46.7% for the United Kingdom and 14.3% for the United States (Figure 2.10). This means that France has fewer foreign companies performing R&D on its soil than other countries of comparable size.

In 2010, 1 400 foreign companies invested EUR 5.5 billion in R&D in France. They represented 11% of the businesses conducting R&D in France and contributed 20% of total investment in R&D by companies located in France. Foreign companies' R&D investments in France rose 1.2% per year in the 2000s, compared with 1.3% for French companies. In Germany, the United States and the United Kingdom, foreign companies registered higher annual growth in R&D investments than domestic companies.

Foreign companies employ one-fifth of the R&D staff working in businesses in France, with a slightly larger proportion of foreign researchers (7%) than French companies (5%). These companies mainly originate in the United States (which accounts for 6% of corporate R&D conducted in France), Germany (3%), the Netherlands (3%), Switzerland (2%) and the United Kingdom (1%). Overall, foreign companies feature more prominently in manufacturing than in the services sector; hence, their R&D intensity is higher than that of French businesses operating in France. Factoring out the structural effect, however, and considering each sector separately shows that French businesses engage in more R&D than foreign-owned subsidiaries. Moreover, foreign companies are responsible for 27% of industrial output (compared with 20% of R&D). This tends to indicate that the main motive for foreign companies locating in France is not R&D as such, or the associated access to knowledge resources such as researchers and laboratories (Sachwald, 2012), but that they engage in R&D designed to support manufacturing activities specifically designed for the French market. Added to the limited contribution of foreign-owned subsidiaries to corporate R&D in France, this raises the question of France's attractiveness as a locus for R&D.

Figure 2.10. Percentage contribution of foreign-owned subsidiaries to corporate R&D, 2009



Source: OECD Main Science and Technology Indicators, www.oecd.org/sti/msti.htm (France: MESR).

On the whole, France would appear to enjoy limited international appeal in the realm of R&D. There are many factors that make a country attractive as an R&D location, just as there are many reasons for firms to locate their R&D in a foreign country – the size and growth of the domestic market, access to high-quality knowledge-based services (particularly researchers and public research) and cost. The first of these factors – the size and growth of the domestic market – also applies to investments in production capacity, which have been shown to exercise more appeal in France than R&D. The last of the factors seems to be dissuasive in gross terms: the cost (excluding the research tax credit [CIR] of a French researcher employed by a large company in 2013 has an assigned value of 100, compared with 93 for Germany, 86 for the Netherlands and 81 for the United Kingdom, for example (according to the National Research and Technology Association survey, 2013; the limited size of the sample used in this survey dictates a degree of caution in interpreting the findings, although these have been fairly consistent over the course of time). After taking into account the CIR, however, the cost per French researcher falls to 71, which is comparable with that of a Spanish or Italian researcher. Nevertheless, this cost competitiveness does not seem sufficient to make France an attractive location for R&D and we must therefore turn to the second factor, namely access to high-quality knowledge-based assets and infrastructure, staff and public research. As the relevant chapters show, human resources have certainly been competitive, but businesses have still been experiencing difficulty in accessing public research or have little interest in it, particularly due to its focus on subjects often far removed from the concerns of industry.

The shrinkage of French industry outside the realm of R&D

The development of corporate R&D since the early 2000s has also partly been determined by overall trends in industry. Between 2001 and 2010, the nominal BERD increased by 39% in France (and 52% in Germany), while the value-added by industry (including services) grew by 31% (36% in Germany). Between 2000 and 2010, the contribution of the manufacturing industry to GDP fell by five percentage points – one-third of its initial value (Figure 2.8). Of the other major countries, only the United Kingdom experienced such a drastic fall during that period. The reduction was linked to the decline in France's global competitiveness (see previous section), which cannot be ascribed primarily to a lack of innovation.

In fact, other innovation indicators, including non-technological innovation indicators, show that the performance of French businesses is comparable with the OECD average. It is even observable that R&D has been less severely affected by this decline than value-added, which suggests that R&D has become more central to French industry than previously – either because the surviving companies are those with the largest volume of R&D or because they stepped up their efforts at a time when other firms were disappearing. This diagnosis is borne out by the sharp increase in the number of R&D-specific companies – which more than doubled between 2003 and 2010 – compared with the total number of companies in the various manufacturing sectors (Table 2.6). This is due to both a decrease (of 25%) in the total number of manufacturing companies and an increase (of 66%) in the number of those engaging in research.

Table 2.6. Number of businesses with ten employees or more in manufacturing industry in France, 2003 and 2010 (to the nearest hundred)

	2003	2010
Total	41 800	31 400
Of which businesses engaging in research	3 100	5 200
Ratio (%)	7.4	16.6

Sources: INSEE (totals); MESR (research figures).

Conclusions

The low R&D intensity of the French economy is as much due to the reduction of its industrial base as to R&D activity itself. Such a diagnosis points first of all, to a need to improve the basic conditions for business activity in France, without which innovation policies can have no more than a palliative effect serving to limit business losses in some sectors, but certainly not generating gains. This diagnosis will also serve as a starting point for the analysis of innovation policies in the next section.

Notes

1. *Le Chiffre du Commerce Extérieur – année 2012*, http://www.douane.gouv.fr/data/file/8101.pdf.

2. Le Ru (2013), "Les entreprises étrangères représentent un cinquième de la R&D privée française", information note MESR DGSIP/DGRI SIES, www.enseignementsup-recherche.gouv.fr/reperes/public/publicat/nr/ni1308/default.htm.

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Chapter 3

Initial training of human resources for research and innovation in France

This chapter examines the matching of human resources and their training in France to the research and innovation system. It reviews the OECD indicators in this area, more specifically those provided by the PIAAC and PISA surveys, using them to compare France with the other countries. It presents the initial training system, as well as primary and secondary education, but above all higher education (the universities and "grandes écoles"), which have been the focus of significant reforms over the past decade. It analyses doctoral and vocational courses in particular, as well as action in this area under the "Investments for the Future" Programme. In each case, it raises the issue of the capacity of the educational system to instil creativity in the generations it is training. Lastly, the chapter examines the positioning of the French higher education system with regard to internationalisation.

The human resources (HR) available for research and innovation are a key factor in any innovation system. Much of the knowledge and know-how available in an economy is more or less tacitly embodied in individuals. While that knowledge is reflected in patents, articles, innovative products or processes, it is first and foremost transmitted through peer learning. This means that the initial and continuing training of staff and their ability to assimilate, pass on and develop knowledge and know-how are key factors in achieving innovation and productivity. This knowledge can then circulate, both nationally and internationally, as a result of individuals' mobility, co-operation and sharing.

The French research and innovation system, like that of all the other countries, is faced with two key questions. First, are France's home-trained HR and current innovation system well matched? Does France train HR that are in line with its dominant innovation model, geared towards advanced technology, major corporations and large organisations? Finally, is France's training system producing the HR that can underpin its future innovation strategy? A renewed French strategy would give a greater role to entrepreneurship, interdisciplinarity, innovative sectors that are less centred on high-tech – such as services, luxury goods sectors and agri-food – and incremental innovation in every sector.

Higher education and research, as well as the training and the quality of the HR available in France, are some of the main strengths of the French research and innovation system. All the stakeholders questioned during the review particularly praised the generalist engineers trained in France's higher education system, whom they consider world-class. Moreover, none complained of a shortage of skills for innovation. Even in domains that have long been considered problematic, such as innovative entrepreneurship, the new generation of graduates seems to embody a new entrepreneurial mentality that is more conducive to innovation, and the venture capitalists have noted the recent spate of serial entrepreneurs.

The French initial education system is still somewhat elitist and continues to produce a small fraction of people capable of innovating or adapting quickly to highly innovative situations in the traditional French innovation model. Meanwhile, another part of the population does not appear sufficiently endowed with a sufficient generalist or specialist level of education to adapt to innovation. A better trained and more innovation-friendly population would facilitate implementing innovation on a broad scale and would give France a greater capacity to adapt its economic structure to future innovation needs.

The issue of HR for innovation can be considered from two viewpoints. First, is Frances workforce sufficiently qualified to contribute to its innovation system? Second, do higher education graduates have the appropriate skills to contribute towards innovation, i.e. to create and adopt new products, processes and organisations? It is easier to answer the first question than the second. These questions relate not only to the initial education system (from primary school to higher education), but also to the continuing education system and businesses' use of skills. This chapter will focus on the initial education and training of HR in both school and higher education.

Workforce training (skills available for innovation)

Most of the quantitative indicators relative to workforce training place France in the international average. France even offers certain benefits in terms of workforce qualifications. The levels of population literacy and numeracy, however, appear far lower than in other countries for which information is available. Literacy is defined as "the ability to understand and employ written information in daily activities, at home, at work and in the community to achieve one's goals and to develop knowledge and potential", and numeracy as "the ability to use, apply, interpret and communicate mathematical information and ideas".

Level of qualifications of the working population

In quantitative terms, France does not suffer from a lack of higher education graduates. In 2011, 30% of the population aged 25 to 64 had a higher education degree, compared with 32% on average in Organisation for Economic Co-operation and Development (OECD) countries. France has also seen more rapid growth in its higher education system than most other countries, so that the younger cohorts have more qualifications than the average: 43% of the population aged 25 to 34 have a higher education degree, compared with 38% in other OECD countries (OECD, 2013). Given the growing demand for higher education graduates in the economies of industrialised countries and their role in innovation production and adoption, France has assets for accomplishing innovation and can be said to have successfully expanded its higher education system, at least in quantitative terms. In terms of the level of initial training of its population, therefore, it has a head start on the future. Very few indicators currently exist of the quality of higher education courses – which is ultimately just as important as the number of graduates.

In 2011, 0.78% of the French population aged 25 to 64 held doctorates – slightly more than in Spain (0.61%) or Belgium (0.55%), but less than the average in OECD countries for which this indicator is available, particularly the United Kingdom (0.99%) and Germany (1.28%). Insofar as doctoral graduates are theoretically at the forefront of their discipline, this weakness may hinder certain forms of innovation, although it can be explained in great part by the peculiar organisation of higher education in France and the lower wage return on doctoral degrees in France than in other countries (Auriol and Harfi, 2010). Indeed, the French system of *grandes écoles* produces highly competent engineers and senior executives who are more likely to hold doctorates in other countries.

Level of adult literacy and numeracy

The OECD Programme for the International Assessment of Adult Competencies (PIAAC) shows, however, that the level of literacy and numeracy of the French population aged 16 to 65 is lower than the average of the 24 countries and subnational entities taking part in the survey (Figure 3.1) (OECD, 2013a).

In 2012, 7.7% of French adults aged 16 to 65 were at the two highest levels of literacy skills (Levels 4 and 5) and 34% at Level 3, compared with 11.8% and 38.2%, on average, in the OECD participant countries. This puts France in the 21st place (out of 24) for literacy, with 41.7% of its population at or above Level 3, compared with an average of 50% in the OECD participant countries. Although France's level of performance is considerably lower than that of Japan and the Netherlands, it is only slightly lower than in the United Kingdom, Germany and the United States, and slightly higher than in Spain and Italy (Figure 3.1).

Similarly, 8.3% of French adults (aged 16 to 65) are at the highest levels of numeracy (Levels 4 and 5) and 29% at Level 3, placing France 19th in the ranking of countries taking part in the survey, here again a fairly long way behind the average (of 12.4% and 34.4% respectively). France is still at a considerably lower level than Japan, the Netherlands, and this time Germany as well, but more or less equal to that of the United Kingdom, and slightly higher than in the United States, Italy and Spain (Figure 3.1).

In 2012, 7.7% of French people aged 16 to 65 were in the top two literacy skill levels (levels 4 and 5) and 34% at the third level, compared with 11% at Levels 4 and 5 and 38.2% at Level 3 on average in the participating OECD countries. Thus, France ranks 21st (out of 24) for literacy, with 41.7% of its population at Levels 3, 4 and 5, compared with 50% on average in the participating OECD countries. While this performance level is much lower than the levels of Japan or the Netherlands, it is only slightly lower than the levels of the United Kingdom, Germany and the United States, and slightly higher than those of Spain and Italy (Figure 3.1).

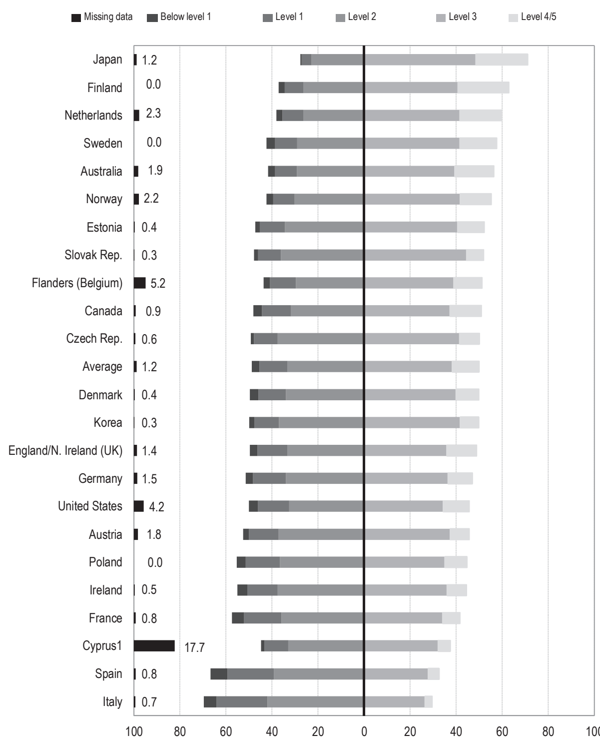
Similarly, 8.3% of French people aged 16 to 65 rank at the two highest numeracy skill levels (Levels 4 and 5) and 29% at Level 3, ranking France 19th of the countries participating in the study, again quite far behind the average (12.4% for Levels 4 and 5 and 34.4% for Level 3). France ranks lower than Japan, the Netherlands and again Germany, but is just about on a par with the United States, Italy and Spain (Figure 3.1).

The proportion (21.6%) of French adults obtaining low scores in literacy (equal to or lower than Level 1) is one of the highest of participating OECD countries (15.5%). The same applies to numeracy: 28% of French adults are at Level 1 or lower, as opposed to the 19% average of participating OECD countries. In both literacy and numeracy, France has a greater proportion of adults at the lowest level, and a smaller proportion at the highest level than Japan, the Netherlands, the United Kingdom and Germany. The literacy level is similar when comparing France with the United States, but the proportion of adults at the lowest numeracy level is equivalent in the two countries. Lastly, France does not seem to have a particularly numerous "elite", but it does suffer from a high proportion of adults with very low literacy and numeracy skills.

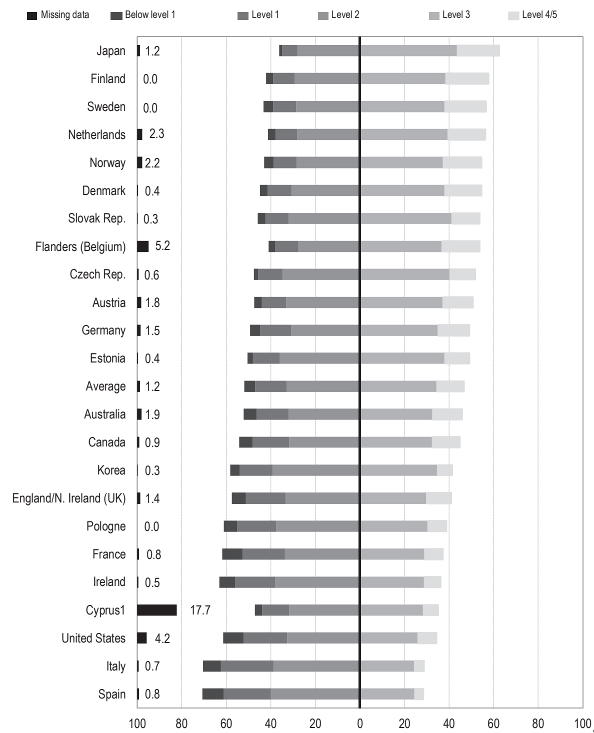
By comparison with the other countries, the generational differences in skills are fairly marked in France. The country's low performance levels are mainly attributable to the 45 to 65 age group, whereas scores in the 16 to 44 age group are closer to – although consistently lower than – the average. The older the respondents, the further their scores are from the OECD average – although the skills of the French respondents aged 16 to 24 are also lower than the OECD average for the same age group. This means that France is on a dynamic trend, but not dynamic enough to catch up with the OECD without additional effort: the newer generations are more competent in these fields than the old, but still less competent on average than the newer generations of other countries. Some of the countries participating in the survey have in this regard less encouraging profiles: in the United Kingdom, for instance, the older cohorts post better performances than the younger ones.

Figure 3.1. Adult literacy and numeracy skills, 2012

Percentage of adults by level of literacy



Percentage of adults aged 16-65 by level of numeracy



Notes: The adults from the “missing data” category were able to provide enough contextual information to obtain scores on a competence scale by virtue of linguistic differences, training issues or mental health issues (“no response linked to literacy skills”).

The countries are ranked by decreasing order of the combined percentage of adults at Level 3 and at Level 4/5.

1. Note by Turkey:

The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

2. Note by all the European Union Member States of the OECD and the European Union:

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: PIAAC (2012), Table A2.1 (left figure) and Table A2.5 (right figure).

Interpreting these data in the light of the needs of a productive research and information system is no easy task. That said, the high proportion of adults at the lowest literacy and numeracy levels might indicate that a sizeable part of the French population will find it difficult to change jobs and undertake continuing education. Thus, much of the population seems vulnerable to innovation as a force for "creative destruction". The population's average performance level could also indicate a lesser ability to adopt or adapt to innovations. Yet other sources show that in 2005, France had a significant proportion of labour organisations promoting employee learning and autonomy, which are in principle conducive to innovation (OECD, 2010) – although this level seems to have fallen in 2010 (based on private communication on current research by Holm and Lorenz). It is possible that this workplace learning takes place under less formal guises, that it is particularly effective for workers with average skill levels, but that it might be far superior if the workers had higher basic skills.

HR for innovation

Other sources shed more light specifically on HR that contribute directly to innovation.

The Community Innovation Survey (CIS) shows that French enterprises, like those of other European countries, consider the lack of qualified personnel as an obstacle to innovation. In Europe, the lack of qualified personnel is cited on average as the third largest obstacle to innovation that most differentiates innovative from non-innovative companies: an innovative company is 1.44 times more likely to a lack of qualified personnel for innovation than a company that has not innovated over the past three years. In France, the lack of qualified personnel is the 4th critical factor (but with a rating ratio of 1.67, higher than the European average), and the largest non-financial obstacle (the first 3 obstacles being the lack of internal and external funding and the cost of innovation). Yet in 2010, only 12.5% of innovative companies considered the lack of qualified personnel as hampering innovation, compared with 11.1% on average in a country of the European Union (CIS, 2010). Thus, innovative French companies do not appear to suffer more than the others from a particular shortage of qualified personnel when it comes to developing or implementing their innovations: they are close to the European average (Figure 3.2).

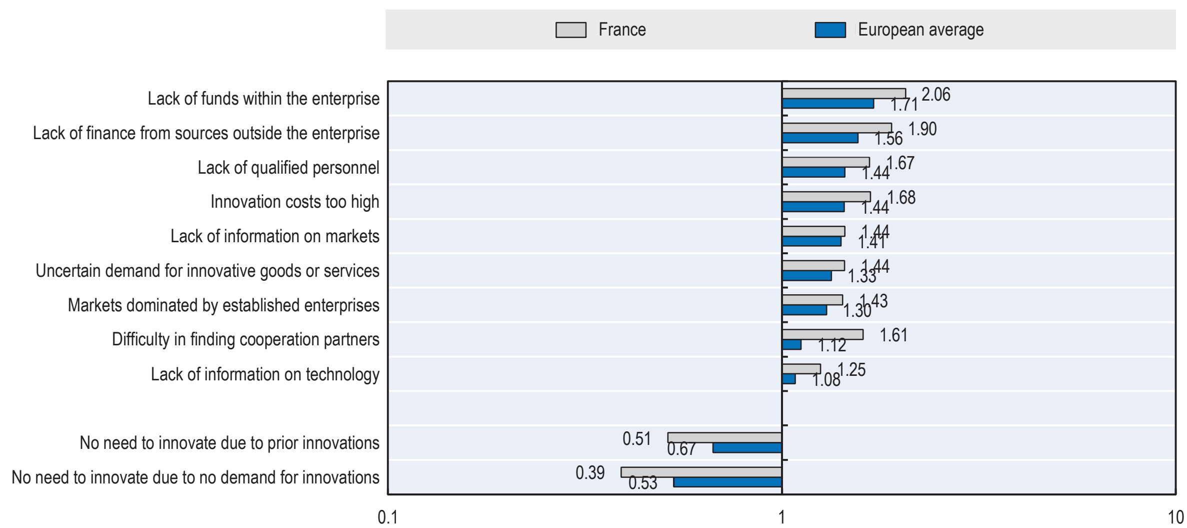
The study seems to confirm two points characterising the French model as "elitist", in the sense that its innovation processes rely on a small fraction of its HR and its engineers, scientists and business management graduates have pride of place.

For instance, while on average 56% of professionals in a country participating in REFLEX-HEGESCO state they are involved in innovation – whatever the type of innovation – when they work in an innovative enterprise, only 46% of French professionals have a "highly innovative job", ranking third-lowest of the 19 countries for which this information could be calculated (after Hungary with 43% and Spain with 45%). By comparison, other countries seem to have more inclusive innovation processes: 55% of professionals in Germany declared they have a highly innovative job 5 years after completing their studies, 57% in the United Kingdom, 58% in the Netherlands and 61% in Finland and Italy. In France as elsewhere, graduates in all subject areas contribute towards innovation.

These findings can be interpreted in three ways. A first explanation may be that the French perceive participating in innovation differently than their European counterparts; without excluding this suggestion, it should be noted that there is no cultural or geographical proximity between France and the other countries declaring little participation. A second explanation might be that it takes longer in France than in other countries to obtain highly innovative jobs and that these differences might disappear after five years. A third, and just as plausible, explanation is that France does indeed appear to have a more "elitist" model of innovation than elsewhere, and one in which a smaller proportion of professionals participate.

Figure 3.2. Obstacles to innovation differentiating innovative from non-innovative enterprises, 2010

Score ratios (innovative vs. non-innovative enterprises)



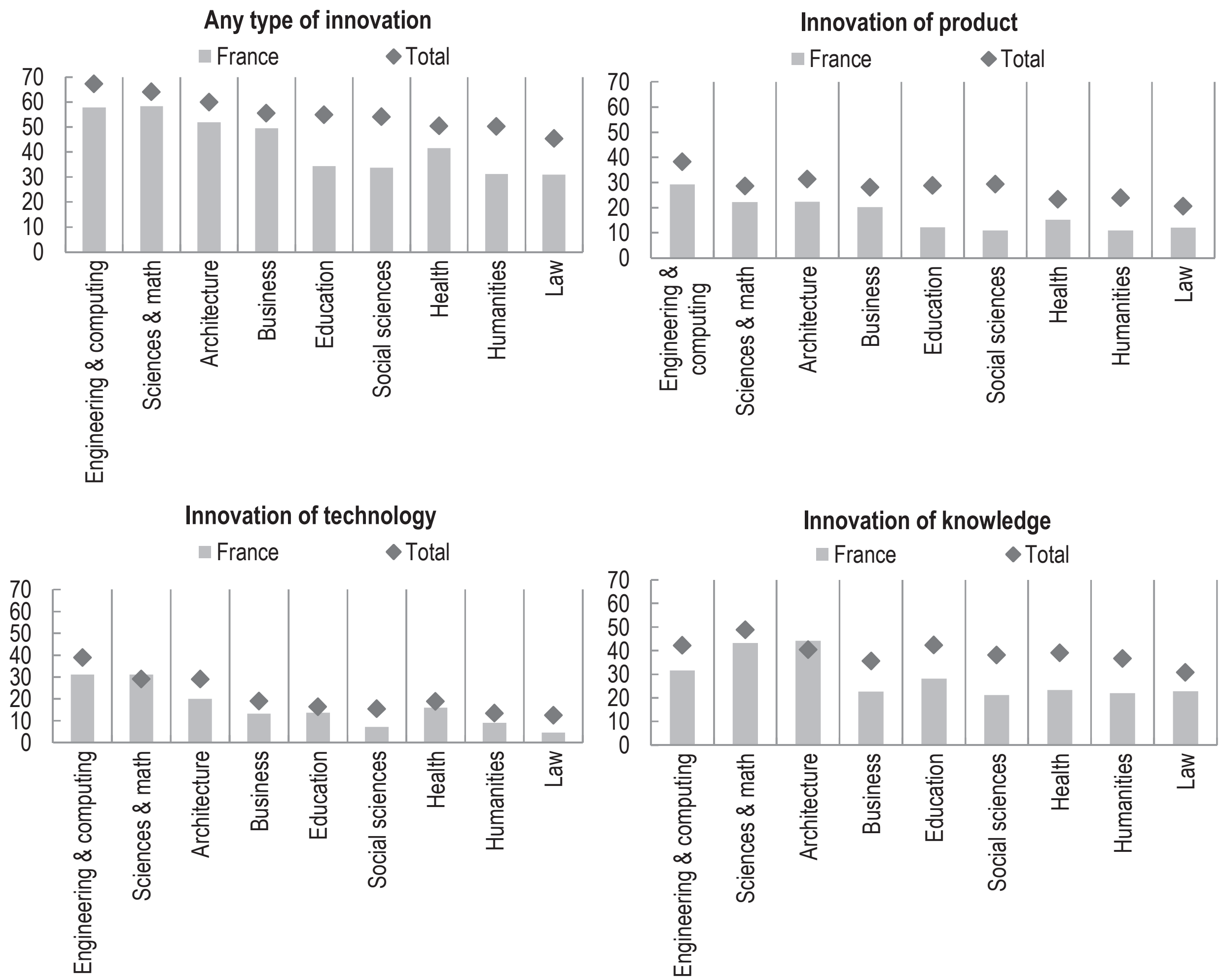
Note: The data are sorted in descending order compared with the European average.

Source: OECD (calculations based on CIS data).

The REFLEX project, conducted in 2005, surveyed higher education graduates five years after they completed their studies in Europe and Japan. A similar study, HEGESCO ("Higher Education as a Generator of Strategic Competence"), was conducted in 2008 in other European countries. This survey helps to better understand and compare the French innovation model with other European countries.

When comparing France with the average of the 19 countries taking part in REFLEX-HEGESCO, it also appears that graduates in non-scientific subjects play a considerably less important role than elsewhere in the innovation process (Figure 3.3). Graduates in engineering and computer science, science and mathematics, and architecture in any country have a far greater likelihood of working in a highly innovative job (irrespective of the type of innovation) than graduates in other subject areas. In France, however, graduates in management and (to a lesser degree) medicine are the only ones to achieve high levels of participation, whereas graduates in social sciences, humanities, law or education are less likely to have a highly innovative job. In other countries, the probability that graduates in management, education, humanities and social sciences will have a highly innovative job is more or less the same. In other words, the innovation system attaches greater weight than elsewhere to the subjects taught by the *grandes écoles* specialising in engineering and business and by the scientific universities, and is less successful at integrating humanities and social science graduates into the innovation process. This may owe to the fact that corporate innovation models do not sufficiently factor in account humanities and social science-related skills and that university curricula in the humanities and social sciences are not sufficiently geared to corporate needs.

Figure 3.3. Percentage of higher education graduates with a highly innovative job in France and Europe, 2005-08, by study area and innovation category



Note: Highly innovative jobs are defined by participants declaring they participate in creating innovation in an innovative organisation. Higher education graduates working in a job reply five years after completing their studies. The subject areas for which the French sample was too small (for example, arts graduates) have been excluded from the analysis due to the unreliability of estimates.

Source: OECD (calculations based on REFLEX and HEGESCO).

Primary and secondary education (the foundations of skills for innovation)

Primary and secondary education performs a key role in HR training. It lays the foundations on which workforce skills can continue to develop. For example, individual access to, and success in, higher education largely depend on the results of school education. Access to lifelong education also depends on the acquisition of basic knowledge: a secondary-level education seems a prerequisite today to undertake and benefit from continuing training (Gossiaux and Pommier, 2013) – hence the importance attached by policies to secondary school diploma – whether general or vocational – and to preventing school dropout. Lastly, as the essential locus for socialising young people, the school system not only transmits knowledge, but also develops a mindset that is more or less geared to innovation, research and entrepreneurship. In matters of innovation policy, there are two particularly important points concerning the school system: the level and distribution of skills in the country and the attitudes or thought processes inculcated in students.

Level and distribution of learning acquired

One characteristic of the French educational system is the polarised distribution of student learning, perhaps due to the system's culture and historic mission of selecting elites. The inequalities in the skills found in the adult population may thus be correlated with those found inthe school system. These characteristics are consistent with an innovation system founded on advanced technology, major organisations and large corporations. On the other hand, a more open innovation system, in which adaptation and incremental innovation would play an important role throughout all economic activities, would call for a broader human capital base.

French national surveys of primary education show that a large percentage of students have a poor or inadequate knowledge of French and mathematics. In 2010, 25% of students in their 1st year of elementary school (CE1) and 27% in their 2nd year of middle school (CM2) year performed poorly or "inadequately" in French; 23% of CE1 students and 33% of CM2 students performed poorly in mathematics. Although the percentage of students struggling in primary school might be expected to drop, the percentage of students struggling in both French and mathematics actually rose between the CE1 and CM2 grades (Ministry of National Education [MEN], 2010). These low levels are good predictors of future school dropout rates (MEN, 2013a).

The OECD Programme for International Student Assessment (PISA) survey assesses the reading, mathematics and science skills of students aged 15 in 65 countries and economies. France's results are close to the international average, with students scoring 505 in reading comprehension (above the international average of 496), 495 in mathematics (similar to the average of 494) and 499 in science (similar to the average of 501). These scores are lower than in some countries, such as Japan, the Netherlands and Germany (except in reading comprehension), but equivalent to scores in the United Kingdom and Denmark, equivalent to or higher than scores in the United States, and higher than scores in Italy and Spain (OECD, 2013b, 2013c).

Between 2000 and 2012, France's results in the PISA survey fell in mathematics: the decline occurred between 2003 and 2006, and the results have not risen again since then. The figures for reading comprehension have remained stable, falling between 2003 and 2006, but returning to the 2000 level in 2012. The results for science in France have not changed between 2006 and 2012. Thus, France's overall performance remained stable over the past decade, as in other countries (25 countries in mathematics, 22 in reading comprehension, and 37 in science). A number of countries, however, have managed to improve their performance over this period (25 in mathematics, 32 in reading comprehension, and 19 in science). One of the challenges of the next decade will be for the French educational system to impart momentum for improving its results, as is happening in other countries, such as Germany and Poland (OECD, 2011).

Just as much as the average results, the uneven distribution of results may lead to problems for the innovation system. In terms of the percentage of top students (Levels 5 and 6), France is close to the average in mathematics (12.6%, versus 12.9% on average) and science (7.9%, versus 8.4%) and ranks 8th and well above the average – in reading comprehension (12.9%, versus 8.4% on average). Without having an advantage over other countries, it can underpin an elitist innovation system with a sufficiently broad base.

To put these findings in perspective, the percentage of top students is lower in France than in Japan for all the subjects tested by PISA, higher than in the United States for all the subjects tested, higher than in the United Kingdom for mathematics and reading comprehension, and lower than in Germany and the Netherlands for mathematics and science (but higher in reading comprehension).

The percentage of students at the lowest levels is also close to the OECD average: the percentage of students below Level 1 is 18.9% in reading comprehension (compared with 18% on average), 22.4% in mathematics (versus 23%) and 18.7% in science (versus 17.8%). The situation is the same when studying the percentage of students at Level 2 or lower. In France, despite good results for reading comprehension, the percentage of students with difficulties (Level 1 or lower) in this domain is slightly higher than in Spain, the United States or the United Kingdom, and significantly higher than in the Netherlands, Germany or Japan. In science, France has the highest proportion of struggling students of all the countries surveyed. When it comes to mathematics, the share of struggling students is higher than in Germany, the Netherlands and Japan, but equivalent to the United Kingdom and lower than the share of struggling students in Spain, Italy and the United States.

Assuming this uneven distribution persists for 15 years – which seems likely, judging by the similar distribution in the OECD assessment of adult competencies – France could certainly rely on a small "elite" of potential innovators, but would be less well placed to disseminate and adopt innovation on a wider scale throughout the production process. Reducing the share of struggling students must therefore be a priority for the coming decades.

In terms of dynamics, the gaps have tended to widen between top students and struggling students. Between 2000 and 2012, the percentages of top performers and struggling students in reading comprehension both rose by 4 percentage points; in mathematics, the percentage of top performers between 2003 and 2012 remained stable, whereas the percentage of struggling students increased (reaching the OECD average). It is only in science that the share of struggling students slightly between 2006 and 2012. To prepare a larger segment of its population to participate in and benefit from lifelong learning, France will have to curb the percentage of struggling students in its school system.

Aptitude and attitudes for innovation

Today's concept of innovation is that many of the qualities required of innovators relate to psychological traits just as much as technical competences. The role of an "entrepreneurial culture", referring for example to creativity, persistence and risk taking, is often mentioned. Some of these traits can be, if not taught, perhaps fostered by primary to higher education curricula. Does teaching in France foster the aptitude and skills for innovation, such as imagination, creativity, critical thinking, communication skills, self-confidence and familiarity with the business world? Few tangible elements can be used to assess these different qualities, which are explicit in school curricula and objectives, but generally not assessed as such in examinations, assessments or national competitions.

Although it is too early to judge, the introduction of an educational programme based on competences (the "common core skills") can gradually change the focus of education to a greater concentration on the acquisition of competences, rather than merely imparting knowledge or selecting elites. Enshrined in law in 2005, the "common core of knowledge and skills" comprises the set of knowledge, skills, values and attitudes considered as necessary for students to succeed in school and in life, as individuals and as future citizens. A personal skills log helps monitor student progress; since 2011, command of the seven core skills is in principle a requirement for obtaining the national school certificate (*brevet*) on completing middle school. The seven skills, which provide the framework for determining school curricula, are as follows: (1) command of the French language; (2) proficiency in a modern foreign language; (3) the key elements of mathematics, science and technology; (4) command of the commonly used information and communication techniques; (5) the humanist culture; (6) social and civil skills; (7) autonomy and initiative. Even though school curricula based on core skills also call for defining knowledge and matching progress in both knowledge and skills, they have the advantage of defining educational attainment not in terms of course content, but of knowledge and skill levels, thus paving the way for greater flexibility in curricula – and even personalised education (unless school assessments and curricula continue to be defined by specific subject content).

Schools do offer students ann awareness of the working and business world, notably through setting up an optional "work discovery" programme and efforts to provide information and guidance.

The European Union's Eurobarometer Survey provides a mixed view of the role of the educational system in developing innovation skills. In 2012, 50% of French adults – 8 percentage points less than in 2009 – felt that their school education had "helped them develop a sense of initiative and a sort of entrepreneurial attitude". This feeling was more or less shared by adults in other European countries, such as Germany (54%), Belgium (53%) and the Netherlands (47%), was stronger in France than in the United Kingdom (35%), but markedly lower than countries like Norway (76%). In 2012, a lower proportion of French adults (36%) believed their school education had given them sufficient skills and know-how to manage a business – a percentage similar to that in Germany and Italy [34%], but considerably lower than in most other OECD and EU countries. Thus, school seems more effective in instilling an entrepreneurial spirit than in providing the technical skills for entrepreneurship, although public opinion only has an indicative value. French schools seem in this regard comparable to schools in other countries.

The PISA surveys not only allow assessing learning in key subject areas, but also assessing information on other important skills and attitudes for innovation, such as students' interest in the subjects learned, their pleasure in learning, their confidence in themselves and in their skills, and their perseverance. Although they are often considered as secondary objectives, these emotional and social skills are crucial and underlie the attitudes that foster innovation and creativity. It bears noting that these skills are not necessarily correlated with scores: a student may have good scores without being curious, or may be curious without having good scores (Avvisati and Vincent-Lancrin, forthcoming 2014).

France seems to have one great advantage and one great weakness. On the positive side, French students generally take more pleasure in learning and are more interested in learning than students in other countries. In PISA 2012, 65% of French students stated they were interested in what they are learning in mathematics (compared with 53% on average in OECD countries) and 42% said they take mathematics because they like it (compared with 38% on average in OECD countries). On the negative side, French students, despite their pleasure in learning and curiosity, have less self-confidence than students in other countries. In 2012, for example, French students were among the least confident in their mathematical skills, after students in Japan, Korea and Macao (China) – and unlike students in North America or northern Europe, who ranked above the OECD average. They are also the most anxious in mathematics, together with students in Italy, Korea, Japan and Mexico – as was already the case in 2003. Although their questions and indicators may differ, all the PISA surveys produce the same findings for France (OECD, 2013d).

In spite of many positive developments, the approach to student assessment in the French system does not foster self-confidence or risk taking, two useful mindsets for innovation and entrepreneurship. The grading system and the grades themselves play a major role in every educational system: they may motivate students, but also discourage them (OECD, 2013e, 2012b). Many features of the French grading system are not regarded as good teaching practices. For example, grades should not be implicitly or explicitly based on a comparative curve, as is the case in France, where teachers tend to reproduce a Gauss curve in their class (Antibi, 2003). This distribution should theoretically be found across a country, but not within each class. This practice of ranking rather than assessment discourages good students enrolled in good schools, who are considered (relatively) "weak" even though they perform better than "good" students in less good schools. Categorical schemes, which assess students based on a level category (e.g. A, B, C, or TB, B, AB), allow a better recognition of the level attained by students, especially since numerical scales tend to concentrate a great majority of students in a small central part of the scale. This therefore allows a more formative or pedagogical use of assessment. Lastly, overly strict grading discourages effort and motivation, undermining self-confidence or communicating the message that the return on the learning effort is low (Sjögren, 2009). Even though the situation has improved, this grading and assessment system also translates into far higher repetition rates on average than in other countries (OECD, 2013c).

Although the courses of study have diversified and there are many more options for moving between them, and the French school system is less segmented than in the past, a striking feature of the educational culture is the institution of the *concours* – the competitive entrance test or exam – which has strong social relevance and is designed to identify and select the best according to the logic of scholastic meritocracy. Much of the grading mentality is derived from these competitive exams. A review of the reports of the examining bodies in the most prestigious French exams gives an idea of this mentality. At the 2013 mathematics *agrégation* – a competitive examination recruiting the elite of French maths teachers, some of whom will become mathematics researchers – the grade for the last in the list was 7.95/20 – a grade whose indicative value is certainly only relative but which, in the standard table of scholastic assessments, corresponds to a "fail" grade ("*insuffisant"*). If even the elite receive fail grades, the institution's judgment of those with a lesser academic level cannot be very encouraging. The examining board does not judge the competence of candidates in the light of clearly defined criteria, as is the case in any good assessment practice, but specifies that it has not assigned all the places – not because it considers the candidates had an unsatisfactory level, but because a selection rate of four candidates per post assigned "seems to be a threshold that guarantees the quality of recruitment" (MEN, 2013b). An analysis of the reports by the examining bodies of the competitive entrance examination for the *grandes écoles* would testify to a similar vision.

As in other countries – especially Asia – where competitive admission and high-stake examinations have pride of place, French school education leaves little scope for learning through projects, investigation or problem-solving, which better prepare students for taking part in innovation processes. Pedagogy, dominated by the teaching of subject knowledge and know-how, with a sometimes immoderate propensity towards rote learning and the strict application of school curricula, is also made weaker by lacunae in teacher training.

Challenges to reinforcing the quality of school teaching for innovation

The reform of initial teacher education, launched in 2013 with the opening of graduate schools for teaching and education aims to disseminate, develop and foster good practice and innovative teaching methods, as well as promote transfers between research and professional practice. While retaining a strong subject-based dimension, it allows some place for didactics and contextualised learning. It is to be hoped that it will develop pedagogical models that are favourable to innovative attitudes and cultures.

One of the difficulties in implementing these changes is the decreased financial status of French teachers. The teaching profession clearly became less attractive in France between 2001 and 2011, as witness for example by the decline in the number of students wanting to become teachers. Whereas 22% of students in the first year of university (L1) in 2001 wanted to become teachers, only 10% expressed that wish in 2011; the share of students who considered this professional choice as a real option fell from 28% to 21%. In other words, 50% of students in 2001 said they would certainly or might possibly become a primary or secondary school teacher, compared to only 31% in 2011 (Ministry for Higher Education and Research [MESR], 2012). Over the same period, the salaries of primary and secondary school teachers fell by 8% to 9% in real terms – Japan was the only other OECD country experiencing an equivalent reduction. On average, teachers' salaries in the other countries rose by almost 20% over the same period, with an increase of about 20% in Denmark and Finland, 7% in England and 3% in the United States. Measured in terms of purchasing power parity, the annual pay of French teachers is below the OECD average at the beginning of their careers and after 10 to 15 years' experience. In terms of their pay per hourly contact with students, the situation is unchanged: a French teacher earns USD 35 per hour-long class in primary school (compared with USD 49 on average in an OECD country) and USD 56 in upper secondary school (compared with USD 66 on average). At the highest echelon of the pay scale, a French teacher's pay admittedly exceeds the average statutory pay in an OECD country, but 34 years of experience are required to reach this level in France, compared with 24 years on average in an OECD country.

Lastly, if the internal attractiveness of the profession is assessed by comparing teachers' salaries with salaries of higher education graduates, a teacher in an OECD country earns on average 11% to 20% less, depending on the level of teaching, than a higher education graduate working full time. In France, teachers earn 18% to 25% less than higher education graduates – far less than their OECD counterparts (OECD, 2013f).

This question should be viewed in the broader context of salaries in the French civil service – which, compared with other countries, are lower for qualified civil servants, but higher for the less qualified (OECD, 2013). Education is therefore in a slightly different situation, but the pay structure for French teachers, like that of civil servants, is not an incentive. Moreover, any adjustment of teachers' pay should occur within the context of a more general transformation involving other aspects, such as working hours (especially at the school itself), the organisation of work and the recognition of new roles for teachers entailing new teaching practices, greater consideration of performance in determining remuneration and career advancement, etc. Other innovations, such as improved information systems to ensure better deployment of teacher resources and support facilities, should also be envisaged.

The question of working conditions, career management and the attractiveness of the teaching profession partly determines not only the quality of the individuals attracted to teaching, but also the propensity of teachers to pursue their training as they work. Even though improving the quality of pedagogy and professional practices does not always call for extra funding, the dynamics of change and the effort to train, learn and adopt pedagogical innovations are more complex in the context of a reduced standard of living for the teaching profession. Consequently, an individual's contribution to creating and implementing innovation should be an essential component of any individual readjustment of salaries.

Measure of the Investments for the Future (PIA) programme in secondary school: Boarding schools for excellence

One measure of the PIA, endowed with EUR 300 million (0.8% of the PIA budget) – may be seen as an attempt to reduce the school inequalities described above and their potentially negative impact on the French research and innovation system: the *internats d'excellence* (boarding schools for excellence). These boarding schools do not cater to the many struggling students in the system, but are directed at "motivated middle and high school students and other students who do not benefit from backgrounds conducive to academic success", making "available to those students in greatest need a school establishment that is innovative both in its operation and the provision of teaching and education" (MESR). This PIA measure aims "to deploy, by 2020, 20 000 seats in *internats d'excellence* throughout the country, reflecting the geographical distribution of needs". In 2013, 45 boarding schools for excellence were fully operational, offering 4 173 seats. In addition, there were 6 940 "labelled" seats (in other words, reserved seats following the principle of the *internat d'excellence* without offering boarding) and 382 seats in private establishments, increasing the number available to nearly 11 500 seats. Given its sparse quantitative coverage, this measure must be regarded as a pilot scheme within the context of an experimental logic of a new form of priority education intended for intermediate (on a national scale) students, i.e. neither weak nor excellent, from disadvantaged districts.

A controlled experimental quantitative study on the Sourdun excellence boarding school, which was the first to open in 2009, shows its markedly positive (causal) effect on students' results in mathematics after two years (but none after one year), as well as its positive influence on their work habits and intrinsic motivation for study, but no impact on their results in French (Behaghel et al., 2013). The authors note that comparing this measure with other initiatives – such as reducing class size by half – that also double the resources available per student shows equivalent positive impacts. While the Sourdun boarding school is not superior to equivalent measures in terms of its cost-benefit ratio, it does demonstrate that a priority education policy can work with considerably higher budgets than those normally allocated. The customary priority education policies only marginally increase the resources per student and do improve student success (French Court of Auditors, 2010; Beffy and Davezies, 2013).

Since the teachers, unlike the students, have not been allocated at random to the Sourdun school and their profile is very different from that of the teachers at the schools in the control group, the positive conclusions from this experience cannot be generalised, nor can it be expected that this model could easily be deployed on a wide scale with similar results. It may be that the positive effects come not from the proven improvement in study conditions or the use of replicable educational methods, but from the characteristics of the teachers selected (who were sufficiently interested in the project to apply). Another study, in this case a monograph, on several *internats d'excellence* gives an account of the strong involvement and innovative teaching methods of the teaching staff in these establishments, stressing that it is possible (even probable) that these professional attitudes had motivated the teachers to come teach in these schools – rather than that they had been developed there (Rayou and Glasman, 2012).

Even though the *internats d'excellence* end up being a success for the handful of students who attend them, this PIA scheme has little chance of significantly influencing the French research and innovation system by reducing school inequalities. Not only does the measure only affect a tiny fraction of students, it also does not reach the weakest students. The established teaching methods do not appear very different from those of "good" schools: the two above-referenced studies mention the difficult first year for the students due to the dramatic drop in their grades and the challenge they face in overcoming a strong initial lack of motivation. The PIA scheme may, however, have a positive effect on the innovation culture of education policies, by demonstrating the possible effectiveness of innovation in teaching methods, supporting experimentation, and enhancing the assessment of innovation in education. To take up these challenges, the French educational system will indeed need to innovate. Although the resources and measures at its disposal still need to be clarified, the National Council on Innovation for Educational Success, founded in March 2013, will certainly underpin these innovations.

Higher education (initial training for innovation)

Higher education courses perform a key role in innovation. France is at least in the average of OECD countries in terms of access to higher education and student success (internationally comparable access rates are not available). As reported above, France has managed to achieve quantitative growth in its system, and the percentage of graduates among the younger cohorts in its higher education population compares advantageously with the OECD average. In 2011, 80% of students enrolled in tertiary education emerged with a vocational or general undergraduate degree, compared with 68% on average for an OECD country, placing France among the leading OECD countries for which longitudinal data are available, on a par with Denmark (81%), slightly ahead of Germany (75% for general higher education) and the Netherlands (72%), and well above Norway (59%) and the United States (53%) (OECD, 2013f). However, although French students entering higher education generally emerge with a degree, they often change direction and repeat years. This is especially true of students receiving a generalist higher education.

As regards courses, the structuring of the higher education system among *grandes écoles*, schools, universities and short vocational courses reflects the dichotomy between universities and research organisations that characterises its research mission. All higher education systems are complex, but the French system stands out for its wide diversity of institutions and courses, comparable only to those of the US or Indian systems, which are also highly diversified. Its uniqueness is the special place occupied by the undergraduate university course: whereas in other countries the university is usually unequivocally at the top of the hierarchy of tertiary establishments, sometimes with competition from certain elite institutions, France is to the best of our knowledge the only country in which the best students often aspire to begin their studies in other types of institutions or courses, even if this means continuing their studies elsewhere afterwards. While the best students overwhelmingly opt for preparatory classes for admission to special tertiary institutions, the first university degree course (L1) is still a first choice or an attractive choice in certain subject areas or pathways (for which another alternative does not necessarily exist), such as medicine, science, literature, law and economics (Convert, 2010; Beaud and Convert, 2010; Orange, 2010). Admittedly, universities, following their closure during the French revolution, have only existed as organisations in France since 1968 and have gradually grown more influential since then (Musselin, 2001).

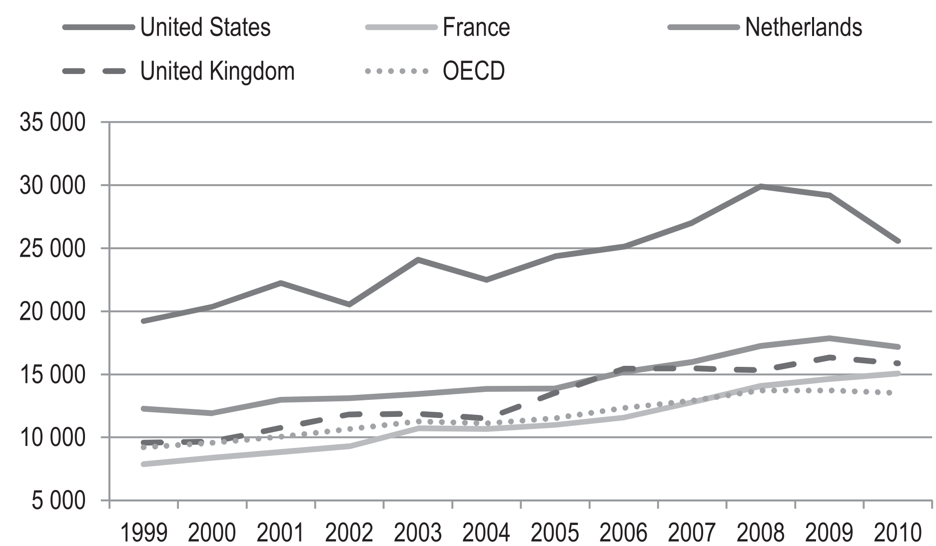
To simplify, it can be said that the higher education system has three main educational functions, depending on the study levels and courses. Its first function is to transmit basic knowledge and vocational skills. This is typically the role of undergraduate education, which covers higher technician sections (STSs), university technology institutes (IUTs), specialist schools, preparatory classes for the *grandes écoles* and university first degrees. A second function is to transmit knowledge and develop higher professional skills. This mission is performed by the *grandes écoles*, the specialist schools and professional master's degrees granted by universities. The third and final mission is to develop more theoretical or academic knowledge and skills. This mission is carried out by the university, through its research-oriented master's degrees and doctorates.

In terms of expenditure per student, France has long been characterised by low higher education expenditure – although it has been catching up since 2008 – whose cost is essentially borne by the State. Thus, in 2010, France was slightly above the OECD average, spending USD 9 473 per student on education, compared with USD 8 889 on average for an OECD country (expressed in purchasing power parity). The distinction between expenditure excluding and including research may sometimes appear artificial, in that part of the research spending is calculated based on the assumption that teachers-researchers spend 50% of their time (and pay) on research (MESR, 2013d, p. 12), which is not necessarily the case in practice. When research and associated services are included, spending per student in France is still above the OECD average (USD 15 067, compared with USD 13 528 on average), but its resources are far lower than those of other countries, such as the United States (USD 25 576), Canada (USD 22 475), Switzerland (USD 21 893), the Netherlands (USD 17 161) and the Nordic countries (around USD 19 000 for Denmark, Norway or Sweden) – and slightly lower than spending in the United Kingdom (USD 15 862). (No comparable data are available for Germany.) This average ranking is, however, the result of recent improvements, since France had been spending less than the OECD average up to 2008. In 1999, France spent USD 7 867 per student, compared with USD 9 210 on average for an OECD country (and USD 9 554 for the United Kingdom and USD 19 220 for the United States); in 2007, it spent USD 21 773, compared with an OECD average of USD 12 907, USD 15 463 in the United Kingdom and USD 27 010 in the United States. It is only in 2008, with the reform of higher education, that France started to spend slightly more than the OECD average (USD 14 079, compared with USD 13 717 on average, USD 15 310 in the United Kingdom and USD 29 910 in the United States) (Figure 3.4). In other words, although France's current level of spending per student is a little higher than the OECD average, it bears noting that higher education in France has long been (and remains) far less endowed than many of its counterparts in OECD countries, including the United Kingdom. Its spending per student, however, is higher than in Spain and Italy.

Finally, a special feature of French higher education is the major role of the public sector and public funding. In 2010, 71% of expenditure on higher education was funded by the State and 12.4% by other public sources (10.7% by local authorities and 1.7% by other public administration authorities), while households contributed 8.5% and businesses 6.1% of the cost. Even though public educational institutions still account for the lion's share of the system, the proportion of students enrolled in private institutions has risen sharply since 2000, accounting for 18% of the student body in 2011.

Figure 3.4. Spending per student in higher education (including research), 1999-2010

Nominal equivalent USD converted into purchasing power parities for GDP



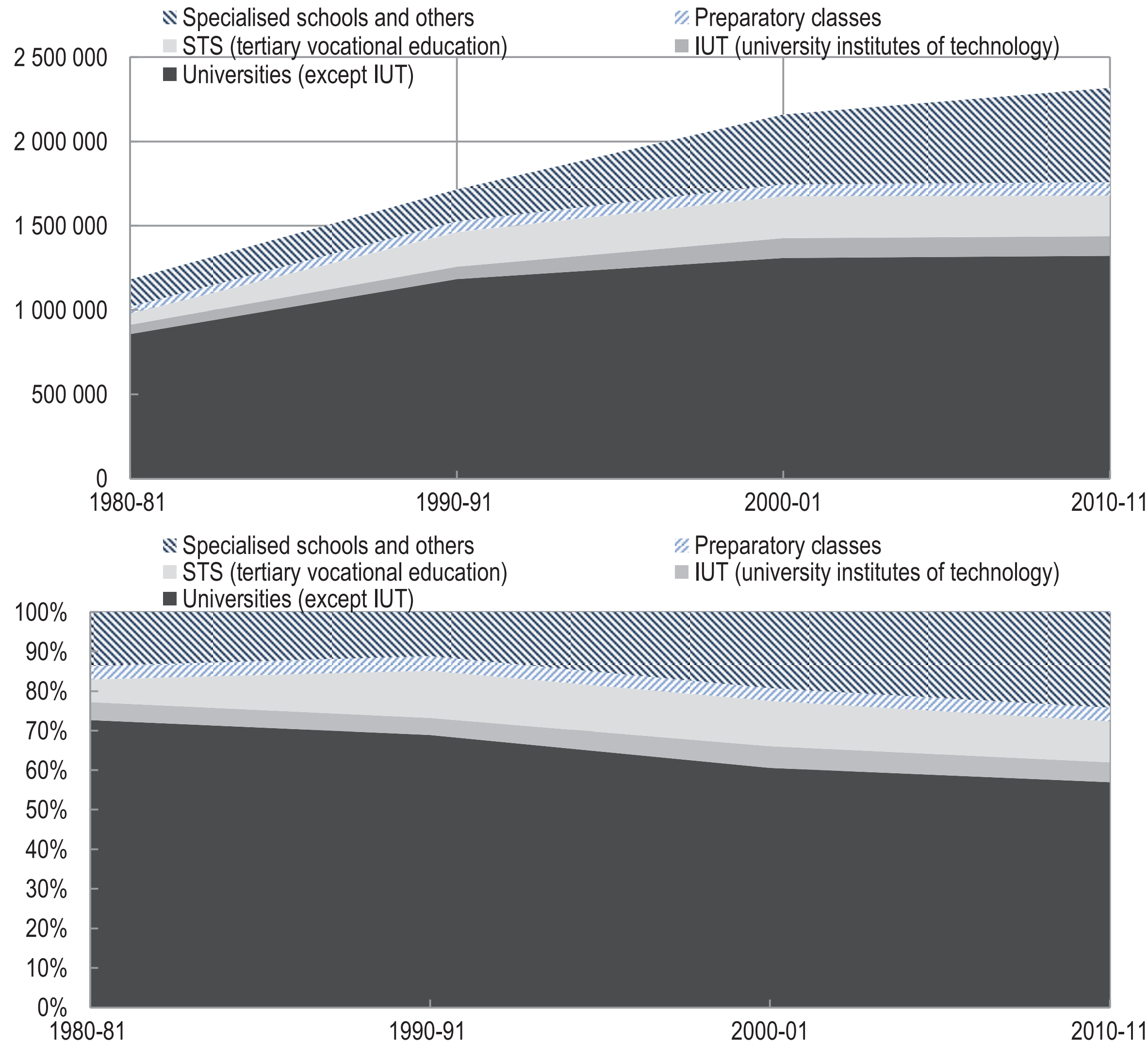
Source: OECD Education Database.

Basic vocational training at university

The main problem of the higher education system is the weakness of basic vocational training in universities (except in IUTs). French universities admitted 845 212 students in undergraduate (*licence*) courses in 2012, i.e. 36% of all students – 5% in IUTs and 9% enrolled in vocational bachelor's degrees. Thus, the students enrolled in a generalist bachelor's degree at university account for about 22% of the French student population. To complete the comparison, students enrolled in STS technical sections represent about 10.5% of the total (246 000 students), and those in the preparatory classes 3.4% (80 000 students). (Other students enrol in schools beginning directly after the baccalaureate, but the MESR does not publish their numbers.)

The question of student success arises above all at the level of the university. The success rates of students entering the preparatory classes for the *grandes écoles* are high (the numbers dropping out of the system after three years are negligible). The short undergraduate vocational education courses also have good success rates and offer good employment prospects. In the IUTs, 77% of students enrolled obtain their university technology degree (DUT) in 2 or 3 years, while 71% of those enrolled in STSs obtain a higher technician's certificate (BTS) or other diploma. Vocational bachelor's degrees in universities have also developed in parallel with IUTs: they now account for about 25% of undergraduate students and also display high success rates.

Figure 3.5. Trend in and distribution of student numbers in French higher education, 1981-2011



Source: MESR.

Succeeding in their studies is a problem for baccalaureate holders embarking on general university courses, especially if they have not earned a general baccalaureate. Success indicators measure whether those embarking on a study course actually obtain a degree in that course (meaning that changing majors is not counted as a success). Today, 58% of those enrolled in the undergraduate *licence* (L1) programme obtain their degree in 3, 4, or 5 years, with only 27% obtaining it in 3 years (and 38.9% in t3 or 4 years) (MESR, 2013e). The failure rate is 35% for holders of general baccalaureates and 76% for holders of technology baccalaureates. After the first year of *licence* (L1), 52% of the students move up to L2, 23% repeat the L1 year and 19% switch to another course (IUT, STS or other), while just 6% drop out entirely. Vocational baccalaureate holders have the highest failure rates in all pathways (52% fail in the STS and 54% in the IUT). Technology baccalaureate holders have a higher success rate at the STS (71%) and IUT (68%) than at university (24%) (MESR, 2012a).

Having long borne the brunt of the system's expansion, the share of universities in total enrolments has fallen over the past few years in comparison with the specialist schools (Figure 5). This development may be beneficial to training HR for the innovation system since, despite recent trends, French universities still struggle to offer their general undergraduate degree students the basic vocational skills recognised by the labour market (or at least, as widely recognised as their vocational alternatives). Apart from the IUT and vocational degrees, they give too little place to teaching basic vocational skills, emphasising the transmission of subject knowledge to be used by future researchers or advanced vocational courses. This teaching is no longer geared to the diversified groups attending the courses, some of whom have been unable to access basic vocational courses in the STS, IUT or specialist school that would have been more in line with their school preparatory studies.

In undergraduate education, the university suffers from its students' very uneven scholastic preparation (on average lower than that of more selective pathways – preparatory courses, *grandes écoles*, BTSs and IUTs), lower funding per student than in the above-mentioned institutions and limited incentives to improve the quality or relevance of undergraduate courses. This is why "degree obtention" is a recurring issue for the authorities and has been one of the action points in recent higher education reforms, as well as the subject of new measures in the 2013 Law on Higher Education.

The first difficulty arises from the fact that some university students are not necessarily prepared for general academic courses: those coming from technological and vocational streams often opt for university because they were not admitted into short vocational courses better suited to their scholastic background. The university is the only higher education institution that is required to admit any baccalaureate holder – although not necessarily to the course of their choice. In practice, the best students often choose more selective courses than the general university pathway at the start of their studies, while some students who have prepared for certain vocational courses are unable to access them because they have not been admitted into the selection process based on their applications. This is less a problem of academic guidance (in the sense that the students may not have been properly informed about their chances of success in the various streams) than of strategy – both on the part of the best students and the heads of establishments. In fact, seats are left unfilled ever year in the STS and IUT, while 25% of baccalaureate holders enrolled in general university studies are not pursuing their preferred course of study and are enrolled "by default" (MESR, 2012b). These students who are enrolled by default have obtained less information about their studies and chances of success than the others, from which it might be concluded that they could have better chosen their orientation had they been better informed. It is, however, more likely that they already know their chances of success: indeed, they are the best informed of the possibilities of switching majors after their first year of study (MESR, 2012b).

The inadequacy of university training is also due to budget issues: expenditure per student at university amounted to EUR 10 180 in 2010 (including in the IUT, whose expenditure per student is equivalent to that of the STS), compared with EUR 13 800 in the STS and EUR 15 240 in preparatory classes (MESR, 2011). Of all higher education courses, the general first degree university course (*licence*) receives the lowest budget (or at least is the least costly). In these circumstances, and even if they wished to do so, universities would find it hard to replicate the teaching model of the basic vocational courses or *grandes écoles*, which are better staffed or whose teaching methods are project-based, collaborative or based on case studies. This teaching model, which is better suited to –

and probably more effective for – training personnel for intermediate innovative professions, would also call for higher spending per student.

The difficulty of establishing such a teaching model is also due to the identity of the university and its strongly subject-based organisation, which has traditionally attached paramount importance to transmitting advanced knowledge in a subject area and is primarily concerned with training future researchers. Due to the Bologna Process, this identity is evolving in line with the reconsideration of education in the light of the skills acquired rather than the knowledge accumulated. Thanks to the Bologna Process, this identity has been evolving with the renewed assessment of training programmes through the lens of acquired skills rather than accumulated knowledge. Launched in 1998 with the aim of facilitating student mobility in Europe and recognising foreign degrees, the Bologna Process has led to some harmonisation of the structure of university systems in Europe according to the "bachelor's/master's/doctoral" model (known as LMD in France), although there are still marked national differences (Witte et al., 2009). In France, the Bologna Process has led to an in-depth review of education, causing the departmental authorities and higher education establishments to reflect on the skills that students should acquire and the criteria for awarding points used to establish equivalences between European degrees (the European Credit Transfer and Accumulation System).

However, the failure to improve the status of teachers and reward good teachers (unless they are also good researchers) and the lack of training in teaching skills for professor-researchers hamper innovation in teaching and the adoption of practice-based teaching methods and lower the quality of education. France may not differ from many other countries in this respect, judging by anecdotal evidence that the teachers who most influenced famous US innovators never became tenured professors of the leading universities in which they taught (Wagner, 2012).

Positive changes in the provision and practices of teaching in universities must however be highlighted, with the many interesting initiatives in universities that could be observed during the monitoring of the Successful Graduation Plan (PRL) introduced by the Law on the Freedoms and Responsibilities of Universities (LRU Law) (French Court of Auditors, 2012; General Inspectorate for National Education and Research [IGAENR], 2010). Several pedagogical measures bear mentioning, such as extra support for "at risk" students (remedial measures and courses in addition to the normal curriculum), deferred specialisation (facilitating undergraduate major changes), cross-disciplinary teaching and the growing importance of internships during generalist undergraduate courses. Universities have also improved the teaching framework, with diminished recourse to lectures and staff for tutorials and practical work, the almost universal introduction of professor-advisers for students and a strengthening of the tutoring method introduced in 1997. Some universities have also invested in digital resources and infrastructure – a development that should be reinforced when France Université Numérique opens in 2014, even though the technology requires a good command of teaching skills to have a positive effect on learning.

The multiplicity of interesting small-scale schemes should not conceal the fact that French universities are still elitist and that practical support for students (remedial classes, tutoring, small group teaching, digital resources, etc.) and the use of active teaching methods are still scattered. The systematic organisation of educational innovation to improve learning and success rates is also limited. The PRL graduation plan and the PIA – through its initiatives for excellence in innovative training (IDEFI) – have provided welcome support for these teaching innovations. The 2013 Law on Higher Education also proposes new measures along these lines. But a good deal remains to be done to improve the quality of the generalist bachelor's degree in French universities and better adapt it to the needs and characteristics of the students studying towards it today.

Higher-level vocational training

Graduates of the *grandes écoles* continue to meet the needs of the major businesses and technological innovation companies. These schools have close links with the worlds of business and the higher civil service, which continue to recruit senior executives and future leaders from within their ranks.

For foreign readers, the *grandes écoles* are traditionally institutions whose students are recruited by competitive examination, generally after studying in preparatory courses. The stringent selection for accessing these schools is also one of their characteristics. Students from courses other than the preparatory classes are also increasingly being accepted on the basis of their academic record and/or a competitive selection procedure, generally at the M1 level (first year of the master's degree), as is also often the case for foreign students. Over the past decade, the *grandes écoles* have adopted a more international outlook and have diversified the academic requirements for student recruitment (as a whole, they admit only 38.5% of students from preparatory courses and now offer other degrees than their classic "*grande école*" degree).

There are principally three types of *grande école*: engineering schools (generally public), teacher training colleges (public) and business (or management) schools, generally overseen by chambers of commerce and industry. Some institutions, such as Sciences Po (the Paris Institute of Political Science), have acquired a similar prestige to the *grandes écoles*. Since they are publicly rated by the media every year and *de facto* rated by the order in which students choose them, these schools are more or less prestigious. In addition to these major categories, there are many other schools with other specialities. The "*très grandes écoles*", which facilitate access to the highest positions of power, are sometimes distinguished from the "*grandes écoles*", which provide access to senior positions.

In 2011, 5% of French students were studying at engineering schools and 5% at business schools. Engineering schools numbered 117 582 students in 2011, spread out among public schools overseen by the MESR (57%) and by other ministries (15%) and private schools (28%). Close to 20% of students were enrolled in schools within or linked to universities. While higher education enrolments grew by 37% between 1991 and 2011, enrolments in engineering schools doubled over the same period (98%). The private school sector grew more rapidly (+133%). Although their selectivity and prestige vary, all these institutions ensure rapid access to employment. Business or management schools accounted for 112 371 students in 2011. Schools recognised by the MEN and delivering a State-approved degree represented 85% of enrolments, compared to 5% for schools recognised by the State but not providing State degrees and 10% for schools not recognised by the State, the latter two categories not typically included in the *grandes écoles* category (MEN, 2012). National statistics do not reproduce the distribution by "training mission" adopted in this chapter.

The Conférence des Grandes Écoles (CGE) is another source of useful information to illustrate the positioning of the *grandes écoles* in the French higher education system, thanks to its annual surveys of "enrolments" and "statements of students enrolled in accredited training" (excerpts from the CGE). Its members encompass virtually all the *grandes écoles* for management and around two-thirds of engineering school students. In 2013, the CGE numbered 208 member institutions (147 engineering schools, 40 management schools and 21 schools with other specialities). A total 208 888 students were enrolled in their "*grande école*" programme, 50 806 students in other courses (bachelor's degrees, MBAs, doctorates, etc.) and 9 016 students in continuing education. While 85% of the 149 900 engineering school students and 90% of the 15 300 students in other than engineering or management schools wee enrolled in their "*grande école*" programme, management schools had more students enrolled in other types of courses: only 66% of their 103 500 students were enrolled in their "*grande école*" programme. Only 2% of their total students were studying towards doctoral degrees. These figures are not identical to those presented above since they do not correspond exactly to the same area.

A number engineering *grandes écoles*, teacher training schools and other administrative *grandes écoles* (e.g. the École Nationale d'Administration, national school of public administration) produce many "senior civil servants": according to their grades and interests, some graduates may be entitled to join by right the ranks of the Council of State, French Court of Auditors or General Inspectorate of Finance, as well as the corps of mining engineers (who hold senior positions in the Ministry of Finance, as well as in French banks and industry) or state civil engineers (working in energy, sustainable development and agriculture), the senior administrative staff of the National Institute for Statstics and Economic Studies (INSEE) and the corps of weapons engineers. The members of these bodies – mostly graduates of the same *grandes écoles* – are also employed in ministerial offices and the French Parliament. Some schools are therefore closely linked to the management and administration of French government. Such an organisation of the higher civil service by "senior State bodies" does not exist outside France. Meanwhile, graduates of the most prestigious business *grandes écoles* hold senior executive and managerial positions in major French companies.

Most French *grandes écoles* are small, training around 400 students per school every academic year (400 from preparatory courses for the École Polytechnique, 310 for the École Normale Supérieure and 300 for the HEC Paris business school). With the foreign student admissions, special status students and doctoral candidates, these establishments train around 2 000 students in total. Judging by their salaries 3 years after graduating (setting an arbitrary average salary of EUR 46 000 per year, according to ranking established by *L'Expansion* magazine), this gives 16 "major" engineering schools and 6 "major" management schools – plus those specialising in other subjects. Assuming that these schools accommodate 2 000 students, they account for around 2% of enrolments in French higher education, and 20% of enrolments in the *grandes écoles*. The average expenditure per student at these institutions is not published, but it is likely to be well above that of the above-mentioned preparatory courses (regardless of the salaries some of the most prestigious schools pay their "*fonctionnaires-stagiaires*" – probationary officials).

The *grandes écoles* play a key role in providing innovation-driven training, whether it be the traditional corporate-based model or the entrepreneurship-based model. The teaching model of these institutions seeks to train generalists by combining theoretical and practical teaching, and favours student-centred initiatives via collaborative projects. It therefore develops skills that are both relevant to innovation and recognised in the business world. In addition to a permanent academic teaching staff, a significant pool of business executives and experienced practitioners contribute as associate teachers and visiting lecturers, adding a practical dimension to teaching and informing students of the latest developments in industry practices or areas of interest. Compared to universities, the teaching delivered by the *grandes écoles* is defined by the importance attached to teaching in small classes, the very broad use of case studies, projects and group work and the increased adoption of new methods and tools, particularly digital resources. Student training leads to very close co-operation with economic circles, which generally participate in the governance of the institutions and contribute to defining needs and organising training courses and thesis projects. Sandwich courses (in companies) are an increasingly common option for students at these schools. Another indication of this link with the business world is that half of the entries into the labour market are the result of internships (CGE).

The schools' teaching model is changing and becoming a little more academic, with a larger proportion of staff with a research background than in the past (Bécard, 2011). This strengthening of the theoretical dimensions of teaching in the *grandes écoles* reflects an awareness of the need for trained specialists to be more flexible. Moreover, the quest for international accreditation has had a similar effect, leading the *grandes écoles* to adjust the profile of their teaching staff to increase the level and impact of their research output. This should allow greater alignment with the more theoretical education of university students, which will moreover be reinforced due to the many pathways between universities and the *grandes écoles*, including in the form of dual degrees.

According to a 2011 CGE survey of schools, virtually all the institutions offer training for entrepreneurship and have an entrepreneurial dimension, i.e. training to set up a business and acquire entrepreneurial attitudes. This generally involves teaching beginning with awareness raising (third year of the *licence* [L3]), followed by specialisation (M1), and finally guidance (second year of the master's degree [M2]). The aim is to develop the following entrepreneurial attitudes: dynamism, initiative, self-development and autonomy. In terms of entrepreneurial know-how, all schools seek first and foremost to develop students' capacity for creativity, innovation and project management. Engineering schools then insist on a capacity for enquiry and seizing opportunities, while business schools favour the capacity to draw up and develop business plans. The teaching models for developing these skills are, however, highly diversified and not always very mature, each institution interpreting and implementing this education for entrepreneurship in its own way. Nevertheless, all the schools seem to offer project supervision to their entrepreneur students (Bécard, 2011). Other measures are presented in the chapter on entrepreneurship. In another approach, and possibly more to prepare students for the multidisciplinary nature of innovation rather than entrepreneurship, a greater number of institutions are offering courses or activities – theatre, dance, cinema, visual arts, the link between technology and art, research and creativity workshops, but also oenology, theology and humanities – drawing on culture, the body and sensitivity, with the goal of fostering creativity (CGE).

According to a 2010 survey, 67% of French engineers and scientists believe their education prepared them well for innovation, irrespective of their seniority or area of expertise. While 60% believe that the addition of a specific module on innovation in the curriculum would improve training for innovation, 82% put practical learning, e.g. through case studies or project-based learning, at the heart of that improvement. Responses in this context are determined more by the functions of the engineers polled. Finally, while 54% believe that research develops the spirit of innovation, this view is mainly held by engineers and scientists who work in R&D (French National Council of Engineers and Scientists [CNISF], 2010).

In terms of business start-ups, 1.4% of new engineering school graduates were starting up (0.6%) or had started up a business (0.8%) in 2012, while this percentage rose to 3.5% for new management school graduates (1.3% for incipient start-up projects and 1.5% for active start-ups) (CGE, 2013).

Meanwhile, universities have developed many higher vocational programmes in addition to their internal or linked engineering schools, such as vocational master's programmes (45% of master's students) – also closely linked to the business world – research master's (18%) and undifferentiated master's (37%) programmes. Academic subjects, such as mathematics, also contribute to information technology disciplines and related innovations. In 2012, students enrolled in university master's degrees represented around 21% (493 000 students) of total French higher education enrolment, 70% of whom entering the programme with a university degree (66.7% with a generalist degree and 3.3% with a vocational degree). Master's degrees are therefore a natural continuation of generalist degrees, but not of vocational degrees: 73% of generalist degree graduates go on to do a master's, compared to 9% of vocational degree graduates. Among university graduates, 22% end their university studies after the *licence*.

As in other countries, courses specifically geared to teaching innovation are also being developed for university students in France. While most programmes focusing on innovation (e.g. "design thinking") or entrepreneurship are offered by the *grandes écoles* and specialist schools, some universities are also beginning to develop them (e.g. "Paris-Est d.school at École des Ponts" at the University Paris-Est Marne-la-Vallée). This training continues to be developed at the university and may in future modify the learning methods proposed. Indeed, considering that universities generally fulfil their teaching functions satisfactorily in academic areas and higher vocational education, the success rates of master's students are not much higher than those of generalist undergraduate degrees (*licenc*e). The question should therefore be asked whether the educational programmes and methods are, in fact, better adapted than in the *licence* to "average" students enrolled in non-vocational study programmes.

Despite the filter of the *licence* degree preceding the master's courses (and the selection to enter the M2 degree programme), only 46.4% of master's students in 2009 had obtained their degree in 2 years, and 57.2% in 2 or 3 years. Around 30% of master's students leave university at the end of their first year, either to end their studies or to pursue non-university training. Vocational master's courses have considerably higher success rates than research and undifferentiated master's courses: 84% of students enrolled in the M2 obtain their qualification in one year, compared to 64% for research master's degrees and 42% for undifferentiated master's courses. However, students who are already behind in their academic career have the least chance of success (MESR, 2013e).

Doctorate holders

The quantity and quality of doctorate holders is also important for a country's research and innovation system, in that many researchers now have PhDs, particularly in public research. Universities largely dominate PhD training, although the MESR also authorises other institutions to deliver doctorates. As in other countries, PhDs in France represent around 3% of higher education graduates – and doctoral students also represent around 3% of higher education students.

Just as the percentage of doctorate holders in the French population is below that in the OECD, French students have a lower propensity to begin doctoral studies is lower than their OECD counterparts. In 2011, the admission rate to advanced research programmes (International Standard Classification of Education 6) was 2.5% in France, compared to 2.7% on average in OECD countries – slightly more than in the Netherlands (1.3%), but less than in the United Kingdom (3%) or Germany (5.3%). Although France is the 5th-highest provider of doctorates in the OECD (around 12 000 doctorates in 2009), the 21% growth in the number of doctorate holders between 2000 and 2011 was much lower than in the United States, the United Kingdom or South Korea – where it was nearly 50% – but higher than in Germany, which has been stable for the past 10 years (although it began from a much higher issuing of doctorates than France) (OECD, 2013; OECD Education Database). Since 2006, the number of doctorate holders has increased in France (although the number of doctoral students has been falling for some years).

In terms of scientific fields, new PhD candidates are distributed differently in France than in the average OECD country. In 2011, the number of such students studying sciences in France was disproportionate (37%, compared to 23% on average in the OECD), particularly for physical sciences (18%, compared to the OECD 9% average). Thus, France has the highest percentage of new doctoral students in sciences and physical sciences of all OECD countries. New French doctoral students also study to a lesser degree the social sciences, business and law (27%, compared to the OECD 21% average). Conversely, they are less likely to choose subjects linked to engineering, manufacturing and construction (11%, compared to 17% in the OECD), as well as health-related studies (3%, compared to the 15% OECD average) (OECD Education Database).

While these specialities correspond in part to the French innovation model, which as shown is heavily science-based, a larger proportion of engineering doctorates could be expected, given the importance of engineers in French innovation processes. This is probably a result of the separation between universities and *grandes écoles* (for engineers, among others). Although universities currently teach 20% of French engineers in their engineering schools, the vast majority of engineers are trained in public outside of universities (36% in schools overseen by the MESR and 14% in schools overseen by other ministries) or in private schools (30%) (MESR, 2013a). Engineering training therefore remains mostly at a remove from institutions that issue doctorates. In fact, engineers taught in the *grandes écoles* continue to enjoy a strong advantage with French industry, which does not necessarily attach much weight to the doctoral qualification obtained at university. Perhaps bearing witness to their lack of familiarity with research, 50% of working engineers and scientists did not respond when asked whether doctorates can improve the innovation skills of engineers and scientists. Among the 50% who did respond, positive and negative responses were on a par (CNISF, 2010).

Doctorates undertaken in the framework of industrial agreements on training through research (CIFRE) are no doubt most attractive to engineers – and a valuable tool for co-operation between universities and companies. Introduced in 2000, the CIFRE represented 11% of doctorates funded in 2012, i.e. 1 350 agreements. Unlike for doctorates as a whole, engineering sciences and information and communication technology represent 42% of CIFRE doctoral research projects. In 2012, 46% of new CIFRE PhD students had an engineering degree. CIFRE PhDs readily find employment, with an entry rate of 96% within one year. The CIFRE mechanism was often commended by firms during the interviews conducted, although some respondents were concerned about the excessive demands of universities and research organisations in terms of intellectual property rights, compromising the signing of agreements in some sectors with high capitalisation of research.

The (relatively) weaker output of doctorate holders in France is due in part to the separation between engineering schools and universities, as well as the fact that the doctoral degree is less recognised on the French labour market. Thus, doctorates are not always included in collective agreements and are not recognised by the civil service. The new 2013 Law on Higher Education introduces the possibility of an external competition on the basis of qualifications (or qualifications and tests) for certain senior civil service bodies. Whether this new opportunity will bear fruit remains to be seen.

In fact, surveys show that it is more difficult for French doctorate holders to enter the labour market than it is for their peers in other OECD countries. In both 2007 and 2010, the unemployment rate for doctorate holders3 years after obtaining their degree stood at 10%, and even though 96% of such graduates obtained executive positions, they often took longer than master's graduates to secure a steady job (Calmand and Recotillant, 2013). While the surveys are not strictly comparable, the unemployment rate for PhDs in the United Kingdom was estimated at 2% in 2008 (Destinations of Leavers from Higher Education Survey, 2009). In the countries participating in the OECD survey on doctorate holders, only 1% to 4% were unemployed 5 years after obtaining their degree, which suggests that the integration process in France is longer than in other countries (OECD, Careers of Doctorate Holders survey; Auriol and Harfi, 2010).

Assessment of higher education

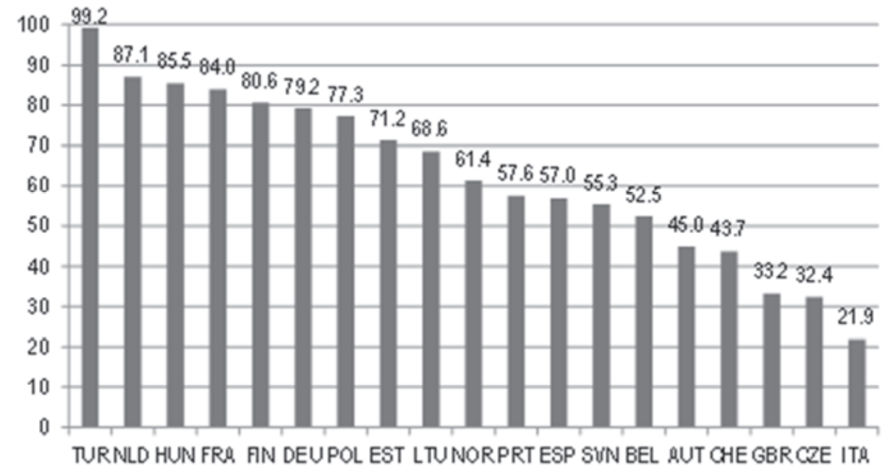
Very little international data exist with which to assess higher education systems, at least in terms of their training dimension. The REFLEX-HEGESCO survey nevertheless contains indicators assessing training in higher education by former students in the system five years after obtaining their final degree. The Eurostudent survey also compares higher education outcomes based on students' subjective judgment.

French professionals as a whole have a more positive retrospective judgment of their higher education than their European counterparts. This does not necessarily indicate a positive bias, since the "bias" is reversed on other issues. In 2005, higher education graduate professionals in all combined subject areas said that their initial higher education was a good foundation for beginning work (63%, compared to 55% on average in other countries), learning on the job (65.3%, compared to 57.5% on average) and carrying out their work tasks (55.1%, compared to 50% on average), while there was no statistically significant difference from the European average for their future career (54.2%) or personal development (64.3%).

French professionals believe much more than their European peers that their education provides a sound basis for developing entrepreneurial skills (43.3%, compared to 21.7% on average in Europe). While this may be the reality, it may also mean that French professionals have different perceptions of entrepreneurial skills than their European peers – since the survey is not aimed at professional entrepreneurs.

A characteristic of French higher education is the importance of internships, which may in fact offer better preparation for the working world than in other countries. The REFLEX-HEGESCO survey shows that 84% of French students did an internship in a company during their studies, compared to an average of 68% in the countries taking part in the survey. This percentage is a little lower than in the Netherlands (93%), but a little higher than in Germany (79%), and much higher than in Spain (57%), Great Britain (33%), or Italy (22%) (Figure 3.6). Here too, universities are probably a little behind other institutions. In 2010, the number of internships during bachelor (*licence*) programmes was virtually nil in the first year, low in the second year and still modest at the end of the course: only 3% of students in L1 did an internship, 11% of students in L2 and 30% of students in L3 undertook internships. With the exception of vocational pathways, and given the difficulty in finding internships in France for a great number of students, internships typically occur during master's programmes.

Figure 3.6. Percentage of higher education graduates doing an internship during their studies



Source: REFLEX-HEGESCO data.

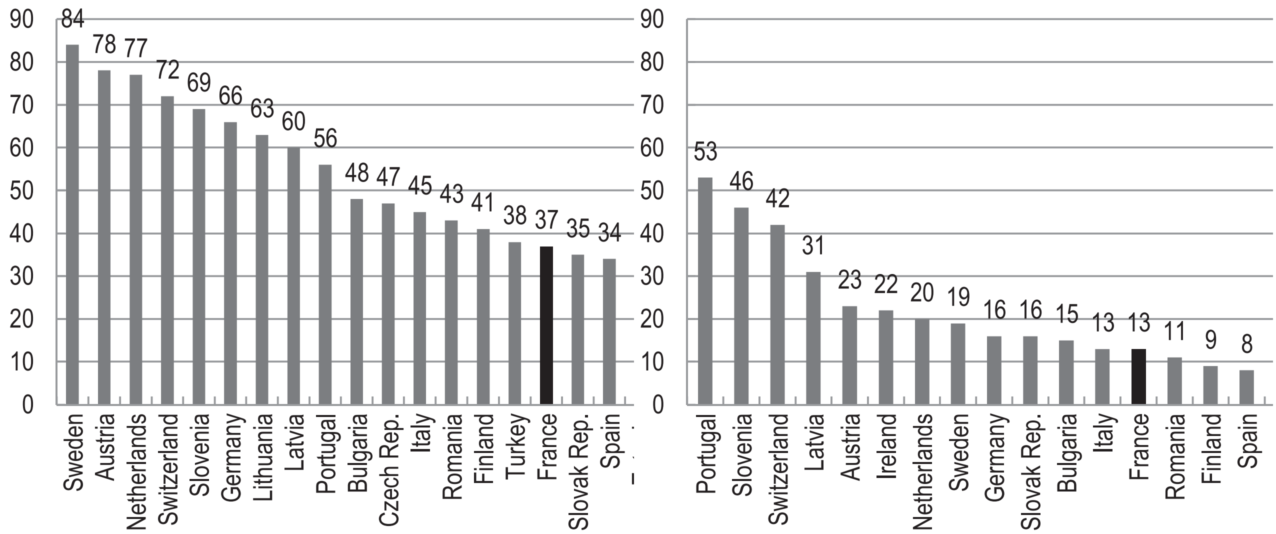
The REFLEX-HEGESCO survey also questions higher education graduate professionals on the strong and weak points of their higher education in terms of skills development. The strengths and weaknesses of the French system do not appear to differ from those of other countries covered in the survey. Although their ranking may differ slightly, the four skills most often quoted as strong points are the same: analytical thinking, mastery of own field, acquisition of new knowledge and writing of reports or documents. France differs from other countries in the use of information technology tools: while European students see this as the 6th strength of their training, French students see it only as the 11th (out of 19). Conversely, French students believe more than their European counterparts that their training developed "clarity of thought" (8th ranking of strengths in France, compared to 12th on average).

The weaknesses are also rather similar, first among which foreign language learning. While professionals in all countries state that foreign language learning is one of the main weaknesses of their higher education (Avvisati et al., 2013), France is one of the European countries with the lowest percentage of students with a good level of English (or foreign languages in general): towards the end of the 2000s, only 37% of students claimed to have a good level of English, compared to 66% in Germany and 77% in the Netherlands (Figure 3.7). France's participation in international networks is therefore partly limited by its students' poor foreign language skills.

Figure 3.7. Percentage of students with a very good level in foreign languages, 2005-08

Percentage of students claiming to speak English well or very well

Percentage of students claiming to speak two foreign languages well or very well



Source: Eurostudent III (2005-08).

Professionals in "highly innovative" jobs, i.e. working in an innovative organisation and personally participating in innovation, stand out from those who do not work in innovative jobs by their much greater use of the following skills: creativity (coming up with new ideas and solutions), critical thinking (willingness to question ideas), oral communication (presenting ideas in public), opportunism (alertness to opportunities) and analytical thinking (Avvisati et al., 2013). As elsewhere, the capacity to come up with new ideas and willingness to question ideas are not among the skills most developed by French higher education. French professionals nevertheless believe more than their European and Japanese counterparts that their education developed their critical thinking (13th rank in the most developed skills, compared to 15th on average), but developed their capacity to come up with new ideas and solutions less (14th rank, compared to 11th on average); the development of oral presentation skills is the 5th-ranking weakness (and 4th-ranking weakness on average in countries participating in the survey). Knowledge of other fields can be interpreted as the result of attention to interdisciplinarity or a certain degree of general culture and is thus important for innovation: French graduates and their foreign counterparts place its development during their training on roughly the same level of strength and weakness (in fact, slightly less as a weakness in France than elsewhere). It should be noted that while French higher education does not excel at developing most of the critical skills for innovation, nor do the other countries for which information is available.

While it does not allow an international comparison, a recent study of skills acquired by doctorate holders during their doctoral studies was also based on a retrospective subjective assessment. These graduates believe that their doctorate allowed them above all to acquire strong specific scientific skills in their thesis area (4.34 on a 5-point Likert scale), but also a strong capacity for adaptation (3.82) and innovation (3.14). Doctorate holders in life and earth sciences and in engineering sciences believe their doctorate developed their innovation and adaptation skills most, while doctors of letters, human sciences and social sciences believe their education did not foster these skills (Calmand and Recotillet, 2013).

Another (albeit partial) way to assess higher education is to observe the employability of higher education graduates. Employability rates can often assessed according to the quality of the training provided by enterprises, which find more or less usefulness to the skills acquired by new entrants. From another perspective, the social hierarchy of academic disciplines and training leads to self-selection in subject areas and a "highlighting" of skills not necessarily linked to the useful skills taught in these programmes areas, especially with regard to innovation. Be that as it may, the integration of French students into the labour market, assessed every year by the MESR, seems quite positive. Nearly 3 years after graduating, 90% of master's degree holders, 91% of vocational degree graduates and 88% of graduates of a DUT (technology degree issued by the IUTs) had a (generally steady) job. These employability rates are close to those of engineering schools (96%) and business schools (93%), measured by the 2013 *INSEE Formations et Emploi* training and employment survey (MESR, 2013b). *Grandes écoles* graduates, however, find employment more quickly, with employability rates of 94% for the penultimate 2012 graduation cohort (95% for engineering schools and 93% for management schools) and high job satisfaction rates (4.1 on a 5-point Likert scale) (CGE, 2013). Unemployment rates 3 years after obtaining their degree stood at 10% for general sciences in 2010 and 7% for vocational degrees (Calmand and Epiphane, 2012). As seen above, doctorate holders also have very good employability rates – though not always better than those of master's graduates – but are slower to find employment than doctorate holders from other OECD countries, which perhaps explains students' reluctance to study for this university qualification.

Internationalisation and training of HR

Participation in international knowledge and innovation networks plays an important role in innovation, particularly in terms of adopting tacit knowledge and know-how and finding partners in narrow skills areas. With its long history of immigration, France has in principle the means to participate in these international networks, even if public opinion pressure limits its immigration policies. While there is no certainty that the French research and innovation system makes the best use of immigrants and gifted foreigners, its higher education system is much more internationalised than the OECD average.

University and post-doctoral student mobility

The internationalisation of higher education has a significant influence on innovation and the internationalisation of the research and innovation system, of which it is both the reflection and the product. It facilitates the creation of international networks, exposure to new ideas and the transfer of tacit know-how.

Although it has lost ground in this respect in the past decades, France is still one of the countries in the world numbering the most foreign students; the number of foreign students has continued to rise, as has the proportion of foreign students enrolled in higher education. In 2010, France ranked fifth as a host country for foreign students (after the United States, the United Kingdom, Australia and Germany) and sixth in terms of outgoing student mobility (after China, India, South Korea and Turkey). With 12% of foreigners in its total student body, France hosts more students in relative terms than the average OECD country (8%), well below Switzerland, the United Kingdom or Australia (around 20%), but slightly more than Germany (10%) and well above the Netherlands (8%), Spain (5%), Italy (4%) and the United States (3%).

France continues to stand out as the world's leading host country for African students, a role it must continue to cultivate in coming years in order to position it favourably for exchanges when Africa becomes a more important economic player. France has nevertheless diversified the geographic composition of incoming students over the past decade and now hosts more Asian and American students. It must continue its efforts in that direction; the introduction of English as a teaching language can help achieve this goal.

French students are also more mobile than their OECD counterparts, with an outgoing mobility rate of 2.4% in 2011. Among the countries with the highest absolute outgoing mobility, France ranks 13th among OECD countries and 3rd among European countries (after Slovakia and Greece) in terms of relative mobility (Vincent-Lancrin, 2014). The country's outgoing mobility rate is well below the 20% anticipated in the European Union's "Horizon 2020 strategy", though this target is particularly unrealistic: only small countries or countries with an undeveloped higher education system now have an outgoing mobility rate greater than 20% (OECD and World Bank, 2007).

The number of foreign doctoral students studying in France stood at 27 400 in 2012, or close to one-quarter of doctoral enrolments. This figure has been rising for 20 years, more rapidly than the total number of doctoral enrolments over the period (19 480 foreign doctoral students in 1993). This increase has clearly benefited the sciences (around 12 000 doctoral candidates in 2012), literature and humanities (around 9 000) and, to a lesser extent, law and economics (between 2 000 and 3 500). These enrolments and the success of doctoral programmes naturally involve a thesis defence: three times more (i.e. around 3 000) doctoral students defended their thesis in scientific fields in 2012 than in 2003 (1 000 students). This growth clearly benefits the opening of research laboratories geared towards Asian students, who accounted for 10% of enrolments in 2002 and close to 31% in 2012 (MESR, 2013c).

The post-doctoral experience of young doctorate holders trained in France is also an indicator of the quality and integration of HR produced by the French research system. The proportion of these post-doctoral studies has been stable since 2009, particularly in France (nearly 40%), outside the European Union (30%) and within the European Union (around 20%).

Despite an established internationalisation policy, backed by the Campus France agency, France still does very little compared to the United Kingdom and Germany to attract and host foreign students, and offer them appropriate facilities and courses. Among the handicaps identified, the General Inter-Inspection Mission (MII) carried out by four ministries (MII, 2013) highlights the administrative support to foreign students, which is insufficient during and after their stay compared to other European countries (the Netherlands, United Kingdom or Germany) or non-European countries (the United States or Singapore), which are more proactive in this respect.

Despite real internationalisation in quantitative terms, there is currently no indicator to measure France's relative appeal to the best foreign students compared with other countries. While the mere presence of foreign students is beneficial to the French higher education system, attracting foreign students who will become involved in innovation or entrepreneurial networks, in France or elsewhere, would be an asset for French research and innovation.

Studies on the integration of foreign students in France after completion of their studies are still very inadequate, with the exception of some studies that focus on outcomes for foreign doctoral student (Confédération des Jeunes Chercheurs, 2012), isolated university initiatives or a more recent study by Campus France.

The participation of "gifted" foreigners – whether students, former students, professor-researchers or researchers – in French research and innovation is based in part on immigration policy. In its report, the MII identifies a number of weaknesses, but also some strengths of the framework for hosting "gifted individuals" in France, defined as "students having at least a master's 2 (Bac +5), researchers, artistic professions, high-level athletes, highly qualified employees, investors and entrepreneurs, and promoters of a specific project contributing to the international influence of France" (MII, 2013). Table 3.1 shows residence permits granted in France to different categories of "gifted individuals".

Among its 27 recommendations, the report recommends, among others, a complete overhaul of the conditions for granting residence permits to "gifted people" and their families by reducing the length of time required to obtain them. These measures could, for example, involve temporary residence permits bearing the title "scientist-researcher". Taxation and better communication of measures (clarity and coherence) both within and outside the national territory are also important policy instruments.

Table 3.1. Residence permits granted in France to "gifted foreigners" between 2007 and 2011

	2007	2008	2009	2010	2011
Number of permits issued (except renewals)					
"Skills and expertise"card (newly arrived)	5	184	372	321	293
European Blue Card	–	–	–	–	–
Temporary "scientist-researcher" residence permit	1 502	1 885	2 042	2 058	1 946
"Skills and expertise" card and Long-term visa for study purposes – "Student" residence permit	5 240	5 760	6 270	6 490	7 150
"Artistic and cultural profession" temporary residence permit	261	288	183	174	165
"Exceptional economic contribution"* residence permit	–	–	–	–	–
Total	7 008	8 117	8 867	9 043	9 554

Note: *Three residence cards of this type were issued in 2012.

Source: MII, from data provided by the General Secretariat for Immigration and Integration (MII, 2013).

Challenges to improving the quality of training in higher education

The contribution of French higher education to the training of innovative HR thus seems mixed. French higher education trains (and grants degrees to) a significant proportion of the French population, higher than the OECD average for the youngest cohorts. Although it produces fewer doctorates than other countries, this is partly due to the fact that the *grandes écoles* partly fulfil the function of the doctorate (i.e. to train the highest level of specialists or generalists), companies and the civil service attach less value to this qualification, and the dichotomy between *grandes écoles* and universities probably makes the pursuit of a doctorate less natural and desirable for graduates of *grandes écoles*. As for skill development, the strengths and weaknesses of French higher education follow roughly the same order as in other countries for which such information is available. Moreover, while skills for innovation are moderately developed in France and elsewhere, French higher education seems to prepare relatively well for both the working world and entrepreneurship. Training for innovation and entrepreneurship seems universal in the *grandes écoles*, albeit in highly varied formats, and is also developing in universities. Current sources do not allow a convincing comparison of graduate skill levels, and the same hierarchy of strengths and weaknesses does not imply the same development of skills: for example, while graduates of all countries believe that their education did not adequately develop their foreign language skills, French students appear to far less competent in this area than their European counterparts. The reverse may be true in other fields.

France faces two important challenges: on the one hand, it needs to increase the quality of training and the success of students undertaking generalist undergraduate degrees and master's degrees at university, and on the other, to continue to develop skills and attitudes favourable to innovation, which seems to be the prerogative of vocational schools and vocational training rather than universities. This could involve a renewed division of labour between higher education institutions and training, but also renewed reflection on the place of teaching in the strategies and policies of higher education stakeholders.

A new division of labour between institutions

In some countries, the division of labour among higher education institutions gives universities limited scope for basic vocational training, restricting access to these institutions to academically stronger students. This training is ensured by short programmes that are less onerous for the public authorities. In the Netherlands, for example, 70% of students are enrolled in HBOs – vocational higher education institutions. In the United States, community colleges provide short-term general or vocational training to 40% of students, and state-run universities offering 4-year courses are clearly teaching – rather than research – institutions. The teaching missions in these countries are relatively clear, even if there is always a risk of mission shift. In other educational systems, such as the United Kingdom's, there is no nominal distinction among institutions, even a strong distinction exists in practice. In France, similar missions are ensured by several types of institutions and training – and by several types of teaching staff (secondary school teachers, generally holding the *agrégation* qualification, professor-researchers or researchers). Redirecting certain students who currently enrol in universities "by default" towards short vocational training that would offer them a greater chance of success seems both advisable and logical.

One of the measures in the 2013 Law on Higher Education will make it possible to direct technology baccalaureate holders towards IUTs and vocational baccalaureate holders towards STSs, by allowing rectors to set quotas for holders of such diplomas in these programmes. Insofar as the number of vocational students will rise significantly in coming years, this effort is welcome. The effectiveness of these measures will depend on the manner in which they are implemented and may mean that all available places in IUTs and STSs are taken up. This restreaming may also have just as much of an impact on specialist schools as on universities.

The proposed introduction of an additional filter for admission to university is often mentioned in the interviews conducted, as well as in several reports on French higher education. The baccalaureate – the first level of higher education – is naturally the first selection criterion, but is combined in vocational higher education with a scrutiny of applicants' academic record. Universities also select on the basis of the academic record for certain undergraduate courses, namely IUTs and vocational degrees. On that note, it is fair to question why they are selecting for vocational degrees rather than general undergraduate degrees. Additional selection requirements the general *licence* might help universities make their initial training more attractive to the best students, as well as clarify their mission. Restreaming could be offset by increased efficiency, linked to more rapid student success and less restreaming and repeating. Moreover, vocational schools may not be better equipped than universities to accommodate students they have been reluctant to admit so far. There is no record of any public study focusing on different cost and achievement scenarios.

Perhaps due to the diversity of their students' educational background, French universities have found it difficult to establish research-based vocational training, with a vocational component directly linked to research skills. General undergraduate degrees often merely provide students with advanced subject knowledge. It is conceivable that students could take part in empirical research or even interdisciplinary projects in their field beginning at the undergraduate degree level.

The institutions in which baccalaureate holders would be *entitled* to enrol when all their other choices have been rejected remains to be seen. In the United States, community colleges play this role. Introducing selection for *all* higher education programmes risks reducing the rate of admissions and the percentage of higher education graduates in the population, with a negative impact on the system and on French research and innovation in the absence of a dual education system such as that in place in Germany or Switzerland.

A foreign observer would be surprised to find that it is the university's mission to admit students as a last resort. The right of access to higher education did not initially guarantee success, and this is still the case for many university students. As has been seen, the cost structure of different training programmes in France also differs from that in the above-mentioned countries, since their general undergraduate degree is the cheapest study programme. Selecting or restreaming university students towards other study programmes will require a budgetary effort that may have dulled the enthusiasm of public decision makers, even if they may change the cost structure of educational programmes.

Specialisation and site strategy

Another (possibly complementary) solution is to establish university campuses bringing together several institutions, gradually differentiated and ranked according to their enhanced autonomy and competitive allocation of research funds. The policy of establishing contractual arrangements also encourages universities to define an institutional framework and identity. These groupings are encouraged by the 2006 Law on Research, the "Campus Plan", the PIA and the 2013 Law on Higher Education.

In reality, French universities and higher education institutions already have a hierarchy. Some universities are more like research universities than others, and most doctoral schools with research master's students are already concentrated in a small number of French universities. The aim, therefore, is rather to ensure the clarity of the hierarchy.

Greater differentiation could be beneficial to universities' teaching mission: if some universities lose their international research ambitions, they will be able to focus on other activities, such as high-quality education. There is no certainty, however, that such a spontaneous organisation will be established, in that universities and their staff continue to be encouraged to promote research over other missions, for reasons related to careers and prestige. The relative lack of differentiation of universities (or the lack of transparency of the hierarchy) benefits students: their national degrees give them access to competitive proposals and jobs, even if some are in fact more prestigious than others and university degrees have long allowed differentiation. The principle of equal status for institutions and academics also facilitates the mobility of academics – which in the absence of real career management, is a key element of their career progress.

The bringing together of different types of institutions and training programmes in groups or university campuses has potentially positive impacts in terms of training and developing skills for innovation. While they have the advantage of fostering a wealth of practices and variety in training, the diversity and fragmentation of French higher education do not always help disseminate good educational practice within the system, or even an understanding of several traditions of teaching and thinking by students from different types of institution. It is often thought that universities' failure to acknowledge graduates of the *grandes écoles* has a negative effect on links between industry and universities. The bringing together of such institutions could mitigate this problem and allow the educational practices of the *grandes écoles* to spread (even though it cannot be said whether the latter would be as successful without the strict student selection taking place before entry). In certain cases, it could also allow multidisciplinary training to develop and foster conditions to promote greater co-operation for innovation. This was the path taken, for example, by the University of Aalto in Finland in 2010, which resulted from the grouping of Helsinki University of Technology, Helsinki Business School and Aalto School of Art, Design and Architecture.

While it is important for such groupings to be possible, they should not be encouraged as a matter of principle. The synergies referred to above may very well arise without grouping institutions, and a great deal of programmes are already been jointly supervised by several institutions. Synergies between institutions already exist, mainly owing to the higher number of pathways among programmes, requiring institutions to build mutual awareness and sometimes allowing them to enhance their programme with courses they do not offer themselves. Today, co-operation also goes beyond national borders, and the number of dual and triple degrees is increasing, spurred by European programmes such as Erasmus Mundus (which even promotes the much less popular joint degrees).

Other arguments for establishing groups are often based on the pooling of resources, but above all on excellence, international "visibility" or "renown", which would attract gifted foreigners into the teaching and student bodies: large structures would be more visible through bibliometry, and therefore through foreign students and teachers, who would be better able to understand the French system because of the smaller number of sites. These arguments deserve more elaboration. On the one hand, insofar as they are added on to the old structures, French-style groupings make the French higher education system even less transparent than previously. There is a need to simplify existing structures in order to make them more efficient. It must be noticed that not all fields of activity benefit to the same extent of an increase in size. The most prestigious world universities are medium or small-sized, such as Harvard University (2 107 faculty members, 22 000 students), Stanford University (1 910 faculty, 15 300 students), Massachusetts Institute of Technology (MIT) (1 018 faculty, 10 900 students), Yale University (3 700 faculty, 11 700 students), Princeton University (1 172 faculty, 7 000 students), University of Oxford (21 500 students), University of Cambridge (6 000 faculty and 18 500 students), Columbia University (3 220 faculty and 20 000 students), or the University of Tokyo (7 600 faculty and 27 800 students). By comparison, the University of Strasbourg has 40 000 students, the University of Lorraine 54 000 and the University of Aix-Marseille 70 000. Groupings make more sense at the doctoral level, where critical mass allows for more specialised training, richer seminars, more diversified interaction among researchers and students, etc. Foreign universities listed above owe their prestige to their research activity and the training of PhD students.

While there may be legitimate reasons for mergers and groupings, they may not need to be defended as a matter of principle. These groupings also entail organisational and transactional costs and may lead to fewer and less diverse programme choices – and a plethora of missions within the sites – which does not necessarily make defining a true institutional strategy any easier. In the case of the French system, higher de-compartmentalising among different types of institutions can be expected. Certain groupings, such as the Saclay Plateau, should allow promising synergies between the leading *grandes écoles* and French universities. According to people interviewed during this review, the clusters at Nancy or Strasbourg have also fostered the dissemination of the good practices of the *grandes écoles* in the universities, as well as other fruitful exchanges between the parties involved.

Above all, the strength of these groupings lies in the momentum for change and the opportunities for innovation and improvement they offer at the teaching and research level – at least if they focus less on creating new institutional structures than new ways of teaching, carrying out research and serving society.

Lending greater weight to the training mission of universities

While one of the challenges facing French higher education is to train students better for innovation, particularly at the university level, the innovation dynamic driven by the various higher education reforms and the PIA could seek to ingrain further the importance of training within the different missions of higher education, and particularly universities. Businesses benefit as much from well-trained HR as from academic research in order to develop and implement their innovations.

Lending greater weight to teaching is a challenge for all OECD countries, such is the domination of research over higher education and educational policies. International rankings, such as the Shanghai ranking, do not feature any teaching-linked indicators in their composite indicators. Indeed, that is not their objective.

Nevertheless, France has a tradition which values teaching outside the universities. A significant part of its elite higher education, in fact, had the sole mission of teaching (which is still true for certain curricula): *grandes écoles*, preparatory courses, IUTs, BTSs and specialist schools did not focus on world-class research. Preparatory course teachers are better paid than lecturers and are not expected to do research. With their limited number of permanent faculty, the *grandes écoles* did not particularly value research profiles for their teaching staff, at least until the changes that have taken place in recent years. Indeed, this could have become a handicap in a world in which knowledge develops rapidly and where a connection to research is therefore necessary for advanced technical teaching. Suffice it to say that valuing teaching (without research) at the higher education level does not constitute a "Copernican revolution" for the system, regardless of what might be thought elsewhere.

The challenge for the universities is different. It involves enhancing the quality of teaching in general training by granting greater recognition to this mission among professor-researchers, researchers and universities. Through the PRL graduation plan, the LRU Law aimed to support innovative teaching strategies in generalist degrees. The PIA did the same thing with the IDEFI excellence initiatives. Finally, by redefining the bachelor's degree (*licence*), the 2013 Law on Higher Education set an important marker and established a new framework for education. Although slightly improved, the success rate is nevertheless not sufficiently high in master's courses, particularly for average students – perhaps because too little attention is paid to whether the educational programmes and curricula meet student needs.

While it is too early to assess the outcomes of the IDEFI, the implementation of the PRL has been rife with difficulties.

In a memorandum on the implementation of the PRL, the IGAENR states that the objective of improving student success in L1 "is far from unanimous among professor-researchers" and that it is "very difficult to promote such a mechanism to professor-researchers who are not particularly motivated by these aspects of student training, given that their own professional assessment is based on their research output, as well as to students who are only interested in support measures endowed with ECTS [European Credits Transfer System] or extra credits" (IGAENR, 2010). Thus, universities that have benefited from the PRL may have disbursed only 25% to 50% of these resources on measures to promote undergraduate success, essentially by supporting or expanding existing teaching or mentoring initiatives (IGAENR, 2010).

The French Court of Auditors makes the same observation in assessing the PRL: it also notes that resources were underutilised, which it attributes in part to the fact that the MESR had not notified the universities of a timetable for this multi-annual plan and to risk avoidance by the universities given their new their budgetary context, as well as to the fact that, "taking advantage of the increasing globalisation of their operating resources, the universities tended to consider such resources to be 'subsumed within their assets as a whole'. The result was that the loans were more often than not underused, the corresponding remaining balances being credited to universities' general operating costs" (French Court of Auditors, 2012). The Court also states that: "Although the majority of mechanisms were established by general legislation, in many cases their implementation remained on the initiative of the institutions, which did not necessarily regard undergraduate success as a priority in itself. The de facto pre-eminence attributed to research in the career of professor-researchers does not foster increased investment on their part in teaching activities" (French Court of Auditors, 2012).

In short, it is not sufficient to promote or fund educational initiatives for them to be implemented, since incentives for professor-researchers and university presidents to devote time and resources to improving training for the majority of students are limited.

The public authorities, furthermore, help to shape these weak incentives. As in many other OECD countries, higher education policy places greater emphasis on research, partly because of the pressure of international rankings, which are based almost exclusively on research indicators.

Education and training have a relatively limited place in both the LRU Law and the PIA, which focus on reforming university governance and encouraging excellence in French research, even though the quality of training is also one of their objectives. The expected impact on the quality of the training proposed is often merely indirect and mainly concerns the training of elites, particularly through research.

The PRL was the most ambitious policy to address the problems of the general undergraduate university degree (*licence*). At the budget level, however, it represents a tiny portion of initial and continuing education expenditure from the baccalaureate to the *licence*, since the plan has an appropriation of EUR 730 million over 5 years, including EUR 565 million for the overhaul of the general *licence* (EUR 113 million per year on average). In 2011, the plan's credits totalled EUR 212 million – i.e. 7.6% over the EUR 2.7 billion spent on initial training (or an annual average of 4%). The French Court of Auditors notes that, "even though the intended objectives were without doubt not very realistic, the combination of high ambition and available funds which allowed only cursory measures should have ensured a selective distribution of the appropriations provided in order to optimise the effectiveness of the plan" (French Court of Auditors, 2012, p. 664). The Ministry of Higher Education and Research in fact allocated the funds with no real selectivity and monitored the plan only to a limited extent. The French Court of Auditors thus laments the Ministry's "lack of guidance", which possibly reflects the low priority accorded to training within the Ministry itself. The priority given to research and the limited attention paid to the training of HR and their contribution to productivity or innovation were clearly highlighted as a blind spot– if not as an assumed and conscious choice – during interviews with public decision makers responsible for the LRU Law.

What is more, despite the inclusion of training issues in the LRU Law, the LRU Law monitoring committee has made very few recommendations on this matter. The 2012 LRU Law monitoring report contains no formal recommendations on initial training, despite a section on student success that calls for institutions' pedagogical autonomy, a strong link between training and research and the introduction of a "genuine assessment" of educational programmes and training. The 2011 LRU Law monitoring report recommends further encouraging researchers at institutions to teach in order to enhance the quality of the link between training and research. In the same vein, the 2010 report recommends "ensuring the continuity of the training-research link – universities' great asset – within the institution, irrespective of the choice of structure", referring to the importance of co-ordination between training and research units and their research components and units.

The PIA also funds several projects related to training excellence in the context of its initiatives for excellence (Idex), through a call for proposals for the "initiatives for excellence in innovative training" (IDEFI). As far as we know, this action is unprecedented. Direct and indirect actions in favour of training represent only a very small fraction of the funds allocated by the PIA, despite the significant budget devoted to higher education and research. Out of the EUR 34.64 billion budget devoted to the PIA, EUR 18.9 billion are allocated to higher education, research and training (Priority 1) – 54% of the total budget. Under this budget, improvements in training are covered *directly* by the IDEFI (part of the "Idex"), and *indirectly* through the Campus Plan, which can be expected to have an impact on the teaching conditions of the institutions concerned (even if it should have just as much of an impact on research). Education is also present through the actions of the "boarding schools for excellence" (EUR 500 million) and its inclusion as a target for aid directed at R&D in the digital economy (through support for innovative digital uses, services and content). Finally, EUR 500 million are also allocated to improving the vocational training infrastructure ("development of training facilities and accommodation for young workers") (Finance Bill, 2012).

A review of the budgets calculated by the French Court of Auditors (2013) – which make it possible to assess the consumable and non-consumable parts of the PIA and thus present a real "spendable" budget for each initiative – shows that the IDEFI measure for higher education programmes represents EUR 186.2 million of the EUR 8.8 billion pegged for future investment projects managed by the French National Research Agency (ANR) – i.e. 2.1% of these funds and around 1% of the PIA. This is the only PIA measure that *directly* concerns training in the undergraduate and master's degrees – and hence one of the main challenges highlighted above. The Campus Plan, endowed with EUR 524.2 million to finance real estate transactions, will also benefit all students by improving the buildings in which they are taught (but will also benefit the research conditions just as much): it represents 8% of the funds dedicated to higher education and research (and 4% of the PIA as a whole).

Other measures also contribute indirectly to improving training, particularly PhD training, through improved research conditions in research laboratories: the Labex (laboratories for excellence) excluding Idex) (EUR 689.5 million), which improve research conditions in some laboratories; and Idex with their Labex (EUR 2.2 billion), which are intended to develop world-class multidisciplinary clusters and also include innovative training (25% of the IDEFI budget is pegged for Idex). Labex and Idex funding represents 32% of the ANR-managed PIA budget. Insofar as bachelor's and master's degree teaching is today quite often removed from the boundaries of knowledge, such investments can be expected to benefit the training of PhD candidates, particularly in these laboratories and new higher education clusters (i.e. around 1% of French students). Finally, the Saclay Plateau will benefit the 30 000 students from 2 universities and 11 *grandes écoles* (i.e. around 1% of French students) who will be studying there when operation is complete: the PIA allocates EUR 1 billion (or 11.3% of PIA funds managed by the ANR) to the Saclay initiative. These indirect measures, which represent 43.3% of the PIA budget allocated to higher education and around 20% of the total PIA budget, are clearly intended to reinforce the excellence of the best French institutions and students, rather than improving the overall quality of French higher education training. They will affect around 2% of French students directly or indirectly, which is consistent both with the current French model of innovation focusing on a small elite and with the philosophy of the PIA.

Insofar as the stakeholders responsible for training and research tend to take decisions favouring research and the training of elites, broadening the HR base capable of contributing to the French innovation system could involve a greater separation of training and research budgets (and policies), as is the case – at least in formal terms – in the United States and England. Education and research in these two countries are funded separately by different institutions. Universities' operating resources could, for example, be applied only to their teaching and research linked to education (sometimes known as scholarship in English-speaking countries), and thus fund only limited research by professor-researchers, while the additional "research for excellence" could be funded by the ANR and research bodies, and supplementing such funds.

This would involve further reflection on the status and career of teaching staff, a different allocation (with a possible increase) of higher education expenditure and measures to make the professor-researcher career path more appealing. Like primary and secondary school teachers, French professor-researchers often have less favourable working conditions and salaries than their foreign peers (measured in purchasing power parity) (Altbach et al., 2012), even if differences among the various statuses and structures of the academic profession may make comparisons difficult (Musselin, 2005). The Labex have addressed the lack of international appeal of French research and higher education by increasing the resources allocated to research and researchers' working conditions – but this lack of appeal may also relate to the appeal of a career as a professor-researcher to the France's top graduates.

The planned – but always postponed – assessment of professors-researchers should include criteria that genuinely recognise teaching, programme development and involvement in excellence or innovation learning schemes. Like research, teaching could be assessed, not only by students – which is the norm in many institutions as a formative mechanism – but also by peers. Remarkable teaching skills could also be rewarded through promotions, special statuses and salary increases. In short, improving the quality of pedagogy and teaching at university without reappraising the career management of professors-researchers seems difficult.

As in school education, pedagogical innovation encompasses, among others, initial and continuing teacher training. No teacher training provision currently exists in France for professors-researchers and higher education teaching staff. While it must be acknowledged that France is not an exception and that higher education teaching staff have rarely undergone teacher training, many universities now offer their staff the opportunity to improve their teaching with teaching support or continuing education. Such services do not appear to exist in French universities. McGill University in Canada, for example, supports teaching staff optional teaching and learning services to develop their teaching skills or improve their courses. Te Teaching and Learning Laboratory (TLL) at MIT plays the same role and other universities use the same model.

Other models supporting teaching quality are used elsewhere (Hénard, 2010; Hénard and Roseveare, 2012). In the case of France, two pathways initiated by the higher education reform and the PIA could be made permanent: a fund for pedagogical innovation in higher education (as exists in the United Kingdom) and a formal mechanism for exchanging pedagogical know-how and practice, both classroom-based and online, which would help pool and disseminate best practices and promising practices, fostering knowledge transfer among different types of institutions. These additional funds should be allocated on a competitive basis and within an effective assessment framework to teams and institutions capable of producing demonstrating the best projects.

As with school education, an important contribution of the PRL Successful Graduation Plan and the PIA, with its IDEFI, lies in the very act of funding pedagogical experimentation and innovation (even if the PRL rarely funded innovation, but rather supported existing pedagogical measures). Institutionalising a fund for pedagogical experimentation and innovation along the lines of the IDEFI – by assessing the most ambitious experiments – and funding seminars and national exchange networks on pedagogical innovations (both successful and unsuccessful) in institutions could contribute to developing teaching models that will allow higher education to develop the HR required by its research and innovation system.

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Chapter 4

Public research in France

This chapter presents the French public research system. By comparing international statistics, it analyses France's output in science, research organisations' primary sphere of activity: the number of articles published, recipients of international grants, etc. It goes on to examine the major public research organisations, such as the National Centre for Scientific Research, that are central to public research in France, as well as research at universities: its budgets, staff management and governance. These sectors have undergone successive reforms over the past decade. This chapter analyses them in detail, focusing in particular on the development of project funding and evaluation.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Introduction

Until recently, and even to a large extent today, the French public research system focused on large public research organisations (PROs), the largest of which is the National Centre for Scientific Research (CNRS). These PROs fulfil all the primary functions of a public research system: planning, funding, implementation and evaluation. This structure is unlike that of other countries in the world, where PROs are generally smaller and have more limited powers, where universities play a greater role in performing research and where resources – especially financial resources – are allocated by separate bodies.

Successive French governments since the late 1990s have sought to foster scientific excellence and to steer public research towards specific economic, social or environmental objectives. They believed that a more open organisational structure, in which politicians would have more control over planning and the various powers would be exercised by separate entities, would be more appropriate to these objectives. In this context, successive reforms over more than a decade have created new structures and mechanisms, generally reflecting a rationale closer to that of the international model. Consequently, the public research system has undergone a number of changes and reforms since 2005. The Law on the Freedoms and Responsibilities of Universities (LRU Law) in 2007, the creation of research and higher education clusters (PRES), the National Research Agency (ANR) in 2005 and the Evaluation Agency for Research and Higher Education (AERES) in 2007, and the "Investments for the Future" Programme (PIA) in 2009, which involved the establishment of the Idex (initiatives of excellence), are all changes that have shaped the French research landscape. These measures all have in common the quest for excellence and an increased focus on directing research towards socio-economic objectives. The chosen pathway is to concentrate research funding on teams or universities that fulfil the excellence criteria and are working on government-selected priority areas. At the same time, some PROs have themselves taken the path of reform, with the aim of promoting excellence internally and responding more systematically to the economic and social requirements of research with the framework of their existing structures and procedures. The new mechanisms and stakeholders complemented, rather than replaced, the old ones, even as some underwent significant changes: the system has therefore become less consistent while also becoming significantly more complex, leading to decreased transparency and increased operating costs.

The system now finds itself in a hybrid situation, which raises questions that will be discussed in this chapter: how does the quality of French science compare with that of other countries? How are the PROs positioning themselves in relation to the changes underway? To what extent are universities prepared to play the central role assigned to them under the new rationale? Do the new mechanisms concerning the competitive allocation of funding and evaluation meet expectations? How can the overall balance of the system be optimised in light of the various transformations underway?

This chapter will first describe how French science compares with that of other countries. It will then analyse the main stakeholders – the PROs and universities – as well as the resource allocation mechanisms (recurring or competitive) and the evaluation mechanisms.

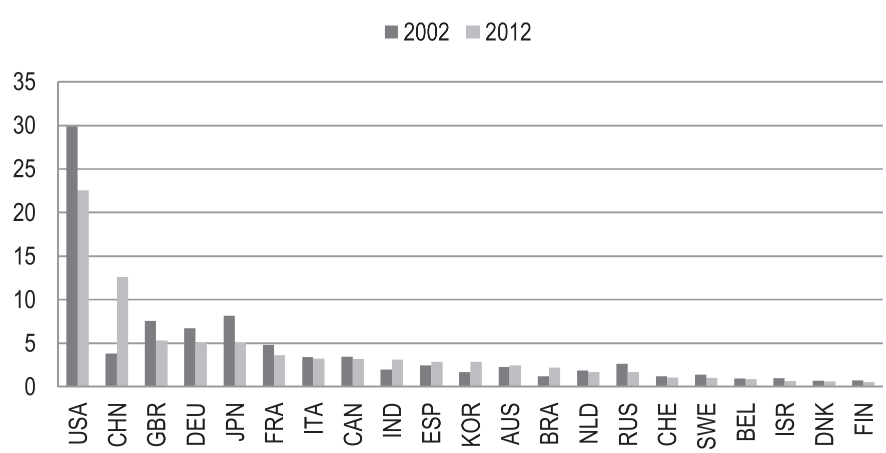
Scientific output and the cost of French public research

Scientific output of French research

It is surprisingly difficult to provide an overview of the scientific output of French research, and particularly to provide an analysis combining information on the system's performance with budgetary data. French scientific output has not recently been subjected to a detailed independent review (the 2013 report by the French Court of Auditors provides a very in-depth analysis of resources, but does not review output in the same detail). This contrasts with other aspects of the French research and innovation system (SFRI), which have been the subject of recent reports, such as the General Inspectorate of the Administration of National Education and Research (IGAENR) and Beylat-Tambourin reports on the commercialisation of public research and the Gallois and Beylat-Tambourin reports on industrial innovation. It would be helpful for the French Government to commission such a study, including a detailed analysis of performance indicators (publications, etc.) and budgetary data for the stakeholders concerned (organisations, universities). An annual publication produced by the Observatory of Science and Technology (OST) as part of the AERES and presented to the French Ministry of Higher Education and Research (MESR) would enable objective and official monitoring of the issue. Without such information, analysis can only be conducted on a relatively general level.

As measured in terms of publications, France has average scientific output in comparison with other countries of a similar size. In number and quality of publications, it is significantly outstripped by the United Kingdom and Germany, but is ahead of Italy and Spain. This intermediate position has not changed substantially over the past decade – an indicator of the low impact of the reforms undertaken so far.

Figure 4.1. Global share of scientific publications, 2002 and 2012

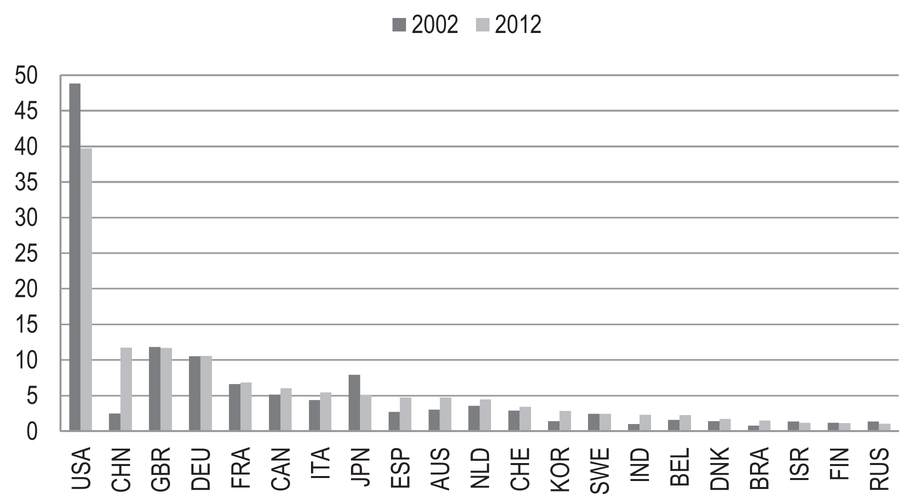


Source: OST, http://www.obs-ost.fr/fr/frindicateur/analyses_et_indicateurs_de_reference.

France's scientific output is average in relation to other countries of similar size in terms of publication numbers. Measured in terms of both the numbers and quality of publications, it is significantly outdistanced by the United Kingdom and Germany, but is ahead of Italy and Spain. This intermediary position has not changed substantially in the last decade, indicating that the reforms undertaken to date have had a limited effect on scientific output.

Between 2002 and 2012, France's global share of all scientific publications (Figure 4.1) fell from 4.8% to 3.6%, while Germany's share went from 6.7% to 5.1%, the United Kingdom's from 7.6% to 5.3% and Italy's from 3.4% to 3.2%. This reduced share among most countries is due to the rise of emerging countries and particularly China, whose share increased from 3.8% to 12.6%, while India's rose from 2.0% to 3.1% and Brazil's from 1.2% to 2.2%. Thus, France's quantitative decline, which concerns also other developed countries, largely reflects the arrival of new countries on the world's scientific stage.

Figure 4.2. Scientific publications: Countries' share in the 10% most frequently cited, 2002 and 2012



Source: OST, http://www.obs-ost.fr/fr/frindicateur/analyses_et_indicateurs_de_reference.

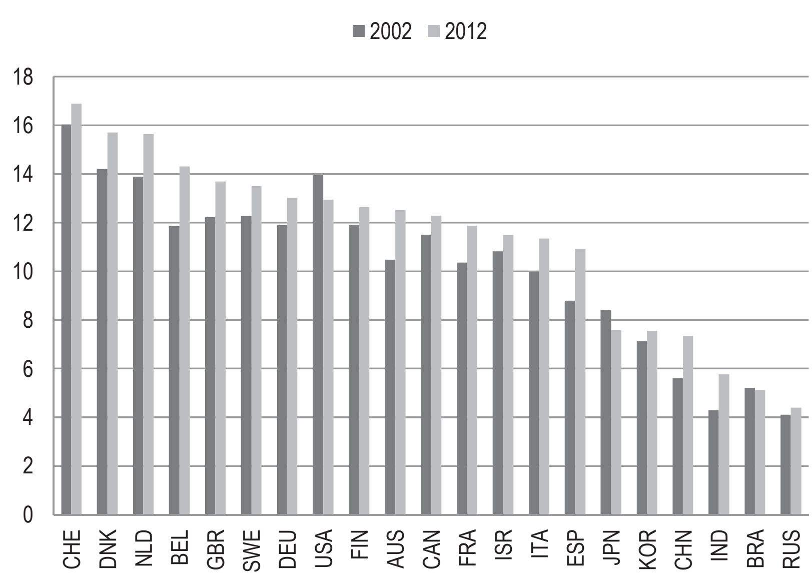
It is generally accepted that only a fraction of scientific publications are valuable enough to significantly affect the course of science or lead to applications. It is therefore a matter of identifying these publications to calculate them. The criterion most often used is citations – the number of citations received by an article purportedly reflecting its scientific value. Counting the share of the countries with the most frequently cited articles, we have identified the 10% most frequently cited (tests with the top 5% and top 1% produced similar results). France's share of the 10% most frequently cited publications relative to comparable countries is also average (Figure 4.2): it went from 6.6% to 6.9% between 2002 and 2012, while Germany's share went from 10.5% to 10.6%, the United Kingdom's fell from 10.8% to 11.7% and Italy's rose from 4.4% to 5.4%. These shares are higher than to these countries' shares in the total number of publications because of the relatively lower quality of publications from emerging countries such as China, which are therefore cited less often. The increase of China in the total publications explains directly the increase in the relative rate of citations of developed countries as it reduced the world average. The United States remains the world's leading scientific power, accounting for 39.7% of the most frequently cited publications in 2012 – compared, however, with 48.8% in 2002.

When comparing countries for this indicator, it is important to control for size: it is natural for a small country, such as Denmark, to produce fewer publications than a large country, such as China, quite apart from the quality of its scientific research. The rank often attributed to France as the 4th or 5th most important scientific power says more about the size of the country than its actual research performance: evaluating France's performance requires studying indicators reflecting the individual quality, rather than the number, of its publications. The average quality of each country's publications is measured by the share of their publications which feature among the 10% most frequently cited publications (Figure 4.3). This amounts to comparing among countries the probability that a publication from the country will feature among the 10% most frequently cited. A country for which this indicator is high has a larger share of qualitative articles among its total publications, the world average being by definition equal to 10% (in fact, for statistical reasons it is slightly different). This can also be interpreted as reflecting greater selectivity in that country's scientific policy: funding is probably restricted to research that is deemed promising, evaluated *ex ante* as having great potential. Conversely, a country whose indicator is low can be seen as having a "broader" policy of financing a number of low-value research projects. In this context, this indicator reflects the relative selectivity of national scientific research funding models. In 2012, France's indicator was 11.9%; Germany's indicator was 13.0%, the United Kingdom's 13.3% and Italy's 11.4%. Some countries are way ahead, such as the Netherlands (15.7%) and Denmark (15.6%), while others are behind, such as Spain (10.94), Japan (7.6%), China (7.3), whereas the United States are at 12.9%. The increase in the indicator for most countries between 2002 and 2012 comes notably from the increase in China's share in total publications, which has reduced the world average of citations.

Overall, France therefore appears to hold an intermediate in terms of the quantity – and even more so the quality – of its scientific publications. French research appears both averagely productive and averagely selective.

Figure 4.3. Scientific publications: average quality indicator

(share of the country's publications which are among the 10% most cited in the world), 2002 and 2012



Source: OST, http://www.obs-ost.fr/fr/frindicateur/analyses_et_indicateurs_de_reference.

Beyond the national aggregate level, the position of individual stakeholders – in France's case, mainly PROs – can also be reviewed.[1] The performance of PROs in terms of publications was recently quantified as part of a broader review of major research organisations in Europe (Science Metrix, 2013). First, it appears that France has a high institutional concentration of publications, with the largest (the CNRS) and the fifth-largest (National Institute of Health and Medical Research [INSERM]) PROs in Europe. The CNRS produced nearly 189 000 publications between 2007 and 2011, compared with 62 000 by the Helmholtz (Germany), the next-largest organisation. In terms of the quality of the publications (as measured by the number of citations or the standing of the journals in which they are produced, adjusted for thematic structure; thus, the size of the institutions evaluated and their disciplinary focus do not affect their ranking), the CNRS falls behind most comparable large organisations in other countries, except for the Italian National Research Centre (Science Metrix 2013, Table V, p. 36), while INSERM fares rather well. In some areas, French PROs rank among the best, such as in mathematics (CNRS), physics and astronomy (Alternative Energies and Atomic Energy Commission [CEA]), and information and communication technologies (ICT [INRIA]). In other areas, French PROs rank better than average, such as biology (CNRS), cognitive sciences, health and clinical medicine (INSERM). By contrast, in many areas, such as humanities and social sciences (HSS) and clinical medicine, the CNRS ranks poorly or very poorly. The rather average overall ranking of the CNRS is the result of satisfactory rankings in some areas and much less satisfactory rankings in others; this presumably raises the question of the size and range of research fields at this organisation, especially since the areas where it produces lower quality are mainly the focus of other organisations (clinical medicine at INSERM and in hospitals, HSS at universities, etc.).

Researchers' level of excellence: European Research Council (ERC) grantees

ERC grantee figures by country, field and age group provide an insight into the importance of this "level of excellence" among researchers. ERC grants are awarded on a competitive basis at the European level in response to "open calls", i.e. calls stating minimal thematic content, thus allowing open proposals produced by the researchers themselves. There are three eligible research areas: physical sciences and engineering, life sciences and HSS. There are two types of ERC grant: "starting grants" for researchers under 35 and "advanced grants" for more experienced researchers. Grantees may be considered as undertaking projects recognised by their peers; they are "excellent" researchers. A country's share reflects its standing in the level of excellence of European researchers. Researchers can be affiliated with a country based on two distinct criteria: nationality (e.g. a French researcher is affiliated with France, regardless of the country where the research is undertaken) or the place where the research is undertaken (e.g. a foreign researcher who conducts research in France is affiliated with France). Indeed, a researcher who wins an ERC grant can then choose a host laboratory, and the relative research conditions in different countries will serve as an important criterion: a review f these choices indicates the relative attractiveness of the national research systems in terms of environment, salary, etc.

Over 2007-12, France had a total share of around 12% to 13%. This share was identical for "national" and "domestic" researchers, and for "starting grants" and "advanced grants" (Table 4.1). This share corresponds to that of French research in Europe and accurately reflects the "average" standing of French research, behind Northern Europe, the United Kingdom and Germany, and ahead of Southern Europe. The fact that national and domestic grantees have an identical share also reflects the "average" level of attractiveness of the French research system, which attracts as many excellent foreign researchers as it has national researchers who choose to work abroad. In proportion to the number of its researchers, France sends far fewer researchers abroad than Germany, but many more than the United Kingdom. Conversely, it hosts far fewer foreign researchers than the

United Kingdom, but as many as Germany. France also has a less pronounced specialisation than other countries (Table 4.2), with a relatively equal share of each of the three identified research areas; its share in the physical sciences is slightly higher than in the life sciences, unlike Germany and the United Kingdom.

Table 4.1. Country shares of ERC grantees, 2007-12, %

	Total		Starting		Advanced	
	National	Domestic	National	Domestic	National	Domestic
CHE	2.7	7.4	2.2	6.2	3.2	9.0
DEU	17.4	14.1	18.3	14.0	16.2	14.2
ESP	5.5	5.4	6.3	5.8	4.4	4.8
FRA	12.4	13.0	12.6	13.5	12.0	12.4
ITA	9.6	5.8	10.3	5.4	8.6	6.3
NLD	8.3	8.2	8.1	8.3	8.5	8.0
SWE	3.1	3.6	2.8	3.5	3.6	3.8
GBR	15.3	22.2	10.6	21.2	21.6	23.6
EU+A.C.	100	100	100	100	100	100

Source: European Commission; OECD calculations.

Table 4.2. Country shares of ERC grants by area, 2007-12, %

	HSS		Life sciences		Physical sciences and engineering	
	National	Domestic	National	Domestic	National	Domestic
CHE	1.0	2.4	3.2	8.9	3.0	8.3
DEU	14.4	9.5	18.7	15.8	17.6	14.6
ESP	4.3	5.4	6.3	5.4	5.3	5.4
FRA	10.6	10.5	11.9	12.5	13.5	14.5
ITA	12.0	8.8	7.6	4.2	10.2	5.9
NLD	10.7	11.4	7.9	7.2	7.5	7.6
SWE	2.4	2.1	3.9	4.5	2.7	3.6
GBR	19.7	32.5	14.8	20.1	13.9	19.7
EU+A.C.	100	100	100	100	100	100

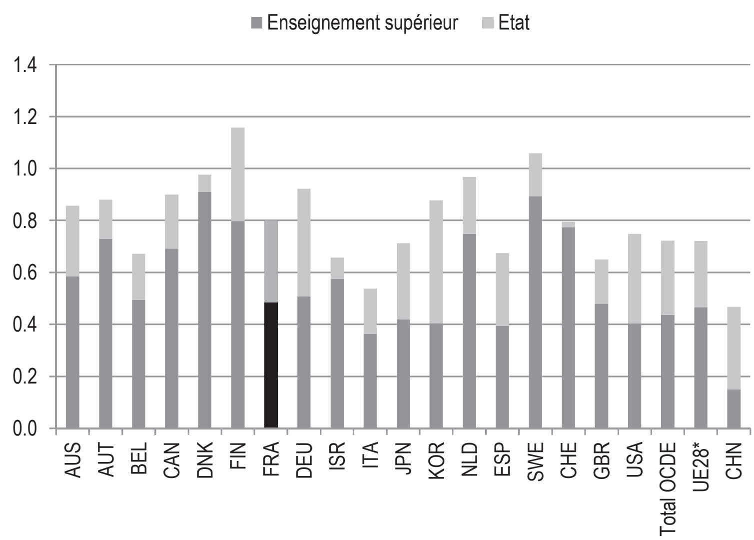
Source: European Commission; OECD calculations.

Public research resources

Funding

What resources are allocated to public research in France? How have they evolved over the past decade and how do they compare with those of other countries? According to the method described in the Frascati Manual for measuring R&D (OECD, 2001), public research is made up of PROs and universities. R&D conducted by the public sector accounted for 0.8% of France's GDP in 2010 (Figure 4.4). This figure stood at 0.9% in Germany, around 1% in Northern Europe, 0.7% on average in the OECD and the European Union, and 0.65% in the United Kingdom. This means France is just above the average and that the State plays a greater role in France than in many other countries. It should be noted, however, that countries where public R&D has greater weight than in France are those where business R&D also plays a greater role, which is not the case in France.

Figure 4.4. Research & development (R&D) conducted by government and higher education sectors, 2010, as a % of gross domestic product (GDP)



Note: *OECD estimates.

Source: OECD, Main Science and Technology Indicators, www.oecd.org/sti/msti.htm, June 2014.

Public R&D as a percentage of GDP was almost constant between 2000 and 2010 in France, unlike in many other countries where it significantly increased over time, such as Germany (where it was 0.7% in 2000 and therefore grew 0.2% over the decade) and the United Kingdom (0.6% in 2000, an increase of 0.05% over the decade), while the OECD and EU averages grew by 0.1% over the decade. French public R&D fell between 2000 and 2010 relatively to other countries. The continued decline of defence contributed significantly to this drop: defence R&D expenditure accounted for 0.17% of GDP in 2000, compared with 0.08% in 2010, with a significant proportion conducted in public laboratories. Resources allocated to civil R&D have therefore grown over the same period, but probably to a lesser extent than in other countries.

The gradual ramping up of the PIA Programme after 2010 should help boost public research. The PIA allocates around EUR 9 billion (euros) to research between 2011 and 2020, including consumables and interest on non-consumables, of which over EUR 7 billion goes to public research (French Court of Auditors, 2013). This represents over EUR 700 million per year over the decade, i.e. around 5% of public research expenditure in 2010 – which could, providing the other components remain unchanged, reach 0.85% of GDP.

The review by the French Court of Auditors (2013) of French budgetary data (the MIRES, Interministerial Mission for Research and Higher Education, see below) provides a more in-depth view of developments in the various components. The resources of most organisations increased significantly between 2006 and 2011, but with three caveats:

- First, "subsidies for public service costs", a fixed annual funding paid by the State, increased slightly. "Own resources", particularly research contracts mainly undertaken by the ANR, are mainly responsible for this overall increase; they indicate policymakers' commitment to influencing more directly the thematic focus of public research, thereby promoting excellence.
- Second, in the case of organisations– particularly the CNRS – employing civil servants, pension costs have increased sharply, thereby reducing the resources available for funding the research itself.
- Third, funding channels became more complicated during the same period, with an increase in the number of stakeholders and programmes resulting in a fragmentation of contracts; it is likely that a greater share of resources (including some researchers' time) is used for management rather than research purposes.

Employment of researchers

In 2010, France numbered around 162 000 full-time equivalent (FTE) jobs in the public research sector. This figure includes researchers (research directors, research officers, professors, lecturers) and research engineers, who represent 50% of the workforce, as well as design engineers, assistant engineers and technicians (27%), other support staff (11%) and funded PhD students (12%). Human resources (HR) for public research are shared between universities (around 45% of the workforce) and PROs (50%); the remainder of the workforce is employed at non-profit organisations and other public administrative institutions and government departments. These staff numbers grew 11.6% between 2000 and 2010, with significant growth in the number of researchers (4.2%) between 2005 and 2010.

Public research has not been subject to the policy of not replacing every other departing civil servant enforced throughout the rest of the State civil service in France. Civil servant staff numbers have therefore remained more or less stable since the mid-2000s. This is also the case for staff employed by the CEA under private-law contracts. Conversely, the same period registered a marked increase in employment on a contract basis across all organisations: between 2006 and 2011, numbers increased from 1 064 to 1 869 at the CEA and from 5 750 to 7 550 at the CNRS. This development is directly related to the growth in short-term, contract-based funding (ANR, etc.) versus lump-sum awards (see the conclusion of this chapter).

Public research organisations (PROs)

Overview

The French public research system is structured around large PROs with recurring institutional funding by the State. The universities and competitive funding organisations that play such a large role in other countries have a more recent and lesser role in France. The main PROs (Table 4.3) are the CNRS for basic and applied research, the National Institute for Agricultural Research (INRA) for agriculture), INRIA for digital sciences and technology, INSERM for health, the CEA for energy and the French Space Agency (CNES) for space. Two types of PRO are recognised in law: scientific and technological public institutions (EPSTs), which conduct upstream research, and industrial and commercial public institutions (EPICs), which conduct finalised research. The following chapter focuses more on EPSTs than EPICs, which are discussed in the chapter on knowledge transfer. These organisations each have their own heading in the budget – the MIRES – adopted by the French Parliament. They are linked to their supervising ministries via a multi-year contract that assigns them general objectives, which they take into account when allocating their resources internally among their priorities and among their research teams.

The CNRS is the largest PRO in terms of the number of researchers. Its task is to "identify, carry out and organise any research of relevance to the advancement of science and to national economic, social and cultural development". Approximately 70% of life and materials science publications with at least one author based in France emanate from research units of which the CNRS is a member or partner (CNRS website, 2014).

Table 4.3. Resources of major research organisations in 2012

Organisation	Research field	Total budget (EUR billions)	Staff numbers (FTE)
CNRS	Basic research; all disciplines (including human and social sciences)	3.310*	33 200
INRA	Agriculture	0.844*	10 100
INSERM	Health	0.598	7 900
INRIA	Digital science and technology	0.167	2 600
CEA	Nuclear, energy	2.681	13 000
CNES	Space	2.163*	2 400

* 2011 data.

Sources: 2011* and 2012 CNRS, INRA, INSERM, INRIA and CNES budget data, from www.assemblee-nationale.fr/13/pdf/budget/plf2012/a3807-tix.pdf (in French).
The budget data for the CEA relate only to the civil sector and are derived from the CEA 2012 financial report.

Budgets and employment

In total, PROs employ around 70 000 research staff, of which nearly half work at the CNRS and one-fifth at the CEA, the other organisations being smaller. Public research staff have a variety of statuses in France. At the EPSTs (CNRS, INSERM, INRA, INRIA etc.), most research staff have civil servant status; at the CEA and at the CNES, they are employed under private-law contracts. Civil servants (researchers, engineers, technicians and administrative staff) apply for these posts through a national competitive examination and become permanent employees after a probationary period. Career development is occurs through grade advancement according to length of service and is subject to review by a committee. PROs also employ a number of contract workers (non-civil servants): researchers, engineers and research technicians who meet more specific needs, as well as doctoral and postdoctoral students whose posts are by definition limited in time.

Governance

In the unanimous opinion of the senior officials interviewed during the preparation of this review, the PROs have considerable supervisory latitude in their strategic choices and internal allocation of resources. Hence, they are highly influential in setting actual research priorities in France. Financial resources in the CNRS are allocated according to set of mechanisms involving laboratory directors, elected staff representatives from all categories (via the National Council) and the organisation's government-appointed leaders

(IGAENR, 2012). Researchers are allocated to research units based on the "freedom of research" principle (researchers may freely choose the laboratory they will work in within the research organisation, provided the laboratory agrees) (IGAENR, 2012). On the other hand, an organisation such as the CEA is more centralised: due to the nature of its work, a "top-down" approach prevails.

These organisations bring together under a single authority different functions that in other countries are spread out among several institutions: the orientation (planning), funding, execution and evaluation of research in their respective fields. The most common model internationally is research steered by the ministry (or the ministries in their respective fields) under the supervision of the Parliament, mainly funded on a competitive basis by a specialist agency and implemented by university-based teams. Variants of this model are found in all leading global research countries in North America, Northern Europe, etc. This separation of functions can be explained by the State's desire to set the direction of research according to economic and social priorities, as well as by the potential conflicts of interest generated by the joint exercise of different prerogatives. If the research agenda is determined by those implementing it – the researchers – then purely scientific considerations can take precedence over extra-scientific considerations (such as economic and societal demands). In addition, existing disciplines are likely to persist at the expense of emerging domains, since they benefit from an established – and therefore influential – community of researchers. Funding must be separated from implementation for similar reasons, and also because competitive project funding calls for specific competences. Finally, the evaluation must of course be independent so as to be neutral and credible. Fulfilling all these functions under a single authority raises problems, which the reforms of the 2000s tried to address by creating specialist agencies for funding and evaluation, and publishing national strategies – the National Research and Innovation Strategy and then the PIA – setting the guidelines to be followed by the scientific community. The next section will show that these new stakeholders and mechanisms complemented the PROs without significantly changing their powers, and that the PROs themselves have implemented reforms aiming to internalise the objectives of excellence and relevance – as opposed to economic and social objectives – pursued by these policies. In that regard, the French research programme bears some similarities with the German programme (Box 4.1).

Box 4.1. PROs in Germany

Germany has four main PROs: The Max Planck Society (Max-Planck Gesellschaft), the Fraunhofer Society (Fraunhofer-Gesellschaft), the Helmholtz Association of German Research Centres (Helmholtz Gemeinschaft Deutscher Forschungszentren) and the Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz)[2].

	Institutes	Subject areas	Staff, including researchers	Budget in 2011	Share of contract funding
Max Planck	80 institutes	Life sciences, natural sciences, HSS	17 000 (5 200)	EUR 1.77 billion	20%
Fraunhofer	60 institutes	7 subject areas (ICT sciences, materials, photonics, etc.)	20 000	EUR 1.85 billion	66%
Helmholtz	18 centres	6 strategic programmes (energy, transport, health, etc.)	30 000 (9 700)	EUR 3 billion	30%
Leibniz	87 institutes	5 subject areas covering a wide spectrum	16 000 (7 100)	EUR 1.4 billion	33%, a majority of public contracts

Source: Data: Science Portal, French Embassy in Germany, 2013, www.science-allemagne.fr.

These organisations have autonomy in defining their scientific projects and allocating resources among their centres, institutes and laboratories. However, the degree to which decisions are "centralised" varies from one PRO to another: they are highly decentralised at Max Planck and Fraunhofer, but much less so at the others. Unlike in France, these PROs are not attached to universities as the joint units of the CNRS tend to be, but this does not prevent cross-collaboration. These organisations are multidisciplinary and have specific scientific orientations: basic research at the Max Planck institutes, more applied research focusing on technology transfer at the Fraunhofer societies, centred on major research tools at the Helmholtz societies and more rooted in the local/regional area at the Leibniz societies. Of the some 800[3] research units in Germany[4], nearly half are integrated into these four large PROs; the others are attached to one of the country's 392 higher education institutions. These research units are entirely funded through recurring funding from the Federal Government and by the 16 *Länder,* according to an established distribution grid. Universities, regional research organisations and academies are funded by the *Länder*, which also cover 50% of the financing of the Max Planck, 42% of the Deutsche Forschungsgemeinschaft (German Foundation for Research [DFG]) and 10% each of the Fraunhofer and Helmholtz. This distribution enables each *Land* to promote research activity in the fields it considers key, and the Federal Government to influence scientific activities through Germany's Federal Ministry of Education and Research (BMBF). Competitive funding is overseen by four large agencies: DFG, Projektträger[5], DAAD and foundations (e.g. the Alexander von Humboldt foundation).

The DFG is the main project funding agency in Germany, with a budget of almost EUR 2.5 million in 2011. It is involved in all scientific fields, with a greater focus on life sciences and medicine. It finances projects, coordinated research centres, priority programmes and graduate schools.

The project managers, in turn, implement BMBF research programmes, from managing the calls for projects to awarding funding. A large part of its budget funds university research projects.

Two other major stakeholders complete the governance of this system: the Gemeinsame Wissenschaftskonferenz (Joint Scientific Conference) and the Wissenschaftsrat (German Council of Science and Humanities), which advise on strategic policy.

Reforms

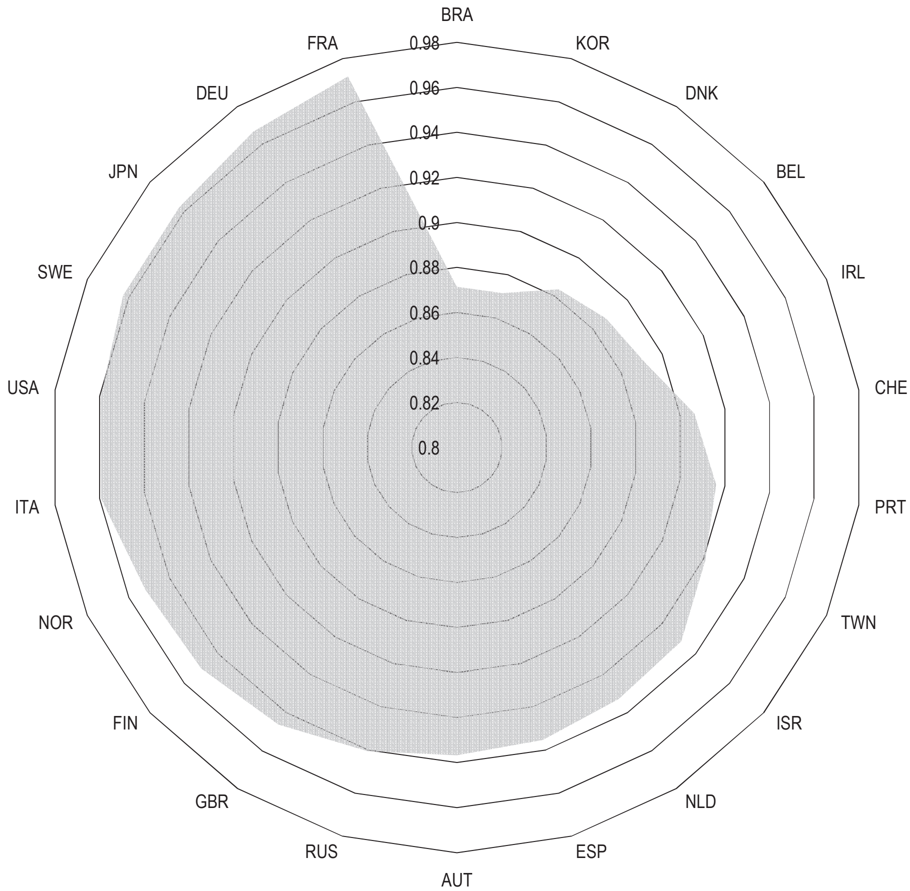
Successive French governments have stated their commitment to developing this French model into a system in which the State would steer the direction of research, and universities and project funding would play a greater role. A number of steps have been taken as a consequence, particularly in the past 15 years.

Justifications for the reforms

This change has multiple justifications:

- The organisation-based system makes directing research "from the outside" difficult, as the PROs have integrated control of the research – its thematic focus, funding, implementation and evaluation. They are therefore largely autonomous, leaving less room for influence by politicians; thus, a policy decision in 1998 to focus on research in biology was not reflected in the funding allocated to the organisations concerned (French Court of Auditors, 2007). On the other hand, an organisation ensuring a separation of functions could give the State greater influence with regard to the orientation of research and give stakeholders greater responsibility with regard to excellence.
- A governed organisation, which is more inflexible due to the internal (governed) resource management processes, does not meet the need for a high degree of adaptability in the changing thematic priorities of research. This is due to the influence of established disciplinary communities that wish to maintain their projects and because full-time researchers cannot easily be re-assigned to other work according to the research's evolving thematic focus. Figure 4.5 illustrates the high degree of thematic inflexibility of the French research system compared to that of other countries; it shows that of all the major research countries, France made the fewest changes to the thematic distribution of its publications between 2001 and 2011. While excessive flexibility is detrimental to the continuity of programmes and therefore to their success, excessive inflexibility means on the contrary that inertia becomes an important factor in resource allocation, at the expense of new demand and opportunities.
- The divide between teaching and research is detrimental both to high-level teaching (which draws on the most up-to-date research) and research (which needs to draw on the best students). Training at all levels must draw on research – and on the most advanced research in the case of doctoral training. Joint research units and other measures have certainly reduced barriers between universities and research organisations, but they have not abolished them completely, particularly with regard to staff management and careers (recruitment, progression, responsibilities, status). An additional step must be taken to integrate teaching and research more closely, particularly at the centres of excellence.
- The boundaries between the organisations do not reflect the disciplinary divisions of science. The CNRS is involved in all fields, rather than basic research only. INSERM, INRA, the CEA and the CNRS all deal with the life sciences. The very structure of the PROs has made co-ordinating their respective research agendas in similar or identical fields difficult, hindering the overall effectiveness of the system.

Figure 4.5. 2001-11 similarity index in specialisation (174 specialisms)



Note: The similarity index measures the degree of similarity between two vectors, representing here the thematic specialisation of a country's research in 2001 and 2011 respectively. The index has a value of 0 in the case of total dissimilarity and a value of 1 in the case of perfect similarity.

Source: OST data.

Reforms

Related policies have been implemented at several complementary levels for over 20 years: bringing together research organisations and universities, which could lead to partial integration; development of competitive project-based funding for research; creation of an independent evaluation system; reinforcement and autonomy of universities; and co-ordination between PROs through thematic "alliances". A series of reforms was introduced in 2005-2008, and these are currently being put into practice and evaluated in the French public research system.

Integration of PROs and universities

A policy has existed for over 20 years of bringing together large research organisations and universities, which at this stage has proven partial, complex and costly. The CNRS and other PROs created and then extended the joint research unit model, under dual PRO-university supervision (in some cases where other organisations are involved, supervision may be carried out by three or more authorities). These units accounted for 88%

of the 1 303 CNRS research units in 2000 and 95% of the 1 029 research units in 2012 (French Court of Auditors, 2013). The joint units have multiple sources of funding: organisations, universities, contracts and projects (ANR, EU programmes, etc.). They employ staff assigned by each of the supervising authorities. While they lessen the divide between universities and research organisations, they also face problems stemming from their multiple supervisory authorities. The incompatible accounting and management systems and procedures of the research organisations and universities, the potential strategic differences among supervisory authorities and the different staff statuses mean that managing joint units is complex, expensive and opaque (each authority is unaware of the other's contributions).

A policy of "delegated management" aims to enable one of the partners – a PRO or university – to secure in some cases sole management of the joint research unit. Although the agreement between organisations and universities has been in place for several years, it does not appear to have been followed very effectively (French Court of Auditors, 2013). Yet such an approach makes perfect sense for large research universities, since they have the required management capacities.

One obstacle to further integration of the PROs with universities is the difference in staff statuses at universities and research organisations (which are themselves diverse). This obstacle was identified long ago, and the solution appeared to be a focus on recruiting in universities, thus allowing a de facto gradual unification of statuses. It appears that this policy has not been followed over time, with a significant level of recruitment still taking place at the EPSTs.

Project funding and competitive funding

Public research can be funded using two main mechanisms: institutional funding and project funding. In the first, a given institution – e.g. a PRO – receives a certain budget, which it manages according to its priorities and a number of requirements specified by the supervisory authority. The budget amount may be fixed or linked to performance indicators (from the previous period). Institutional funding is sometimes competitive, at least initially (as for Idex in France and universities in the United Kingdom), but it is generally non-competitive (in the case of PROs in France). Alternatively, research can be funded on a project basis. In this case, each candidate project is evaluated by the authority in charge of funding, which will decide whether or not to fund it and will set the grant amount. This process is generally competitive: based on a call for tender published by the funding agency, various teams submit applications, only a few of which are selected. Most research countries have a joint system in which the research infrastructure (including the administrative infrastructure) and certain types of research are funded institutionally and part of the research is project-funded (Box 4.2).

Box 4.2. Project funding agencies in other countries

In the United Kingdom, seven Research Councils provide project funding. These seven councils, all members of Research Councils UK, cover all major scientific disciplines and granted EUR 3.1 billion in 2011-12. The allocation of grants by sub-field follows a four-year plan devised by each council and is based on the opinions of evaluation committees. Like France's ANR, calls for projects may be subject-specific or open and focus to varying degrees on commercialisation initiatives; 70% of recurring funding is allocated to the 20 highest-ranking institutions according to a periodic (every four years) evaluation of the research units.

In Italy, there is no research funding agency. The Ministry of Education, University and Research (Ministero dell'Istruzione, dell'Università e della Ricerca) funds projects directly.

In the Netherlands, one of the leading project funders is the Netherlands Organisation for Scientific Research (Nederlandse Organisatie voor Wetenschappelijk Onderzoek), which a budget of EUR 500 million. The funds are distributed to different programmes focusing on specific disciplines in the context of open or subject-specific calls for projects. The proportion of research funding dedicated to project funding was 27% in 2010.

In Germany, project funding is overseen by three main agencies: DFG, Projektträger and the foundations (e.g. Alexander von Humboldt). Nearly 44% of Federal Government funds allocated to R&D activities are allocated through calls for tender.

The Excellenzinitiative (excellence initiative): with a budget of EUR 1.9 billion for the period 2007-11, the excellence initiative was renewed for the period 2012-17 with an even larger budget of EUR 2.7 billion. The funding revolves around three areas: the graduate schools (Graduiertenschulen) to promote young scientists and researchers; the clusters of excellence (promoting cutting-edge research) and the universities of excellence (promoting high-level research within elite universities). Calls for projects cover various scientific fields (natural sciences, life sciences, engineering sciences, HSS). The objective is to increase the visibility of German research in the international scientific community through cutting-edge research.

The DFG and the German Council of Science and Humanities (CFS) oversaw the competition. Universities submitted proposals, which were subsequently evaluated by a panel of experts. Projects preliminarily selected by the Joint Commission (DFG and CFS) were finally submitted to a Grants Committee made up of the Joint Commission, federal authorities and the Ministry of Education and Research. This is a prominent example of co-operation between the Federal Government and the various Länder, which contribute 25% of the budget of the excellence initiative.

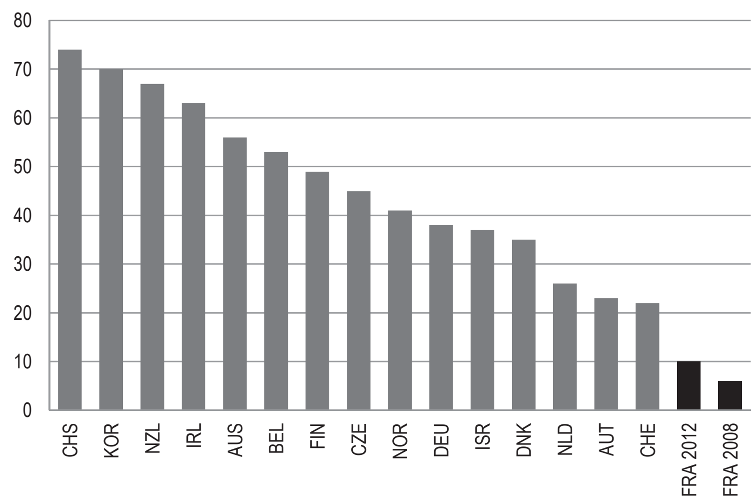
Following the 9 universities of excellence selected in the first round, a total of 11 qualified as universities of excellence in the second round (2012-17)[6]: Heidelberg, FU Berlin, LMU Munich, TU Munich, Constance, RWTH Aachen, Humbold Univ. Berlin, Bremen Cologne, Tübingen and TU Dresden.

	Budget	Higher education institutions	Clusters of excellence	Universities of excellence
2006-11	EUR 1.9 billion	39	37	9
2012-17	EUR 2.7 billion	45	43	11

Source: www.excellence-initiative.com/excellence-initiative; www.science-allemagne.fr/fr/donnees-comparatives/.

Project funding is less common in France than in other countries: 7% in 2008 and 12% in 2012 for higher education; 7% in 2008 and 10% in 2012 for the PROs (FutuRIS-National Technical Research Association [ANRT] estimate, 2013). This places France among the OECD countries with the lowest proportion of projects (Figure 4.6). These estimates are likely to be slightly below actual figures, since they do not take into account the fact that funded projects also receive institutional resources from the PROs, including the salaries of tenured researchers. However, the gap with other countries is such that it will not be filled even when taking this factor into account (the country that immediately precedes France in this ranking is Switzerland, with a 22% total share – 10 percentage points higher than France in 2012). The significant increase in France between 2008 and 2012 is due to the increased activity of the ANR, and particularly of the PIA.

Figure 4.6. Proportion of project funding in public expenditure on R&D, 2011, %



Sources: OECD and ANRT (for France).

The National Research Agency (ANR)

The ANR is the main player in the competitive project funding of French research. The Agency was set up in 2005 to manage the competitive resource allocation processes, which are believed to promote excellence (generated by competition) and flexibility in research areas (the re-allocation of funds is sufficient to spark new research). The ANR budget was gradually increased until 2009, after which it levelled off and began to drop. The ANR has since become an important source of funding for PROs and universities, complementing their budget allocations. Through calls for projects, the ANR steers the focus of research. This orientation has not always matched that chosen by the PROs, which has created friction. The solution to this problem adopted in 2010 was to increase the proportion of non-thematic programmes ("Programme Blanc" open to all research fields, postdoctoral fellowships, young researcher programme, Chairs of Excellence). These calls for projects select researchers based on their degree of excellence, without interfering with their research topics, and now comprise more than half of the ANR budgets dedicated to public research. In 2013, the decision was taken to involve alliances (and thus the PROs) more specifically in ANR planning. This entails reinstating the planning function itself within the PROs, which runs counter to the previous trend of separating powers.

In 2011, the ANR budget amounted to EUR 738.5 million, including EUR 557 million dedicated to calls for proposals and calls for tender. Nearly 1 300 out of 6 319 submissions have been financed since 2011; the average funding granted per project is EUR 350 000 for open calls for proposals and EUR 700 000 for partnership projects. The distribution of the ANR operating budget in 2012 is shown in Table 4.4.

Table 4.4. ANR operating budget in 2012, in EUR millions

Non-thematic programmes	266.3
Partnership research and commercialisation	18.8
Progress in knowledge of living organisms	56.5
Environmental emergency and ecotechnologies	107.2
Information, communication and nanotechnologies	71.9
HSS	12.0
Safety and dual research	21.3
Programming total	554.0
Partnerships and competitiveness	156.1
Total ANR commitment authorisations budget	710.1

Source: ANR and report of the French Court of Auditors (2013).

Decreased budget allocations since 2010, coupled with an increase in the number of submissions, lowered the success rate from 26% to 20% between 2005 and 2012. Although this rate seems lower than t abroad (40% for the DFG in Germany and 25% for the UK Research Councils, according to the French Court of Auditors [2013]), the success rate at the National Institutes of Health in the United States was 23% in 2010 and 19% in 2013; it was 22% at the National Science Foundation in 2011, which is not significantly higher than at the ANR, but the amounts allocated to each grantee are significantly higher. Moreover, average funding also declined somewhat over the period.

In addition to these funds allocated to the winners of the call for proposals, the ANR also makes a "*praecipium*" to the institutions hosting these projects. This praecipium amounts to approximately 11% of total funds allocated by the ANR, i.e. EUR 50 million in 2012. The beneficiaries are universities or the PRES research and higher education clusters (EUR 23.5 million), other higher education institutions (EUR 9.5 million), research organisations (EUR 14.4 million), hospitals (EUR 226 865), foundations (EUR 1.5 million) and other agencies and research units (EUR 1.2 million).

Since its inception, the ANR has demonstrated its ability to manage the sometimes complex processes of identifying research topics and selecting projects. As the agency in charge of implementing the PIA, it has had to manage numerous new procedures and has given a number of internationally recognised French research teams access to substantial resources. It is subject to criticism from several quarters, for several reasons:

- Many Blanc programme projects since 2009 have weakened the thematic steering of research by the ANR. This increase in the number of projects was a result of demand from the PROs, dissatisfied with interference by the interference the subject area chosen by the ANR and their own.

- The capacity of the ANR to establish thematic priorities for French public research has been called into question by some stakeholders; recent changes in the governance of the ANR (2013), which gave alliances (i.e. the PROs) an increased role in setting the Agency's priorities, seek to answer this. The aim is therefore to restore full control over planning to the PROs. In other countries, especially Nordic countries, high-level thematic orientation is initiated at the political level, rather than within the scientific community, thus avoiding the inevitable conflicts of interest that arise when planning and implementation fall under a single authority.
- Some ANR procedures are cumbersome, with declining success rates and appropriations (according to the AERES), particularly since a number of the appropriations are for collaborative projects, and the sum therefore has to be shared between different partners. The problem here is the ANR budget, which has been reduced over time.
- The ANR has been accused of failing to take into account all the administrative costs the research projects generate for the grantees ("praecipium"), forcing recipients and their institutional backers to bear part of the costs generated by the selected projects. This issue could be resolved by increasing the ANR budget, which could then incorporate a higher praecipium. On the other hand, organisations' basic funding also finances administrative services that could be put to contribution to manage this financing. A budget transfer from the PROs to the ANR (unlike the one carried out in 2013) would reduce the burden on the PROs of managing their administrative services, allowing them to devote more resources to managing funds received from the ANR, which would also include a higher praecipium thanks to the supplementary budget received by the Agency.

Overall, it appears that the first French experience of research project funding has worked well, beyond the inevitable teething problems. The ANR has, however, struggled to fit into a broader research landscape that has remained largely unchanged, with a decisive weighting towards the PROs, even though a project funding mechanism is more suited to a university-based research system. Thus, the overall balance of the system must be considered to allow a full assessment of the ANR.

Competitive funding in the PIA

The PIA was set up to promote the excellence and relevance (e.g. against clearly defined economic and social objectives) of research. To do this, it has created and uses specific mechanisms and new stakeholders, which complement established mechanisms and stakeholders and are driven by a rationale of competition and openness. The PIA allocates its funds mainly through open and competitive calls for tender, many of which are managed by the ANR. The aim of the PIA is to promote excellence in public research, through operations such as Equipex (equipment of excellence), Labex (laboratories of excellence) and Idex (initiatives of excellence), which together represent nearly EUR 3.5 billion over 10 years (this amount includes consumables, plus interest on non-consumables: French Court of Auditors estimate, 2013, pp. 194-195). Given the non-consumable aspect of some of the funds – only the interest of which is paid to beneficiaries – it is estimated (that the PIA allocates approximately EUR 1 billion to research and higher education every year (FutuRIS, 2013). The conjunction of the ANR and PIA explains the jump in project funding between 2008 and 2012t. These activities bear a strong resemblance to initiatives taken in most OECD countries over the past ten years to promote excellence in research (Box 4.3).

The ANR is the leading operator of these initiatives, which it manages from the selection to the contract stage, and subsequently from funding to follow-up. The eligibility of these projects has been evaluated by international jury panels consisting of academics and leading figures from the public and private spheres. These panels have then appointed external experts to provide informed and graded reports. The projects have been evaluated according to criteria on to team and infrastructure quality (including an evaluation by the AERES), the project's innovativeness and scientific ambition, its potential spin-offs and ripple effects, the match between the resources and the project, and finally the project's governance and structure. Some criteria are more specific to each programme: stakeholder structure, landscape simplification, consistency and ambition of the overall project, as well as governance and credibility of the implementation capacity for the Idex[7], the laboratory's involvement in high-level master's and PhD courses for the Labex[8], and the innovativeness of the project in relation to existing facilities for the Equipex[9].

Labex: with EUR 1.94 billion in funding, including EUR 1.8 billion in capital assets, this programme aims to "strengthen the international visibility and role of the best French laboratories, in all disciplines and throughout the country". The two successive rounds awarded the label to 100 grantees and 71 new Labex.

Equipex: with EUR 850 million in funding, including EUR 600 million in capital assets, this programme focuses on major scientific infrastructures and intermediate-size equipment (EUR 1 million to EU 20 million). The infrastructures include supercomputers, digital databases and experimental platforms. In 2011, 52 Equipex projects were selected[10], with capital grants ranging from EUR 1.28 million (for the REC-HADRON project in biology and health) to EUR 20 million (for the CILEX [Interdisciplinary Centre on Extreme Light] project in the field of energy).

Idex: with an initial funding of EUR 7.1 billion, subsequently reduced to EUR 6.35 billion in 2012, this programme aims to develop 5 to 10 multidisciplinary clusters of excellence in higher education and in world-class research in France. Idex submissions are evaluated by an international panel consisting of academics and leading economists. Following a four-year trial phase, a new evaluation by the international panel determines whether to renew the funding. Applications were examined in 2011 and 2012. The first round in 2011 produced three winning Idex (under the aegis of the universities of Strasbourg, Bordeaux and Paris Sciences-Lettres); the second round in 2012 selected five new projects (won by Sorbonne Universities, Sorbonne Paris Cité, Saclay, Aix-Marseille and Toulouse). The funding associated with these projects ranges from EUR 700 million to EUR 950 million.

Other PIA programmes include the Instituts Hospitalo-Universitaires (medical research and training institutes), the Plateau de Saclay and the commercialisation initiatives in line with the clusters of excellence strategy, along with the Idex and Labex.

Although most of this funding finances new operations, a small part has replaced existing funding, e.g. for demonstrations innovation incubators (French Court of Auditors, 2012).

Box 4.2. Promoting excellence in research: New financing methods

To response to growing scientific competition, many OECD countries have set up "research excellence initiatives" (REIs). These initiatives are based on competitive funding mechanisms and linked to results. REIs aim to promote research excellence with stable, long-term funding, allocated directly to the selected research units. In general, REIs combine elements of institutional funding and competitive funding; they fund the research infrastructure and the researchers' salaries and training. REIs now exist in more than two-thirds of OECD countries. Most of these initiatives have been implemented in the past ten years: Norway (Centres of Excellence, 2002) and Germany (*Exzellenzinitiative*, 2005) are two examples thereof. REIs are usually launched to foster interdisciplinary and collaborative research, attract talent from abroad, create high-level graduate schools, stimulate competition among research teams and increase the visibility of national research. In most of the countries covered by a recent OECD survey (OECD, 2014), REIs have achieved these objectives and have received positive feedback.

The results of the OECD survey on REIs can be summarised as follows:

- REIs provide long-term funding for ambitious, complex research projects. This is particularly important for high-risk interdisciplinary and co-operative research.
- Competition for the funding made available by REIs takes place through a transparent selection process. REIs generally use panels consisting of international experts to ensure the best quality of the selected projects.
- REIs allow for greater flexibility than other forms of funding, notably in terms of managing and recruiting personnel. Moreover, REIs are often able to offer attractive contractual terms to attract high-level researchers.
- REIs recognise the importance of (domestic and international) talent mobility. REIs therefore make it easier for research centres to recruit foreign scientists.
- Attracting and training the best students is a fundamental aspect of REIs. REIs fund doctoral and postdoctoral programmes in order to train and attract future generations of researchers.
- REIs concentrate research expenditure on a limited number of well-equipped laboratories. While on the one hand, the concentration of resources can create the critical mass necessary for high-level initiatives on a global scale, on the other hand, an excessive concentration of resources can be detrimental to the diversity of the system.
- REIs can affect the overall structure of the research system, through a virtuous circle of competition between research centres.
- REIs have the effect of enhancing the international reputation and visibility of domestic research institutions.
- The activities funded by REIs can promote the dissemination of knowledge and create positive externalities in the national research system as a whole.

This approach has been adopted in France for the "excellence initiatives" of the PIA (Idex, Labex, Equipex).

Source: OECD (2014), *Promoting Research Excellence: New Approaches to Funding,* OECD Publishing, doi : 10.1787/9789264207462-en.

Evaluation

Evaluation is an essential part of any public research system (Box 4.4). Although the innovation system is designed to sell products and is therefore ultimately sanctioned by the market, there is no such objective sanction for science. Ad hoc mechanisms therefore need to be put in place to govern the allocation of resources according to criteria of excellence and relevance, at the level of individuals, laboratories and organisations alike. *Ex ante* evaluation is carried out during the project or research group selection procedures that decide whether or not to fund them, depending on their potential. *Ex post* evaluation provides the information needed to judge stakeholders' past performance, which will eventually serve as a basis for decisions on current resource allocation.

PROs have internal systems for evaluating individual researchers and research units. But the increased use of joint research units and the reinforcement of universities have created a need for an evaluation system covering those new stakeholders. In addition, the self-evaluation that helps PROs manage their teams and researchers must be supplemented by an independent, and therefore external, evaluation.

Before the AERES was created in 2007, the 40 divisions of the CNRS evaluated the laboratories owned by and associated with the CNRS. This four-year evaluation is still in place in order to determine whether a research unit should be maintained or evaluate the creation of a new laboratory. "They [the sections] evaluate CNRS researchers every two years, and every year they review the promotion of these researchers within the research and research director bodies; they are made up of panels that evaluate eligibility for recruitment to each of these bodies before admissions panels appointed by the CNRS take the final recruitment decisions" (Fixari and Pallez, 2010).

The evaluation procedures of the PROs differ in their frequency, criteria and implications. In 2008, the CNRS compared the different internal evaluation practices of the French PROs. Thus, in the case of researchers, verbal or written recommendations or graded opinions were forwarded in full (with the exception of the French National Institute for Transport and Safety Research [INRETS]). These evaluations are sometimes passed on to superiors for follow-up (or, depending on the PRO, archiving) or to the panels responsible for recruitment and promotion. Evaluations of research groups follow similar procedures, with opinions forwarded to the persons in charge, possibly involving other technical departments within these organisations. A negative evaluation for the group may result in a reduction of its resources, or even its non-renewal or merger with another group, after a temporary status as an intermediate "evolving" team or unit (at the CNRS or INRA, for example) during which the group may attempt to address the shortcomings identified in the evaluation. The procedure often provides for a new – sometimes merely informative – passage in front of the evaluation authority (CNRS, [National Institute for Environmental and Agricultural Science and Technology Research, INRETS, INSERM, INRIA, Research for Development Institute, CEA) to see how its recommendations have been implemented.

The wide range of such practices and the inherent limitations of self-evaluation contributed to the need for a single agency in charge of evaluating research units and research organisations: AERES, created in 2006 to evaluate public research laboratories, graduate schools, universities and institutions. AERES has a modern approach to evaluation: independence, transparency, multilateral procedures, etc. Most stakeholders interviewed during this review believe it has largely fulfilled its role. A number of problems stemming from a lack of experience have been or could be resolved by adjusting its rules and procedures: team and university evaluations are considered too cumbersome and bureaucratic; evaluations of research organisations are sometimes not sufficiently incisive; publishing ratings in full might sometimes be seen as stigmatising. An important problem – although it does not relate to the AERES itself – is that these evaluations are sometimes ineffective, particularly where some PROs are concerned: although there are many reported cases of "C" or "B"-rated teams being restructured or closed, these teams' supervisory authorities have no obligation to take action, or even to perform simple reporting to the AERES. Universities, on the other hand, do appear to use the AERES reports effectively. From this perspective, the removal in 2012 of the overall rating obscured the Agency's evaluation of the units concerned and does not help decision makers – and especially universities – act on the findings of the evaluation.

Box 4.3. The evaluation of public research in other European countries

The evaluation systems for research activities in Germany, the United Kingdom and in Italy are quite different French systems. In the United Kingdom, the Research Excellence Framework (formerly the Research Assessment Exercise launched in 1986) is supervised by the Higher Education Funding Council, which allocates funding. Evaluation reports, conducted by committees, have evolved over time. They have evolved from quality rankings based on different scales to a "quality profile" reflecting indicators of scientific output. The results of these evaluations determine grading, and ultimately the allocation of funds. This method leads to restructuring research units with poor ratings.

In Italy, the National Agency for the Evaluation of Universities and Research Institutes (ANVUR) has been responsible since 2010 for evaluating both research and training. ANVUR resources, and HR in particular, are limited, with a total of 15 staff members and 45 experts. The ANVUR director is selected by the Bank of Italy.

Finally, the German model combines an *ex ante* competitive element, the *Exzellenzinitiative*, and an *ex post* evaluation, conducted by the Wissenschaftsrat.

Universities

In most countries, autonomous and responsible universities are the pillars of the higher education and academic research system. In the United Kingdom, higher education institutions are legally independent. They enjoy great freedom regarding the organisation of teaching and research activities. In Germany, they decide for themselves how they are organised, under the law of the *Land* to which they belong. The French system, on the other hand, is a dual one (universities and *grandes écoles* in higher education, universities and major research organisations in research) and highly centralised, which is not without implication for the governance of the research units distributed throughout the country. However, while centralisation is truly a distinctively French feature of the research systems, the duality between universities and large, non-university research institutions is less unique. It is actually quite close to Germany's model, for example.

The overall rise in universities' teaching and research capacity and the establishment of a select group of major research universities of global renown have been key objectives of French policy for the past decade or two. This is the reason for the various reforms implemented since. In a model where the key competences of a research system (planning, funding, implementation, evaluation) are separated, universities are responsible for implementing this goal, alongside PROs operating within a revised framework.

A first course of action was to group universities into larger units, either via merger or integration into federative structures – the PRES under the 2006 Law on Research, or "Communities" under the 2013 Law on Higher Education. There are several reasons for seeking an increase in the size of universities. The first is international visibility. For the past decade or so, universities have competed and cop-operated within global networks, and benchmarking tools have grown accordingly. Thus, rankings – such as the Shanghai ranking – which aim to reflect the quality of research carried out at universities, have a profound effect on their reputation, and therefore their access to HR (researchers, students). In this scenario – in which visibility becomes important – size, of course, matters: grouping institutions enhances their collective brand, and therefore the number of corresponding publications, researchers employed, etc. A second objective is to strengthen universities' influence in steering French research, since major universities are better equipped than smaller ones to enter into dialogue with PROs on an equal footing, or to replace them in managing research units. Grouping them together also aims to enable the creation of large and diverse research units, the idea being that size and multidisciplinarity promote quality (in the style of American campuses) for both research and teaching at doctoral level. Finally, the PRES emerge as a way of bringing universities and *grandes écoles* closer together, while respecting their differences (status, activities), which are still profound.

The second course of action is university autonomy. The 2007 LRU Law outlined certain conditions for autonomy that have gradually been fulfilled by all universities. Autonomy has multiple objectives: improving management efficiency; enabling management and objectives to be adapted to the specific conditions at each university; allowing each university, based on its specific strengths, to develop its own research and training strategy, thus leading to increased differentiation of the higher education system (particularly between research universities and universities that focus on teaching). A study by Aghion et al. (2008) on American and European universities shows a significant link between universities' degree of budgetary autonomy and the proportion of competitive funds (as opposed to recurring funds) in their budget on the one hand, and their research output (measured by their position in the Shanghai ranking) on the other hand.

Box 4.4. The PRES

The 26 PRES were formed in 2007 and were to allow universities, PROs and the *grandes écoles* to pool their activities and resources within a single entity: the PRES. The PRES could have different forms and statuses: scientific interest grouping, scientific co-operation foundation, public interest grouping, or even public institution of scientific co-operation (EPCS). The PRES selected the EPCS form. They were headed by a president and vice-presidents and had an administrative board (CA) that included the directors and president, as well as staff, student and founding member representatives.

The 2013 Law on Higher Education and Research abolished the PRES and replaced them with communities of universities and institutions (CUEs), without detailing the transitional arrangements[11]. These CUEs have the status of scientific, cultural and vocational public institution. Each founding institution can transfer part of its competences or assimilate some of its members into the CUE. The law allows for great flexibility in this regard (see the current discussions surrounding the future Poitou-Charentes-Limousin[12] or Bretagne-Pays de la Loire CUEs). These new groupings have similar objectives to the PRES (co-ordination of training, research and commercialisation activities), with a stronger regional co-ordination and a focus on student life. The structure of these institutional groupings is also evolving from a confederation to a more federal approach (e.g. with their own HR). Ultimately, the MESR will sign a single multi-year contract with the CUE (co-ordinating a joint project and those of partner institutions). Their governance is structured around a chairperson elected by the CA, an academic council and a members' council.

Three main types of autonomy have theoretically been acquired since the LRU Law was enacted:

- Administrative autonomy: the university is headed by its president, elected from the ranks of its professors-researchers, researchers, professors and lecturers; the university's training and research units are also headed by an elected director.
- Financial autonomy: the institution receives a block grant from the State to perform its work. It manages the funding allocated by the State, as well as its own resources; it has control over its HR as well as its immovable assets if it wishes.
- Educational and scientific autonomy: the university, in keeping with the national framework set by ministerial decree for each discipline, determines its own programmes, content, educational methods and materials and knowledge management methods.

However, university autonomy is still limited in its implementation.

Access to and management of resources: for the three key university resources – human, financial and immovable resources – universities are dependent on decisions over which they have only partial control.

- HR: some recruitment procedures, as well as the articles of association, careers, and promotion and remuneration levels are defined at the national level, in accordance with to the national public service grading.
- Financial resources: the ministerial budget allocation system (SYMPA) integrating performance indicators has been neutralised, and the current approach largely ignores performance. It also does not take sufficiently into account the differentiation of needs between research universities and other universities (the management costs associated with research are considerable); the joint research units are funded on the basis of decisions taken primarily within the organisations.
- For immovable resources: devolution is virtually impossible due to the poor state of the building stock (including building security) and the absence of a depreciation allowance, as well as problems with securing the necessary competences within universities.

Educational and scientific autonomy: the main qualifications are national (bachelor's degree, master's degree, PhD, university degree in technology...). Universities are subjected to prior accreditation in order to award these degrees. This accreditation is issued by the ministry on the basis of national criteria, including regarding their designation. Accreditation is valid for four years (currently five years) according to models evaluated by the ministry (but with no commitment as to specific or additional methods). In the case of research, most laboratories (particularly the most productive) are joint units for which scientific policy is decided in conjunction with the PROs. Thus, French research universities have narrower leeway compared with foreign universities, while their research policy is dependent on the choices made by the PROs according to their own priorities.

Governance of universities

At the "top", the president of the university runs the institution, chairs the councils and mandates expenditure and revenue. He is elected for a four-year term by absolute majority of the elected members of the administrative board. The external members serving on the board are appointed by the president himself. The statutory bodies of French universities are the CA, the scientific council (CS) and the council for studies and student life (CEVU).[13]

The CA[14] consists of 20 to 30 members (8 professors-researchers representatives, half of whom are university professors; 3-5 student representatives; 2-3 library, administrative, technical, social and healthcare representatives and 7 or 8 external experts[15]). The university's CA determines the institution's strategy and approves the institutional contract, the agreements signed with the president of the university and the annual report. It also approves the budget and sets the allocation of HR. The CS[16] distribution is 60%-80% staff representatives, 10%-15% PhD student representatives and 10%-30% external scientific representatives. It proposes the institution's research strategies to the CA and is consulted regarding training programmes, research contracts and qualifications. Finally, the CEVU comprises 75%-80% professors-researchers, lecturer and student representatives, 10%-15% administrative staff representatives and 10%-15% external stakeholders.

Universities in other countries also have academic bodies equivalent to the CS and CEVU. These are the university board or conference in Germany, the academic board or senate in the United Kingdom and the university senate in Spain. The European equivalents of the decision making bodies (CAs in France) are the senate in Germany, the governing body or council in the United Kingdom and the governing council in Spain. Finally, the advisory and supervisory bodies have no equivalent in France: these are the governing board in Germany, the assemblies in the United Kingdom and the social council in Spain. Decision making powers and advisory and supervisory powers are sometimes grouped together in some countries (in Ireland and Sweden, these are the governing bodies). Depending on the country, the university president is nominated and appointed internally (France, Germany, Spain, United Kingdom, Ireland, Denmark) or appointed externally (e.g. Portugal, Belgium, Estonia, Latvia, Sweden, Czech Republic).[17]

University budgets

Each university receives allocated funding from the MESR. The overall budget for universities is distributed according to a key (the SYMPA model) that primarily takes into account each university's volume of activity, especially the number of students (60%), the number of professors-researchers who publish (20%) and performance in teaching performance (e.g. the number of graduates) and research (AERES evaluations). However, it appears that the model has not been used for several years, with the MESR using instead a "historical" system ensuring the stability of university resources. The financial position of some universities has deteriorated, in a scenario where staff costs are tending to grow mechanically (due to age and technical advances) and insufficient internal management capabilities have led universities to pursue a fiscally unsustainable HR policy.

Staff management

Since 2009, universities are responsible for payroll. Large disparities exist between the status of the professors-researchers, researchers, research technicians and engineers, and administrative staff who make up overall HR. Some are employed under private contracts (e.g. at the CNES and CEA, while others – the majority – are employed under statutory provisions (such as the civil service status, on the basis of legislation and regulations) or different types of public contracts.The funding sources for their salaries, as well as their status, also vary depending on the PRO. Similarly, the frequency and process of (local or national) recruitments and staff mobility vary widely among universities and PROs. This diversity has an impact on the management of HR in the public research and higher education system, but also on the orientation of HR towards scientific fields. It particularly complicates HR management in research units, most of which are joint units answering to several supervisory bodies, and therefore have heterogeneous staff (in terms of status, recruitment, promotion mechanisms, career development, etc.).

The devolution of payroll management to universities in 2009 might arguably have been expected to produce better HR management by the institutions. However, it also introduced new challenges. In addition to the recruitment methods mentioned above, this reform has led to increased expenses, particularly pensions and retirement contributions, for the majority of operators in the research and higher education system. Furthermore, while the overall number of staff has not significantly changed since 2006, their composition has changed. Today, the trend is for universities and PROs to fund contracts – and therefore fixed-term contracts – with their own capital (Tables 4.5 and 4.6). This increased use of temporary employment reflects the need for greater job flexibility to remain competitive in a scientific arena that presents ever-changing opportunities, as seen for example in the ANR thematic calls for projects.

The duality of the French research and higher education system (Tables 4.5 and 4.6), which is also found within research units, raises the question of how the distribution of research time and teaching loads for some of these staff members, most of whom work for several entities.

Table 4.5. FTE staff at universities

	FTEs remunerated by MIRES (P150)	FTEs remunerated by universities		
		Below threshold	Above threshold	Subsidised contracts
2008	125 170	13 434	5 253	
2009	91 603	48 858	10 357	
2010	37 513	101 882	12 591	707
2011	10 354	125 901	15 260	708

Source: Annual performance reports, French Court of Auditors, 2013.

Table 4.6. FTE staff in the main PROs

	Tenured staff		Contractual with state subsidy		Contractual with equity		Total	
	2006	2011	2006	2011	2006	2011	2006	2011
CNRS	25 485.6	24 964.8		2 611.0	5 764.9	5 635.4	31 250.5	33 211.2
INRA*	8 181.9	8 188.0	1 030.0	976.8	562.6	898.5	9 774.5	10 063.3
INSERM	5 016.5	4 896.0	591.6	711.1	948.8	2 301.0	6 556.9	7 908.2
INRIA	993.7	1 204.5	264.0	461.8	556.6	909.3	1 814.3	2 575.6

Note: * 2007 data for INRA.

Source: French Court of Auditors, based on EPST data.

Conclusion: What is the current status of the public research system in France?

The conclusion that can be drawn today is not substantially different from to that which could have been drawn in 2010. The current French public research system is composite, juxtaposing elements from two different ways of organising research: the traditional "governed" model, based on large autonomous structures with a high degree of control over their own fields of activity; and a new model, based on programming administered by the State, some competitive project funding, laboratories linked to universities and independent evaluation. A hybrid model normally allows for selecting the appropriate mechanisms according to the work assigned and the specific conditions of public research. Some types of research require specific resources, stability and planning that governed mechanisms can better provide. Conversely, other types are characterised by, for example, multiple *ex ante* alternative solutions that can be better explored through a competitive mechanism. The path followed by France over the past decade has been to extend the area covered by the competitive mechanisms over those covered by the governed model, in order to promote excellence and relevance (with regard to economic and social objectives). At the same time, PROs have made a number of changes in a bid to internalise excellence and relevance within their own organisations, while preserving their identity:

- They have emphaised transfer, including intellectual property and enterprise (see the next chapter).
- They have increased pressure for scientific excellence on researchers and teams: internal evaluations increasingly rigorous and effective, use of AERES evaluations, closure of underperforming units, etc.
- They have enchanced co-ordination between PROs, and with universities, through "alliances": these informal structures (with no articles of association or dedicated infrastructure) group together PROs and universities around major research fields (health and life sciences: Aviesan; energy: Ancre, etc.). Their task is to facilitate thematic and administrative co-ordination between stakeholders when preparing research programmes, managing certain programmes and procedures (e.g. recruitment), and so on.

However, these changes have so far not challenged the very foundations of the current public research system, i.e. the integration of the different roles (steering, funding, implementation and evaluation) within the PROs.

Thus, reform has progressed in France through two channels – the internal evaluation of existing organisations and mechanisms on the one hand, and the establishment of new organisations and mechanisms on the other. The first channel offers limited changes, while the second aims to effect more radical transformation.

In this context, the French research and innovation system now faces two questions: what is the appropriate balance between the two models under the current research and innovation conditions? And how can they co-exist in such a way as to maximise their complementarities and minimise systemic frictions?

In the current balance between the two models, incompatible mechanisms are operating simultaneously and leading to system inefficiencies. The creation of new entities and rules – which generally added to, rather than replaced, the existing entities and rules – has increased the system's complexity (leading to specific costs and inefficiencies) and created a feeling that resources are insufficient. Indeed, since resources have not increased as fast as new entities have been created, they have to be shared among a larger number of stakeholders, each receiving a smaller share.

The case of HR clearly illustrates this point. The juxtaposition of the research organisation system with project funding has led to inconsistencies in resource allocation. In the second half of the 2000s, financial resources were increasingly allocated by the ANR, while HR (in this case, tenured researchers) still worked under large research organisations, such as the CNRS (where researchers decide in which laboratory they will work). Since those two processes were disconnected, the consistency of their results could not be guaranteed. This resulted in a shortage of staff in laboratories that had won ANR grants. Since these laboratories were unable to recruit permanent researchers (government employees whose overall recruitment volumes are controlled by the State), they had had to recruit staff on short-term contracts. At the same time, tenured researchers of the CNRS were tied to laboratories that had not received competitive funding, and whose insufficient resources prevented them from carrying out the planned research. There are several possible ways of resolving this inconsistency: one would be to revert to the previous system and reduce the share of project funding. This would amount to depriving the French research and innovation system of an essential tool to help it adapt to modern research conditions and the political authorities of a potentially powerful strategic steering mechanism. Another solution would be to establish mechanisms that promote the mobility of permanent researchers, perhaps by considering changes to the status itself required to promote such mobility (civil servant researchers fall under civil service regulations, albeit with some special clauses).

The composite nature of the French research system at this stage of its evolution creates further complexity, which itself makes the system both less efficient (a growing share of resources, e.g. researchers' time, is spent on management rather than output) and less transparent (and therefore less possible to steer). After a phase where new stakeholders and mechanisms were created, a thorough review should now take place in order to consolidate existing frameworks and make the system more consistent and transparent. Consideration should certainly be given to the reforms implemented by the PROs in this regard, which should facilitate better integration into the rafts of reforms already undertaken.

For example, the integration of the PROs with universities is already quite advanced where the joint research units are concerned. The internal management systems of the PROs have incorporated some parameters for managing university research (increasingly effective evaluation, role of competitive funding), and the switching of some units with partial PRO status to full university status could occur all the more easily as the single administrator system seems to be progressing. If such a direction were taken, major research universities would need to be allocated some of the management capacity (including staff) currently allocated to certain PROs.

The site policy, which aims to strengthen the integration of the different research stakeholders on a geographical basis – i.e. around universities – and which is promoted by the MESR and supported by the PROs, is also moving in this direction. It has the added advantage of being able to call on the regional authorities, which can provide useful resources for helping with the necessary adjustments.

The competences and experience built up by the PROs, particularly at the strategic and administrative levels, are considerable, and must of course be preserved in a model where the balance would be tipped towards project funding and universities. It could be partially reinvested in other organisations – the MESR, the ANR and major research universities – which would see their role enhanced under this new model.

Overall, it appears that additional structural changes would enable French public research to achieve a higher level of excellence and relevance, with reduced operating costs and increased transparency. The changes required are ultimately minor, as the components of this evolution– the alliances, the ANR, the AERES, university autonomy, the integration of some PROs within universities, the site policy and the PIA – are already in place. They now need to be leveraged strategically.

Notes

1. Scientific performance is always difficult to measure. The most common source is scientific publications. These have the advantage of reflecting the core activity of most researchers, the publication of articles in scientific journals. Publication data are traceable: researchers and their membership are well identified, and there is information reflecting the scientific value of the work (the prestige of the publishing journal, the number of citations received). Thus indicators publications are commonly used worldwide to assess individual researchers, research teams and universities. As such they are subject to intense monitoring by the agencies responsible for evaluation and by employers. However, they are not free of defects, many of which can be reduced by proper treatment of the data. For example the fact that the majority of major scientific journals are in English favours researchers in countries where this language is more prevalent; researchers often have to multiply poorly differentiated publications (of low marginal value) to increase their score; some scientific fields are less based on publication than others; etc. These faults are not present in the indicators used in this review, which is aligned with the best international standards in the field of bibliometrics as practiced in France by OST. In addition, the bias in favour of English could affect comparisons between France and the English-speaking countries, but it should not affect comparisons between third countries, France and Germany for example. It is, however, necessary to complete the analysis of bibliometric data with that of other sources. Indeed, the publication of articles is not the only activity of researchers: they also publish databases, research materials, blogs etc. and those working in the more applied areas are also involved in transfer activities and innovation.

2. For a complete overview of R&D in Germany, see: BMBF Federal Report on Research and Innovation 2012 or Research in Germany: The German Research Landscape 2011.

3. Data: Research in Germany (2011).

4. View distribution map: www.forschungslandkarte.de/en/institutional-research-priorities-of-universities/map-search.html.

5. Responsible for managing the research programmes of the regional and federal ministries.

6. See the distribution of funded projects per area: www.dfg.de/download/pdf/foerderung/programme/exin/entscheidung_exin_karte_120615.pdf.

7. For a complete list of the selection criteria for the Idex, see: www.agence-nationale-recherche.fr/investissementsdavenir/documents/ANR-AAP-IDEX-2010.pdf.

8. For a complete list of the selection criteria for the Labex, see: www.agence-nationale-recherche.fr/investissementsdavenir/documents/ANR-AAP-LABEX-2010.pdf.

9. For a complete list of the selection criteria for the Equipex, see: www.agence-nationale-recherche.fr/investissementsdavenir/documents/ANR-AAP-EQUIPEX-2010.pdf.

10. See the complete list of grantees: http://media.enseignementsup-recherche.gouv.fr/file/Investissements_d_avenir/94/9/Equipex-liste_des_52_projets_166949.pdf.

11. The presidents and CA of the PRES have one year to adopt the CUE articles of association (on an interim basis).

12. www.cese-poitou-charentes.fr/IMG/UserFiles/Image/Avis%20PRES%20L%20PC%20octobre%202013.pdf.

13. Composition of these bodies before the 2013 Law.

14. The 2013 Law on Higher Education and Research sets the number of members of the CA at 24 to 36, including 8 external parties appointed by university partners and elected members of the CA.

15. The openness of the CA, CS and CEVU to external stakeholders (business leaders, executives and representatives of regional authorities for the CA and other external stakeholders for the CS and CEVU) is also an example of how the research system has evolved.

16. The CS and the CEVU are becoming research and training committees that make up the academic council. See the breakdown of compositions and competences in the 2013 research law, Journal Officiel (Official Gazette).

17. See Eurydice (2008), Higher Education Governance in Europe, http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/091EN.pdf.

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Chapter 5

Transfers between public research and businesses in France

This chapter presents knowledge transfers between public research and the economy. These transfers are a priority of research policy in France, as in other countries, and have undergone numerous reforms over the past decade. The chapter reviews the main channels used for these transfers: partnership research (including research contracts), staff mobility, intellectual property and entrepreneurship (business start-ups by researchers in particular). In each case, it describes the mechanisms in place, examines their performance based on available statistical indicators and compares them with similar mechanisms in place in other countries.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the Organisation for Economic Co-operation and Development (OECD) is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Introduction

In every country with public research capacity, transfers towards business and society have become a political priority over the past 10 to 20 years (OECD, 2013). The public research sector is a unique potential source of know-how and technology that businesses cannot develop themselves, for example because they are based on open methods of scientific invention that are incompatible with an economic profit goal. Conversely, it is important for governments to translate their substantial research and development (R&D) expenditure into added value and jobs, and only businesses can do that.

France is no exception: it has made knowledge transfers a political priority since at least 1994 and has over the years adopted numerous measures to this end. This chapter begins with a review of the general context in which these policies have been adopted. It then examines the main types of transfer in turn: collaborative research, contract research, academic consulting, personnel mobility, intellectual property (IP) and business start-ups. It concludes with an overall assessment of these policies.

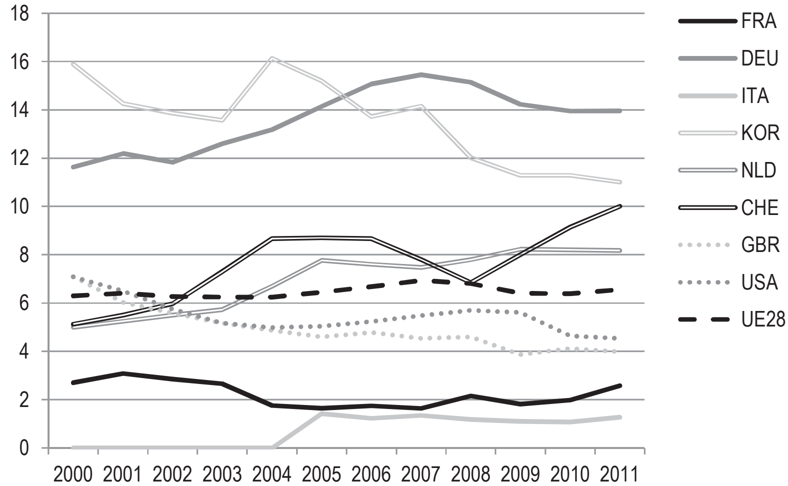
Rapidly changing environment

Public research is an important source of the basic and applied knowledge that can contribute to business innovation. It supplies inventions and qualified human resources (HR), both of which are crucial to business development. One of the main problems in establishing a diagnosis and analysis of the interfaces between public research and the economy or society is that their multiple forms and mechanisms. Professional mobility (of researchers, PhDs, etc.), spin-offs from public research, IP and its commercialisation, collaborative research, contractual research and expenditure targeted at research development (proof of concept, scaling up, prototypes of industrial processes, etc.) are just some of the indicators, complemented by a number of non-commercial mechanisms: conferences, publications and informal collaborations. Commercial transfer activities are often described in French as "*valorisation*" ("commercialisation"). See Table 5.1 for a description of the transfer channels most widely used in the OECD countries.

Substantial public investment in research over the past decades in all OECD countries, particularly France, is usually justified by the need to promote economic growth and competitiveness. The resulting innovations are a means of ensuring the future competitiveness of a region, country or organisation (including a research organisation). It is therefore vital to have a national research system that incorporates efficient knowledge transfer processes. Furthermore, an additional expectation is becoming more and more pressing locally: that of the regions, which have increased their – often sub-critical – support for higher education and research, but whose primary responsibility is economic development.

However, most OECD countries experience difficulties in developing links between the academic world and industry, since these two "worlds" have very different functions, cultures and operating rules. Those difficulties are also found in France, where the low level of private funding in the budgets of higher education and research institutions (around 2% in 2010, compared with 6% on average in the OECD countries, including 15% in Germany [OECD, 2013]) appears to indicate a lack of interaction between public- and private sector participants. This lack of interaction is also illustrated by the low rate of public-private co-publications, which is significantly lower in France than in countries such as Switzerland, Germany, the United States and Sweden (Figures 5.1 and 5.2).

Figure 5.1. Percentage of higher education expenditure on research and development (HERD) financed by industry

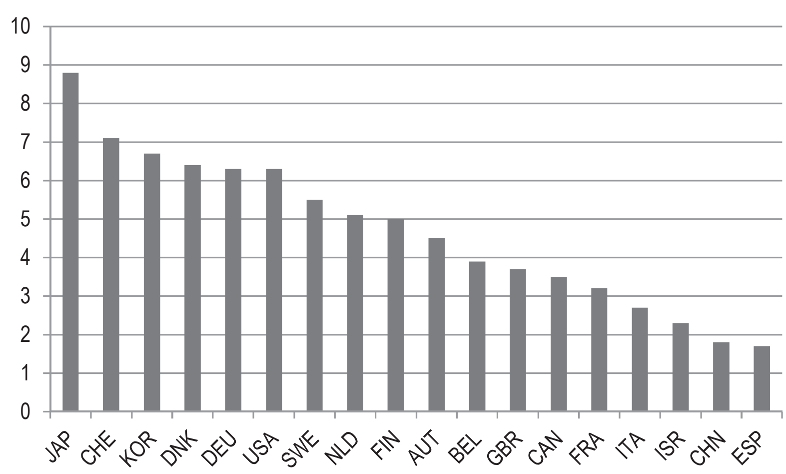


Notes: Some data are estimates or projections by the OECD based on country sources. For the United States, capital expenditure is excluded (wholly or partly). From top to bottom (right column): Germany, Spain, European Union-15, European Union-27, total OECD, United States, United Kingdom, France, Italy.

Source: OCDE (2013), *Main Science and Technology Indicators,* Volume 2013, No. 1, OECD Publishing, doi : 10.1787/msti-v2013-1-en.

Figure 5.2. Industry-science co-publications, 2006-10

Industry-science co-publications as a % of all scientific publications

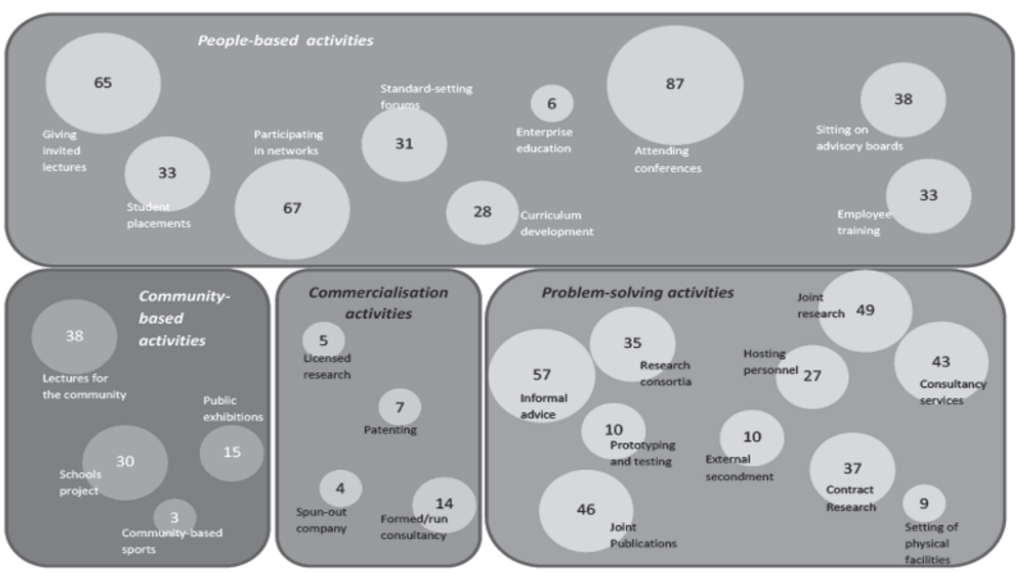


Source: Centre for Science and Technology Studies (CWTS), Leiden University, using the Web of Science database.

In order to establish the national context, this chapter presents and analyses the changes in the technology transfer and commercialisation mechanisms introduced in France since the end of the 1990s. It describes the existing or missing structures in the four main transfer areas: partnership research, researcher mobility between the public and private sectors, IP and public research spin-offs. France appears to be well supplied with mechanisms, both at the national and regional levels and within the research institutions. However, these mechanisms are often subject to criticism, which explains the frequent reforms they undergo, as well as the introduction of new instruments. However, no systematic and stable statistics are available concerning French transfer mechanisms – neither on their resources or inputs (human or financial) or their results, let alone their socio-economic impact.

One of the major limitations of this analysis should be mentioned at this point. This presentation is essentially concerned with transfers towards companies, in the form of a quantifiable economic transfer of technology based on a transaction or a contractual relationship. Yet most of the links between universities and research organisations on the one hand, and business and society more generally on the other, are not of this nature. Although the surveys by Alan Hughes and his colleagues (Hughes and Kitson, 2012) relate solely to the United Kingdom, they demonstrate the plethora of forms and procedures and the limited importance of commercial relationships (Figure 5.3).

Figure 5.3. Percentage of academics reporting interaction with an external organisation in the last three years



Source: Hughes and Kitson (2012), "Pathways to impact and the strategic role of universities: New evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development", *Cambridge Journal of Economics*, Vol. 36, Issue 3, pp. 723-750.

Thus, they demonstrate the importance of personal relationships ("people-based activities") as ways of interacting with society. Systematic business surveys confirm this diagnosis. The OECD report on commercialising public research (OECD, 2013) stresses the importance of transfers brought about by human capital and individual mobility, particularly students entering the industrial sector following experience in public research during their doctorates. Similarly, a fuller examination of relations between academia and society, especially the economy, under the heading "academic engagement" shows that this engagement is generalised and historical (Perkman et al., 2013). The organisation, procedures, content and distribution of these relations should be analysed in order to gauge the nature and effectiveness of knowledge transfers and to conduct pertinent international comparisons.

The questions raised are therefore as follows: do policies to commercialise public research, which focus on the economic and commercial aspects, have an impact on other forms of interaction – and, if so, is that impact positive or negative, and is it significant? Does the changing structure of relationships lead to a change in the nature of the research and research programmes conducted by researchers and their institutions?

Table 5.1. Summary of knowledge transfer and commercialisation channels

Channels	Description
Publishing	The most traditional and widespread mode of knowledge transfer, it is mostly limited to published papers.
Conferencing, networking	Professional conferences, informal relations, casual contact and conversations are among the channels ranked as most important by industry across all sectors.
Collaborative research and research partnerships	Scientists and private companies jointly commit resources and research efforts to projects; research may be co-funded (unlike contract research). The level of co-operation varies from individual to institutional, from small-scale projects to strategic partnerships with multiple members and stakeholders (i.e. public-private partnerships).
Research contracts	Research – generally more applied than collaborative – commissioned by a private firm to pursue a solution to a specific problem.
Consulting	Research or advisory services provided by researchers to industry clients are the most widespread – yet the least institutionalised – activities in which industry and academics engage. There are three different types: research, opportunity and commercialisation-driven consulting. They are important to industry and do not compromise the universities' missions.
Student hiring by industry	The major motivation for firms to engage in industry-science linkages and the main benefit for universities, e.g. through joint supervision of theses and internships or collaborative research.
Patenting and licensing	Patents and licenses are ranked among the least important channels by industry and researchers, but are greatly scrutinised both in academic literature and among policy makers.
Public research spin-offs	Spin-offs have received substantial attention, even though their numbers are limited compared to alumni and student start-ups.
Personnel exchanges/intersectoral mobility	May take many forms; generally university or industry researchers spend time in the partner institution's laboratory. The most important form of "personnel mobility" is employment by industry.
Standards	Are at least as important as patents as a knowledge transfer channel.

Source: OECD (2013) *Commercialising Public Research : New Trends and Strategies*, OECD Publishing, Paris, doi: 10.1787/9789264193321-en; based on Ponomariov et Boardman (2012), "Organizational Behavior and Human Resources Management for Public to Private Knowledge Transfer: An Analytic Review of the Literature", *OECD Science, Technology and Industry Working Papers*, No. 2012/01, OECD Publishing, doi: 10.1787/5k9d4gt7mdbp-en; and adapted from Cohen et al. (2002), "Links and Impacts: The Influence of Public Research on Industrial R&D", *Management Science*, Vol. 48(1), pp. 1-23; Perkmann et Walsh (2007), "University–industry relationships and open innovation: Towards a research agenda", *International Journal of Management Reviews*, Vol. 9(4), pp. 259-280.

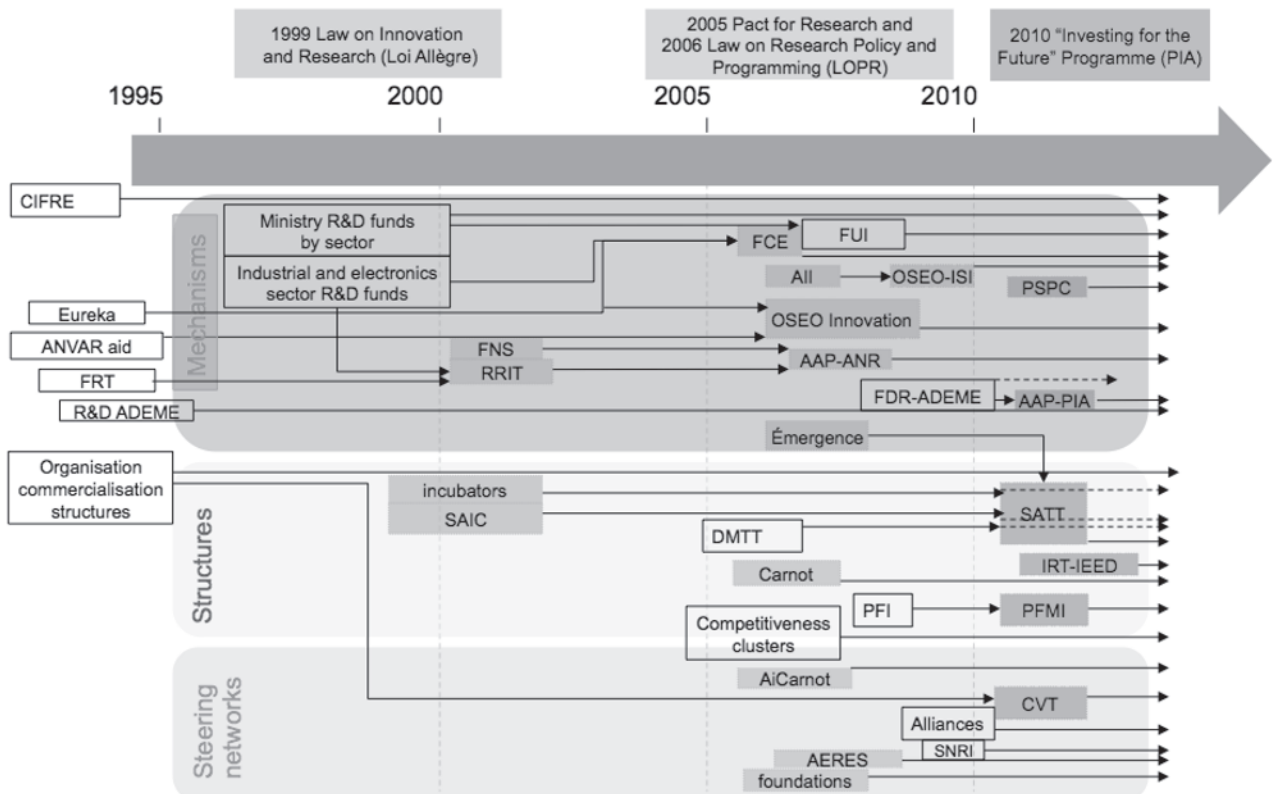
Successive reforms have been introduced and measures and instruments created in France since at least 1999, although how they fit in with the pre-existing mechanisms is still not clear. The situation in 2010 reflected a concerted effort by the public authorities to strengthen knowledge transfers between public (especially academic) research and industry – or more generally, the commercial system. This chapter presents a reasoned analysis of the state of commercialisation mechanisms in France by introducing an international comparison. It also examines the mechanisms introduced by the "Investments for the Future" Programme (PIA), although it is still too early to evaluate its effects (Box 5.1). The major obstacles to this analysis are the lack of coherent information systems, the complexity of the system itself (with its multiple institutions with different compositions or partnerships) and the lack of forecasting or benchmarking exercises, and especially of impact evaluation procedures, beyond the reports produced by the Government itself.

Constantly evolving knowledge transfer mechanisms

For nearly 15 years, all the reforms relating to research and higher education have been linked to transfer mechanisms. The report by the General Council for the Economy, Industry, Energy and Technologies [CGEIET]), the General Inspectorate of the Administration of National Education and Research [IGAENR]) and the General Inspectorate of Finance [IGF]) (2013) perfectly illustrates the layering of measures already highlighted by previous studies (especially the report by Guillaume and Cyterman, 2007). Three main reforms punctuate this process of creating incentives for research partnerships:

- 1999: Law on Innovation and Research – establishment of industrial and commercial activities departments (SAICs) and university commercialisation centres, creation of public incubators, changes in rules applied to HR in the public research system to encourage links and mobility. The Law launched two mechanisms: the National Science Fund (FNS) and the Technical Research and Innovation Network (RRIT).
- 2005/06: Research Pact and Law on Research Policy and Planning: numerous mechanisms, including the Business Competitiveness Fund (FCE), OSEO Innovation, the calls for proposals issued by the National Research Agency ([ANR] the "Émergence" programme), the Carnot institutes – with State-matched funding of partnership research for the public partner, if certified – the competitiveness clusters and the Single Interministerial Fund (FUI) for collaborative research funding.
- 2010: the PIA, with, in particular, technology transfer acceleration companies (SATTs), profit-making organisations with a regional or thematic scope, responsible for commercialising IP for the universities, further developing their results and those of the associated public research organisations (PROs), and facilitating their transfer to industry), IRTs (technological research institutes) and institutes of excellence for carbon-free energy (IEEDs), consortium for thematic commercialisation and France Brevets (see Box 5.1 for a description of transfer instruments within the PIA.)

Figure 5.4. Main measures and instruments associated with collaborative research, 1995-2012



Source: CGEIET, IGAENR and IGF (February 2013).

Several mechanisms have thus been created, but very few abolished, resulting in a large number of transfer mechanisms and often ad hoc institutions (see the diagram above). This diversity could be perceived as an advantage in that this set of mechanisms appears to meet a range of needs on the part of businesses and researchers. However, the profusion of mechanisms inevitably leads to a lack of clarity in the system for the participants, especially when local government and the European Union add mechanisms of their own. This profusion, particularly when combined with the lack of a coherent information system, also makes it impossible or at least difficult to co-ordinate and manage activities so as to achieve the objectives set by the State, i.e. its national research and innovation strategy with sectoral and thematic priorities.

This approach is not new – industrial agreements for training through research (Conventions Industrielles de Formation par la REcherche [CIFRE] have existed since 1981) and is not solely and directly the result of State initiatives. In fact, every national public research organisation has long structured itself to meet this commercialisation imperative: INSERM (National Institute for Health and Medical Research) Transfert, founded in 2000; INRA (National Institute for Agronomic Research) Transfert, France Scientific Innovation and Transfer (FIST) – founded in August 1992 with the National Centre for Scientific Research (CNRS), French Agency for Commercialisation of Research (ANRE), INRA, the French Institute for the Exploitation of the Seas (IFREMER) and Novespace as shareholders – and CEA (Alternative Energies and Atomic Energy Commission) Tech. The CEA has been very active in commercialising research through the Electronics and Information Technology Laboratory (LETI) in 1967, then the Systems Integration and

Technology Laboratory and Innovation Laboratory for New Energy Technologies in 2000. The PROs have developed and deployed their own strategies within their research institutes, units and centres.

One characteristic of the French public research sector (see the chapter on public research) is that it is organised into joint research units (UMRs) managed by several trustees (generally a university and one or several PROs). This increases the number and length of procedures (granting a licensing contract or selling a patent requires the agreement of all co-owners, each with its own procedures). Moreover, the different trustees do not always share the same strategies and interests when it comes to commercialisation. This situation is a source of difficulties, obstacles, costs and hence inefficiency. Pooling resources is therefore a natural response, which explains the emergence of new structures such as the shared systems of technology transfer (DMTTs) and, more recently, the SATTs.

Box 5.1. The main commercialisation and technology transfer mechanisms of the PIA (2010): Carnot Institutes, SATTs, IEEDs and IRTs

The Carnot Label is conferred on research structures that engage in partnership research. Launched in 2006, the Carnot institutes predate the PIA. However, the PIA has given them a significant boost. A first wave of 33 projects was selected initially (2006-10), followed by a further 34 projects (2011-16, including 10 new laboratories). The initial funding for this mechanism was EUR 500 million under the PIA. The Carnot institutes are responsible for 65 start-ups, 967 priority patents filed in 2012 and a contract volume of EUR 420 million (Ministry of Higher Education and Research [MESR]).

The SATTs (EUR 855 million budget within the PIA) aim to co-ordinate the commercialisation teams of the educational and public research institutions within a region, thereby improving the transfer of technology originating in public laboratories to industrial or social applications. At the end of 2013, France had 14 SATTs (including SATTGift and SATT Paris-Saclay since November 2013 with EUR 123 million in funding). The SATTs invest in research development projects and provide commercialisation services. These companies have pooled certain functions (e.g. IP management) and developed new activities (such as innovation development). Their activities, management powers, business models and governance vary from one SATT to another; hence, it is very difficult to identify their generic role, if not that of developing research.

The aim of the IEEDs is to pursue top-quality research in the areas of energy and climate (carbon-free energy), especially through public-private partnerships. There were nine IEEDs in France in 2013. The IRTs are similar to the IEEDs, but target different sectors. Both IRTs and IEEDs have public-private governance and greater ambitions in terms of contract volume than the Carnot institutes. Compared with the latter, they offer a wider range of services (provision of research personnel and equipment) and must be certified by a competitiveness cluster. They are facilitated gateways for companies, particularly small and medium-sized enterprises (SMEs), helping to improve their competitiveness in a given sector. The training aspect (vocational training and higher education) is important to IRTs and IEEDs, whose mission is to meet the skills needs of a business sector and in areas of technology developed by IRT-IEEDs.

Given their respective positioning, IEED-IRTs and SATTs may be encouraged to work together: the SATTs may fund activities to develop IEED-IRT projects, or IEED-IRTs may provide technology development services for SATT development projects. IRTs may also entrust SATTs with commercialising their research.

It is too early to gauge the impact of these recent mechanisms, and especially their impact on the effectiveness of knowledge transfer to and from companies.

A French Senate information report (2006) stated that "since 1984 [*note*: the Savary Law], universities have had the option of setting up subsidiaries as specific commercialisation structures, although they have made little use of this solution (Université de Technologie de Compiègne, Université de Lyon 1, Université de Valenciennes), as those pursuing commercialisation activities prefer to use an internal department or an association". The 1999 Law establishing internal university commercialisation departments, or SAICs, discouraged these opaque management structures.

Commercialisation structures, which are sometimes shared and have different legal forms, are organised into a network known as CURIE. This approach aims to co-ordinate and professionalise the public commercialisation structures. Between 2000 and 2008, the number of CURIE members rose from 70 to 162. Only 30% of universities had a commercialisation department before 2000, compared with 79% in 2011 – 90% or 95% if counting only the science and technology universities (Gorry and Haunold, 2011). Universities, (former) PRES, PROs and university hospitals are connected through the CURIE network, which also includes the private and institutional stakeholders of commercialisation. This network promotes and provides all of its members with training in best practices, specific services (legal counsel, etc.) and pooled services or operating tools associated with IP management. CURIE has also launched since 2013 a national survey of commercialisation and partnerships in order to establish reliable commercialisation indicators at national level. The most recent (current) survey covers 2008-11.

Thus, numerous structures exists, some mutualised, some organised by institution, region or organisation and/or nationally. The question is whether the system – and particularly its performance – is coherent.

Forms of transfer: A few performance-related aspects

Very few studies have been devoted to commercialisation in France. On the other hand, many institutional reports have been produced over the past 20 years. Apart from a number of ad hoc reports, few studies have provided food for thought or made it possible to evaluate the performance of different commercialisation tools on the basis of figures derived over extended timeframes. The Research Laboratory in Theoretical and Applied Economics (BETA) study (2010) constitutes an exception, although it does not cover all aspects of transfer exhaustively, nor it is particularly analytical. However, difficulties (which also exist in other European countries) in accessing information make research and international comparisons even more complicated (Lallement, 2013).

The following analysis will focus on four transfer channels which have received the widest political attention:

- partnership research (research projects involving both public and private partners)
- researcher mobility between the public and private sectors
- industrial property and its management
- business creation.

Partnership research

Partnership research concerns collaborative research, contract research and consulting services provided by public researchers to the private sector.[1] Various incentives are offered, including calls for partnership proposals (collaborative research), tax incentives, establishment of networks/clusters, creation of new partnership structures and assistance for doctoral candidates working in companies.

According to the CGEIET, IGAENR and IGF report (2013), the State's financial contribution (including the research tax credit [CIR]) is estimated at EUR 2 billion, i.e. 10% of the Mission interministérielle Recherche et Enseignement supérieur (MIRES) budget appropriations. It is difficult to assess the exact amounts because France, like most countries, has no budget specific to transfer policies. Transfer-related expenditure is therefore halfway between public R&D expenditure (ANR, FUI), private expenditure geared towards partnership research and contracts between private firms and universities or PROs. Combining this private expenditure and European and local subsidies, the volume devoted to partnership research was around EUR 4 billion in 2011 (of which nearly 50% was funded by the State, the remainder by companies and to a lesser extent by Europe: see Table 5.1), approximately 10% of GERD. Note the substantial proportion attributable to the CIR (EUR 753 million), FUI (EUR 660 million), ANR calls for proposals (EUR 492 million) and European Framework Programme (EUR 392 million).[2]

Table 5.2. The ten partnership research mechanisms in France in 2011

EUR millions

Mechanism	Funding			Research institution grants	Total
	Private	Local authorities – Europe	Public State		
CIR public contracts	534	–	219	–	753
FUI projects	254	80	172	155	660
ANR thematic calls for projects	97	–	192	263	492
Framework Programme for Research and Technological Development co-operation	59	265	–	67	392
OSEO-ISI	120	–	115	15	250
French Space Agency	27	0	110	110	247
FCE-Nano 2012	101	50	66	11	228
CIFRE	130	–	53	–	183
French Civil Aviation Authority	76	–	53	28	158
FCE-Eureka	48	–	58	–	112

Source: CGEIET, IGAENR and IGF report (2013, p. 11).

Collaborative research

Partnership research mechanisms include calls for partnership proposals, tax incentives (CIR), the establishment of networks modelled on competitiveness clusters (discussed in detail in the chapter on business innovation), the creation of structures to accommodate partnership research (IC, IRT, IEED, university hospital institutes (IHU]) and joint public-private research laboratories.

Box 5.2. Carnot and Fraunhofer institutes

The Carnot institutes are often compared to the German Fraunhofer institutes. However, there are marked differences between the two mechanisms:

Carnot institutes	Fraunhofer institutes
A recent mechanism (2005-06)	Founded in 1949
33 Carnot institutes	60 Fraunhofer institutes
Certification awarded to existing structures	Institutes with a unique status
Limited term (four years)	Permanent structure
Positioning centred on partnership research	Positioning on applied, industry-driven research
2011 budget: EUR 1.3 billion	2011 budget: EUR 1.85 billion (including 70% funding of projects comprising 66% contracts with industry)
Multiple forms of governance given the diversity of structures which can make up a Carnot institute	A single national authority: the Fraunhofer Gesellschaft
Public match funding as an incentive (budget depends on volume and growth of contracts with the private sector)	System naturally oriented towards industry
No thematic positioning but specialisation in certain areas	Thematic positioning (seven thematic alliances by group of institutes)
13 000 permanent members (13 000 research professionals)	Approx. 22 000 employees (mainly scientists and engineers)
Substantial proportion of doctoral students (7 500 in 2013) and post-docs	Engineers and higher education graduates
Growing visibility in France	Established visibility in Germany and internationally
880 patents filed in 2012 (this figure includes university and PRO patents as a whole)	494 patents in 2011

Aside from these structural differences, the two mechanisms operate in different economic environments and industry structures and hence address different researcher and business needs. On the research side, the Fraunhofer institutes were created specifically to develop applied research for industrial purposes and are recognised and appreciated for that role. On the business side, the Fraunhofer institutes are recognised for their entrepreneurial culture and knowledge of markets and industrial constraints. The Carnot institutes are "agglomerations" of existing research structures, with a history characterised by an exceptional tendency to engage in contractual research with industry. This is why it is misleading to refer to the Carnot institutes as "French-style Fraunhofer institutes".

Source: Annex to the CGEIET, IGAENR and IGF report (2013); EFI (2012); BMWi (2007); Fritsch et al. (2007); Zenker and Tippmann (2011).

Calls for partnership proposals, whether thematic or not, are issued by government departments (Directorate General for Competitiveness, Industry and Services, French Defence Procurement Agency [DGA], etc.) or other operators (ANR, Environment and Energy Management Agency, OSEO, etc.). For example, the ANR uses various instruments to bring research laboratories and companies together in the form of collaborative research, such as the Inter Carnot-Fraunhofer (2009-11) and Émergence programmes (2006) in the field of biotechnology. The ICs (2006) and, more recently, LabCom (2013) are other key mechanisms of the ANR in the area of collaborative research.

The industrial chairs (2010) are another instrument designed to attract co-operation and private funding. The first invitation to tender in 2011 resulted in six chairs, co-funded by the ANR and industrial partners. However, the Evaluation Agency for Research and Higher Education (2012) determined found that this mechanism was not sufficiently transparent in its selection, monitoring and evaluation procedures.

The Carnot institutes (see Box 5.2) are existing research structures which hold the Carnot Label awarded by the State via the ANR for a term of four years. This certification is intended to increase their visibility and business partnerships and gives them access to additional resources (by State matching of funding obtained from private partners). An impact study on this mechanism was conducted in 2011 (ANR, 2011) on the first 33 Carnot institutes. The sample included 121 projects, 44 of which were completed. For the 74 projects estimated at full cost, the average cost per project was EUR 600 000, with a wide spread. The survey showed that 51 of the projects studied resulted in 108 formal contracts, including 75 collaborative research contracts. Some projects (10%) produced more than five partnerships. Carnot institutes project management seems to entail substantial transaction costs. The average amounts are relatively small (most are below EUR 100 000). In terms of dynamics, the Carnot institutes' revenue from collaborative research increased by 28% from 2007 to 2009; the advent of ANR and FUI projects probably contributed to this growth. Note that the Carnot institutes' matched funding is separate from their budget allocation, as it is based on their contract volume and growth.

Joint public-private research laboratories have existed in France for many years (the first were created in the 1970s), but have mostly seen significant development since 2005 under the guise of joint public/private research structures (SCRs). SCRs allow the sharing of HR, equipment and operations between a business or technical centre and a laboratory of a higher education and research institution, for the benefit of a joint research strategy over the medium to long term (four to five years, extendable twice). They are mixed, co-managed teams without legal identity. According to the MESR (2011), there were 214 SCRs in 2011, divided into three categories:

- the "dominant" model, comprised of mixed research and business teams (55 SCRs)
- the extended model, corresponding to industrial chairs (26)
- the alternative model, including academic teams and technical centres (33).

These 214 SCRs involve a total of 79 research operators, but with a strong presence for the CNRS (55), CEA (44, including 18 for CEA-LETI alone) and engineering schools (79). A total of 33 universities are involved in 70 SCRs. Altogether, 100 companies are involved, three-quarters of which are major groups.

The Cyterman-Guillaume report (2007) recorded 107 SCRs with 1 or more industrial partners. However, this figure appears to have risen since then. More recently, the ANR launched the LabCom programme to develop joint laboratories with SMEs and intermediate-sized enterprises (ISEs).

Generally, information on these structures is – once again – scarce. Moreover, no evaluation or follow-up of these particular structures appears to have been conducted, or at least published, even though they employ significant resources.[3]

Among the other mechanisms for collaborative research in France are the calls for thematic or non-thematic candidates. The FUI, administered by OSEO/Bpifrance, is intended to support applied research. It funds collaborative R&D projects (large companies, SMEs, laboratories) by competitiveness clusters. Competitive clusters are involved more generally in bringing laboratories and private firms together, by certifying R&D projects to facilitate their funding and taking a proactive role in private-public relations.

Such mechanisms, i.e. calls for thematic or non-thematic candidates, are also found in other European countries, such as Germany and the United Kingdom.

Partnership research is firmly established in Germany, including in terms of structures (with institutions such as the Fraunhofer institutes or the Steinbeis Foundation). According to the Deutsches Institut für Wirtschaftsforschung (DIW), EUR 1.5 billion in funding was allocated to support R&D in SMEs in 2011: nearly two-thirds of this was direct funding and one-third was granted via research organisations, generally in the context of co-operative projects directly benefitting SMEs. This means that at least EUR 1 billion of the federal R&D budget is devoted directly to collaborative research (French Embassy in Germany, 2013). Estimates are particularly hard to make because innovation policies and partnership research policies have a strong regional component through the *Länder*.

Another method involves asking companies about how they co-operate with public research institutions. The Community Innovation Surveys (CIS) (2004 and 2008) compare and analyse some of the differences between France and Germany in terms of co-operation between companies and public research. They show that French companies that engage in research co-operation tend to do so with non-academic partners, unlike German companies (Robin-Schubert, 2013).The impact of corporate partnerships with academia in terms of innovation is significant when it comes to product innovation and systematically higher in Germany than in France. This difference widened significantly between the 2004 and 2008 studies. One explanation might be the greater decentralisation of German research and its closer proximity to business – whereas there may be a preference in France for non-academic co-operation, i.e. with suppliers or clients rather than university laboratories. This attitude is reflected in the low rate of public-private co-publications in France.

In the United Kingdom, the Industrial Partnership Awards, stand-alone LINK and Technology Strategy Board competitions are some of the collaborative research programmes under a system of calls for thematic collaborative proposals (in the biosciences in these cases). The Higher Education-Business and Community Interaction Survey found that collaborative research revenues were around GBP 872 million in 2010-11 (i.e. an increase of 16% over the previous year), with contributions from the public sector accounting for 76% of the total, i.e. GBP 663 million (up 10%) and private sector contributions for GBP 208 million (up 42%). (CGEIET, IGAENR and IGF, 2013, supporting documents attached to report.)

In France, the growing number of opportunities and mechanisms for co-operation between laboratories and companies is a unanimous finding which leads to several observations. On the one hand, evaluation of these mechanisms is generally poor. Evaluating the overall mechanisms is made more difficult by the proliferation of mechanisms and institutions, making it impossible to pinpoint trends or even suggest a general direction. Moreover, this diversity of structures raises the question of the governance and strategic management of national policy in the area of partnership research.

Finally, the lack of information available about the performance of these mechanisms means that a number of questions raised in recent or older reports (French Senate, 2008) remain unanswered: would a more co-ordinated approach (by sector?) be more appropriate in order to meet corporate needs and improve the visibility and effectiveness of the mechanisms and structures (especially the Carnot institutes)? Do the main targets (SMEs and ISEs) actually feel the impact of the various measures designed to encourage partnership research? And are they the right targets?

In the end, this diversity is likely to lead to instruments crowding each other out, but also to windfall benefits. To date, there has been no systematic analysis of these effects.

Contractual research

Contractual research covers all contracts between private companies (as shareholders) and public institutions with the purpose of conducting research projects. Its share in institutional' budgets has increased very little – from EUR 700 million in 2000 to EUR 743 million in 2010 (CGEIET, IGAENR and IGF, 2013) – and has fallen from 5% to 4.5% as a proportion of the internal R&D expenditure of public institutions. The share of R&D carried out in the French academic sector (including the CNRS) funded by industry was 2% in 2010, compared with 2.7% in 2000. In 2010, that share was 13.9% in Germany, 4.1% in the United Kingdom, 6.4% in the European Union and 6% in the OECD. This budget information relates only to contractual research, but shows that France clearly lags behind other countries and that the gaps are widening. It should be noted that this finding was recorded following a period in which successive governments had made it a priority, by increasing the number of mechanisms (from the SAICs in 1999 to the SATTs in 2011) without abolishing any...

In the specific case of the Carnot institutes, their evaluation (2011) shows an increase in contractual revenue between 2006 and 2009 – but this revenue represents a stable share (around 15%) proportion of their consolidated budget over the period. The particularly strong incentives given, especially the CIR, do not appear to have had any impact on this situation. The CIR is offered at a double rate in the case of public-private collaborative research, i.e. 60% or 10% depending on the companies' total R&D expenditure (see the chapter on business innovation). However, it is important to qualify this finding because the absence of contractual research (identified by the financial aspect of the contract) does not necessarily imply the absence of actual co-operation, as the financial flows may be managed by third parties (a foundation, an association, or even the business itself). The absence of a coherent information system again appears to be a consequence of the multiple institutional mechanisms. The IRTs and institutes for energy transition (ITEs), created more recently thanks to the PIA, have specific sectoral or technological features but the same purpose: to pursue technological development via contractual research and partnership research.

Consulting and expertise

From a contractual perspective, researchers may provide consulting services to a private company as long as they do not work full-time at the company. At the CNRS, consulting activities should not account for more than 20% of a researcher's time. Most universities apply a similar rule.

Consulting represents an attractive opportunity to disseminate or even implement research results. Exchanges resulting from consulting activities can help decompartmentalise perceptions of the worlds of public research and business. Because the differences between these two worlds are often highlighted as barriers to transfer, exchanges of this type are an interesting avenue for progress, provided the rules of professional conduct are respected. However, it is very difficult to gauge the true financial importance of these consulting and expert services, since they are self-declared and the institutions' information systems only have a partial view of their true extent. For example, the law requires academics providing consulting and/or expertise to request approval deriving income from multiple sources. These requests are often very limited in number and by no means systematic. The amounts of income stated in these requests are approximate (because they are *ex ante*) and self-declared.

Looking beyond consulting as a commercialisation activity, it should be noted in general terms that a researcher's independence and impartiality should not be jeopardised by private interests, let alone personal interests; relationships between researchers and consultants and, more generally, the links between scientists and industry remain a topic of discussion within the scientific community[4] (on the specific case of the humanities and social sciences, see Latour et al., 2008; Darlinghton and Dobson, 2013; and Baron, 2008; for an overview, see Perkmann et al., 2013).

Researcher mobility between the public and private sectors

HR mobility is a channel and an indicator of the links between public research and business which allow the transfer of skills and knowledge. Following the 1982 Law on Research Policy and Planning, the 1999 Law on Innovation and Research relaxed the rules on participation by research staff in business start-ups and the activities of existing companies. The Law governs participation by a public employee as a partner or manager in a business start-up (Article 25-1), as a scientific adviser or shareholder – holding a maximum 15% share (Article 25-2) and as a member of a management or supervisory board (Article 25-3). Such participation requires the approval of the Committee on Standards in Public Life. The Committee's statistics provide important information about this mobility, which appears to be marginal and very limited compared to the number of public sector researchers.

The Committee issued 122 recommendations in 1997 and 121 in 2011 (the last year for which a figure is available), following a peak of 207 in 2003 and a low of 78 in 2007, i.e. between 0.1% and 0.2% of the staff of the scientific and technological public institutions (EPSTs) and universities. Most of these applications, between 70% (from 2000 to 2005) and 83% (from 2007 to 2011), relate to Article 25-2 (scientific adviser or shareholder). Consequently, this does not mobility in the strict sense but a case of close structural co-operation. Two-thirds of cases come from the CNRS and professors-researchers. These figures are backed up by those collected by the MESR Business R&D survey, which found that 0.8% of researchers recruited by companies in 2011 came from the public sector.

Furthermore, research organisations or EPSTs very rarely recruit staff from industry despite the options opened up by the legislation. The figure is thought to be no more than around ten (Cyterman and Guillaume, 2007). This might be explained by the difference in remuneration, the rigidity of the public sector structure and the limited opportunities for accelerated career advancement, irrespective of personal performance.

Industry recruitment of university doctoral graduates is also seriously hampered in France, with the obstacles often benefitting *grandes école* graduates. The title of "PhD" is not an asset when it comes to corporate recruitment, unless it comes with a degree from an engineering or business school.

Box 5.3. Industrial agreements on training through research (CIFRE)

These are one of the key mechanisms of research, linking a French business with a French or non-French laboratory and a doctoral student. The latter is granted a research mandate within the business, supervised on the academic side by the laboratory to which the student is attached. A CIFRE has a term of three years, with a minimum gross salary of EUR 23 484 per year, on which the partner business receives a subsidy from the National Association for Technological Research (ANRT) of EUR 14 000 per year. CIFRE agreements cover all scientific disciplines and all sectors of activity, without restrictions on the doctoral student's nationality.

By hosting a doctoral student, the business gains access not only to the student's skills but also to those of the laboratory. The business is therefore a location for and an ally in the student's training. Thanks to these mediators, these agreements create or reinforce strong links between these "two worlds" with their sometimes differing methods and cultures (Levy, 2005). CIFRE doctoral students receive recurrent funding and are able to anchor their research within a field by combining and developing their scientific and professional experience.

Large companies account for half of those applying for CIFRE grants (50% in 2012), ahead of companies with fewer than 250 employees (36%), ISEs and local government. Among SMEs, those with fewer than 50 employees have the greatest demand for CIFRE doctoral students. They operate primarily in the sectors of electronics, communications and information technology, transport and energy, and to a much lesser extent construction and the banking and insurance sector. More surprisingly, there are very few CIFRE agreements in the pharmaceutical and medical sector (3% of the total signed in 2012).

The research conducted by the partner laboratories is geared towards information and communication sciences and technologies (22% of CIFRE agreements signed in 2012), engineering (20%), chemistry and materials (13%) and humanities (13%). Measured in terms of publications, CIFREs are a force to be reckoned with in research (at least 1 037 class A international publications in 2012) and development (2 000 patents filed between 1981 and 2012). Employment rates for CIFRE students are close to 90% after 6 months and virtually 100% after 1 year (ANRT data, 2000-10). In 54% of cases, the host company or laboratory provides this first job.

The mechanism remains relatively straightforward for the various signatories to CIFRE agreements; the project evaluation mainly consists in determining whether the business and laboratory are relevant to the doctoral student's field of competence. The processing time (around three months) is another key to the success of this mechanism. Between 1981 and 2012, CIFRE grants contributed to training 16 000 doctoral students and brought together 7 500 companies and 4 000 laboratories.

Since 2013, new CIFRE grants (40 open grants in total) have been created. The first novelty is the "Defence" CIFRE (in partnership with the French Ministry of Defence and the DGA). Limited to EU nationals and subject to an age limit, it is confined to specific disciplines and sectors of activity relevant to defence. The second is the "Brazil" CIFRE (in partnership with the National Council for Scientific and Technological Development). It is limited to Brazilian doctoral students in scientific and technical disciplines across all sectors.

Source: Levy (2005), "Les doctorants CIFRE: médiateurs entre laboratoires de recherche universitaires et entreprises", *Revue d'économie industrielle*, Vol. 11, No. 111, pp. 79-96, http://cifre.anrt.asso.fr/.

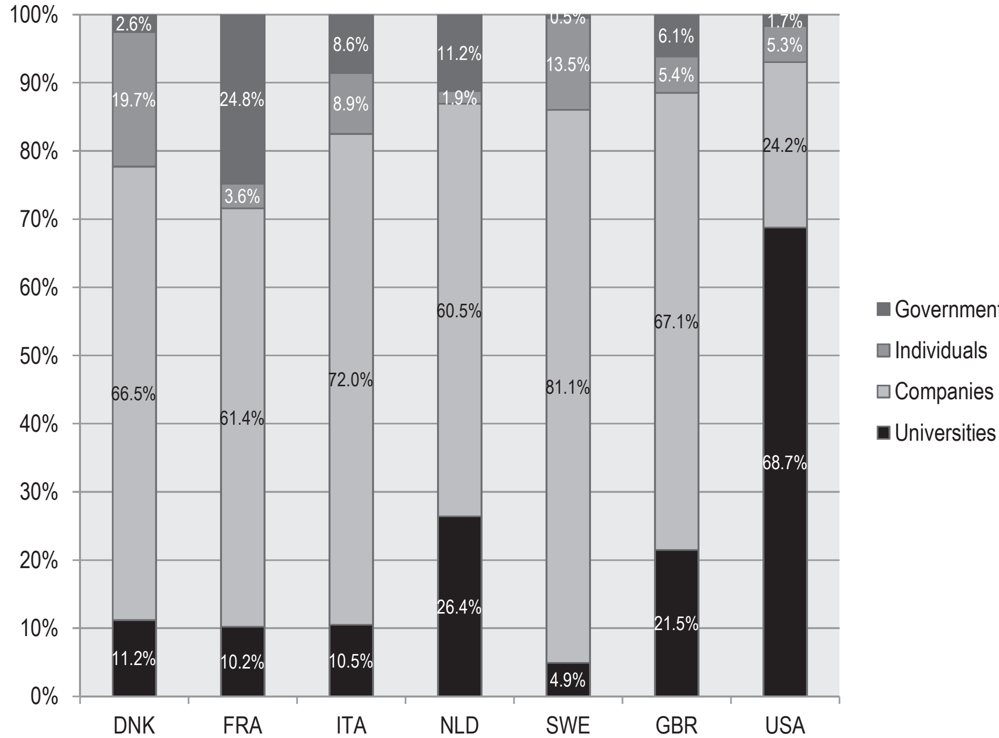
One exception, however – which is encouraging for public-private HR links – is the performance of one of the longest-standing mechanisms: the CIFRE agreements (Box 5.3) under which doctoral students and their employment can be jointly funded by a business in co-operation with a research laboratory. Introduced in 1981, the number and share of CIFRE agreements among the larger proportion of doctoral students are on the increase (from 9.4% of doctorates awarded in 2001 to 10.1% in 2010), indicating that they meet a real need on the part of industry. However, it bears noting that, here too, most of the doctoral students concerned are from engineering schools, further underlining the difference in capacity between the universities and the *grandes écoles,* or companies' lack of knowledge about the skills of HR from public university laboratories. Furthermore, the significant increase in the number of CIFRE agreements has occurred within a general context of rising private R&D expenditure – from 2007 to 2010, BERD rose 15% and CIFREs 14% (CGEIET, IGAENR and IGF, 2013).Overall, these findings are signs of structural weakness in the relations between these two worlds via exchanges of human capital trained and skilled in research (see the chapter on HR). It is therefore likely that these relations are maintained via other channels. Expertise, i.e. consulting contracts, and the resulting multiple income streams, are more flexible and hence likely preferred by researchers and academics. As stated above, there is practically no systematic information available on the true extent of these services.

Industrial property and its management

One indicator commonly used to measure the transfer capacity of public research is the number of patents filed. In most countries, the generalised deployment of policies to protect inventions stemming from public research – whether or not as a direct result of the Bayh Dole Act – has led to an increase in patents filed by research organisations (Haussman, 2012).

These industrial property policies applied to public research, and their indicators (number of patents filed and patent rights), are based on a comparative analysis with the United States. Typically, a comparison between European countries – and specifically France and the United States – of the number of patents filed by research institutions (especially universities) revealed a substantial gap (Figure 5.5). Yet recent studies of researcher inventiveness within these institutions (Lissoni et al., 2008; Lissoni, 2012) show that this gap is much narrower and less significant when the analysis factors in the different ownership systems: in the United States, almost all patents are filed by universities (especially since the Bayh Dole Act in 1981), while in France and more generally in Europe, they are filed by the partner companies. Although the comparison was conducted for patents invented by academic researchers, the findings primarily reflect a difference in ownership systems, not in the degree of inventiveness (Figure 5.6). The reforms in France, as in all European countries, have had the effect of bringing the ownership system for academic patents closer to the US model – i.e. patent ownership is awarded to the research institutions (Lissoni, 2013) – although it is not possible to determine whether this is actually more effective in terms of knowledge transfer towards companies.

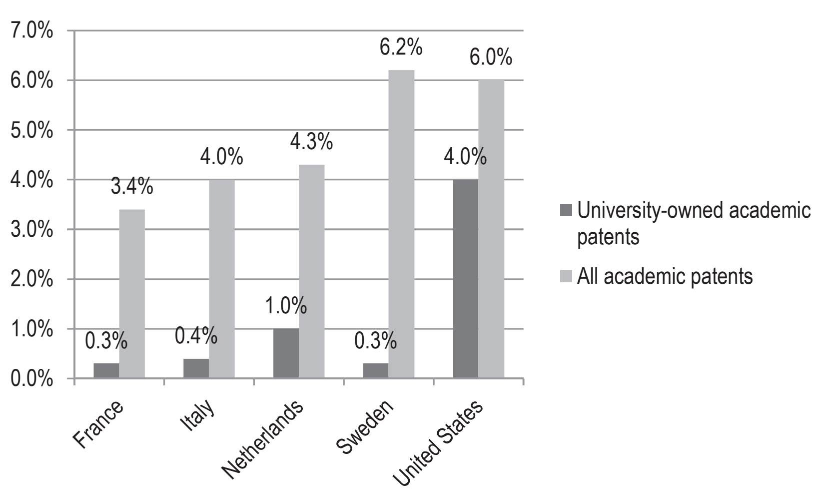
Figure 5.5. Who owns public sector researchers' inventions? (1994-2002)



Note: In the case of France, the CNRS is included in the government sector; distinguishing between universities and government is particularly difficult in France due to the existence of the UMRs.

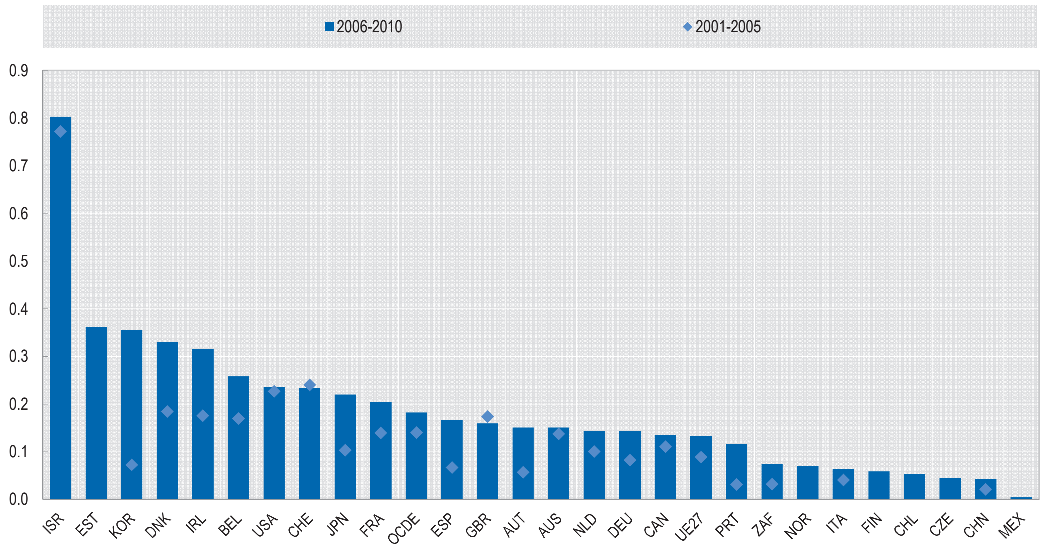
Sources: Lissoni et al. (2008), "Academic Patenting in Europe: New Evidence from the KEINS Database", *Research Evaluation,* 2008, vol. 16; Lissoni (2012), "Academic patenting in Europe: An overview of recent research and new perspectives", *World Patent Information*, vol. 34, no. 3.

Figure 5.6. Patents invented by academics and university-owned patents – as a share of total number of patents per country (1994-2002)



Sources: Lissoni et al. (2008), "Academic Patenting in Europe: New Evidence from the KEINS Database", *Research Evaluation,* 2008, vol. 16; Lissoni (2012), "Academic patenting in Europe: An overview of recent research and new perspectives", *World Patent Information*, vol. 34, no. 3.

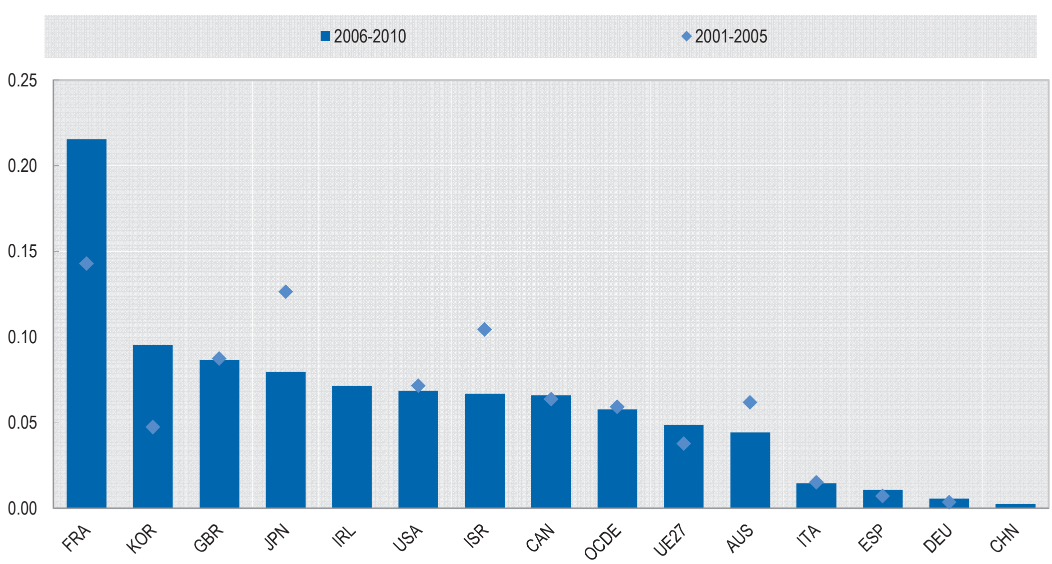
Figure 5.7. Patents (Patent Cooperation Treaty [PCT]) filed by public research, related to GDP



Source: OECD (2013), *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, doi: 10.1787/9789264193321-en.

Figure 5.8. Patents filed by PROs, 2001-05 and 2006-10

Patent applications under the PCT, by USD billon GDP (constant 2005 USD PPP)



Notes:

1. The names of the patent applicants are assigned to institutional sectors using a methodology developed by Eurostat and the Katholieke Universiteit Leuven. Due to considerable variation in the names recorded in patent documents, the distribution of applicants between sectors is sometimes uncertain, which introduces a bias in the resulting indicator. Only countries that filed a minimum of 30 patents in the period 2001-05 or 2006-10 are included in the figures.

2. Data broken down by date of priority and applicants' country of residence, using fractional counting.

3. Hospitals are excluded.

Source: OECD Patent Database, February 2013.

The creation of a patent database structured by inventor has made it possible to analyse the networks of French inventors or inventors with addresses in France. Combining this information with the option of identifying inventors from public sector research within these networks also makes it possible to analyse the specific position of these academic inventors within the innovation networks. Lissoni et al. (2013) showed that the propensity towards structuring networks as highly interconnected "small worlds" increases with the presence of academic inventors because this shortens the average path between inventors. This means that academic inventors, by moving between "cliques", i.e. moving from one sub-network to another depending on the project, create links communities that would otherwise be isolated. Thus, their role is more central than that of other inventors. This approach demonstrates their role as knowledge "brokers" in academic research – a role which is primarily structural and functional rather than quantitative.

France has seen a significant increase in the number of patents filed by public research institutions in the 2000s (Figures 5.7 and 5.8). Judging by the number of patents in relation to the gross domestic product (GDP), it is in a respectable position internationally (slightly ahead of the United Kingdom and well ahead of Germany). Thus, while research institutions published 656 patents in 2001 – i.e. 7% of the total – this number had risen in 2011, 10 years later, to 1 309 – i.e. 12.1% of the total (OPI/INPI, 2012). The reforms carried out in France in 1999 appear to have borne fruit. However, as was the case of Germany with the abolition in 2002 of the "professors' privilege", the regulatory changes have affected not so much the volume of patents as their ownership schemes. Recent studies focusing on these two countries in particular (BETA, 2010; Della Malva et al., 2013, for France; S. von Proff et al., 2012, for Germany) demonstrate this. The impact of the reforms for patents resulting from public research has essentially been a shift away from patents filed by companies towards patents filed by the research institutions (universities or PROs) themselves. In the case of France, these patents are often filed under a co-ownership arrangement. Collaborative research results, which were normally patented by companies (especially for reasons of cost and IP management), are increasingly being patented by the public research partner(s); it is not certain whether this change improves the conditions in terms of commercialisation (Beylat-Tambourin, 2013).

Another aspect of performance in relation to IP management is the number and value of operating licences. The few figures available suggest that revenues from IP are uncommon and limited, except in very rare cases. A Research Laboratory in Theoretical and Applied Economics (BETA) survey of universities (BETA, 2010) estimated them at EUR 8.5 million in 2007, which is minimal. In the same year, the Association of European Science and Technology Transfer Professionals (ASTP) estimated them at EUR 89.2 million in Europe, which is also not very high given the research expenditure in the higher education sector. Those figures, however, do not include the PROs, which are more active than universities in that respect. At the time, the annual revenue of the FIST (the CNRS commercialisation service) was estimated at EUR 55 million, over 90% of which was generated by a single patent – for Taxotere, a drug used in chemotherapy for most cancers. The patent protects the procedure for synthesising a product obtained from yew which has the property of slowing down the proliferation of cancer cells. The entry into the public domain of this blockbuster drug launched in 1995 explains the current drop in FIST royalties. Filing and maintaining patents is expensive and even though the inventions they protect are novel and inventive, and have potential applications, their benefits remain very uncertain. These low numbers of "profitable patents" are similar to those observed in other countries, including the United States, where only a small minority of universities manage to obtain a positive net profit on their patent portfolios. In Germany, the patent portfolio of the Fraunhofer Society, known for its performance in this area, shows the same characteristics: IP revenues are based essentially on a small number of patents (especially on MPEG-1/2 Audio Layer 3 [MP3] technology) and revenues have been declining since 2005 (the MP3 technology will be public by 2016). In 2012, Fraunhofer's licence revenues were EUR 117 million, following a record EUR 125 million in 2011[5] (see Box 5.4 for a detailed description of IP strategy in the Fraunhofer institutes.) It is likely that despite a very proactive IP policy on the part of PROs, this activity is not a significant profit centre for these institutions.

Box 5.4. Fraunhofer's IP strategy: Taking the long-term view

Germany's Fraunhofer Society licenses out its IP and is also involved in patent pools. A hallmark of Fraunhofer research is its proved know-how, technological expertise and scientific excellence. In many collaborative and research projects – whether proprietary, publicly funded or carried out in direct co-operation with industry – many valuable patents have been generated. This "background IP" makes the Fraunhofer Society an attractive partner.

Each new project gives rise to further intellectual assets. This "foreground IP" evolves according to specific orders while also strengthening the existing knowledge base.

The Fraunhofer institutes use the following options to commercialise their IP:

- contract research
- out-licensing
- use of IP to acquire new projects
- spin-offs and company participation.

In contract negotiations, the Fraunhofer institutes attempt to retain control of their IP assets even at the risk of reducing the profitability of each individual contract, since industry partners sometimes wish to take control and are prepared to pay accordingly. Due to tensions between short-term advantages and long-term losses, the Fraunhofer institutes act like investors. Thus, the collaborating firms receive proprietary rights on the products, prototypes and other materials developed within the context of the joint project. In addition, firms receive a *non-exclusive* licence for specific applications related to these inventions and the attached know-how ("foreground IP"). In exceptional cases, firms also receive non-exclusive licences on the background IP.

Licenses unrelated to contract research are less important to most Fraunhofer institutes, because research – not IP management – is the core business of the Fraunhofer Society. The Fraunhofer's preference for not owning IP is appreciated by its industry partners, who thus have exclusive control over the research results.

Licensing options:

- "Carrot licensing": Fraunhofer offers to license out the protected technology and to provide the necessary know-how. The licence fee is agreed in advance. It is often restricted to a specific application field.
- "Assertive licensing" (or "*ex-post* licensing"): Fraunhofer grants a non-exclusive licence to the user following detection of unlawful use. In this sense, unauthorised and unpaid use is transformed into an authorised, paid licence.

Patent pools are used for licences that are not exclusive to different pool members. The pool management also covers licensing contracts.

With this strategy, the Fraunhofer institutes seek to:

- increase the institutes' innovative potential
- permit a wide range of applications of IP
- protect partner firms' interests (hence the possibility of exclusive rights).

Source: OECD (2013), *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, doi: 10.1787/9789264193321-en.

Among patent applicants, PROs are particularly active in France (Table 5.3), which begs the question of a possible surge in management costs if the financial returns on royalties are not up to the mark. In 2011, the CEA was the 3rd-largest applicant (in terms of patent requests) to the INPI and the 6th if the other main agencies are included (with 573 published patents). The CNRS, whose research is more upstream, ranks 6th for patent requests to the INPI and 8th when including the other agencies (with 510 patents published). As for INSERM, it ranked 22nd, with 149 patents published in 2011.

Table 5.3. Ranking of main applicants to the INPI by number of patent applications published in 2011

Rank in 2011	Name of applicant	Published
3	Alternative Energies and Atomic Energy Commission	545
6	National Centre for Scientific Research	383
11	IFP Énergies Nouvelles	193
34	Université Claude Bernard Lyon 1	40
36	French Space Agency	38
40	Université Pierre et Marie Curie Paris 6	28
45	French National Institute for Agricultural Research	21
54	University of Strasbourg	17

Source: INPI (OPI), 2012.

The CNRS has a greater proportion of co-filings than other PROs: 75% of patents filed by the CNRS have several owners, half of which are other research organisations or universities. This is a mark of increasingly shared IP management among the UMR trustees. Patent co-ownership is not a gauge of effectiveness for the owner organisations. In fact, the proliferation of stakeholders may lead to higher management costs and longer transaction times, harming the commercialisation of these assets (CGEIET, IGAENR and IGF, 2013). In other words, this frequent co-ownership is an obstacle to commercialisation.

The solution of a “single mandate holder” status (2006 Law, decree 2009-645) and, more recently, the creation of the SATTs, are at least partial responses to this splintering of IP among public research institutions. They grant an operating mandate for patents resulting from research to one of the public partners. The research institutions retain ownership of their patents. The mandate holder (e.g. a SATT) is granted an exclusive licence by the owners, which it may re-allocate in whole or in part to potential users. Apart from a certain sluggishness in implementing even partially the single mandate, a number of significant issues still hinder IP commercialisation. Under a single mandate, the partners become owners and hence:

- Legal uncertainty remains for users in the event of disagreement between the mandate holders over the operating procedures.
- Any commercialisation involving surrender of ownership or a change in the ownership scheme is not covered by the single mandate. Contributing a patent as an intangible asset towards a business start-up is a typical example; in this case, only an exclusive licence would be possible.

- The single mandate rules apply solely to patents. Yet the difficulties associated with co-ownership also apply to other forms of IP, notably database or software protection.

Lastly, this management mandate relates to already filed or acquired patents; i.e. once the results are protected. The mandate or pooling does not cover contractual negotiations with an industrial partner. And yet such contracts naturally include IP clauses, which must be negotiated with all trustees. The partner company therefore has to contend with numerous strategies, and hence delays. This is a significant obstacle to the development of partnership and contractual research activities, which are the main source of the results to be commercialised.

Furthermore, the CNRS appears to be more internationally orientated than the CEA.[6,7] The private sector technological partners of the CEA –AREVA, EDF, STMicroelectronics, Soitec and Renault – may partly explain this trend.[8] However, it is probably merely a reflection of the patent filing strategy of the PRO, which is more or less selective with a view to obtaining more expensive international protection.

The evolutions in the IP policies of the PROs are symptomatic of a dilemma which lies at the heart of the commercialisation of public IP in every country: inventions are identified and developed locally, close to the laboratories, but the innovation market is global. The question of the "optimal" technological and geographical proximity between researchers and companies and the influence of other factors (business size, researcher experience, implementation method) remains open (Dornbusch and Neuhäusler, 2013). The status of the commercialisation structures (whether independent or part of PROs and universities) is not without consequences on the nature of the results expected and the evaluation methods of the results. An assessment of the effectiveness of internal or external commercialisation bodies, whether dedicated or shared, remains to be done. However, it appears that the existing structures still present some room for improvement in terms of effectiveness. A recent study of data on French universities' efforts to commercialise their research estimated their effectiveness at around 50%, using a data envelopment analysis (DEA) approach (Curi et al., 2012).

Although patents are certainly an important issue in technology transfer between public sector laboratories and companies, the growing volume of patent portfolios should not mask the fact that the actual quality of a transfer depends not only on the quality of the patents, but also on companies' ability to grasp this fundamental advanced knowledge (Czarnitzki et al., 2009; Guellec et al., 2010). In the case of France, the question is whether the low transfer rate is partly due to the lack of corresponding capabilities on the part of French companies (Robin and Schubert, 2012). IP strategy should be seen in the light of changes in innovation methods, which nowadays are more open and probably based less on the idea of protection and more on the idea of openness.[910] Filing a patent application is not an end in itself: the ultimate objective is commercialisation, creating economic value from the invention. From this point of view, filing a patent is sometimes necessary – but not always, especially where other commercialisation methods are available. Filing a patent is merely a preliminary step towards actual commercialisation of the patented invention, which generally calls for an extremely professional approach that not all public organisations are able to deliver (OECD, 2013b).

The PIA comprises two key measures related to IP (see Box 5.1): the creation of SATTs and of France Brevets. The mission of the SATTs is to exploit the IP entrusted to them by their members – universities and PROs. Their scope is essentially geographical. They have been endowed with a total of EUR 900 million in funding (released in several instalments). The SATTs have been given the extremely ambitious target of balancing their operating accounts by 2020. A variety of ideas led to their creation: the aim was to make commercialisation more professional in terms of competences (by entrusting it to operational experts rather than the administrative services of universities or other organisations) and to provide appropriate, performance-based incentives for those in charge of commercialisation. In addition, to achieve that aim, the emphasis (and probably the principal function) was placed on developing the research results to facilitate their transfer to industry. However, some SATTs also conduct in parallel contractual relationships with industry on behalf of their shareholder beyond the scope of IP alone. In the case of patents, this commercialisation is under a single management mandate.

While it is too early to gauge the results and the impact on the effectiveness of transfers, several observations are possible. The fact that SATTs have to maintain close contact with inventors despite their regional rather than local base might sometimes pose a problem, hence the importance of the "local commercialisation advisers" employed by the institutions themselves. In addition, the SATTs sometimes actually add to rather than replace the existing mechanisms, with the risk of further obscuring the commercialisation landscape unless the State takes steps to provide clarity. Although the DMTTs have been abolished, most SAICs have curtailed their sphere of activity and a number of PROs have transferred part of their IP to the SATTs, the landscape remains complex: many SAICs are still operating (e.g. to manage certain contracts), and organisations such as the INSERM (with INSERM Transfert) and the CEA (CEA Tech) are still operating in their own right while participating in the new mechanism. However, the main mission of the SATTs – and the main use of the allocated funds – is to develop technology originating from the laboratories, and in this field they have a degree of exclusivity compared with the SAICs.

The mission of France Brevets (see the chapter on business innovation) is commercialisation at the global level, which calls for specific expertise. By fulfilling a unique role, the organisation could therefore complement the SATTs. However, it will have to focus on constructive commercialisation – by ensuring the effective transfer of knowledge – rather than on "*ex post* licensing" which, in many respects, is reminiscent of "trolling" practices inappropriate for a public organisation ("trolling" is a tactic that consists in using generally non-robust patents to obtain royalties from licensees – often SMEs – that are in a legally vulnerable position).

Business creation originating from public research

The direct resources allocated to technology transfer through the creation of businesses originating from public research declined in the 2000s (at the same time, measures concerning young innovative enterprises [JEI] as a whole, especially the JEI initiative, increased sharply); the two key measures are the national competition for the creation of innovative companies and the incubators. First held in 1999, the competition has had over 2 500 winners and backed the creation of over 1 300 companies, 88% of which were still operating after five years. Its budget fell from EUR 28 million in 2000 to less than EUR 15 million in 2012.

Box 5.5. Determinants of spin-off formation

One of the findings in the literature on spin-offs is that institutional policies and rules have effects on the rate of spin-off formation (Di Gregorio and Shane, 2003). The primary institutional factor that positively influences spin-off formation at universities is the flexibility of the licensing contract policy. O'Shea et al. (2005) found that previous success in commercialisation is a key determinant of a university's rate of spin-off formation. One study of UK universities showed that the number of spin-offs was positively associated with university expenditure on IP protection, business development capabilities of its technology transfer office and the university's royalty regime (Lockett and Wright, 2005).

The academic level and contextual characteristics of the university also shape the likelihood of establishing start-ups: Müller (2010) found that the main impediment to academics establishing a business is usually the need for them to acquire complementary skills and assemble the appropriate teams; this process is greatly facilitated if the founders have access to university infrastructure/services and receive formal and informal support through their networks.

External determinants of academic entrepreneurship include the availability of venture capital, the whether the infrastructure is endowed with the relevant knowledge base, government policies (see the chapter on entrepreneurship) and the industry structure. Some universities have therefore established their own venture capital funds, sometimes co-funded with external resources.

Source: OECD (2013), *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, doi: 10.1787/9789264193321-en, compiled from Ponomariov et Boardman (2012), "Organizational Behavior and Human Resources Management for Public to Private Knowledge Transfer: An Analytic Review of the Literature", *OECD Science, Technology and Industry Working Papers*, No. 2012/01, OECD Publishing, doi: 10.1787/5k9d4gt7mdbp-en

Box 5.6. Spin-off support programmes in OECD countries

In Germany, support for university spin-offs was developed through the EXIST programme. EXIST has three components: an entrepreneurial culture and spirit, business start-up grants and knowledge transfer. These initiatives focus primarily on encouraging the commercialisation of research results generated by universities and research institutes; they provide both grants and coaching to help scientists, university graduates and students create start-ups and market their ideas.[11]

In the United States, the Small Business Innovation Research (SBIR) programme, launched in 1982, aims to encourage high-risk R&D linked to new business creation and serves as a bridge between universities and the markets. The SBIR programme is highly decentralised, as is most US R&D funding, which is spread out across 11 agencies with different missions and sizes and lacks a formal budget process. SBIR funding is equal to 2.5% of federal R&D funding, a percentage that will rise to 3.2% by 2017. In addition, the Small Business Technology Transfer Research programme funds high-risk R&D with commercial potential, enabling researchers to overcome financial barriers. A key criterion for funding is that small companies must formally collaborate with PROs. Participating agencies set aside 0.3% of their R&D budgets to support the programme.

In Sweden, the 2008 Research and Innovation Bill included the launch of "innovation offices" ("*innovationskontor*") to facilitate the (commercial) utilisation of university research results. Their purpose is to support researchers and university management with a number of services, including advice related to innovation and business development, as well as verification, intellectual asset management and awareness raising services. In the first round, 8 innovation offices linking a total of 11 Swedish universities were founded. A recent government review of innovation-stimulating activities at universities stresses the importance of innovation offices in increasing universities' ability to act innovatively. Accordingly, the 2012 Research and Innovation Bill increased the allocation of funding to innovation offices and announced the establishment of a further four offices to extend the scheme's reach to cover all universities.

Source: OECD (2013), *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, doi: 10.1787/9789264193321-en.

France numbered 28 public incubators for innovative companies in 2013. They support business creation projects, most of which originated from public research, by providing advice, accommodation and funding during these companies' developmental stage. Their status varies from region to region: from autonomous (in Franche Comté) to more integrated into the structure of the university or *grande école* from which they originated. They have handled 3 670 projects (2 500 business start-ups), nearly 41% of which originated from public research (38% were associated with collaborative research).[12] These start-ups operate mainly in the sectors of the life sciences (28.6%) and information and communication technologies (34%). These public incubators, resulting from the 1999 Law, actively support business creation projects. Despite a high survival rate (over 80%[13]), it seems that very few of these start-ups grow to a significant economic size (see the chapter on innovative entrepreneurship). Finally, as Lallement (2013) observes, institutional reasons for creating companies differ from one country to another, leading to major organisational differences for the commercialisation structures (see Boxes 5.5 and 5.6). In the United Kingdom, the idea of the university as a shareholder in spin-offs is dominant, while in France PROs are rarely involved in the capital of these new research spin-offs (see Mustar and Wright, 2010).

Conclusions

A general survey of policies on the commercialisation of publicly funded research points to a profusion of initiatives, instruments, regulations, mechanisms and institutions lacking direction and coherence (for a more detailed analysis, see the CGEIET, IGAENR and IGF report, 2013). Despite the political priorities underlying this profusion, the lack of coherence clearly affects the overall effectiveness of the system.

In some respects, the co-existence of different models (such as the CEA, the CNRS and universities) is an advantage, in that it allows responding to the wide range of needs and contexts (spanning subject areas, types of business, etc.). However, the lack of co-ordination between mechanisms and the parties involved is a handicap, since it does not allow the State to provide a coherent range of mechanisms that cover all the identified needs while avoiding the duplication of responsibilities and supervision. It is also a handicap for the institutions themselves, as it makes it difficult for them to pursue a long-term commercialisation strategy. Finally, it is also a barrier to corporate access to laboratory skills, in a country where business leaders are rarely the product of research-based training. According to the business managers met during the preparation of this review, multinational companies sometimes turn to universities in other countries, where they find the mechanisms for collaboration easier to grasp.

Thus, this institutional, regulatory and administrative complexity leads to redundancies (or at least overlaps in skills and/or objectives), co-ordination difficulties (if not competition among structures) and a lack of information on the overall system, generally making it impossible to manage the overall policy. Despite the considerable public resources involved (at least EUR 2 billion per year for partnership research – see CGEIET, IGAENR and IGF, 2013), no step-by-step evaluation of the impact, effectiveness or relevance of the system has been done over the years.

Not only does the lack of an overall understanding of the system make it difficult to devise evidence-based policies, but the lack of resources dedicated to benchmarking and economic intelligence on research and innovation is an additional handicap (not just for the laboratories and institutions, but also for the agencies and ministries). These two aspects are, furthermore, complementary.

While the transfer mechanism entails the existence of an organisational context for the interfaces between public research and business, there are also structural barriers *within* each of these two areas; hence, improving the transfer system would have little effect if those barriers were not reduced. Part of the public sector leaves little room for "demand pull": research topics are largely decided by the researchers themselves, without necessarily taking into account external factors, such as the needs of society or the economy. For a researcher, it might even be counter-productive from a career or reputational standpoint to embark on research leading to commercialisation rather than on traditional academic research (assuming the two are contradictory), in that only academic results are taken into account in individual assessments (for instance, patents are not, or rarely, considered). Thus, promoting the commercialisation of publicly funded research requires more than establishing efficient interfaces – it also entails reforms at the very core of the public research sector.

The issue of IP management between PROs/universities and companies remains a topical subject. Since the 1999 Law, PROs have been encouraged to take control of IP resulting from partnership research. Indeed, IP management is a focal point of the PIA, thanks in particular to the creation of the SATTs. Commercialisation indicators and objectives have been incorporated into most of the PIA funding (IRT, ITE, IHU, etc.), including those geared towards academic research (Idex, Labex, Equipex, etc.). It is true that in many cases, this approach might foster commercialisation by providing researchers and their institutions with sufficient incentives to create value from the invention. However, at least four conditions are required for a public IP transfer policy to succeed.

First, a proper choice must be made as to what should be patented by the research organisations (and hence what should not – or no longer – be, or what should be patented by the private partner instead). Some general guidelines issued by the MESR on the basis of related collaborative thinking would be useful.

Second, research organisations and universities must be capable of managing their IP portfolio in a structured and professional manner. The first point does not appear to have undergone in-depth review, contrary to what has happened in other countries (e.g. the *Lambert Review* in the United Kingdom, 2003).

Third, although the creation of SATTs is a sign of considerable progress (particularly because it simplifies the problems related to multiple ownership of patents and enables management teams to become sufficiently large and professional), and although the target of financial equilibrium by 2010 was useful in itself, international experience shows this may be difficult to achieve. Pursuing such an objective must not lead SATTs to adopt excessively aggressive strategies towards partner companies, which is not necessarily desirable from the perspective of creating jobs in industry. It will be important for the State to monitor and, if necessary, adjust SATT transfer practices by focusing on their primary mission – to accelerate and facilitate technology transfer, the revenue itself being merely an indicator and not an end in itself.

Finally, the overall mechanism needs to be coherent. Like many other PIA mechanisms, the SATTs will only be able to simplify the French research and innovation structure if the PROs agree to pool certain functions and do away with the duplication of structures within their individual institutions.

Notes

1. See CGEIET, IGAENR and IGF (February 2013).
2. Amounts evaluated by the CGEIET, IGAENR and IGF (2013), not excluding the possibility of double counting. Double counting is more likely where incentive and structuring mechanisms overlap, e.g. FUI, CIR and competitiveness clusters.
3. "Concerning joint laboratories, the Guillaume-Cyterman report had already noted in 2007 the need for the supervising ministries to 'develop a better understanding of the reality of co-operation in the form of joint research teams of public sector and industry researchers' (Proposition 10). Despite an MESR survey conducted in 2009, none of the participants surveyed currently has data which provide a full picture of the sums involved in partnership research conducted within joint laboratorie." (CGEIET, IGAENR and IGF, February 2013, p. 11).
4. Recent examples have criticised health researchers for overly close links with pharmaceutical laboratories, particulary on regulatory issues.
5. Fraunhofer website: Facts and Figures, "Contract research revenue 2008-2012".
6. The CNRS commercialisation strategy is linked to the Carnot institutes and SATTs, but also to its strategic innovation focus. See CNRS response to the AERES evaluation (2012).
7. An examination of the CEA's commercialisation strategy (2008) partly explains this tendency to file for patents at national level: "There are two ways to extend a patent into other countries: (i) by direct applications via national or regional routes, or (ii) by the PCT (Patent Cooperation Treaty) route. This is a single filing procedure for multiple countries – the patent is then examined by each national office. If the invention appears sound, extension by direct national routes should be preferred, as this allows matters to be formalised more quickly; for example, it can be attractive to enter the state of the art quickly in the United States. If there are questions about the quality and patentability of the invention, the PCT route should be used, as this gives the option of taking more time (+18 months) at moderate additional cost and of having better visibility."
8. According to *Les transferts industriels au CEA*, interview (October 2011), CEA website.
9. Or taking forms of protection other than the patent (secret, copy-left, etc.), but also depending on the fields under consideration (e.g. software or life sciences).
10. INRA commercialisation tools are very interesting in this respect, as they are highly diversified. See Lallement (2013) for a more detailed analysis.
11. In 2012, the federal budget supporting the creation of innovative businesses was EUR 68 million, including EUR 35 million for a capital injection fund (High Tech *Gründerfonds*) and EUR 32.1 million for the EXIST programme for scientific start-ups (stable budget compared with 2010 and 2011). EXIST is programmed until 2014 (Erawatch; BWI).
12. MESR data: between 2000 and 2013.
13. According to the survey of 27 incubators in March 2013.

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Chapter 6

Research and innovation support policies in France

This chapter discusses policies that support business research and development (R&D) and innovation in France and draws comparisons with other countries. It illustrates the State's changing objectives and methods in this field, where France is now part of a trend towards "new industrial policies". It examines in detail the chief instrument by which the State influences business R&D, namely the research tax credit, whose breadth places France at the top of Organisation for Economic Co-operation country rankings. It reviews direct support instruments, including agencies such as Bpifrance (which handles financing), programmes such as competitive clusters (which provide localised support) and sectoral programmes (related to defence, aeronautics, etc.). The chapter concludes with a discussion of France's policy mix.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Overview of business innovation policies

Innovation in France: motivation and strategy

France's innovation policy has undergone fundamental changes over the past 15 years. It previously focused on "major programmes" and military programmes in response to community needs (telecoms) or State-led industrial strategies (Airbus). These programmes were driven by the State and involved large companies regarded as "national champions". The doctrine of public action has changed since then. It now views competitiveness, and meeting community needs (environment, health, etc.), as the major drivers of innovation policy and sees the market as a necessary mechanism for implementing it. This brings France in line with the contemporary trend towards "new industrial policies" (see Box 6.1).

According to economic theory, innovation policies are a response to market failures: first, knowledge spillovers, because the return on private investment in innovative activities is lower than its social return, leading to insufficient investment (according to market-driven theory); then, specific information asymmetries between entrepreneurs and investors, leading to inadequate capital investment in entrepreneurial activities. The first market failure relates more to research activities – the source of more generic knowledge than more specialised downstream activities; the second concerns small and new enterprises, which rely on external funders.

It is also helpful to recall the main features of the current industrial environment and the way in which they differ from the previous environment in which France's innovation policies were initially forged.

- "Innovation" does not refer merely to high technology inventions in research and development (R&D)-intensive sectors – it has the potential to be everywhere. The service sectors, which account for between 70% and 80% of value-added in developed countries cannot, cannot – and do not – remain in the background: they generate technological (especially related to information and communication technologies [ICT]) and non-technological innovation. An exclusive focus on the manufacturing industries runs the risk of overlooking this fact, which is all the more damaging as the competitiveness of a country's manufacturing industry also depends on the productivity of its service sectors, which are also major industry suppliers.
- The gradual establishment of global value chains has changed the concept of "national industry". The chains are segmented across countries, in line with internal decisions taken by multinational companies and according to the competitive environment. This leads to a disconnect between the various segments in the value chain (for example, Apple designs its products in the United States, but its components are manufactured in different countries and assembled in China; the German automotive industry partly regained its competitiveness in the 2000s by relocating some activities to countries in Central and Eastern Europe). In view of this, a policy that seeks full integration of innovative capacity on the one hand and manufacturing on the other hand makes no sense in many industries where knowledge flows across the various stages of the production process. Such a policy might well have negative effects, by providing incentives for companies to relocate even their design activities. The increased mobility of factors associated with innovation– skilled labour, patents, etc. – should also be taken into account.

Thus, the important factor for innovation policies is the area's attractiveness and making sure conditions encourage companies to establish their design activities in the country.

- Productivity growth – the main competitiveness factor – requires a very active industrial demographic: the least productive enterprises decline or disappear, while more promising projects are encouraged and the most productive enterprises are able to grow. In many new industries, e.g. biotechnologies or the Internet, new ideas and technologies are led by new entrepreneurial projects and not directly by established companies (which may subsequently recruit the innovators). This requires policies that foster new business creation and impede neither their expansion nor the decline of less productive companies.
- Although innovation is occurring at an unprecedented rate and often calls on knowledge from different disciplines, most innovators need to access and form relationships with multiple sources of knowledge: this is "open innovation", a term that refers to linkages between companies – particularly between large and small enterprises – and links between publicly funded and privately funded research. Open innovation is now structured on a global scale. Hence, policies must emphasise co-ordination among players – which market forces do not always allow – and national openness to international knowledge.

It is against this background that the "new industrial policies", with their heavy and sometimes exclusive focus on innovation, emerged. Industrial policies, i.e. direct government intervention in business investments, had fallen into disuse since the 1980s as a result of international agreements (World Trade Organisation [WTO]) that severely restricted them as well as a number of spectacular failures, especially among nationalised enterprises. In recent years, the 2008 crisis and the economic success of countries in which where the State has a strong role (China) have led to renewed interest in industrial policy among OECD countries and beyond. In some countries, political decision-makers feared that manufacturing output had fallen too low, and more broadly that knowledge-intensive sectors were not sufficiently developed. Industrial policies were then introduced in a bid to strengthen technological areas or industries, such as advanced manufacturing, services to knowledge-intensive companies or the "green" economy, whose aim is to promote new sources of economic growth. When formulating their policies, governments must also take into account international treaties that restrict their room for manoeuvre, especially the WTO agreements of 1995 (which restrict trade policies and impose ceilings on direct business subsidies) and the European Union treaties related to trade, government aid and public procurement. The new industrial policies have the following characteristics (Warwick, 2013):

- Recognition of the fact that framework conditions, including a sufficient level of competition and the availability of human resources, are also important The new industrial policies place great faith in market mechanisms, which they seek to build on, rather than replace, by providing them with a solid foundation. The aim is to improve the conditions for the activities of the companies concerned rather than to support specific companies, the "national champions" of the old industrial policies.

- Support that relates more to upstream activities and technologies (especially to research, often involving developing linkages with publicly funded research) rather than industrial sectors. Thus, industrial policies essentially become innovation policies.
- The search for a balance between “neutral” aid that is not sector-specific – especially indirect aid, such as the research tax credit (CIR) – on the one hand and targeted aid and the focusing of resources on certain activities on the other.
- The opening up of measures and programmes to small and medium-sized enterprises (SMEs) and entrepreneurs, even if large companies often remain key conduits for certain targeted policies. Entrepreneurship is itself the object of specific policies.
- The emphasis on co-ordination among actors, in order to allow them to internalise externalities, e.g. through joint research projects. Governance of sectoral programmes often involves the players themselves.
- Political will for effectiveness: in a challenging budgetary environment for all countries, governments must seek to minimise the cost of these policies. This requires strategic consistency (issue clear instructions, avoid redundancy) and focusing exclusively on measures whose effectiveness has been demonstrated – hence the importance of effective assessment (leading to decisions to reorient or terminate programmes whose evaluation came back negative).

These features occur in varying degrees in the industrial recovery plans (Box 6.1) announced by a number of countries since 2008 in response to the crisis – including France, despite its markedly different national tradition (emphasis on State control rather than market mechanisms, promotion of national champions, etc.). But the French plans also feature more specifically French traits that allow adapting these principles to the national context, some of them linked to the old model of support for innovation; as a result, the various characteristics are not always consistent with each other.

At the national level, innovation policy is led by a number of ministries (the ministry in charge of industry [actually the Ministry of the Economy, Productive Recovery and Digital Media], Ministry of Higher Education and Research [MESR], Ministry of Agriculture, Agri-food and Forests, Ministry of Sustainable Development and Land Use, Ministry of Defence) and other bodies (General Commission for Investment [CGI]) A number of operators (OSEO/Bpifrance, the National Research Agency [ANR] and the French Environment and Energy Management Agency [ADEME] in particular) implement support measures for industrial R&D. The system is highly complex and features a host of measures, programmes, calls for tender and bodies responsible for administering them.

France is notable for its ongoing strategic and generally analytically astute strategic reflection conducted by numerous institutions – the Commission for Strategic Action (which became the General Commission for Strategy and Foresight in 2012), the MESR, the ministry in charge of industry, the CGI – based on report issued by the parliament or commissioned by the government (the Juppé-Rocard report in 2009, the Gallois report in 2012), recurrent forecasting operations (the “key technologies” of the ministry in charge of industry), etc. This informs the public debate and allows well articulated viewpoints to be compared and contrasted.

By contrast, it would appear that the decisions implemented lack strategic consistency: the accumulated strategies allow setting useful long-term prospects, but sometimes apparently at the expense of consistency. Today, French policy is guided by several strategy plans (the national research and innovation strategy [SNRI], launched in 2009, was replaced by the national research strategy [SNR] in 2014), the "Investments for the Future Programme" ([PIA] which is usually, but not always clearly, consistent with the SNRI) and more recent industrial plans, such as that for a "New Industrial France". It also features a large number of sectoral plans and measures that do not seem to fit into a broader vision.

Box 6.1. The renewal of industrial policies: Examples of industrial policies in OECD countries

A number of OECD countries have also launched industrial policy initiatives in recent years, some in direct response to the economic and financial crisis, and others with a more long-term vision.

- Japan recently presented a new industrial policy plan with a view to moving away from its current "monopoly" structure based on the automotive and electronics industries towards a structure based on five strategic areas: infrastructure, environment/energy (including green vehicles), culture (fashion, food, tourism), traditional areas in Japan (robotics, space, aeronautics) and health.
- Korea, which has traditionally promoted an active industrial policy, recently formulated sectoral strategies for what it views as flagship industries: the automotive industry, shipbuilding, semiconductors, steel, machinery, textiles and materials. Additionally, Korea has identified a certain number of growth drivers as a priority for the future. Based on an analysis of its comparative advantages, Korea has identified 17 in three categories: green technology, high-tech convergence technologies and value-added services (Ministry of the Knowledge Economy, 2011).
- Until recently, the United Kingdom had not expressly embraced a formal industrial policy. However, various plans were presented in 2009 and 2011 in response to the economic crisis. Successive governments stressed a plan for economic recovery that included horizontal measures and identifying key sectors for working to eliminate obstacles to growth. Under the Labour Government, a Strategic Investment Fund (SIF) was established in 2009 to support a number of targeted investments – in carbon-free technologies, advanced manufacturing, digital infrastructure and export promotion – to strengthen the United Kingdom's capacity for innovation, create jobs and drive growth. Although the SIF was not retained by the coalition government that took office in 2010, the Secretary of State for Business, Innovation and Skills pledged his support for an appropriate industrial policy and set out his industrial strategy in September 2012.
- The United States does not have a formal industrial policy, but its recently launched innovation strategy (National Economic Council, 2011) includes classic horizontal measures such as improvements to ICT infrastructure, education and public services, in conjunction with vertical priorities including clean energy, biotechnology, nanotechnology, space and advanced manufacturing. Additionally, the 2009 American Recovery and Reinvestment Act included support for energy technologies, housing and other sectoral measures, in addition to horizontal measures and demand stimulation. The support afforded to two of the country's largest car manufacturers is a further example of industrial policy.

Objectives, finance and policy mix

The stated aims of government support for industrial R&D are: *i)* increase business R&D; *ii)* encourage co-operative R&D between companies; *iii)* develop co-operation between companies and public research organisations (PROs); *iv)* support innovative entrepreneurship; *v)* promote certain thematic or sectoral priorities linked to competitiveness or societal needs. For each of these aims, a number of instruments have been introduced, each generally pursuing more than one aim, as shown in Table 6.1. An important point to note in relation to these aims is the high level of importance given to R&D in each case.

France has a substantial and very diverse system of public aid for business R&D. The Government transferred EUR 7.2 billion (euros) to companies for R&D in 2010, broken down into direct aid (EUR 1.3 billion), government defence contracts (EUR 1.2 billion) and indirect aid – mainly through the CIR and secondarily the young innovative enterprises ([JEIs] (EUR 4.5 billion). The question for the French Government is how effective such a massive system can be: which components (measures and instruments) are efficient and which are not? How well does the policy mix dovetail and how efficient is it?

In 2011, the total paid amounted to 0.38% of the gross domestic product (GDP), ranking France 3rd globally after Korea (0.39%) and Russia (0.41%), while the United Kingdom spent 0.16% and Germany 0.09% of its GDP (Figure 6.1). Of the countries for which statistics are available (Figure 6.1), France ranks 7th for direct support (0.12% of GDP) and 1st for indirect support (0.26%).

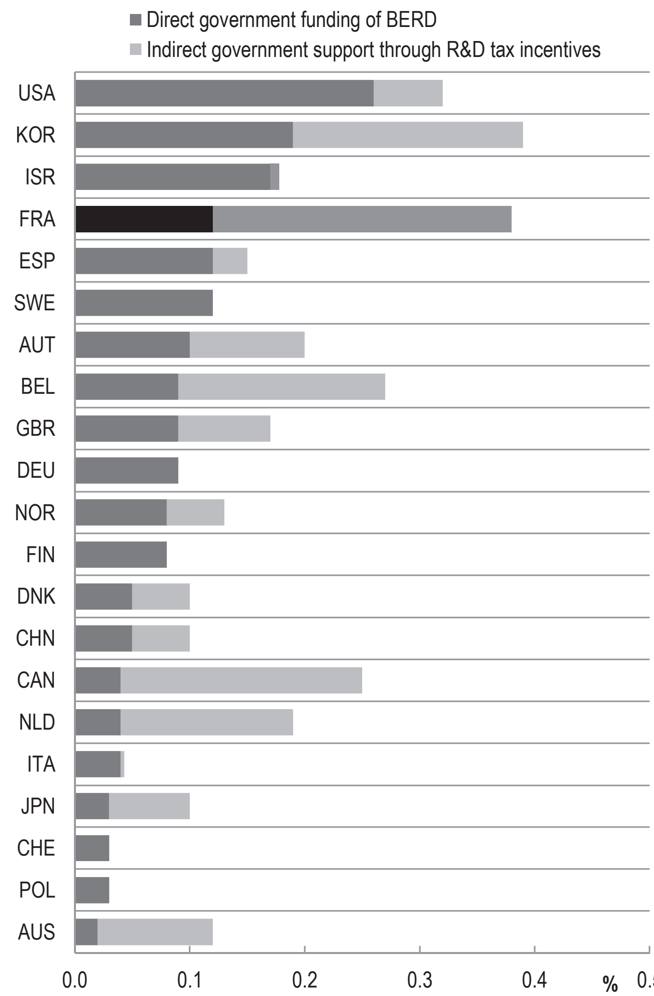
The policy mix used by governments to support the funding of private investment in R&D varies widely among countries (OECD, 2010). Some countries, including Sweden, Finland and Germany, do not offer a tax credit. Others, such as Canada, Japan, the Netherlands and France, have a funding system heavily anchored in tax assistance and direct aid represent only a small share. In Korea, Belgium and Austria, policies are more balanced between these two types of public aid. The policy mix has also changed a great deal over time in France: while the CIR has been strongly enhanced since 2008, the amount of direct aid has fallen considerably.

Table 6.1. Policies supporting business innovation in France

Aims	Corresponding programmes
(i) increase business R&D	CIR; OSEO programmes for SMEs
(ii) encourage co-operative R&D between companies	Competitiveness clusters (Single Interministerial Fund [FUI]; ANR); platforms (PIA)
(iii) develop co-operation between companies and PROs	Competitiveness clusters (FUI, ANR, PIA); Institutes of excellence for carbon-free energy (PIA); technological research centres (PIA); CIR (external R&D); Carnot institutes (PIA); ANR programmes for research partnerships
(iv) support innovative entrepreneurship	JEI; CIR (certain clauses); "Émergence" (ANR); National Seed Fund (PIA)
(v) promote certain thematic or sectoral priorities (environment, key industries, etc.)	French Civil Aviation Authority ([DGAC] aeronautics); defence credits; 34 key industries (Ministry of Productive Recovery [MRP], 2013); competitiveness clusters

Figure 6.1. Direct government funding and tax incentives for R&D

Budgetary impact as a percentage of GDP, 2011 or latest available year



Note: DIRDE is the French acronym for gross domestic expenditure on research and development (GERD) of companies established in France.

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth,* OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

In 2011, public funding (excluding CIR, tax assistance and reductions of social security contributions) accounted for 7% of BERD. The State's direct share in financing BERD has been divided by almost 3 compared to 20 years ago, principally because of the fall in public defence contracts. State aid to companies for (civil) research and innovation are set out in Table 6.2.

Table 6.2. Public support to innovation in France (EUR million)

Funding source	Type of instrument	2010	2007-10 in %
CIR	Research tax credit	4 500	+350
JEI	University JEIs and others	157	+46
Other tax expenditure		54	+13
ANR	Subsidy for companies	62	-32
OSEO	Aid for the creation of sole proprietorships, aid for aeronautics sector, Aid for innovation, strategic industrial innovation (ISI), programmes to promote industrial innovation	488	-24
Business Competitiveness Fund	FUI (R&D projects + platforms), EUREKA clusters, Nano 2008 and 2012, thematic calls for projects	312	-28
DGAC	Aid for upstream aeronautics research, direct aid for component manufacturers, aid for major airplane, helicopter and aircraft engine programmes	271	-4
ADEME	Research demonstrator funds, other aid for research	82	+550
Other government loans	Industrial agreement on training through research (CIFRE) grants, incentive loans from the Ministry of Ecology, Sustainable Development, Transport and Housing, loans from the Strategic Council for the Healthcare Industry	71	+20
Total		5 997	+142
Total excl. tax and social security instruments		1 286	-16

Source: French Court of Auditors (2011), www.ccomptes.fr/Publications/Publications/Les-aides-aux-entreprises-en-matiere-d-innovation-et-de-recherche-la-coherence-des-dispositifs-fiscaux-et-budgetaires (in French).

The next part of this chapter will review these innovation-promoting policy instruments according to the objectives they seek to achieve: the CIR, which seeks to increase BERD; the instruments offering direct support, such as competitiveness clusters (regionally based instruments aiming to spur co-operation among companies and between companies and publicly funded research) and various programmes run by the ministry in charge of industry; and finally, measures and programmes with sectoral and thematic goals.

Research tax credit (CIR)

The CIR is a tax reduction granted to companies on the basis of their R&D expenditure. It represented a credit of EUR 4.5 billion in 2010. IT and has represented around EUR 5 billion per year since then and could reach EUR 7 billion per year once fully operational (French Court of Auditors , 2013b), i.e. between 4 and 6 times the amount of direct aid and around one-third of public R&D expenditure (in which is it not counted). The CIR is the main form of fiscal support to business R&D in France, but it is not the only one; other measures are the reduced rates of taxation for long-term capital gains from patent transfers and assignments (EUR 810 million in 2010) and the mechanism for reducing social security contributions for JEIs (EUR 152 million).

The CIR in France

The CIR was introduced into the French tax system in 1983. At the time, it was incremental in nature: the reduction in tax was proportional to the increase in the company's R&D expenditure compared to a benchmark period (the preceding year or an average of the two preceding years). The system was altered beginning in 2004 with the introduction of a volume component (the tax credit was proportional to the amount of expenditure) alongside the incremental component, which gradually shrank over time. The first argument for that change was simplification: the incremental system results in specific calculation difficulties that make it more impenetrable and force SMEs to hire costly specialist services to "optimise" their tax declarations. Additionally, an incremental credit does little to incentivise companies whose R&D expenditure is stable over time, for example after a previous spike. In 2006, the rate for the volume-based share rose, but the EUR 16 million ceiling still made it unattractive to large companies. In 2008, the CIR became wholly volume-based, and the ceiling was repealed and replaced by a reduced rate beyond a given threshold value. The 2008 changes resulted in the system that is still largely in place today.

Under the system, companies are entitled to a tax credit equivalent to 30% of their eligible R&D expenditure up to EUR 100 million annually, and 5% beyond that. Any surplus CIR not paid in a given year (because the company did not make enough profit) constitutes a claim on the State and can be set off against tax for the next three years; companies can apply for reimbursement of any remainder at the end of that period. Increased CIR rates (50% in the first year, 40% in the second) are offered to new entrants, defined as companies that have no declared R&D for the past 5 years: that measure was gradually reduced, then repealed as of 2011. JEIs and new companies, companies established in certain geographic areas and (since 2011) firms that meet the European Community definition of SMEs, are also eligible for immediate reimbursement of unclaimed CIR (because the company did not turn enough profit), making the CIR a type of subsidy. A double tax credit (i.e. 60% up to the EUR 100 million threshold and 10% above it) applies to research the company contracts out to PROs and to expenditure on recruiting a young PhD graduate. Moreover, business conglomerates also benefit from the "tax integration" scheme: they declare the R&D expenditure of their subsidiaries (even 100% owned) separately, enabling them to keep most of their spending below the EUR 100 million threshold, and thus to claim the 30% CIR rate on a higher portion of their R&D.

R&D is defined as in the Frascati Manual, with the addition of textiles collections and some expenditure related to patents, standardisation and technological monitoring. The expenditure covered includes staff costs, operating costs, depreciation of equipment used in R&D and R&D entrusted to outside experts and PROs. Government aid (subsidies) must be deducted from the base.

Since 2013, the CIR has been supplemented by an "innovation tax credit", which covers innovation expenditure other than R&D (prototypes, pilot installations, patents) and applies only to SMEs.

Following the 2008 reform, the cost to the State budget soared; it was even higher in 2009 because under the economic recovery plan, companies obtained reimbursement for CIR claims in the first year, thereby providing them with useful capital at the lowest point of the macroeconomic cycle. The "tax claim", in other words the rights to the tax credit accumulated each year, whether used that year or not, rose from EUR 1.8 billion in 2007 to EUR 4.5 billion in 2008; according to some forecasts, it could reach EUR 7 billion in the future (French Court of Auditors, 2013b). BERD was EUR 23.4 billion in 2011 in France; the CIR is therefore likely to have funded close to 20% of French companies' R&D effort.

Tax treatment of R&D in OECD countries

Tax support for R&D can take various forms, and some countries use more than one. The first form consists in excluding R&D from the tax base ("tax allowance"). All OECD countries provide tax relief for R&D by allowing complete and immediate complete depreciation, i.e. full exclusion from the tax base. This is an advantage, since R&D is an investment and should therefore be subject to progressive partial depreciation, in the same way as physical investments. However, a number of countries (9 of the 34 OECD countries, including the United Kingdom, plus the BRICs – Brazil, Russian Federation, India, China, South Africa) go beyond this, allowing depreciation of over 100%, such that R&D results in a reduction of the non-R&D components of the tax base. A second form of fiscal support is the CIR, which consists in directly deducting from the corporation tax an amount related to the company's R&D expenditure. This amount may be proportional to the volume (as applied in eight OECD countries, including France since 2008), or at least partly based on the variation in R&D compared to a benchmark year, generally the preceding year) (six OECD countries have a hybrid system along these lines). The third type is where the tax support relates to the revenue (rather than the expenditure) generated by R&D, which is subject to corporation tax at a lower rate than the company's other revenue. As R&D revenue is difficult to isolate from other operating revenue, the definition is usually limited to revenue generated by patents, including royalties from licences (the "patent box", which concerns ten OECD countries, including France and the United Kingdom). Finally, some countries have systems to reduce social security costs for research jobs, sometimes subject to a time limit.

Fiscal measures are termed "horizontal" in that the State does not intervene in the type of R&D undertaken by the company, in contrast to subsidies, which are generally "targeted" (see Box 6.2). That said, the State can discriminate between the types of companies and expenditures eligible for aid. Some countries (ten in the OECD, including France) afford more favourable treatment to SMEs than to large companies, often in the form of a higher credit rate up to a certain expenditure amount or a threshold related to the size of the company.

The number of OECD countries that offer tax incentives for R&D rose from 12 at the end of the 1990s to 24 in 2012 (out of 34 member countries). Although 14 countries have recently introduced such mechanisms, two have abandoned them (Mexico and New Zealand). Several emerging countries also have these mechanisms (China, India, Brazil, Russia, Singapore, etc.). One reason for the growing spread of these mechanisms is that they are not subject to WTO and European Union limits on government aid (50% for research, 25% for experimental development). It should be noted that countries where BERD is highest, including Sweden, Switzerland and Germany, have no specific fiscal mechanism for research.

Thus, while France is part of a widespread trend, it is at the cutting edge, both as regards fiscal expenditure (the cost of the mechanism to public finances) and impact on the unit cost of R&D (Figures 6.1 and 6.2).

Box 6.2. The economics of tax assistance for research

Fiscal support for R&D consists in tax relief for companies based on the amount of their R&D expenditure. The government's aim is to reduce the cost (or "price" to the company) of R&D in order to motivate the benefiting companies to do more. The externalities and other market failings result in an R&D market price that exceeds its social value; the State seeks to remedy this by introducing an indirect subsidy. The aim is to increase thereby the overall amount of R&D by companies.

In comparison with direct aid (subsidies), tax assistance is notable for its "horizontal" nature, i.e. its principle of neutrality. Indeed, aid is independent of the company's R&D decisions, e.g. its thematic choices. When a company is more knowledgeable than the State on the best orientations for research – which is likely the case for competitive markets – then this neutrality is preferable to the State controlling the direction of research, as happens with targeted subsidies. Conversely, when the community has specific needs for technologies with limited profitability, a targeted subsidy is preferable. However, upon closer examination, tax assistance is not in fact wholly neutral: it promotes certain types of innovative efforts (founded on R&D) over others (resulting in non-technological innovation), and those that undertake them (R&D tends to be conducted by large companies – which are the chief beneficiaries of the measure). To remedy this bias, some countries have introduced special mechanisms for particular categories of companies (often SMEs or fledgling companies) or R&D (e.g. co-operative R&D). Although more neutral than targeted aid, the CIR can nevertheless be a targeted tool.

The chief potential drawback of this measure is the "deadweight loss effect" it can generate. When a tax credit is based on the total volume of R&D (which is currently the most widespread situation), the overall R&D efforts benefits from the price cut – even if the company would have conducted a significant share of it without the subsidy, making at least some of it redundant. Ideally, only "marginal R&D" should be subsidised – i.e. R&D that the company would not conduct without the subsidy – but it is impossible to isolate that share from the rest. The deadweight loss effect increases the cost of the measure to the State and dilutes its impact. One way of limiting its effect is to base the tax cut not on the volume of R&D, but on the change in R&D expenditure compared to a benchmark period – the idea being that without the subsidy, the company would simply repeat its previous R&D expenditure. This reduced base allows a higher rate of tax reduction while limiting the cost of the measure. However, it presents the disadvantage of making the measure more complex, hence less easy to navigate, and of introducing trajectory effects (a particular R&D effort will receive more or less aid depending on the company's previous efforts).

Figure 6.2. R&D tax subsidy (1-B-index), 2011

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth,* OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

The reduction in the unit cost of R&D is measured by the "B-index", a kind of average effective taxation rate. The B-index indicates the proportion of each euro of R&D that is payable by the company out of its own equity after the tax concession. In 2011, it was set at 0.656 in France, meaning that the average subsidy obtained by a company for EUR 1 of (eligible) R&D is 34.6%, compared to a benchmark situation where R&D is treated as intermediate consumption in the production process and is neither taxed nor subsidised. The OECD average is 0.879; France ranks 3rd out of 27 for its generosity (Figure 6.2). Indeed, most OECD countries have a tax incentive mechanism for R&D.

Box 6.3. Tax incentives for tax assistance for R&D in the Netherlands

The current policy mix in the Netherlands places particularly high emphasis on indirect measures to promote R&D. The share of indirect funding compared to direct funding instruments is among the highest of all he OECD countries (only Canada and Australia have a higher share of indirect funding). Two instruments to support innovation – the Research and Development Promotion Act (WBSO) and the Research and Development Allowance (RDA) – are in place. A third instrument, the Innovation Box, applies to revenues from licensing and the commercialisation of intellectual property (IP).

The WBSO is a tax measure applied to R&D staff salary costs. It was introduced in 1994. In 2009 and 2010, the tax reduction was temporarily increased to support R&D during the crisis. In 2012, the reduction amounted to 42% up to EUR 110 000 and 14% beyond that. For new companies, the tax reductions amounted to 60% up to EUR 110 000 for a total of three years. Self-employed entrepreneurs are also eligible for the measure. Of the total number of companies using the WBSO, 97% are SMEs (accounting for 73% of the budget for the measure). An evaluation of the WBSO over 2011/12 showed that the mechanism has positive effects on promoting business R&D. However, it also showed that the increase in aid did not translate into an equivalent increase in R&D. In the light of the evaluation, the Government decided to reduce the scope of the tax benefits.

The RDA is a tax reduction measure for BERD established in 2012. It allows companies to deduct a share (40%) of their R&D expenditure from income tax. The RDA supplements the WBSO: it applies to tangible and intangible R&D expenditure, whereas the WBSO applies to staff expenditure.

The Netherlands introduced the Innovation Box (a "patent box"-type measure that provides tax relief for a share of the revenue from patent exploitation) in 2007, after Ireland, France and Hungary. The effective rate of the Dutch Innovation Box is 5% (it is 15.5% in France and 10% in the United Kingdom) and, since 2009, the ceiling for tax reductions has been abolished (it had previously been equal to 4 times the cost of the IP associated with the invention). In the Netherlands, the Innovation Box applies to companies that develop patented inventions, as well as companies that receive an "R&D Statement" certifying that a share of the activities linked to the new IP was conducted in the Netherlands.

Source: OECD (2014), *OECD Economic Surveys: Netherlands 2014*, OECD Publishing, doi: 10.1787/eco_surveys-nld-2014-en.

Effectiveness

Tax assistance for R&D has undergone numerous evaluations in various countries, often using econometric techniques. One of the difficulties in this area lies in the lack of uniformity of the measures – which, leaving aside the "tax assistance for R&D" label, vary widely among countries, as well as over time. Hence, the results obtained for one country or one period do not necessarily apply to another. This is particularly true when assessing the system currently in place in France, which has no historic precedent or "twin" with comparable scope. It is risky to extrapolate the results obtained from much more modest support measures, such as the CIR in France prior to the 2008 reforms, to the current situation.

Generally speaking, most of the evaluations of tax assistance for R&D conclude that the measure is somewhat effective, in that it seems that where such assistance exists, companies spend more on R&D than they would do in its absence: there is "additionality". Moreover, a number of studies conclude that there is "net additionality", in that the supplement to BERD is probably higher than the tax cost of the measure.

An OECD analysis of a panel of 19 countries for the period 1982-2018 (Westmore, 2013) estimates that a reduction of 5% in the effective rate of R&D taxation generates a 6% increase in the stock of business R&D, all else being equal. This is a linear estimate, which holds for the average taxation rates observed in the OECD countries.

With regard to France, a study using econometric techniques was performed in 2012 as part of the compulsory evaluation of the CIR by the MESR (Mairesse and Mulkay, 2012). The study first estimates the price-elasticity of R&D capital at 0.4%, meaning that a 10% reduction in the cost of R&D (e.g. thanks to the CIR) leads to a 4% increase in R&D capital in the long term. Using this coefficient, estimated over the period preceding the reform (up to 2007), the authors calculate that an increase in the CIR rate will have a favourable effect on business R&D. The effect takes a while to emerge, but after five years it exceeds the increase in tax expenditure on R&D: there is therefore net additionality (lever effect).

It is, however, difficult to extrapolate an estimate based on a modest CIR to the very weighty CIR as it stands now, since for various reasons companies' reaction coefficients probably depend on the amount of assistance received: the CIR affects the price of R&D and price is only one of the factors that determine a company's R&D expenditure. The other determining factors, according to corporate analyses, are as follows: the industry to which the company belongs (a biotechnology company must spend much more on R&D than a textiles company); its market positioning (an up-market company by virtue of its image and investments in quality must generally innovate more than mid-market companies or companies at the lower end of the range); the environment provided by the country in terms of skilled labour, research, accessibility; and companies' incentives to grow (depending on the economic or fiscal environment, etc.). Lowering the price of R&D when the other determining factors are fixed is effective up until to the point where they become limiting factors. Even if R&D is very inexpensive, a company whose market no longer expects innovation or that is not intent on growth will have no real reason to invest in that area, all the more so as R&D is only a (sometimes small) part of the cost of innovation, which also includes production and marketing costs. A modest CIR serves to correct market-induced distortions – since the market generally does not remunerate investment in research sufficiently– and therefore provides incentives for companies to spend more; but the effect of a very high CIR is kept in check by all the other factors that affect R&D expenditure beyond its direct cost. The question is to identify the generosity threshold of the CIR beyond which these constraints come into play.

Business R&D did not really flag in France during the crisis, in contrast to several other countries, a fact possibly and partly to be attributed to the CIR. Indeed, the volume of business R&D rose (at constant prices) by 10.0% between 2007 and 2011, even as GDP fell and business investment in physical capital fell further. However, Germany – which does not have a CIR – registered an 13.8% rise in its corporate R&D, and the European Union a 9.6% increase, over the same period. It would therefore appear that although R&D remained relatively stable during the crisis, this phenomenon was not solely attributable to the CIR. At the macroeconomic level, the tax expenditure associated with the CIR rose from EUR 1.7 billion in 2007 to EUR 5.1 billion in 2011 – i.e. an increase of

EUR 3.4 billion (or: EUR 3.1 billion at constant price). At the same time BERD (including the CIR received) was growing by 13.8% at constant price between 2007 (when it was EUR 19.9 billion) and 2011 (plus 20.2% in nominal terms minus 5.6% of inflation), hence an increase of EUR 2.8 billion (at 2007 constant price). Overall, after controlling for inflation, business expenditure on R&D grew less between 2007 and 2011 than the CIR received (EUR 2.8 billion against EUR 3.1 billion). Some crowding out therefore occurred during that period, at least at the macroeconomic level, as public funding tended to substitute to companies own funding instead of boosting it. This does not necessarily mean that R&D would have remained at that level in the absence of the CIR, because French industry was in crisis at the time, and it is likely the CIR acted somewhat as a shock absorber, avoiding to many companies bankruptcy or a reduction in their expenditure on R&D.

At the microeconomic level, the number of claiming companies rose by 80% between 2008 and 2010, to almost 18 000 in 2010. Of the new entrants, 70% are small, independent companies, which received 75% of the CIR for new entrants. This increase denotes success in one of the aims of the 2008 reform – to make the CIR more accessible through administrative streamlining and enhanced economic attractiveness. More companies than previously, especially small companies, now find participating in the mechanism useful. Does this entail actual growth in the number of companies conducting research? Against the economic background of recent years, and in light of weak global R&D expenditure by French companies, it is likely that only a small proportion of new *claimants* are in fact new *performers* of R&D.

What is the amount of the CIR by company size? The CIR is degressive, since above the EUR 100 million threshold for R&D, its rate falls from 30% to 5%. However, corporations are able to circumvent this threshold by spreading their financial statements across subsidiaries. The outcome is a real rate of assistance more or less along a "U' curve: the companies receiving the greatest assistance in proportion to their R&D expenditure are the smallest and the largest. Table 6.3 illustrates the fall in the assistance rate for companies with up to 2 000 employees. Beyond that level, an MESR study (cited by the French Court of Auditors, 2012) gives the subsidy rate for the 50 largest claimants as 21% in 2010. This can also be explained by the greater involvement of very large companies in co-operative research with publicly funded bodies and universities, which receive a double CIR rate (60% or 10% depending on the amount). The CIR was designed as a more egalitarian measure than direct aid, whose asymmetrical nature (favouring large companies) has long been recognised. It has partially achieved that objective, in that it benefited very small companies more than medium-sized or large companies. The CIR does not register as deep a "dip" as direct aid in its distribution by company size. While it reaches medium-sized companies better than direct aid, they still benefit relatively less from the measure as a category – which therefore serves only to lessen, rather than reverse, the inegalitarian nature of the distribution of public aid. It should be noted that when companies are consolidated within the conglomerates to which they belong, intermediate-size enterprises (ISEs) appear to receive relatively better treatment, since several of the less subsidised ones probably belong to a conglomerate.

Table 6.3. Rate of public funding for business R&D in 2009

Staff	BERD, EUR billion	Direct funding/BERD, %	CIR/BERD, %	Public funding/BERD, %
<50	2.5	13.3	32.5	45.8
50 to 250	3.2	5.7	19.2	24.9
250 to 499	2.1	7.6	17.8	25.4
500 to 1 999	5.1	4.7	14.3	19.0
>= 2 000	13.5	12.0	15.6	27.6
Total	26.4	9.6	17.8	27.4

Source: Draft Budget Bill 2013.

The CIR also affords preferential treatment to JEIs, thereby supplementing the JEI mechanism. Introduced in 2004, the mechanism supports eligible companies (companies in the first eight years of their existence whose R&D intensity is greater than a given amount) in the following ways: *i)* exemption from social security contributions for all employees involved in research; *ii)* exemption from corporation tax for the first three years and 50% reduction in the following 2 years, up to a ceiling of EUR 200 000 over three years; *iii)* exemption from property taxes for 8 years. Since the introduction of the JEI mechanism (2004), it seems that the number of companies in this category has risen sharply, illustrating a certain amount of success for the measure (which is only one component of the broader policy to encourage innovative entrepreneurship, also involving OSEO, the Deposits and Consignments Fund, etc.). As noted in the chapter of this report on innovative entrepreneurship, advances in the establishment and longevity of these companies have not been matched by growth: very few start-ups have experienced significant growth propelling them above the size thresholds of 50 or 250 employees. Although the CIR and the JEI mechanism foster the establishment and survival of these companies, they may also inhibit their growth. A growing company will see both the direct aid and tax assistance it receives fall fairly quickly, which will not motivate entrepreneurs to pursue a path that increases the risks and decreases the advantages. It is obviously difficult to identify each company's capacity for growth with precision, and the State cannot be expected to do so. By contrast, it is reasonable to assume that companies that essentially survive on aid over many years do not have much capacity for growth, and that aid should therefore be redirected to companies with greater potential. The JEI mechanism is limited to eight years, which is already a considerable length of time, but there is no such restriction on the CIR. The non-discriminatory nature of the CIR, which helps companies with no growth potential to survive, could therefore have negative effects in terms of fostering the growth of JEIs.

A further argument in favour of the current mechanism is the attractiveness it gives France in the international competition to attract or retain multinational companies' research laboratories. The CIR has a significant impact on the cost of research. The direct costs of research in France are arguably high, particularly given the social security contributions owed on researchers' salaries (French National Research and Technology Association, 2013). The impact of the CIR on the unit cost of research (excluding immovables) can be assessed at 30%. Some operations to establish foreign companies' laboratories in France after 2008 have been largely attributed to the CIR. Studies of multinational companies show that while cost plays a role in their choice of where to establish R&D facilities, it is not the chief criterion (see the section above on attractiveness). The chief criterion is the quality of the environment, including the availability of qualified researchers, respected universities and companies in the same line of work, and its central role in global knowledge networks. The second criterion is demand for the company's products, since it seeks proximity to its markets in order to better determine their characteristics and adapt its product offer. For new projects, multinational companies initially select several possible locations based on the quality and demand criteria outlined above. It is only at the second stage that they consider cost-based criteria, and that measures such as the CIR can play a role. A country's attractiveness as a locus for research depends first on the quality-based criteria provided for the activity, and second on the dynamics of its internal market. Although the effect of the CIR at that level could be considerable, it would probably be limited in the absence of additional changes, e.g. related to opening publicly funded research to industry (in fact, the number of new facilities owned by foreign companies registered during the reference period remains low).

Another aspect of the CIR worthy of consideration is the management costs it entails for the receiving company: one of the reasons for the change to a volume-based CIR was to simplify the mechanism in order to reduce companies' management costs, especially for SMEs. These costs include the measurement of eligible expenditure, identifying the perimeter and estimating the expenditure within the perimeter. This is not necessarily a trivial undertaking for SMEs, who fear *ex post* tax adjustments should they commit an error in analysing the perimeter. The previous growth-led mechanism was more costly to manage because it involved retrospective estimates of R&D expenditure and more complex calculations in relation to the anticipated tax credit. This component was withdrawn, greatly simplifying the procedure. However, it would appear that companies' management costs are still high. This is evident in the fact that a number of consultancies specialising in provide CIR assistance to SMEs still exist in the market, and that they seem to charge a significant commission, in the order of 15% to 20% of the credit obtained (source: information obtained during one of the interviews).

Conclusions on the CIR

The recorded or estimated effects of the CIR, particularly since its reform, are as follows:

- The number of claimants has increased significantly, from around 10 000 in 2007 to 18 000 in 2010.
- Spending on R&D by companies in France increased during the crisis (by EUR 1.6 billion between 2008 and 2010), whereas in many countries it stagnated or fell. By contrast, non-CIR expenditure funded by companies themselves fell (even taking into account the slight reduction in direct public funding).
- The credit supplement is directed at large or very large companies. Companies with over 2 000 employees received EUR 2.1 billion in CIR in 2009 out of a total of EUR 4.7 billion. Thus, they received 45% of the CIR, while undertaking 51% of business R&D (Table 6.2; the consolidation of companies into the conglomerates to which they ultimately belong, effectively subordinating ISEs and SMEs to larger entities, qualifies this finding, although it remains valid [MESR, 2013]). Moreover, the CIR is paid in addition to direct aid, which tends to be even more biased towards large companies, so that all in all the aid they receive is disproportionate to their share of R&D. This bias is even greater if we focus on very large companies, e.g. the largest 50 (French Court of Auditors, 2011).

The stated goal of the CIR is to encourage companies to increase their research expenditure. However, several arguments suggest that this objective has only partially been attained: companies have indeed increased their expenditure, but not to a degree matching the aid received. The CIR can however be given a second, broader function – to boost the competitiveness of companies that do R&D by reducing their tax burden. This second objective is completely different from the first in that it targets not R&D, but the company itself and its survival. Thus, in the context of the 2009 economic crisis, the CIR probably contributed to the survival of R&D-intensive companies that would otherwise have disappeared. This broader objective can be understood in the light of the falling competitiveness of a large segment of French industry, to which the government reacted in 2008 by favouring a specific category of companies: those that engage in research.

As the analysis in chapter 2 of this study shows, France's deteriorating competitive strength is not due chiefly to a lack of research; it stems from ill-suited framework conditions (see the chapter on macroeconomics and framework conditions). Hence, the CIR can only be a partial solution to the problem at best. It can, indeed, limit immediate losses of price competitiveness through its effect on the costs of the beneficiary companies and improve non-price competitiveness over the longer term thanks to the supplementary research it provides. But it is not enough to focus on research companies a remedy for a problem that affects all companies, especially in a country where the most competitive sectors (agri-food, luxury) are not research-intensive. Indeed, the CIR will not help save companies whose growth does not depend on research, and it risks allowing companies without much growth potential to survive solely because they conduct research (as exemplified by some JEIs). In this light, it is probably preferable to reduce the rate of corporation tax and at the same time reduce the generosity of the CIR, since both measures have a neutral effect on public finances. This could be achieved by reducing the rate offered above EUR 100 million in R&D, or introducing a ceiling (as in the pre-2008 reform days), which would ensure that small companies and ISEs are less affected by the cut.

Direct instruments of public support for innovation in business

This section will consider the chief direct instruments of public support for innovation in France: competitiveness clusters, the Business Competitiveness Fund (FCE), *Bpifrance (OSEO) programmes, France's* involvement in the European Framework Programme on Research and Technological Development (FPRTD), and innovative procurement

Competitive clusters

Objective

The competitiveness clusters policy was introduced in 2004 with the aim of promoting the emergence of "innovation clusters" along the lines of Silicon Valley (see Box 6.4). A competitiveness cluster brings together, in a particular area and on a particular theme, companies of all sizes, public laboratories and training establishments. Its purpose is to support innovation, by promoting for example collaborative R&D projects between stakeholders.

Box 6.4. Rationale and international experience behind cluster policies

Clusters are geographical concentrations of interconnected companies, higher education establishments and other privately or publicly funded research organisations engaged in joint or complementary economic activities. The geographical concentration is assumed to have effects that benefit all parties involved ("spillovers"), e.g. the opportunity to fund shared infrastructure (scientific equipment), an active labour market in highly specialised areas, and shared knowledge and know-how. Clusters are often defined on the basis of their sector(s) of activity and research topics: typical examples are the ICT clusters in Silicon Valley (United States) and Bangalore (India), or the Öresund region (Denmark/Sweden) in life sciences. Most OECD countries have cluster promotion policies that seek to achieve a critical mass capable of generating more innovation and making companies and organisations more competitive globally.

Policies to support clusters can vary depending on their objectives (develop interaction between business and universities or interaction between SMEs and large companies, stimulate competitiveness in more traditional sectors, etc.) and the characteristics of the specific clusters (e.g. how mature they are). In many OECD countries, recent trends have been to combine local cluster policies and national specialisation strategies by selecting and promoting a number of sectors associated with existing assets concentrated in specific regions. The instruments adopted to support clusters include *(i)* the establishment of collaborative networks and platforms among the clusters' member organisations; *(ii)* the formulation of internationalisation strategies; *(iii)* specialisation and profiling in generic technologies and emerging industries.

Examples of recent cluster policies in OECD countries can be found in the Netherlands, the United Kingdom, Germany, Norway, Austria, Sweden and Belgium.

In 2001, the Swedish innovation agency VINNOVA launched the VINNÄXT programme, which seeks to support sustainable economic growth in the regions by developing internationally recognised research and innovation clusters in specific thematic fields. The programme provides long-term funding (ten years) to selected regional consortiums. It emphasises a cross-sectoral, interdisciplinary and collaborative approach, together with research focusing on the economic or societal needs, along with planning and forecasting efforts.

The United Kingdom's Technology Strategy Board set up "Launchpads", through which it funds the development of innovative SME clusters in specific fields and selected locations. In 2011, the first Launchpad was launched in East London, with an emphasis on digital product applications. Since then, 13 additional projects have been funded in various fields and locations (e.g. space in Oxfordshire, digital and creative industries in Glasgow, materials and manufacturing in the North West, and the motorsport industry in Oxfordshire and Northamptonshire). The Launchpad programme places particular emphasis on innovative SMEs and their ability to attract private sector investment.

Several initiatives have been introduced in Germany to promote clustering and concentration of innovative capabilities both at the national and subnational levels. A competition for "specialist clusters" was launched in 2007 by the Federal Ministry of Education and Research (BMBF) and led to 15 clusters being selected and supported (there were three calls for applications – in 2008, 2010 and 2012). The programme is not aimed at specific sectors, but selects the clusters with the best strategies to develop new technologies or new markets and requires significant private sector co-funding. The "skills networks" bring together the most innovative technological networks. The networks selected are compared to those in the "European Cluster Excellence Initiative". The "Clusters of Excellence" programme promotes university clusters focused on cutting-edge science and research activities for a period of five years. Other support measures have been introduced through the German states (*Länder*), generally in the selected technologies or fields and with an emphasis on inter-*Länder* co-ordination.

Implementation and funding

Following a national call for applications in 2004/05, 71 clusters were selected bringing together 7 500 companies. Some 15 clusters are "global" or "globally focused" and receive around 80% of the funding, while the other clusters are essentially national or regional. The main programme providing funding for the clusters is the FUI, financed by several ministries, including the ministry in charge of industry, and by OSEO (Bpifrance in 2013). The FUI contributed some EUR 1 billion between 2007 and 2011 (Table 6.3). The clusters are also associated with other programmes, – since the label effect can result in bonuses for the projects – but as part of separate procedures – OSEO innovation programmes, ANR thematic programmes for collaborative projects, ADEME aid for green projects, European Regional Development Fund aid and assistance from local authorities. Total public funding for companies as a result of the clusters amounted to around EUR 700 million in 2009, out of a total of EUR 2.5 billion in direct public funding for innovation. The funding procedure is as follows: each project must involve at least one company that is a member of the cluster. The procedure for applying for funding is in two phases: the cluster "labels" the project; it is then submitted to the FUI for funding at national level (ANR funding consists chiefly of a bonus awarded to projects labelled by the clusters and selected by the ANR under its own procedures). As well as funding, the clusters provide a number of services: project identification and implementation assistance, technological and commercial monitoring, activities at the international level and to promote the cluster. Activities are led by a permanent team (on average, 12 full-time equivalent (FTE) employees per cluster). The cluster is managed by a "co-ordination committee" comprising cluster member representatives, local authorities and government. Nationally, the programme is administered by a committee comprising representatives from the various ministries involved.

Table 6.4. Sources of funding for competitiveness clusters

Amounts in EUR millions

	2006	2007	2008	2009	2010	2011
FUI	189	239	256	220	157	149
Local government	99	125	227	167	164	167
OSEO	163	242	219	159	172	144
ANR	175	194	118	192	213	182
European Funds	n/a	n/a	92	117	114	72
ADEME	n/a	n/a	n/a	n/a	n/a	170

Source: Scoreboard of competitiveness clusters of the Directorate General for Competitiveness, Industry and Services (DGCIS)[1]

Between 2008 and 2011, the allocation of funding by type of recipient and funding body was as follows (Table 6.5):

Table 6.5. Recipients of funding for competitiveness clusters

Funding body	FUI	ANR	ISI	OSEO	Total
Public and community funding	43%	76.8%	12%		44%
Private sector:	57%	23.1%	88%	100%	56%
– SMEs and ISEs	39.1%	11.6%	85%	100%	43.7%
– large companies	15.2%	9%	3%		10.3%

Source: Erdyn et al. (2012), http://competitivite.gouv.fr/documents/commun/Politique_des_poles/2eme_phase_2009-2011/evaluation/rapport-evaluation-2012-%20complet.pdf (in French).

Companies attracted 56% of total funding, including 36.4% for SMEs and 7.1% for ISEs. Large companies accounted for around 10% of the funding, although in 2010 they received 44% of total direct public funding (both civilian and military); 65% of cluster members are SMEs and ISEs, 7% are large companies and 17% are research and/or training bodies.

Impact

The competitiveness clusters have undergone several assessments, some of which have had an impact on public policy. Thus, the assessments conducted at the request of the ministry in charge of industry at the end of the first phase (2008) and then the second phase (2012) led to significant revisions of certain aspects of the cluster policy, especially a greater focus on the downstream aspects of the innovation process, through commercialisation.

The performance of the clusters in terms of co-operation and innovation was assessed by a team of consultants on behalf of their managing authority (Erdyn et al., 2012). Between 2008 and 2012, 58% of companies belonging to clusters collaborated with new non-industrial partners and 59% with new industrial partners. By contrast, impact was limited in terms of turnover. Between 2008 and 2011, the cluster projects generated just under 1 000 patents, chiefly in ICTs, biotechnology, health and energy. The global clusters lodged on average three times more patents per cluster than the national clusters. Between 2008 and 2011, the clusters generated 2 500 innovations (new products or procedures). Three-quarters of these innovations were generated by national clusters. The most active sectors were agri-food, ICTs and energy. Around 6 500 articles were published between 2008 and 2011, chiefly in the fields of ICTs, biotechnology, health, agri-food and energy. Global clusters performed twice as well than national clusters in terms of the average number of articles per cluster. Finally, 93 start-ups were launched, chiefly within national clusters (61 start-ups). Where patents are concerned, just as with publications or business creation, clusters played a very small role in the French landscape (between 1% and 4%) and their ultimate success did not denote a change in the French research and innovation system.

An econometric assessment of the impact of clusters on SMEs was conducted by INSEE researchers for the period 2007-11 (Bellégo and Dortet-Bernadet, 2013; Bellégo, 2013). However, it is difficult to assess the impact of clusters on large companies, which are typically members of several clusters through various establishments. The assessment shows additionality in the public funding received: companies that are members of the clusters, and even more so those that received FUI funding, increased their annual research expenditure more than similar companies outside the scheme, by EUR 76 000 (cluster members) for EUR 30 000 in extra direct aid received and EUR 100 000 (FUI beneficiaries) for EUR 45 000 in extra direct public aid received. However, participating companies also received more CIR than the others (EUR 33 000 for cluster members and EUR 41 000 for FUI beneficiaries). This shows complementarity between the various measures, but also makes it difficult to perform a separate assessment of their individual effects All in all, the extra private funding for R&D generated by the clusters is positive, but limited (EUR 12 000 for cluster members and EUR 14 000 for FUI beneficiaries). However, the impact in terms of R&D effectiveness (measured by patents) or volume of economic activity (measured by turnover) is not particularly significant. Finally, another purpose of the clusters is to increase co-operation on research between companies, and between companies and public laboratories. The growing number of co-operative projects initiated by the clusters indicates some success on this score, although the multiple measures taken under the various frameworks to increase co-operation makes it difficult to assess their individual contributions.

Questions raised

Several issues have been raised by stakeholders and observers concerning the clusters and could be the object of further assessments, as follows:

- The steering mechanism is very complex due to its interministerial composition and the resulting differences in strategic goals (competitiveness vs. regional attractiveness).
- A number of stakeholders criticised the complex procedure for applying for aid, deeming the two phases both redundant and lengthy. The funding procedures are very complex for companies – especially for SMEs, which are often awarded funding from several sources, each with its own specific rules.
- There is no training in most clusters, even though many companies state that access to a workforce with specific skills is a priority.
- Professionals from the risk capital industry, including venture capital, were barely consulted in the first two phases, so that the clusters' impact on innovative entrepreneurship has been limited.
- In terms of governance, small companies appear to be very under-represented in the management structures, where public research institutions and large companies have the greatest weight.
- Where location is concerned, geography and research themes do not always coincide. Indeed, companies often find partners, whether public or private, far removed from their own base. Moreover, large companies manage their research on a national (or even global) scale and thus end up being involved in a number of clusters working on similar or complementary activities, thus complicating internal project planning. Fixing the clusters geographically thus seems questionable, even if the geographical criteria have been significantly relaxed, including many instances of clusters co-labelling their projects.
- While the clusters cover all the key technologies identified by the ministry in charge of industry over several successive financial years (the most recent being 2011), they are generally too dispersed across the technologies, with the result that overall, co-ordination between the two approaches seems fairly poor.

- Management costs are considerable: over 800 FTE posts are directly assigned to managing the clusters, not to mention managing the FUI, etc. (Erdyn et al., 2012).

Conclusions

Overall, the competitiveness clusters policy plays a positive and significant role in the technical fields and geographical areas concerned. In particular, it links the regions – with their drive and own resources – to a national policy. Care must be taken, however, to ensure that the clusters do not generate excessive operating costs (themselves a reflection of onerous procedures) and are open to new players (entrepreneurs). Clearer expression of the various sectoral priorities of the ministry in charge of industry would permit greater synergy with the other innovation policies.

Business Competitiveness Fund (FCE)

The FCE supports three instruments: *i)* the competitiveness clusters; *ii)* EUREKA and the Joint Technological Initiatives; *iii)* support for strategic R&D. In 2009, the FCE funded 337 R&D projects, including 200 competitiveness clusters and 36 EUREKA clusters to the tune of EUR 401.6 million. The average number of partners funded per project was 4.2, with companies receiving 67% of the total aid (PLF, 2011).

EUREKA

EUREKA was established in 1985 to support the downstream phases of innovation at the European level through a programme with simple and lean administrative procedures. It is a bottom-up programme, geared towards the needs of industry. Projects must meet the minimal requirement of comprising at least two participants, from two different member countries – a rule that was modified in 2012 in order to increase participation from newly associated countries. EUREKA is not a source of research and innovation funding, but it awards a label to projects that meet the evaluation criteria jointly established within the programme, thereby facilitating their access to national funding. Thus, each country funds its own actions. EUREKA also provides services such as assistance with partner searches and networking, access to contacts at the national level and disseminating news about the innovations achieved under the programme.

In 2012, EUREKA awarded labels to 297 projects at the European level representing EUR 1.1 billion in total costs (public and private funding). The strategic initiatives known as "Clusters" account for 69%, the Eurostars Programme 18% and individual projects 13% of the total. France funds all three initiatives.

EUREKA clusters are long-term industrial projects (for SMEs and large companies) aiming to develop key technologies for European competitiveness. Funding is directed at a small number of strategic sectors: micro-nanotechnologies, electronics, energy, the environment and water. In France, the clusters are managed and funded by the DGCIS, which labelled 45 projects (77% of all labelled clusters) in 2012 with a total cost of EUR 245 million (of which EUREKA funded 31.3%). Support for co-operative projects often involves SMEs (60% of partners) in distant downstream projects. In 2012, 12 projects were funded in France at a cost of EUR 15 million. The Eurostars Programme is designed to support high-tech SMEs. In 2012, 34 projects (24%) were selected in France with a total cost of EUR 21 million.

Support for "strategic local" R&D: Nanotechnology

Support of this type mainly consists in supporting the excellence of the French nano-electronics industry. Nano-electronics is a key generic technology, which has been a key priority of France's industrial and innovation policy since the launch of the "Crolles 1" programme in 1992. The Nano 2012 ("Crolles III") programme signed in 2009 for five years is a public/private programme co-ordinated by STMicroelectronics. It brings together industrialists and research bodies (notably the Alternative Energies and Atomic Energy Commission [CEA]-LETI) with the aim of strengthening French industry's place in the development of technologies to manufacture electronic components for the most advanced semiconductors used in communications, consumer electronics, etc. It represents an expenditure of EUR 2.3 billion, including EUR 457 million provided by the State and local government and EUR 340 million by STMicroelectronics. In 2010, the programme received EUR 113 million (including EUREKA/ Cluster for Application and Technology Research in Europe on NanoElectronics [CATRENE] credits), EUR 50 million to support EUREKA projects not related to CATRENE, EUR 10 million for a new call for projects in the field of ecotechnology and EUR 10 million for strategic R&D projects. Nano 2012 has been renewed under the Nano 2017 programme (2013-17) endowed with a total budget of EUR 1.8 billion.

Bpifrance-OSEO

Bpifrance is a key player in policy to support innovation in France. This public institution was created in 2013 from the merger of OSEO (the French Agency for innovation and SME development), CDC-Entreprises (a branch of the Deposits and Consignments Fund, a State bank, which funds companies and is heavily involved in innovation and SMEs) and the Strategic Investment Fund (which provides capital to companies selected by the State). Agencies with a fairly similar purview exist in other countries (Box 6.5). Because Bpifrance was established so recently, this review will focus on analysing the activities of its predecessors, specifically OSEO and CDC-Entreprises (see also the chapter on entrepreneurship).

Activities

OSEO (Bpifrance) is an important player in *i)* aid for innovation; *ii)* credit guarantees; and *iii)* SME and ISE financing. In 2011, OSEO awarded (excluding FUI) EUR 547 million in aid to innovation (Table 6.6), compared with EUR 733 million in 2008. This fall coincided with the enhancement of the CIR since 2008 and probably reflected the State's intention to limit direct aid as indirect aid rocketed (Masquin et al., 2012). OSEO is a major player in direct aid to companies. Direct aid to innovation is distributed through various programmes.

The aid provided by OSEO has different aims, as follows:

- support competitiveness clusters: OSEO manages the FUI
- support innovation in SMEs for projects deemed eligible by OSEO experts in accordance with technical and economic criteria
- support large projects (aid between EUR 3 million and EUR 10 million): the ISI programme, the successor to the Industrial Innovation Agency, was integrated into OSEO in 2007

- encourage co-operation between SMEs and ISEs: with each other, with large groups ("Passerelle" programme), with PROs, internationally (Aid for Innovation Development through International Co-operation), etc.
- support innovation in specific industries (aeronautics, etc.).

Box 6.5. Aid for innovation agencies in Finland and the United Kingdom

Foundation for Finnish Inventions – Finland

This organisation provides risk financing to private individuals and entrepreneurs so that they may develop and exploit their inventions. Financing can take the form of grants or loans, generally ranging between EUR 2 000 and EUR 200 000. The grants cover the early costs of developing an invention. Funding decisions are made on the basis of the innovativeness, technical functionality and economic evaluation of the invention proposal. The funds serve to cover the costs of patenting, product development and commercialisation. The financing incorporates a refund to the foundation, contingent on the success of the project and on the revenue received by the entrepreneur. If the inventor starts a company to commercialise an invention, the foundation can provide a loan on human working capital. The loan is generally granted only if no other adequate sources of funding are available.

Innovation, Research and Development Grants – United Kingdom

This is a grant for individuals and SMEs based in England whose goal is to undertake R&D on technologically innovative products and processes. The grant is administered by the regional development agencies. There are five different types of aid. Proof of market grants test the commercial potential of an innovative idea (USD 31 000 [dollars] are distributed to SMEs). Micro-projects are development projects lasting no longer than 12 months (USD 31 000 available to companies with fewer than 10 employees). Research projects investigate the technical and commercial feasibility of innovative technology and last between 6 and 18 months (up to USD 155 000 available to SMEs with fewer than 50 employees). Development projects focus on the pre-production of a new product or process involving a significant technological advance and last between 6 and 36 months (up to USD 389 000 available to SMEs with fewer than 250 employees). Exceptional development projects entail a significant technological advance and are strategically important for a particular technology or industry: they last between 6 and 36 months, funded by a negotiable grant of up to USD 779 000.

Table 6.6. Activity by OSEO 2010-11

EUR millions

	2010	2011
State funding – AI Programme	308	315
Partnership funding	121	89
State funding – ISI Programme	140	107
FUI	81	112
Investments for the Future Programme (PIA)	0	36
Total aid	650	659

Source: OSEO activity report (2011).

Aid is awarded either in the form of a subsidy (preferably for upstream research projects), or as a repayable advance in case the project is successful (usually for downstream projects, close to market). On average, companies repay 55% of the funds advanced to them by OSEO (Masquin et al., 2012). OSEO also guarantees bank funding. Guarantees are provided to promote creation, transmission, development, innovation and international expansion.

OSEO offers 12 guarantees in all. Innovation guarantees facilitate the access of innovative SMEs to bank funding while Biotech guarantees are specific to biotechnology companies. Guarantees for innovative projects enable banks to issue market guarantees, on order and behalf of SMEs, to the benefit of their customers. The amounts involved in 2010 were around EUR 300 million.

In partnership with banking and finance establishments, OSEO contributes to funding certain investments, funding the operating cycle and bolstering the equity of SMEs. This includes various innovation-related mechanisms. Chief among them are the following: innovation loans finances the industrial and commercial launch of an innovation by an SME. CIR pre-financing provides cash to cover R&D expenses in the year they are incurred. R&D project industrialisation loans for competitiveness clusters fund downstream expenditure for an R&D project with the goal of industrialising or commercialising an innovative product, process or service. Equity seed loans strengthen a company's financial structure to facilitate and prepare for initial fundraising. Innovation development contracts are loans to fund non-tangible investment and working capital requirements associated with an innovation or modernisation programme. Participatory development contracts strengthen the equity capital base to implement development projects. Finally, re-industrialisation assistance is a repayable advance to fund a share of investment expenditure.

Finally, OSEO (now Bpifrance) has been one of the main operators of the PIA since 2010 with regard to aid for innovation and SMEs, including re-industrialisation assistance and the calls for R&D proposals issues by competitiveness clusters. OSEO and Bpifrance also contributed to establishing the Digital Ambition Fund. The Ecotechnology Fund supports equity and quasi-equity transactions for acquisitions of minority stakes in innovative SMEs in the field of renewable energy and green chemistry, sorting and commercialisation of waste, pollution remediation, eco-design products, smart grid and vehicles of the future. The aim of the Rare Diseases Innovative Biotherapies Fund is to invest in the equity of new companies. The National Seed Fund manages equity investments for Bpifrance.

Impact

It is difficult to assess the impact of OSEO, since the companies it supports it also receive other forms of aid and it is not easy to identify the actual effect of each one. It is clear from the econometric study by Masquin et al. (2012) that a project that receives 33% of its funding from OSEO (the average rate of aid in 2009) produces 4 times more patents for an SME and twice as many patents for a large company than a project that receives no aid. Moreover, according to Serrano-Velarde (2008), for each EUR 1 in repayable advances disbursed by OSEO between 1995 and 2004, companies spending less than EUR 300 000 spent EUR 1 more on R&D. This effect diminishes with the recipient company's amount of R&D expenditure and is cancelled out when the budget exceeds EUR 9 million. The OSEO mechanism is therefore more effective for small companies than for large ones. It would also appear that the effect of loan guarantees on moral hazard is significant and merits more systematic assessment (Lelarge et al., 2013).

The adoption in 2014 by Bpifrance of an "open data" policy enabling independent researchers to access its data (stored in a secure warehouse) is an extremely positive decision, which should allow assessing its operations in accordance with the prevailing scientific criteria.

French participation in the Framework Programme for Technological Research and Development (FP)

French participation in European research programmes is low and falling (French Court of Auditors, 2013). Its share of credits distributed under the Seventh Framework Programme was 10.5% at end 2013 (Table 6.7), compared to its 17.5% contribution to the European Union budget. This low level of participation is due to a relatively low number of submissions from French applicants and is not offset by an especially high success rate. Various explanations for this phenomenon have been suggested: the downstream approach of FP topics (in contrast to the upstream approach of French research); the failure to take project management into account (an important component of any work for the FP) in assessments of public sector researchers, who consequently have little incentive to become involved; finally, the increased ease of access to French public funding – especially through the ANR – making European aid, with its more complex procedures, less attractive. These explanations naturally apply more readily to public research than to company-led research, although business participation in FP has also fallen. The fact that France's share of European Union R&D fell significantly in the 2000s may be another factor, since it lowered its capacity to draw up projects from 17.9% in 2000 to 16.4% in 2010 (measured as BERD). The fall in France's share in business R&D (from 17.5% to 17.0%), however, was less significant.

Overall, there has been relatively low FP funding for French companies, since it amounted to EUR 1.3 billion between 2007 and 2013, i.e. less than EUR 200 million per year.

Table 6.7. Participation of the various French stakeholders in FP7, 2007-13

	Participation	**Participation** (%)	**Contributions received** (EUR thousands)	**Contributions** (%)
Higher education establishments	1 900	16.65%	639 554.6	13.97%
Research bodies	4 558	39.94%	2 254 018.4	49.22%
Public sector bodies	395	3.46%	72 161.3	1.58%
Private sector bodies	4 130	36.19%	1 281 116.9	27.97%
Other	430	3.77%	332 754.7	7.27%
Total selection	11 413	100.00%	4 579 606.0	100.00%

Source: European Commission, E-Corda-FP7 projects and participants database (25 October 2013), MESR-DGESIP/DGRI-SIES.

Innovative public procurement

Public procurement can play an important role in innovation (OECD, 2010). This has long been recognised in fields such as defence or infrastructure and, more recently, in areas related to sustainable development (low-carbon energy, etc.). The interviews conducted for this review show that the role of public procurement could be especially important for JEIs, which as a result obtain not only income (for example through subsidies) but receive a kind of implicit "certification" that they can use as a commercial lever with other potential clients.

Market size

Public procurement in France rose from EUR 52.5 billion in 2005 to EUR 87.8 billion in 2005 (according to the Public Procurement Economic Observatory [OEAP] at the Ministry of Economy and Finance). This trend is a reflection of the "major contracts" for equipment and supplies.

What is the share of innovative public procurement in total public procurement? In France, as in other countries, the lack of data on public procurement of R&D and innovation does not allow a precise assessment. The OECD Working Party of National Experts on Science and Technology Indicators uses the input-output tables of the national accounts to measure the volume of intermediate consumption of highly knowledge-intensive products by the public administration and defence. In France, that volume represented 16% of gross sectoral output, but 61% of total intermediate consumption in 2007, compared with gross sectoral output of 36% in the United Kingdom and 17% in Germany and total intermediate consumption of 69% in the United Kingdom and 54% in Germany (OECD, 2013b).

The 2013 report by the Commission of Experts for Research and Innovation (EFI, 2013) analyses public procurement in Germany and France using data from TED (the supplement to the Official Journal of the European Union on European public procurement). The first hypothesis put forward by the EFI is that the public contracts that are most likely to have innovative content have undergone a process of "competitive dialogue". Although these accounted for less than 1% of all public procurement in Germany between 2006 and 2010, they accounted for close to 4% in France. The second hypothesis is that public procurement is more likely to be innovative when it involves certain high technology sectors, as well as defence, the environment and R&D. The EFI estimates that over 2006-10, public procurement in France in these sectors represented 13.5% (high technology), 2% (defence), 6.1% (environment) and less than 0.1% (R&D) of the total volume of public procurement. The figures for Germany were 7.3% (high technology), 2.4% (defence), 4.2% (environment) and 0.5% (R&D).

An OECD study (2010) notes that France is one of the countries that attach the lowest level of priority to demand-side policies (p. 86, it is written that Finland and Spain attach the highest level of priority and Germany a medium level of priority). A report by the European Commission (2011) notes that France has not identified any demand-side measures as full-fledged instruments of innovation policy. France's response to the policy questionnaire for the 2012 edition of the *OECD Science, Technology and Industry Outlook* mentions two programmes: the Passerelle programme managed by OSEO and the measures included in Article 26 of the Economic Modernisation Act 2008 (Law No. 2008-776 of 4 August 2008 on economic modernisation [LME]).

The Passerelle programme and the Small Business Act

The Passerelle programme (managed by OSEO) was launched in 2007 to encourage innovative SMEs to become involved in calls for tender made by public bodies or large companies and to facilitate the creation of new products and services by the same SMEs. The projects are funded in equal thirds by the SME, the public sector or private sector organisation purchasing the product or service offered by the SME and OSEO. The SME retains the intellectual property (IP) rights associated with the innovations. This programme appears to have a very low take-up.

The "French-style" Small Business Act (Article 26 of the 2008 LME) gives innovative SMEs preferential access to public procurement. This temporary experimental mechanism earmarks a maximum of 15% of the average amount of public procurement contracts involving high technology, R&D and technological studies below the threshold for formalised procedures over the past three years, or preferential treatment in the event that equivalent tenders are submitted.

To promote this mechanism, the DGCIS helped ten voluntary public bodies to implement the new measure and published two practical guides – one directed at innovative SMEs and the other at purchasers. A report on the LME (2010)[2] states that the regulatory mechanism was adopted in its entirety and that monitoring mechanisms (survey of public procurement by the OEAP) were still too recent to provide statistics. In 2013, no information on innovative public procurement appears in the survey data available on the Observatory's website. It is therefore difficult to provide a quantitative assessment of the "French-style" Small Business Act. It can, however, be compared to its equivalents in other countries, which seem more successful, at least in the United Kingdom and the Netherlands (Boxes 6.6 and 6.7).

Box 6.6. Small Business Research Initiatives in the United Kingdom and the Netherlands

***Small Business Research Initiative* (SBRI) – United Kingdom (OECD, 2010)**

Introduced in 2001, the SBRI earmarks a share of the Government's procurement budget (11% of the budget in financial year 2007/08) to be assigned to SMEs through competitive R&D contracts. The SBRI has been reformed several times to increase its performance and impact. Since 2009, it has operated in two phases: a feasibility phase (USD 156 000) and a development phase (USD 390 000 to USD 1.6 million). In 2010, 370 contracts in the areas of defence, health and construction were financed at a total value of USD 39 million. It would appear that awards are skewed towards a large number of very small projects still in the feasibility phase.

Small Business Innovation Research (SBIR) – Netherlands

The government launched an SBIR on several different themes: agriculture, energy, transport, water management and defence. Based on the SBIR of the United States, the programme provides funds to SMEs through public procurement to develop innovations that help solve societal challenges. Like the programme described above, it covers two phases (with USD 69 000 for the feasibility phase and USD 625 000 for the development phase). A 2007 evaluation of the SBIR pilot programme showed that it attracts companies that are new to the public procurement market and co-operate more than firms that did not receive a contract.

Box 6.7. Innovative public procurement in Sweden

Historically, public procurement has played an important role in the development of a large number of innovative companies in Sweden. The scope of the related policies has been reduced since Sweden joined the European Union and assumed the obligation to comply with the directives on European-wide public procurement and the Treaty of Rome principles. Nonetheless, a number of initiatives are under way in Sweden to promote innovative public procurement. To date, they are still being prepared rather than implemented. The main initiatives are as follows:

- Three inquiries related to public procurement and innovation have been conducted by the Ministry of Enterprise, Energy and Communications for public procurement innovation, the Ministry of Health and Social Affairs, and the Ministry of Communication to assess the rules governing public procurement from the perspective of economic and social policy, including innovation. The principal conclusions are that:
  - Public procurement innovation can have significant effects in the public and private sectors.
  - Very few contracts incorporating innovation are being issued and there is considerable potential, especially in the areas of infrastructure, health and the environment.
  - Public procurement bodies need better information and direction.
  - The legislation in force does not preclude procurement markets focusing on innovation, even though it entails certain restrictions.
- VINNOVA (the public agency for innovation) has worked to develop innovative procurement. Between 2009 and 2010, VINNOVA conducted a number of pilot activities. In a call for tenders launched in May 2011, the “innovation” aspect was highlighted with regard to supplying meals for the elderly.
- In the draft budget for 2012, VINNOVA was allocated SEK 24 million (kronor) to develop a competency and support initiative for the procurement of innovation. Initially, the initiative will cover preparing concepts for innovation procurement (e.g. public procurement before commercialisation by the company), subsidies, development of templates and guidelines, operational assistance (including legal advice), publicising information (websites, visits, conferences, brochures, etc.) and co-operation with other agencies and organisations, both nationally and internationally.
- Recent changes in procurement legislation also pave the way for establishing procurement centres and using competitive dialogue in procurement. Centralising procurement enables companies to amortise the fixed costs of innovation more easily, whereas competitive dialogue can facilitate the flows of information between purchasers and vendors that are useful when developing and purchasing new products and services.

Source: OECD (2013), *OECD Reviews of Innovation Policy: Sweden,* OECD Publishing,
doi: 10.1787/9789264184893-en.

France Brevets

In 2011, France established a patents fund, "France Brevets", which was allocated EUR 100 million – half each from the Deposits and Consignments Fund and the PIA. The role assigned to France Brevets is to create an "infrastructure" for the patent market – which is necessary to the secure, open and transparent development of the IP economy – and to facilitate access to the IP market by entities for which it is generally less easy – PROs, universities or SMEs. Specifically, the role of France Brevets is to acquire patent rights (preferably in the form of a licence), group them in clusters and license them out (sub-licensing). It can acquire patents from PROs or French SMEs and help commercialise them (obtain licences); conversely, it acquires them on the market and makes them accessible to French SMEs on terms that the SMEs would not have been able to negotiate by themselves. Thus, France Brevets provides a brokerage service in a highly complex market. The fund was created for the following reasons: recognition of the need to bring together patents from various sources and fields to act as a basis for innovation (or ensure operational freedom); recognition of some players' weaknesses when it comes to the complexity of commercialising and acquiring IP rights; the view that developing IP markets is beneficial and should be encouraged by the State; finally, the idea that France is currently lagging behind in this area. France is not the only country to have embraced this route and other countries are also doing so, including Korea ("Intellectual Discovery" and "IP Cube Partners" funds) and Japan ("Life Sciences IP Platform" fund). Since its inception, France Brevets has started to build up a portfolio in ICTs, life sciences and space. In 2013, France Brevets initiated legal proceedings for counterfeiting against a company accused of patent infringement. Two comments must be made in that regard. First, financial gain as an aim of commercialising patents, such as that pursued by private operators, does not appear to fall within the scope of public action – the risk being that France Brevets might engage in the "trolling" that pollutes the American patents system, whereby specialist bodies often take abusive legal action against productive companies in order to extort payments. This is neither within the purview nor the powers of France Brevets. Additionally, the ambitions of France Brevets must remain commensurate with its relatively modest size – which matches its level of experience with a view to establishing a genuine patents market. With an operating fund of EUR 100 million, it would not be able to make the financial commitments necessary to play an effective role in monetising patents, a field rife with giant players such as Intellectual Ventures (United States), endowed with USD 5 billion.

Targeted and sectoral policies

This section will focus on the various sectoral innovation policies implemented in France in the following areas: services, the military, civil aeronautics, space, the automotive industry and the environment.

Policies supporting innovation in companies

Modern economies are marked by a concentration of the service sectors in production activities, and increasingly in innovation (Box 6.8) – hence the growing importance of innovation policies related to those sectors. This raises, however, specific questions regarding policies related to the manufacturing sectors.

To be eligible for public funding in France, innovative service projects must have a technological foundation. The French approach is narrower than the European Community (EC) approach, which does not outright exclude non-technological R&D from public aid. The bodies and programmes concerned include OSEO, the FCE, support for platforms, ANR and ADEME. Intervention by local government is more in line with the EC regime and aid may be used for service-based innovative projects. Thus, national support mechanisms for innovation in France partially take into account innovative services. For example, OSEO will fund service innovations as soon as they employ an innovative technology or group of technologies (principally ICTs). ANR aid is directed at technological programmes, but some programmes in the fields of health and innovative energy storage, as well as the "*Émergence"* and "sustainable cities" programmes seek to support the development of technologies and services. The FUI funds technological platforms in competitiveness clusters and thereby supports a service offered to companies to verify feasibility and test a technological development. It also supports projects in the humanities and social sciences. Similarly, Article 26 of the LME (2008) enhancing SME access to public procurement and the CIR remains focused on technology-based innovation in services.

Box 6.8. Industry and services: Partners, not competitors

The OECD economies are increasingly based on services and less and less on industry. In France, the share of manufacturing in the value-added fell from 22% in 1970 to 10% in 2011, while its share of employment dropped from 23% to 11%. The trend is the same in all the OECD countries, including Germany and Japan, where the importance of the manufacturing industry is higher than elsewhere. Some observers see this as a negative trend and hold it partly responsible for the weak growth since the crisis broke in 2008 and the balance of payments deficits in some countries. Several countries now have policies that seek to restore the manufacturing industry. The two main arguments for this approach are as follows:

- The manufacturing sectors are more innovative, e.g. they spend much more on R&D than service sectors do.
- There is more international trade in manufactured goods, which therefore contribute more to the trade balance.

Both arguments are, however, fragile. The first argument ignores the development of "modern" services (e.g. computers, health, financial services) that are often focused on ICTs and extremely innovative. The second ignores the fact that manufactured goods that move from one place to another incorporate some of the value created in the service sectors, which supply the manufacturers. OECD analyses using input-output matrices show that the share of services in exports reckoned in terms of value-added is 50% for France (compared to 25% in gross terms). Other countries present similar orders of magnitude (OECD, 2013c). The importance of services to competitiveness is illustrated by the fact that the decline in France's competitiveness during the 2000s was not due to a rise in unit labour costs in manufacturing proper, but in services, which in turn increased the total manufacturing costs.

Moreover, as part of global value chains, where production processes are segmented across countries, service industries (e.g. R&D or marketing) are separate from manufacturing, but they are all mutually dependent in that the competitiveness of the one ensures the competitiveness of the others, and vice versa. Establishing competitive manufacturing in a low-cost country ensures the sustainability of the high value-added employment that remained in the most advanced country. Thus, it is not appropriate to view manufacturing and services as incompatible; they are, on the contrary, highly compatible.

Current industrial policies must therefore provide service activities a place that matches their actual economic importance and their role in innovation and competitiveness, which is at least as important as that of the manufacturing sectors, and certainly complements it.

More than other programmes, the PIA emphasises innovation in services by targeting technology-based innovations, although not exclusively. The calls for tenders in the first waves of the PIA related to establishing shared innovation platforms; biology and health-related research infrastructures; innovative digital services for e-education; self-building and co-operative housing; health and social services; sustainable mobility; and the digital field. The PIA also launched a call for tenders on funding the social economy, an important area for human services and non-technological innovations.In 2011, the DGCIS announced an action plan for innovation in services. The plan contained several priorities and resulted in the publication of a guide to service innovation for SMEs and the establishment of a National Service Innovation Prize. The plan seeks to "deploy financial resources for innovation in services", including through OSEO, which in 2012 launched a call for proposals on innovation in services with a EUR 7 million budget. The DGCIS launched a call for "multiservice platform" proposals with a budget of EUR 1 million. This initiative provides a subsidy that encourages companies (especially very small enterprises) to form multiservice platforms offering a set of services tailored to client demand. It also encourages the platforms to be innovative in the services they supply to companies by collaborating with training and research establishments. The DGCIS selected five projects from the 2010 call for proposals and four projects in 2012.

Over the past several years, measures have been taken to co-ordinate all the public institutions supporting innovation (MESR, ANR, OSEO, Strategic Investment Fund [which became Bpifrance Investissement in 2014], French National Institute of Industrial Property, etc.) so that they may work together on improving IP in service innovation, adapting the existing mechanisms that support service innovations mainly based on technological advances and adapting public financial institutions' project assessment processes. This review has not been able to identify any progress achieved in this respect.

The two sectoral plans announced in 2013 by the Ministry of Industrial Recovery (MRP) include "services" components. Of the 34 stated key sectors, several relate to services, with a heavy technological component (ICTs). The "six key priorities" of the Lauvergeon Commission include the "silver economy" (addressing the changes in the economy stemming from the ageing population) and feature measures to support the creation of innovative services that meet the needs of the elderly.

French policy increasingly recognises the importance of innovation in services. The trial-and-error approach taken in implementing the various measures is a normal thing given that this is a new field. However, there is still no set of principles that can guide public action, especially for non-technological innovations. The existence and nature of any market failures with regard to these innovations – failures that are not necessarily of the same nature as those affecting technological innovations – should be examined. Consideration should also be given to the complementarity between technological innovations and service innovations, which mean that the absence of the one can sometimes hinder the development of the other, and vice versa; this is particularly the case in areas where public action is crucial, such as health or the environment.

The military

In 2013, the Ministry of Defence allocated around EUR 3.3 billion to R&D, including EUR 1.2 billion to business. In comparison to OECD countries, the share of defence-related R&D budgets as a proportion of all public R&D budget credits (as an average from 1999 to 2010) was 21% for France, 55% for the United States, 27% for the United Kingdom, 14% for Sweden and 6% for Germany. France's industrial performance reflects this approach to public defence finance: in terms of patents, the specialisation coefficient for defence for the period 1999-2008[3] is 1.6 for France, compared to 1.4 for the United States, 0.7 for the United Kingdom, 2.2 for Sweden and 1.2 for Germany (Moura, 2012). As in other OECD countries, public defence expenditure fell considerably in France, especially during the 1990s following the end of the Cold War. The reduction in France's overall R&D intensity from 2.5% at the beginning of the 1990s to 2.2% at the end of the 2000s is entirely due to the fall in defence credits. Defence had been a driving force in the advancement of a number of cutting-edge scientific and technical fields in the post-war period (see, for example, the role of the Defense Advanced Research Projects Agency in the United States) and the fall in defence expenditure adversely affected a number of the areas concerned.

The "Defence research and technology" component (EUR 902 million in 2013) is managed by the French Defence Procurement Agency (DGA). It comprises upstream studies (research to underpin the launch of arms programmes, EUR 752 million) and subsidies (studies allocated to PROs, including ONERA [the French Aerospace Lab], French-German Institute of Saint-Louis, the French Space Agency [CNES], schools and SMEs). Financial commitments are planned in the form of upstream study programmes covering core research and technology (15%, including training through research), technological studies (50%) and demonstrators (35%). To complement the upstream studies, the DGA supports innovation through mechanisms including RAPID (support regime for dual innovation), ASTRID (specific support for defence research and innovation) and ASTRID-Maturation.

The RAPID programme is an aid to SMEs and ISEs with fewer than 2 000 employees to develop dual innovation. Established in 2009, it received EUR 30 million in from funding from the DGA in 2010 and has received EUR 40 million since 2011. It awards subsidies to companies that spontaneously present dual (and possibly collaborative) innovation projects.

*The ASTRID programme, launched in 2010, is conducted in partnership with the ANR. I*t supports highly exploratory and innovative dual research lasting between 18 and 36 months with maximum subsidies of EUR 300 000. Industrial concerns must have ties to a research laboratory or institute. The ASTRID programme received funding of EUR 12 million in 2011. The ASTRID-Maturation programme, launched in 2013, is funded by the DGA and managed by the ANR. Its aim is to commercialise the results of dual research produced under ASTRID.

Civil aeronautics

With Concorde and then Airbus, France has gradually accumulated world-class aeronautical skills. Airbus and its many subcontractors are a vital component of French industry and a significant contributor to the trade balance. A sophisticated system of public support paved the way for the emergence of Airbus; technological innovation is still at the heart of that support.

Total public aid for civil aeronautical R&D awarded to companies by DGAC amounted to EUR 271 million in 2010 (French Court of Auditors, 2011). Including OSEO aid to the aeronautical industry, direct aid to aeronautics amount to approximately EUR 300 million – nearly one-quarter of direct public aid to industry.

The objectives in this field are to support the aeronautical industry's competitiveness by encouraging the development of breakthrough technologies leading to sustainable and "green" air transport.

The main types of activities financed are as follows:

1. *Aid for upstream aeronautical research.* Transfers to business totalled EUR 120 million in 2010 (EUR 60 million in 2011 and 2012) and are carried out by DGAC. Around 50 (often collaborative) projects are proposed to DGAC each year. Since 2010, around 20 projects are supported every year, benefiting over 20 companies (large conglomerates, component manufacturers and SMEs) and research bodies. The individual project amount ranges from EUR 0.5 million to EUR 8 million for a period of 1 to 3 years.
2. *Support for development of aeronautic programmes.* These repayable advances amounted to EUR 175 million (including OSEO aid to the aeronautics industry) in 2010. The funds are earmarked for the development of new airplanes, engines, helicopters, avionics equipment and systems. Repayments are made in line with product sales.
3. *PIA support.* The amount committed under the PIA to the aeronautics industry is EUR 1.5 billion. It is managed by ONERA and benefits companies in the aeronautics sector by way of subsidies (minimum EUR 500 million) and repayable advances (minimum EUR 800 million). This support makes it possible to co-finance technological demonstrators, develop future aircraft and improve the operational profitability of manufacturers in the sector.

Space

France tops the space industry rankings in Europe[4] with a consolidated turnover of around EUR 2.7 billion in 2009. The French civil and military space budgets (EUR 2 billion per year in total) represent one-third of European space budgets. Moreover, France is the leading contributor to the European Space Agency (ESA) budget, with contributions of EUR 770 million in 2012.

The French Space Agency (CNES) is the body responsible for implementing French space policy, which obviously has a strong technological component. With a budget of around EUR 1.36 billion in 2011 (excluding French participation in the ESA), CNES funnels EUR 800 million to industry to conduct national civil and military programmes. According to the assessment report of the Evaluation Agency for Research and Higher Education (AERES, 2010), the research and technology budget for space systems is a strategic resource for SMEs, but the uncertainties inherent to the programme (budget constraints, programming changes, delays in decision-making) tend to destabilise participating SMEs. Large companies are more resilient because CNES funding accounts for only a small share of their turnover.

Moreover, research and innovation in space are also funded by other channels, such as ANR, the competitiveness clusters, OSEO grants for innovation and the PIA. There are three competitiveness clusters in the aeronautics/space field: Astech, Aerospace Valley and Pégase.

Some of the PIA measures are earmarked for space (EUR 500 million). The CNES is the operator and the beneficiaries are companies in the sector. The aim of the PIA is to contribute to the major technical choices made by the ESA as part of its future launch programme and to accelerate the development of new generations of satellites.

Automotive industry

Introduced at the beginning of the 1980s, the Land Transport Research and Innovation Programme (PREDIT) is a tool for co-ordinating research and innovation. It is run by the ministries in charge of research, industry, transport and the environment, and by three agencies: ANR, ADEME and OSEO. ADEME is involved through contracts or subsidies and is in charge of the Demonstration Fund (support for hybrid and electric vehicle projects). ANR contributes through the Vehicles for Land Transport or Sustainable Cities programmes. OSEO is involved in technological and innovative services incorporating ICTs. PREDIT 4 (2008-12) had EUR 400 million in public funds and was supposed to generate a total research effort of EUR 1 billion. PREDIT 4 has six priorities: energy and the environment, quality of transport systems, mobility in urban regions, logistics and goods transport, competitiveness of the transport industry and transport policies.

Environmental protection and energy management: French Environment and Energy Management Agency (ADEME)

Environmental protection and energy management are research priorities in many countries, for both economic and welfare reasons. They were also championed as priorities in France in the SNRI of the MESR in 2009 and in the Juppé-Rocard report that led to the creation of the PIA, also in 2009. They are one of the missions of the CEA and other PROs and one of the themes selected to feature among the 34 key industries in 2013. The Grenelle Environment Forum (2008) also highlighted innovation. Indeed, this area brings together several strategies embodied by various stakeholders. Here we will focus on the agency that most clearly incorporates these objectives into its mission: ADEME.

ADEME is an objective-led agency that supports research performed by public or private operators and funds phases from pre-industrialisation through research demonstrators. Its annual R&D budget is around EUR 40 million, two-thirds of which go to companies, and one-third to public laboratories. In 2011, over 50% of aid contracts involved ecotechnologies in the fields of energy, waste, air and noise. The Agency calculates that the public/private leverage effect, including demonstrator funding, was 1.68 in 2010 and 2.1 in 2011.

ADEME awards aid for projects conducted by an organisation independently or in co-operation. "Co-operative research" refers to calls for proposals and covers co-operation between at least two independent companies, including an SME, or co-operation between a company and a research organisation. It also supports R&D projects, which can be submitted to ADEME at any time on any of the priority topics. In 2011, ADEME funded 54 new theses, 46% of which were co-funded by a company, a local authority or a public institution.

In 2008, at the close of the Grenelle Environment Forum, ADEME established the Research Demonstrator Fund for New Energy Technologies. The purpose of research demonstrators is to optimise technologies just prior to the industrialisation stage and to enable them to move from the laboratory stage to a size where the technologies can be tested in real use conditions. In 2009, a EUR 151 million envelope was committed to projects as part of the Demonstrator Fund; EUR 600 million will be committed by manufacturers and research bodies to R&D.

In 2010, four PIA programmes were entrusted to ADEME: technological platforms and demonstrators in renewable energy, low-carbon energy and green chemistry; smart electricity grids; the circular economy; and vehicles of the future. In 2013, 115 projects were selected (of the 541 proposed) for a total funding of EUR 940 million.

Box 6.9. The "Top Sectors" policy in the Netherlands

Motivated by concerns over the international competitiveness of the Netherlands and emerging social challenges, the Dutch Government announced the "Top Sectors" approach in February 2011. The "Top Sectors" is a new form of industrial policy, entailing *i)* focusing of public resources in a small number of areas and *ii)* extensive co-ordination of activities within these areas among companies, government, universities and PROs. Nine sectors (which do not exactly match industrial sectors in established classifications) were initially singled out: agri-food, horticulture and high-tech propagation materials, energy, logistics, the creative industry, life sciences, chemicals and water. A tenth horizontal theme, "headquarters", was subsequently added, highlighting the importance attributed to retaining and attracting major multinational companies. In 2011, the nine sectors accounted for over 80% of business R&D and under 30% of value-added and employment. Whereas traditional approaches to industrial policy are too government-centred, industry representatives are at the centre of the co-ordination process in the sectors. The Government, for its part, commits to developing sector-specific policies across ministerial portfolios, including education, innovation and foreign policy, as well as reducing the regulatory burden. The "Top Sectors" policy also aims to reduce the administrative burden for companies, combining the hitherto disparate channels of public support to companies into a single window for service delivery (*Ondernemersplein*). The approach introduces new forms of governance. "Top Teams" comprising senior representatives from industry, research and government in each sector draft innovation agendas, which they submit to the Government for consideration. The Government then evaluates each top team's proposed agenda, which includes a strategic plan and instruments for the sector. The Government's evaluation takes into account the level of ambition, the degree of stakeholder commitment, the degree of openness, the balance between social and economic objectives and the extent to which the set objectives can be monitored and evaluated. The relationships and sectoral plans are then formalised in the top consortiums for knowledge and innovation (TKIs) – in some cases, there are several per top sector. The public budget allocated to the Top Sectors is difficult to calculate with accuracy because it includes funds allocated to other programmes and hence re-labelled, as well as other funds that are also co-financed by industry or the European Union. It also incorporates R&D funding dispensed by thematic ministries (e.g. of health and sports, infrastructure and the environment, and defence) and the regional and local authorities. The Dutch Government estimates that (excluding regional and EU funding), between EUR 1 billion and EUR 1.1 billion will be made available to the "Top Sectors" every year over 2013-16. Of this total, the TKI funding allocation (between EUR 50 million and EUR 130 million) can be identified clearly as additional funding. Between EUR 30 million and EUR 50 million per year are earmarked for education and labour market measures, while EUR 700 million to EUR 900 million per year are earmarked for research and innovation.

Source: OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*, OECD Publishing, doi: 10.1787/9789264213159-en.

Developments in 2013 and 2014: the "34 key industries" and the "7 sectors of the future"

In September 2013, the MRP announced a plan entitled "the new industrial France" aiming to support innovation in "34 key industries". With funding of over EUR 3 billion, the scope of the plan was significant. Following a National Council for Industry study conducted by McKinsey, 34 key industries were selected on the basis of 3 criteria: *(i)* growing world markets; *(ii)* positioning as a French leader in the related technologies; and *(iii)* existence of a sound academic, technological, economic and industrial ecosystem. The chosen technologies also contribute to meeting the social challenges of the future. The 34 industries include renewable energies, new cars and digital hospitals. The deadline for marketing the planned innovations is 2020. Each sectoral plan is managed by a group of stakeholders chaired by a manufacturer, which will have to prepare a plan and submit it to the Government. The governance model is fairly similar to that of the "Top Sectors" in the Netherlands (see Box 6.9). In September 2013, the "Horizon 2030" plan was also released in the wake of the report drafted by a committee chaired by Anne Lauvergeon. The committee initially identified the challenges French industry would face by 2020 and singled out on that basis the following seven areas: energy storage; materials (rare metals) recycling; economic exploitation of marine resources; phytoproteins and vegetal-based chemistry; personalised medicine; the silver economy (for the elderly); and the commercialisation of mass computer data. In the second phase, the State commits funds to implement the stated priorities. The procedure followed is similar to that implemented for risk capital, with several rounds of investment in projects which are reassessed at each stage. Innovation competitions are launched in the seven chosen fields. With a total budget of EUR 300 million, EUR 200 000 in aid will be paid at the end of the first round to selected innovative companies, provided that the developmental work and jobs are located in France. Following a second selection round, much larger budgets of up to EUR 2 million will be made available to the companies.

Conclusion: Assessment of French policies supporting research and innovation

The gradual refocusing of French State intervention in industry over recent decades has tended to refer to the discourse on "new industrial policies" because it takes into account the prevailing environment in which global industry operates. The question is, to what extent do the decisions that are actually implemented tally with requirements of those policies, and hence the requirement that French industry be competitive? From that point of view, the response is mixed: in fact, the genuine progress made over that period must be extended further to fully realise the desired paradigm shift. This chapter concludes with an assessment of the main aspects listed above – the framework conditions, strategic cohesiveness, interventions on linkages and upstream activities, opening up to stakeholders and entrepreneurship, consistency of between the instruments used, and assessment and transparency.

Framework conditions

As shown in the chapter on macroeconomics, France is from this standpoint not very well placed, due to its fragmented labour market, high labour costs, insufficiently reactive continuing education, financially cumbersome State, complex and onerous tax system, and many regulations. The efforts made by the Government to improve this situation are welcome.

Strategy

Despite abundant and in-depth strategy for industry, innovation and innovation policy, decisions ultimately lack strategic cohesiveness. This chapter has reviewed a plethora of plans and horizontal or thematic measures. Systematic mechanisms do not seem to have been introduced so as to ensure that these various strategies and the decisions to which they lead are in alignment: co-ordination, where it exists, occurs ad hoc and is not always effective. The "new industrial France", for example, deserves to be more expressly anchored in the analyses of new demand or globalisation (which can be found in the "Horizon 2030 Committee" report), and even more so in the various analyses that place entrepreneurship (rather than increased support for large companies) at the heart of government objectives. In a context where public resources are scarce, this results in efficiency loss throughout the public support system and in "blind spots" that are obscured by a surfeit of measures.

Despite the absence of a clear single strategy, French policy is clearly focused on supporting R&D, with the result that entire swathes of the most competitive sectors of French industry (agri-food, luxury products, services, etc.) benefit little from innovation policies. This is incompatible with the requirements of the new industrial policies to promote "entrepreneurial discovery" which insist on the necessary connection between the structure of the current or anticipated economy and the orientations of innovation and emphasises the importance of non-technological innovation. The latter has appeared in recent industrial plans, but still in a marginal position.

Political emphasis on the linkages between stakeholders and upstream activities

Since 2004, France has used competitiveness clusters to emphasise linkages between companies, and between companies and public research.

A number of programmes announced as part of the PIA or more recently (e.g. the "34 key industries") target technologies rather than specific companies. However, the dividing line between technologies and companies is not always watertight: some technologies have a very narrow business base, and the support offered to some technologies can be channelled towards specific companies.

Openness towards "non-client" companies

A third feature of the "new industrial policies" is their insistence on the need to open up government mechanisms to a variety of companies beyond the State's traditional "clients" (chiefly large companies). This aspect has also received much attention in France.

Entrepreneurship has been given pride of place in French innovation policy and has been the subject of a large number of measures over the last 15 years (see the next chapter). As a result, France is very much in line with the trend of new industrial policies.

It should also be noted that a growing share of public funds earmarked for companies are allocated on the basis of open calls for tenders (as with the PIA since 2010, ANR grants and funds stemming from the "Horizon 2030" operation), thereby favouring those companies that prepare the best projects – which are not necessarily those that are most accustomed to public financing, especially since often international panels are involved in the selection process. Here again, France is in line with the principles of the new industrial policies.

Nevertheless, it bears noting that large companies continue to be the chief beneficiaries of public support in both absolute and relative terms (rates of assistance). ISEs benefit the least from public aid, despite having become a policy focus since 2008.

Instruments

Recent debates in France demonstrate high awareness of the need to streamline the list of stakeholders and instruments involved in innovation policy, whose excessive complexity has earned it the label of administrative "millefeuille" (this complexity is not specific to innovation, but seems particularly high in this area). However, few actions have been taken to that end.

The fact that each instrument ties up with several objectives, and vice versa, is not a problem in itself and is even desirable in order to ensure system coherence. But it should be recognised that the new instruments were created over time without systematic discussion on which instruments already in place should be withdrawn or amended to provide optimum conditions for the new instruments. The plethora and overlapping of instruments reduces both their effectiveness and effective State oversight of each one.

The instruments can also be considered from the point of view of the balance of the overall package. Here, France stands distinguishes itself internationally by its very high proportion of tax assistance compared to direct aid. The high level of generosity it has now reached means that tax assistance probably has limited effectiveness. At the same time, direct aid often comes in the guise of small lump sums (especially since there are so many measures, leading to a degree of dispersion or even "sprinkling"). Restoring the balance in favour of direct aid would allow increasing the sums allocated to individual measures. It would also give the various strategies' thematic priorities the necessary emphasis so that resources are properly allocated to ensure their effective implementation.

Assessment

Assessments that are both effective (with an impact on policies) and in line with international standards are a central component of the new industrial policies and should enable better management of public funds by identifying and then adjusting or cancelling programmes that do not meet the stated objectives.

France has made significant efforts in this field, especially in the context of the PIA, all of whose projects undergo continuous quantitative monitoring by the authorities involved. A number of important measures, such as the CIR or the competitiveness clusters, were the subject of repeated in-depth – and generally quality – studies commissioned by the supervisory authorities and conducted by academics or consultancies. It should, however, be noted that no independent assessment of these measures has taken place. Moreover, the systemic nature of innovation policies (each measure has several objectives, and vice versa) also calls for systemic, comprehensive assessments that match objectives to results; no such studies have been conducted. The new assessment group for innovation policies established within the General Commission for Strategy and Policy Planning could be the appropriate forum for steering this type of analysis.

Overall assessment

Overall, it appears that France has come a long way since the era when innovation policies focused on major State programmes, State needs, State means, etc. Some significant changes still need to be made for France to take full ownership of its new industrial policies. Although with these new policies government action complements – rather than replaces – the market, France still has a number of programmes that replace the market altogether. A more economical approach would both reduce management costs for the State and increase the coherence and strategic focus of State interventions, making them a more effective tool for developing innovation in France.

Notes

1. http://competitivite.gouv.fr/documents/commun/Les_Poles_en_mouvement/tableaux-bord-stats-communs/2011/Touslespoles_2011.pdf.
2. Ministry of Economy and Finance (2010), Bilan de la loi de modernisation de l'économie, www.economie.gouv.fr/files/finances/lois/pdf/lme/100519bilanlme.pdf.
3. The specialisation index is the ratio between the proportion of space-related and arms-related patent applications in one country and the proportion of such applications throughout the OECD. A value higher than 1 indicates specialisation.
4. http://cache.media.enseignementsup-recherche.gouv.fr/file/Politique_spatiale_francaise/09/8/Strategie_spatiale_francaise-mars-BD_211098.pdf.

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Chapter 7

Innovative entrepreneurship in France

This chapter looks first at the statistics on innovative entrepreneurship in France: business creation in general and innovative business creation in particular, company survival and growth, venture capital financing, "business angels", etc. It then examines the various schemes introduced to support innovative entrepreneurship, which has become a policy priority in French, as well as in the other countries with which it is compared. A first type of scheme offers support for innovative ventures, especially financing for young innovative businesses – whether it is direct (grants, assisted loans) or indirect (taxation). A second type of support targets investors, who can obtain more favourable tax treatment if they invest their savings in these kinds of companies, which are considered to be riskier and therefore less attractive. Lastly, the chapter assesses France's policy mix in this area and offers recommendations for improving it.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Innovative entrepreneurship plays a key role in the production dynamics of modern economies. It is an important channel for developing and implementing of innovations, as well as a source of competition that stimulates more innovation by existing companies. The relevant literature has identified some types of innovation in which start-up businesses often have an advantage over existing companies. These include radical innovations, which might topple the dominant technological and economic models in a market occupied by established companies which have little interest in challenging the status quo, and inventions very closely connected with the fruits of scientific research in the academic world. Rather than presenting start-ups and established companies as antitheses, the present analysis focuses on their complementarity, which operates through "innovation ecosystems" (which also incorporate universities): small businesses enjoy access to capital and markets that large companies can facilitate for them, while large companies benefit from the unique inventions and agility of small businesses. This is the approach underlying the policies that a number of OECD countries have pursued over the past few years to foster innovative entrepreneurship and innovation ecosystems.

This chapter has three sections: the first on business creation, the second on venture capital financing and business angels, and the third on public policies.

A review of innovative business creation in France

Business creation in general

The OECD indicator of barriers to entrepreneurship for 2008 ranked France in the average of OECD countries, between the United States and Germany. This means that the barriers are not particularly high in France, even if the administrative burden on start-ups does seem a little heavier than in a number of other countries. Compare this average ranking with 1998 ranking, when France ranked third of all OECD countries – after Turkey and Poland – in terms of barriers to entrepreneurship. This change reflects a remarkable effort to reduce red tape in the 2000s. Similarly, in 2011, the number of days required to register a business in France was 7, compared with 12 in the United Kingdom and 15 in Germany (Ernst & Young, 2013).

During the decade of the 2000s, there was a sharp upturn in business creation in France. This is partly due to changes in the legal framework, which made it far easier. In 2004, 269 000 businesses were created. This number grew gradually to 332 000 in 2008. Half of these new business creations were companies (i.e. intending companies that would recruit one or more employees) and the other half individual businesses (solely owned, liberal professions, auto-entrepreneurs, etc.). The auto-entrepreneur scheme, introduced under Law No. 2008-776 of 4 August 2008 on economic modernisation [LME], came into force on 1 January 2009. Its effects were immediate: 580 000 businesses were established in 2009 (including 320 000 individually owned companies= and 623 000 in 2010 (including 360 000 individually owned companies) (Filatrau, Hagège and Masson, 2013).

It is interesting to note that within the total number of companies created, the number of companies increased between 2004 and 2008 (from 124 000 to 160 000) and levelled off between 2009 and 2010 (with 152 000 companies created in 2009 and 164 000 new companies in 2010). In other words, the quasi-doubling of the number of companies establish in France between 2008 and 2010 was almost exclusively due to the establishment of individually owned companies (a*uto-enterprises*), while the number of corporate concerns remaining basically the same (Filatrau et al., 2013). These individually owned companies only rarely develop into companies that recruit employees, innovate and export. As a reminder, 94% of the business creations have no employees and even excluding individually owned companies, 88% are established without employees.

Over the past 15 years, a raft of administrative simplification measures (including those relating to the "auto-entrepreneur" status) have made it easier than in the past to establish a business. More broadly, public policies have attempted to support and even inspire and motivate people, from the unemployed to researchers, who had a business creation plan, as well as people wishing to invest in such plans.

Although there has been a sharp upturn in business creation in France, does that mean that France is more entrepreneurial? Looking at entrepreneurship from the point of view of the mere creation of a legal structure, the answer is yes. But from the point of view of an economic definition of entrepreneurship as a process of creating new activities, the answer is less clear. This question brings up what has been described as a major weakness of the French economic fabric: the lack of intermediate-sized enterprises (ISEs), especially compared with France's European partners, such as Germany or the United Kingdom. The challenge facing entrepreneurs is therefore the capacity to establish and develop ambitious ventures that can grow into ISEs.

Put another way, what is more important: having more business creations in general or more "gazelles", i.e. small and ambitious new companies that will grow considerably, thus creating jobs and wealth?

Taking all type of business creation together, the figures are clear: one-third of companies cease trading before they reach the age of three, and half do so before they reach the age of five. Among those still active after five years, only one in 25 companies creates jobs. The causes of such an outcome are also clear (see the French Court of Auditors report, 2012): newly created French companies present characteristics that are unlikely to keep them going in the long term or help them grow (the chosen legal status, such as that of *auto-enterprise,* is not conducive to growth ; own capital is low; many of these individual companies are established by people with few skills and little support, who are therefore not in a position to develop their economic activity). In total, nearly 95% of the companies established in 2011 had no employees.

Creation of innovative companies

How many of the half-million companies establish in France every year are "innovative companies"? There is no source of standardised statistics that could provide an answer to this question. Innovation surveys (such as the Community Innovation Survey) neither identify nor fully cover the relevant population. Current efforts to monitor the European Commission's "2020 objectives" ought to shed some light on the matter. For the time being, however, France is relying on ad hoc studies that do not lend themselves to international comparison.

While there are no consolidated statistics on innovative companies in France, at least three estimates shed light on this phenomenon. The first, drawn up by the French innovation agency OSEO (Tassone, 2013), identifies all the companies supported by OSEO, or that have filed patents or received investment from innovation mutual funds (FCPIs) that are members of the French Association of Investors for Growth (AFIC). Pooling the data from OSEO, the French National Institute of Industrial Property (INPI) and AFIC produces a figure of 10 000 companies in 2011, corresponding to a growth rate of around 500 companies a year. Small and medium-sized enterprises (SMEs) account for 49% of this total, micro-enterprises for 45% and ISEs for 6%. These innovative SMEs therefore represent 3% of the approximately 131 000 SMEs and 12% of the 4 576 ISEs recorded by the French National Institute of Statistics and Economic Studies (INSEE). These 10 000 innovative companies employ 740 000 workers and have a turnover of EUR 200 billion (euros).

The number of innovative companies can also be estimated from the number of companies establish since the 1999 Innovation Act and of two linked measures: incubators and the National Competition for the Creation of Innovative Technology Companies, whose main purpose was to encourage business creation stemming from public research. The Business, Technology Transfer and Regional Aid Service of the Directorate General for Research and Innovation of the Ministry of Higher Education and Research (MESR) has compiled every year since 1999 the number of companies incubated (within the framework of the 30 or so incubators established following the Act) and the number of companies that won the competition. Thus, between 1999 and 2011, 2 693 companies were incubated and/or won the competition (Rodes and Adolphe, 2013), i.e. an average of 225 companies a year. This figure also remained stable during that period.

A third study covers a broader field than the two discussed above (Barrot et al., 2011). It includes companies that were supported during their first three years by at least one of the research and innovation support schemes – OSEO aid for innovation, research tax credit (CIR), national business creation competition or incubator – or were labelled by OSEO as an "innovative company", or were sampled in the MESR research and development (R&D) survey. Based on these criteria, the study found that nearly 10 000 innovative companies were established between 1995 and 2004, i.e. 1 000 per year. Of these, 700 per year on average were established entirely independently (meaning that they were not therefore offshoots or subsidiaries of an existing group).

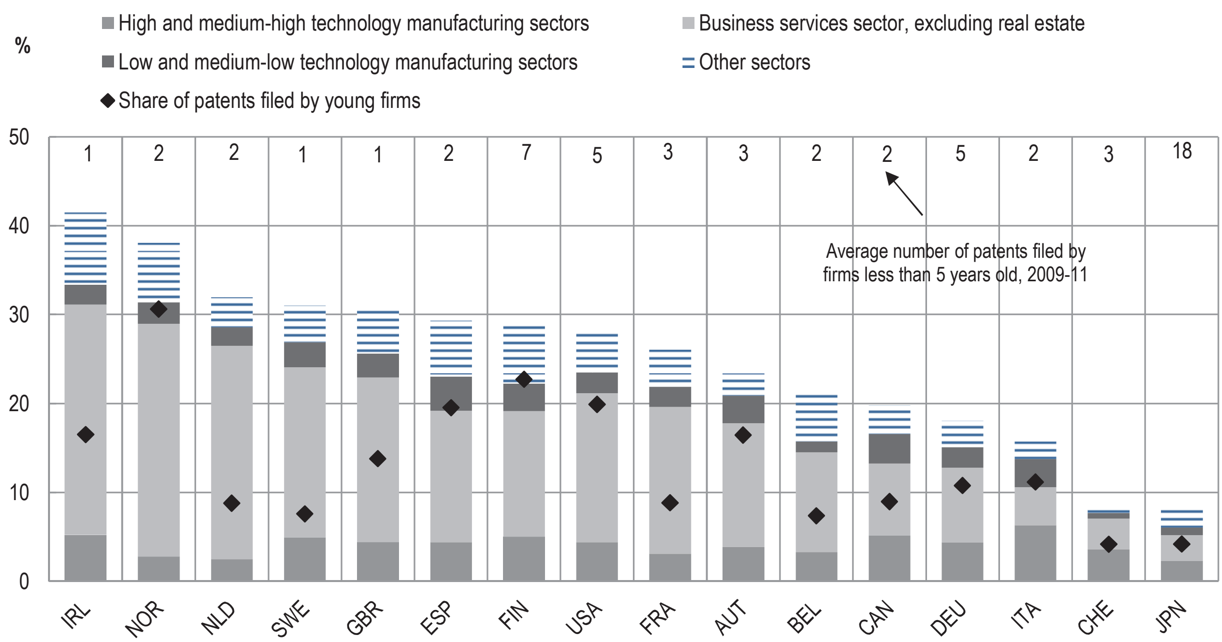
These studies can also be supplemented by information relating to the young innovative enterprise (JEI) administrative status established in 2004; it offers various benefits to the companies that are accorded JEI status, which this chapter will cover later. Since 2008, almost 600 companies have been joining this scheme every year, three-quarters of them being less than two years old, and an average of more than 400 have exited the scheme; almost half of these are companies that are more than eight years old, which is the eligibility ceiling for the JEI scheme.

Overall, according to estimates, between at least 225 (MESR study on the Competition and incubators) and 700 technologically innovative companies are created every year (MESR study undertaken by Barrot et al.). None of these sources shows a growth in the number of innovative business start-ups over ten years, but rather that the figure has remained stable.

It should be noted, however, that the criteria used by these three studies are still closely linked to R&D and technology, i.e. a limited definition of innovation (which, for example, does not take into account a company created on the basis of on an innovative business model or organisation).

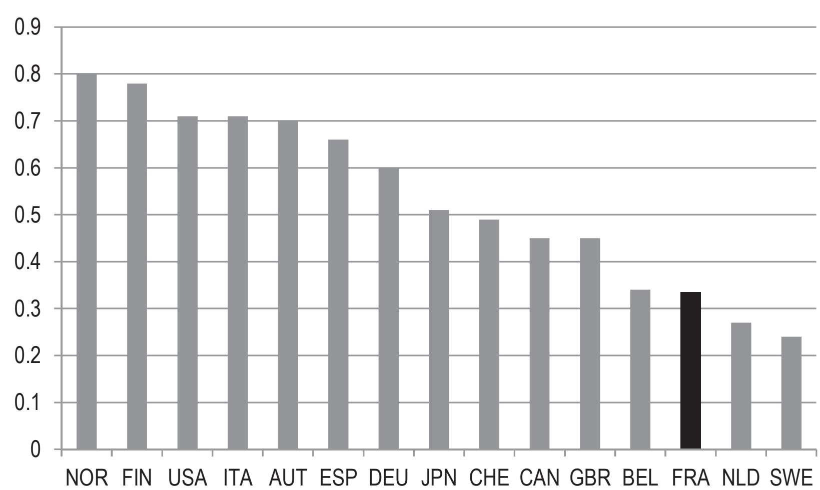
International comparisons are not easy, particularly because of issues related to definitions and the availability of data. Based on a restricted indicator – the percentage of young firms that issue patents – France is below the OECD average (OECD, 2012). With 26% of such firms aged less than 5years (Figure 7.1), France is around the OECD average, behind the Nordic countries, the United Kingdom and the United States, but in front of Germany. However, when it comes to these companies' share of total patents filed by resident firms, France is less well placed, behind Germany. This means that while relatively large numbers of young French firms file patents, each firm files only a few (Figure 7.2): this is probably a low index compared to older firms, indicative of low growth, a problem which will be examined later in this chapter.

Figure 7.1. Proportion of firms under five years old among firms filing patents; Share of these companies in patents filed



Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth,* OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

Figure 7.2. Average number of patents filed by young firms relative to number of patents filed by overall firms, 2009-11



Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth,* OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

What path do these innovative companies follow?

The OSEO study – which identified and analysed 10 000 innovative companies – focuses on the youngest of these companies. It stresses that the average young business (active for less than three years) is a micro-enterprise which has been active for a year and a half, employs one person and has a turnover of EUR 56 000. In the field of innovation, as in business creation in general (see above), the companies involved are generally very small.

The longevity of the innovative companies established by public-sector researchers had already been noted in the 1990s: six years after their creation, over eight out of ten companies stemming from or connected to public research were still active (Mustar, 1994 and 1997); this finding was subsequently confirmed (Mustar and Wright, 2010). At the end of the 2000s, studies by the MESR also found that candidates winning the national competition were also long-lived: "Over five years after they had been established, 84% of the companies established in 2006 were still active in late 2011" (Rodes and Adolphe, 2013). Barrot et al. (2011) note that, among a broader population of young independent companies, 10% to 15% dropped out of the market in their first five years compared with around 30% within the general corporate population. The survival rate of innovative companies is therefore higher than that of their non-innovative counterparts.

While these new innovative companies have a low mortality rate, they are also slow-growing: they continue to be small companies. Mustar (1988, 2003) also found that most of these companies stemming from research continued to be small companies and that success stories were few and far between. This was also borne out by the Ministry's survey which showed that, in 2009, the companies winning the national competition and established between 2002 and 2005 had an average of between four and six employees. Similarly, companies hosted by the public incubators and established between 2002 and 2005 had an average of between three and five employees in 2009 (Rodes and Adolphe, 2013).

This low failure rate raises an important question: why do so few companies of this kind fail and, at the same time, why do so few grow? As many of the companies stemming from public research are also beneficiaries of public funding, does this funding tend to cap the population of these companies and limit their growth?

This situation among companies stemming from research is not limited to France. The same is true of other European countries (Wright et al., 2007; Mustar, Wright and Clarysse, 2008) and also, to some extent, of the United States.

These young innovative companies appear to grow faster than other companies of the same size in the same area of activity, but they regularly post gross operating losses (Hallépée, 2013). Other things being equal, moreover, growth among technologically innovative companies continues to be higher than among their non-innovative counterparts, although that growth continues to be modest. In fact, very few of these undertakings are experiencing significant growth. Companies stemming from public research account for very few of these exceptions. France has had the most success in the Internet sector, where non-technological innovation is as, if not more, important than technological innovation and where public support is not therefore as high: Dailymotion, PriceMinister, Deezer, Rue du Commerce, Meetic, Critéo, etc. are examples of this success.

Acquisitions

The study of young technologically innovative enterprises (JETIs) (Barrot et al., 2011) provides valuable information on acquisitions. It ranks innovative companies established independently into three groups: "survival" (where the business continues to operate without any holding being taken by another business), "exit" (i.e. where financial statements have ceased and the firm has not been acquired) and "acquisition" (where another business has acquired a financial holding or there has been at least a partial buyout).

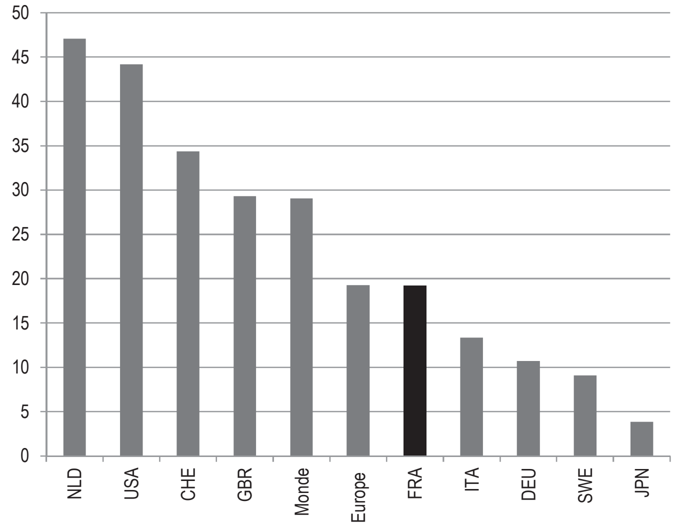
In total, 20% of JETIs are subject to a buyout within five years (acquisition or takeover[1]) (compared with 2% among the general population of new companies) (Barrot et al., 2011). In almost one out of two cases, the acquisition is by a foreign firm, and among French buyers, over half are companies with fewer than 250 employees. The companies acquiring young innovative companies are larger and more frequently foreign than those taking over other companies, reflecting the international character of innovative activities.

Is it necessarily a bad thing if companies are acquired by larger groups? Far from being a sign of failure, a takeover is quite a normal exit channel for an innovative enterprise. Not every business that achieves success is necessarily destined to place its own innovation on the global market; that may require certain assets, such as industrial production capacity, distribution networks or a brand name, which the innovative enterprise does not possess. Some innovations, moreover, have greater value if they are marketed in close association with other innovations, which a large group is better placed to do, as it has a broader innovation portfolio. In point of fact, some start-ups are essentially created as demonstrators in order to validate innovations and then be acquired by a group that will market them; this is particularly true of the biotech industry where companies are bought out by industry giants when a drug that they have invented reaches the advanced and therefore very costly stage of clinical trials. Better economic exploitation of an innovation creates higher value and generates more employment.

There have been some debates in France about takeovers of innovative companies by foreign groups driven by the fear that, when control passes into foreign hands, money and jobs will follow. In fact, the market in technological acquisitions is global, and the large French companies themselves make the bulk of their acquisitions abroad; the reason for this is the narrow specialisation of these start-ups, which can be of interest only to companies which operate in specific fields and which will not necessarily exist in France. In many cases, then, a takeover by a large company, whether national or foreign, is the best way of bringing to fruition an existing activity that might otherwise simply vanish.

A number of successful companies are taken over once they reach a certain size, with the result that none of them ever becomes a high-profile industrial giant. The only company in France's CAC 40 stock market index that is less than 30 years old is Gemalto (formerly Gemplus), a world leader in chip cards which was founded in 1988. France is not the only country in which large and young companies are uncommon (Figure 7.3); Italy, Germany, Sweden and Japan are in the same boat, and France is close to the European average. Countries in which innovation brings about a renewal of the business population (among others, the United States) can thus be contrasted with countries in which it leads to an internal transformation of companies; France tends to be in this latter category.

Figure 7.3. Number of companies established after 1979 among large research companies in 2007 (as a %)



Sources: Innovation Union Scoreboard 2007, http://iri.jrc.ec.europa.eu/scoreboard07.html; Veugelers and Cincera (2012), "Differences in the rates of return to R&D for European and US young leading R&D firms", *Research Policy,* Vol. 43, Issue 8, October, pp. 1413–1421.

Internationalisation

According to various interviews with entrepreneurship professionals when this report was being drawn up, many new French companies are likely to find it difficult to internationalise, gain access to export markets, open subsidiaries abroad and attract foreign investors; in some cases, they look abroad at an advanced stage of their development when it is already too late to capitalise on the benefits that they could have reaped because the market has changed in the meantime and new competitors have emerged at global level. Internationalisation is imperative in these sectors for companies in all countries, apart perhaps from the United States in view of the size of its domestic market. Smaller countries (northern Europe) or countries which are traditionally more open (United Kingdom) tend to understand this imperative more so than in France. Exporting to the European Economic Area often makes it necessary to adapt products and services and to tailor sales methods to different cultural contexts. While several French start-ups have nevertheless had brilliant successes in the United States, they are few and far between. The public authorities have introduced a raft of export aids: consultancy, commercial prospecting credit, promotion, prospecting insurance, guarantees of contributions to a foreign subsidiary, international development contracts, export loans (PPE), international development loans (PPDI), etc. Little seems to be known about many of these aids whose amounts and impact would appear to be limited. Lastly, a whole range of players are involved with and administer these aids: Ubifrance, consular chambers, regional development agencies, competitiveness clusters and so on.

Innovative business creation: Conclusions

We are therefore confronted with a fairly large number of companies that are both durable and, in many cases, slow-growing. The situation does not appear to be very different in a number of other European countries. The slow growth of companies that are direct spin-offs from university research seems to be a common phenomenon in all of these countries.

Why is it that France has such a large population of these innovative start-ups that survive well but experience limited growth? The first factor is that many of these companies are in niche markets. This is especially true of biotech firms that are started up to develop and exploit a specific invention designed to meet a specific need and whose outlets are not likely to grow beyond a certain threshold (exceptions include Internet-related innovations for which the market may grow rapidly and reach a very large scale). These firms have no reason to expand unless they depart from their original purpose, which some may do but on the basis of a different rationale, more economic than technological. Likewise, researchers who create companies are often primarily researchers rather than entrepreneurs, and they do not necessarily wish to see their business expand beyond their own field of expertise, because that would imply the primacy of economic considerations over scientific considerations, which would distance them from their core sphere of competence. It is symptomatic that companies that symbolise entrepreneurial success on a global scale, in particular Dell, Facebook, Google or Microsoft, were established by students (familiar with the technology concerned) whose rationale was economic and not by researchers who would have been tempted to stick to a technological rationale.

As for the second factor, we have seen (see the chapter on business innovation) that the French system of regulation and taxation has been deterring small companies from growing (see Garicano et al., 2013). The threshold of 50 employees seems to have a particular deterrent effect in this respect. A small enterprise that grows loses the benefits associated with small size without gaining the benefits accruing to large companies; it is thus eligible for fewer tax concessions, has less access to public procurement procedures, and so on. As a result, companies with the potential to grow are deterred from doing so. This, in turn, will affect the longevity of new companies. The fact is that slower growth for the best ventures also means less competitive pressure on the others, which will thus be less likely to fold or to be taken over by a more dynamic company; they will simply remain in the market. Durability and slow growth, then, are connected.

The third factor, with which we shall deal in greater detail below, is that the whole rationale of the public system of support for entrepreneurship is more sharply focused on survival than selection. It is designed to ensure the survival of the greatest number without encouraging the emergence of leaders.

Venture capital and business angels

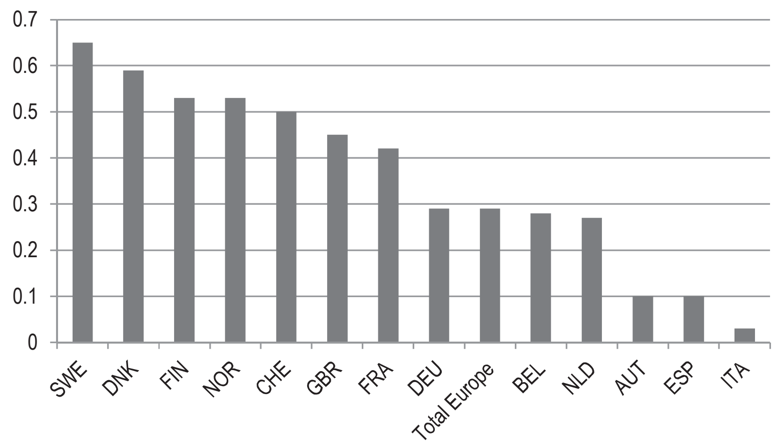
Venture capital is a type of investment specifically for innovative start-ups; venture capital funds are usually closed, managed by professionals and financed by private sources (pension funds, insurance companies, banks, large companies, individuals, etc.) or public sources (governments, public financial institutions). The scale of venture capital in a country can be measured in two ways: from the "industry statistics", i.e. the investment made by a given country's venture capital funds whatever the geographical location of the companies receiving the investment or from the "market statistics", i.e. the investment in innovative companies in a given country whatever the location of the venture capital concern which is investing.

French venture capital investment: how much?

From the point of view of the location of raised funds, investment by European venture capital companies represented 0.029% of gross domestic product (GDP) in Europe in 2010. France is well above this average, at 0.042% of its GDP. It is just behind the United Kingdom (0.045%) but in front of Germany (0.029%). The figures for the northern European countries (Sweden, Denmark, and Finland) are higher (with investment of more than 0.05% of GDP).

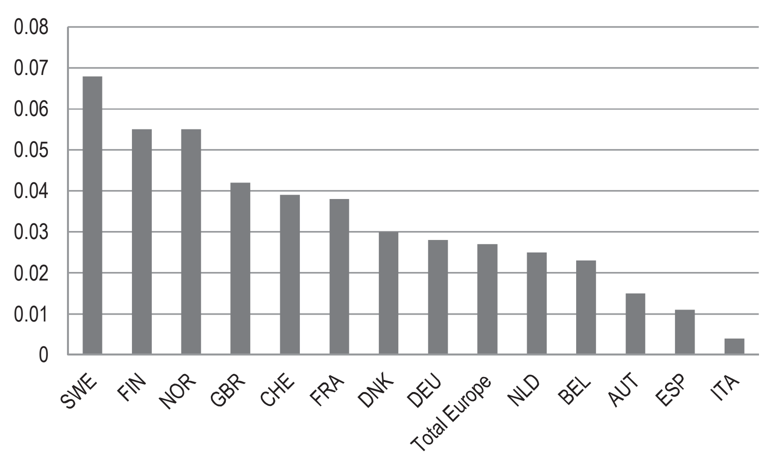
Looking then at the recipients of this investment, i.e. the location of the companies receiving this capital whatever the geographical location of the venture capital company (market statistics), France is not in such a high place.

Figure 7.4. Venture capital as a % of GDP (criterion: location of funds, "industry statistics") in 2010



Source: European Private Equity and Venture Capital Association (EVCA).

Figure 7.5. Venture capital as a % of GDP (criterion: location of investment, "market statistics") in 2010



Source: EVCA.

In 2010, venture capital investment in European firms represented 0.027% of European GDP. France is well above this average, at 0.038%**,** behind the United Kingdom (0.042%) and in front of Germany (0.028%). Venture capital investment accounts for the highest percentage of GDP in the northern European countries.

The difference between "market statistics" and "industry statistics" can be interpreted as representing the attractiveness of a country in relation to its financing capacity: a country which "exports" venture capital has fewer business ventures than it is able to finance, and the barrier to the development of innovative entrepreneurship can then be seen as the shortage of eligible ventures (compared with those in other countries) and not a shortage in the capital available. Investment by French venture capital companies represented 0.042% of GDP, while the investment by (French and foreign) venture capital companies received by French companies was only 0.038% of GDP. That means that France attracts little venture capital from abroad and/or that French venture capital companies invest a substantial share of their funds abroad and that share is not matched by investment by foreign venture capital companies to finance French companies.

In terms of amounts, rather than as a percentage of GDP, French venture capital companies invested EUR 847 million in 2010 (industry statistics), and French companies received EUR 751 million from venture capital companies (market statistics).

While the fact that French venture capital companies are investing in promising companies throughout the world may well be a positive development, it may be wondered whether, overall, funds (whether French or foreign) find more interesting ventures to finance abroad than in France. This is especially striking when comparing the United Kingdom and Germany, which both show a balance between their capital and their domestic ventures, investment in domestic ventures being equal in those countries to domestic funds invested whatever the location of the investment.

International comparisons

Table 7.1. Venture capital investment – 2010 (market statistics)

	Amount	Number of companies
France	751 452	396
Germany	728 996	966
United Kingdom	771 044	364
Total Europe	3 661 375	3 039

Source: EVCA.

In 2010, and by amount, British companies received slightly more venture capital financing than German and French companies: EUR 771 million compared with EUR 729 million and EUR 751 million respectively (Table 7.1).

In terms, however, of the total number of firms financed by venture capital, there were twice as many companies in Germany than in France and the United Kingdom (966 compared with 396 and 364). The average finance received by recipients of venture capital is slightly lower in France than among British companies (EUR 1.9 million compared with EUR 2.1 million) but much higher than among German companies (EUR 0.7 million).

Figures from the National Venture Capital Association (NVCA)[2] show that venture capital investment in the United States was USD 23.4 billion in 2010 for 3 646 deals or ventures compared with EUR 3.7 billion and 3 039 ventures in Europe. That means that the average European venture (EUR 1.2 million), the average French venture (EUR 1.9 million), the average German venture (EUR 0.75 million) and the average British venture (EUR 2.1 million) receive much less finance than the average US venture (USD 6.4 million).

Investment by stage of enterprise development

The EVCA divides venture capital investment into three segments: seed, start-up and later-stage ventures.[3] These segments correspond to three successive stages in the development of innovative companies.

Table 7.2. Breakdown of European venture capital investment (market statistics) by segments – amounts and numbers of companies financed, 2010

Stage	**Amount** (EUR millions)	Number of companies
Seed	128 113	393
Start-up	1 849 136	1 711
Later-stage venture	1 684 126	990
Total	3 661 375	3 039

Source: EVCA.

The start-up and later-stage venture stages account in Europe for almost all (96.5%) venture capital activity, with the seed stage receiving only 3.5% of investment.

Table 7.3. Investment (market statistics) by country and by stage, 2010

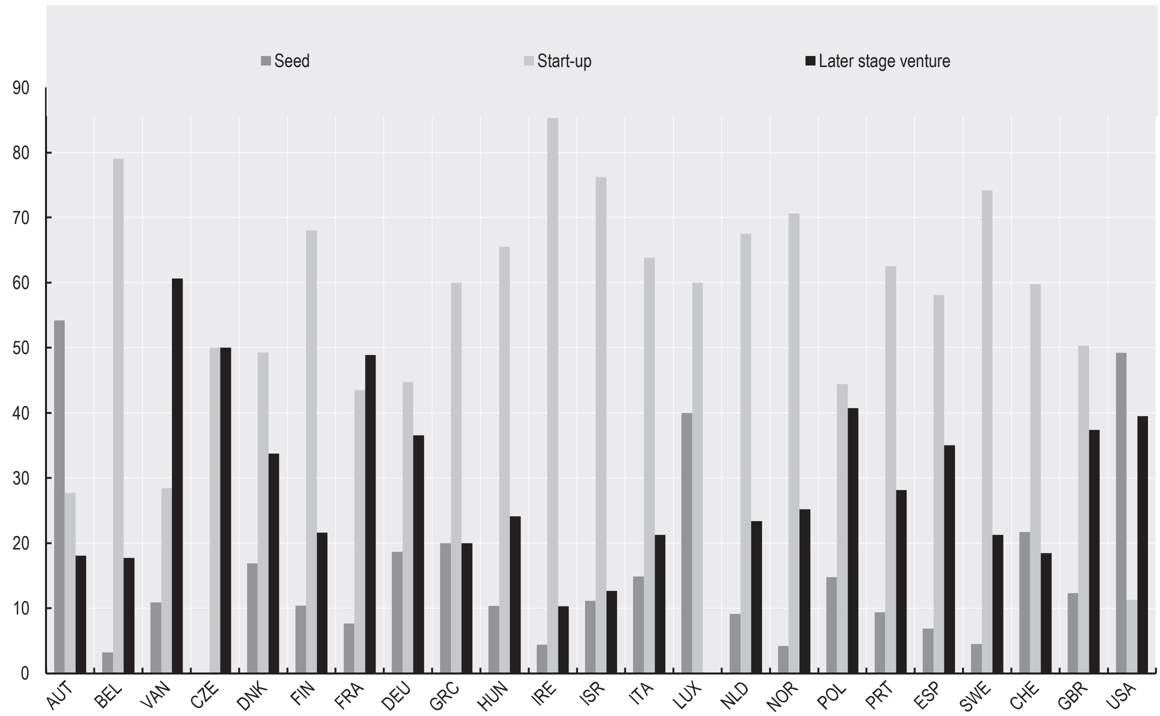
Stage	France		Germany		United Kingdom	
	Amount (EUR thousands)	**Number of companies**	**Amount** (EUR thousands)	**Number of companies**	**Amount** (EUR thousands)	**Number of companies**
Seed	16 098	23	48 208	204	9 464	17
Start-up	298 098	177	387 266	432	311 939	202
Later-stage venture	437 256	207	293 427	347	449 641	147
Total venture	751 452	396	728 996	966	771 044	364

Source: EVCA.

This is borne out by the low-level financing channelled into the seed stage. In Europe, 3.5% of venture capital finance is invested at the seed stage. This percentage increases to 6.6% in Germany and drops to as little as 2.1% in France and 1.2% in the United Kingdom.

The small number of ventures financed at the seed stage is one of the main features of the situation in France. A wider-ranging international comparison (OECD, 2013) confirms that venture capital investment is chiefly at the start-up stage, followed by the later-stage venture stage. Very few companies at the seed, i.e. creation, stage manage to attract venture capital. That is particularly true of France, especially when compared with Israel, Germany, Finland, Sweden, the United States and even the United Kingdom. In these countries, the percentage of venture capital investment at the seed stage is three to five times higher than the percentage in France (Figure 7.6).

Figure 7.6. Enterprises financed by venture capital by stage of development



Source: OECD (2013), *Entrepreneurship at a Glance 2013,* OECD Publishing, doi: 10.1787/entrepreneur_aag-2013-en

It would therefore seem that venture capital in France is distributed more selectively at the seed stage in France than in other countries and tends to be channelled into a limited number of ventures.

Fundraising for French venture capital

Venture capital companies are financed – they raise funds – from public or private investors looking for a profitable return on their investment. The amount of funds raised by venture capital companies in a given country is a good indicator of the attractiveness of the venture capital industry in that country and the quality of its innovative companies (or even of strategic choices by the public authorities, if the latter are major investors). The focus below is on fundraising countries ("industry statistics").

Total budgets raised by European fund managers

The budgets raised by the European private equity and venture capital sectors have declined sharply since the mid-2000s. In 2008, European PE overall raised nearly EUR 80 billion; in 2010, the figure was less than EUR 22 billion. In 2008 and 2010, venture capital raised EUR 8.3 and 6.3 billion, but raised only EUR 3.2 billion in 2010 (Table 7.4).

Table 7.4. Amount of venture capital raised each year in Europe

EUR billions

	2008	2010
Private equity	80.5	21.8
Venture capital	6.3	3.2

Source: EVCA.

Table 7.5. Amount of venture capital raised in 2010

EUR thousands

	2010
France	916 490
United Kingdom	556 210
Germany	563 960
Total Europe	3 200 000

Source: EVCA.

Table 7.6. Amount of funds raised in 2010 (EUR thousands and %) by type of investor

Venture capital	Europe		France	
Type of investor	Amounts (EUR thousands)	%	Amounts (EUR thousands)	%
Academic institutions	8 700	0.3	0	0.0
Banks	111 720	3.5	15 620	1.7
Capital markets	27 030	0.8	0	0.0
Corporate investors	431 530	13.4	207 570	22.6
Foundations	120 430	3.8	83 360	9.1
Family offices	182 090	5.7	69 950	7.6
Fund of funds	111 800	3.5	7 080	0.8
Government agencies	982 840	30.6	**284 430**	**31.0**
Insurance companies	48 750	1.5	120	0.0
Other fund managers	152 740	4.8	50	0.0
Pension funds	300 310	9.4	0	0.0
Private individuals	537 350	16.7	219 010	23.9
Sovereign wealth funds	29 410	0.9	0	0.0
Other	164 890	5.1	29 300	3.2
New funds raised	3 209 590	100.0	916 490	100.0

Source: EVCA.

In 2010, the funds of three countries – France, the United Kingdom and Germany – collected nearly two-thirds of the EUR 3.2 billion of funds raised by European venture capital players (Table 7.5). Among them, France was in top place in Europe as regards the amount of funds raised.

In 2010, French funds in practice dominated the landscape: on their own, they raised nearly a third of the funds raised in Europe (i.e. over EUR 0.9 billion), i.e. considerably more than in the United Kingdom or Germany (EUR 556 and 564 million respectively).

What types of investors finance these funds and to what extent?

These EUR 3.2 billion were raised by 134 funds in 2010, i.e. an average of EUR 24 million per fund. In Europe, all other things remaining the same, there are a large number of small funds.

Various types of investors finance venture capital funds (Table 7.6). In Europe, the main investors are currently government agencies.

In 2010, government agencies[4] were the leading investors in venture capital funds in Europe. They accounted for 30.6% of the EUR 3.2 billion of funds raised by European venture capital. Their share has continued to grow, from 7.9% of funds raised in 2007, to 10.6% in 2008, 24.6% in 2009 and 30.6% in 2010. This increase has taken place against a backdrop of economic recession, where less private equity was invested in venture capital, whereas some governments (including France) had included such expenditures in their macroeconomic recovery plans.

European venture capital is largely supported by the public authorities. Among the European countries, France has one of the highest shares of government agency participation, representing 31% in 2010.

In 2010, private individuals were the second-largest investors in venture capital in both Europe (16.7%) and France (23.9%). These private individuals include a first generation of successful entrepreneurs who have set up funds for investing in new ventures. They are followed by corporate investors (13.4% in Europe and 22.6% in France). Lastly, the traditional "limited partners" of venture capital – pension funds and insurance companies – are no longer active in Europe.

Is the major share held by French government agencies in venture capital funds unusual in the Europe context? How does France's situation compare with the United Kingdom or Germany?

Table 7.7. Amounts of venture capital raised and share of government agencies, 2010

	Venture capital funds	2010	
		Montant (EUR thousands)	%
France	New funds raised	916 490	
	Government agencies	284 430	31.0
United Kingdom	New funds raised	556 210	
	Government agencies	196 330	35.3
Germany	New funds raised	563 960	
	Government agencies	62 000	11.0

Source: EVCA.

In 2010, French venture capital teams raised a total of EUR 916 million: 31% of that amount, i.e. over EUR 284 million, came from government agencies. This situation is not limited to France; it is also true of the United Kingdom, where the public authorities also play a central role (35.3% of funds raised) in the share of equity capital represented by venture capital.

Business angels and seed capital

The vast majority of venture capital operations take place well after the seed stage of the innovative business, either to speed up commercial and industrial activity (start-up) or to finance the activity's growth (later-stage). In the initial stages of development of their ventures (seed and pre-seed), the bulk of entrepreneurs' funding comes from their network of family and friends, their bank and some public support schemes which offer seed funds. These are followed by business angels (i.e. individuals investing their money and advising the creator), as well as other public aids, and at a later stage by venture capital and public support schemes. Business angels and venture capitalists provide both seed capital and expertise.

As mentioned above, French venture capital companies provide very little seed capital. Hence, business angels have a key role to play in terms of both the direct financing they provide and the "smart capital" (expertise, management advice) they can offer during the seed stage.

One of the strengths of the US entrepreneurial system is its financing chain, with tens of thousands of business angels who invest tens or hundreds of thousands of dollars in thousands of new companies. As a result of these business angels, venture capital funds can choose from a large pool of ventures and finance, with larger budgets, several thousand ventures – 3 646 in 2010 (NVCA, 2013) – they believe offer the best growth potential.

Compared with the United States or even the United Kingdom, France has very few business angels capable of investing directly in ventures at a very early stage.

France Angels, the French association of business angel networks, has some 4 100 angels (spread throughout more than 80 association networks). In 2012, these 4 100 business angels invested nearly EUR 40 million in 352 companies (a third of this amount was used to refinance ventures that had already been financed), i.e. an average investment of EUR 114 000 for each company financed, generally spread out among several business angels. Alongside these "formal" business angels, many others exist: France Angels considers that the number of business angels would need to be doubled to give a true picture of the number of angels currently active in France, i.e. nearly 8 000.[5]

A recent report for the European Commission estimated that 5 000 to 10 000 business angels were active in 2009-10 in Germany, 8 000 in France and over 25 000 in the United Kingdom.

According to estimates by Center for Venture Research of the University of New Hampshire, the United States numbered 265 400 active individual investors in 2010. That same year, those business angels invested a total of USD 20.1 billion in 61 900 new companies (Sohl, 2011). In 2010, US venture capitalists invested USD 23 billion in 3 646 deals. The amounts invested by business angels in the United States represented nearly nine-tenths of venture capital budgets, i.e. considerable sums. They invested in 17 times more companies (61 900) than venture capitalists (3 646). These 61 900 new companies represented a real breeding ground for venture capital to select from.

Not only does France number fewer business angels than the United States or the United Kingdom, their average investment is – all other things being equal – not as high: USD 400 000 for a US business angel, compared with EUR 114 000 for a French business angel.

The bulk of investments by business angels take place at the start-up stage or in the company's initial development stage. They help fill the gap between the financing provided by the entrepreneurial team and its personal networks and potential financing by a venture capital fund. The former provide tens of thousands – less often hundreds of thousands – of euros, and the latter rarely make investments of less than EUR 1 million or EUR 2 million. Business angels generally fill this gap, sometimes thanks to public support schemes. In many countries, some of these business angels have formed more or less formal networks. There are 82 such networks in France and 100s in the United States. Within these networks, business angels join forces to make larger investments; they may also share due diligence work and share the risks.

Finally, France is characterised not only by its small number of business angels, but also by the fact that they channel small amounts into the ventures they support. The relatively low financial acumen of business angels means that they are not in a position to support the early stages of assorted projects that venture capitalists can choose from in order to invest substantially higher amounts.

The players who participate in financing new innovative companies provide different kinds of financing at different stages of the company's development. Establishing the right connections is important. Specialist venture capital funds cannot replace these business angels, since they provide very little early-stage financing. Moreover, as shown above, these venture capital companies invest in a large number of ventures much smaller amounts than their US counterparts. Lastly, venture capital companies and business angels first need a "deal flow" of quality companies that are ready for investment; at a later stage, they also need "exit" markets for their investment. France, and more broadly Europe, does not have the same market for these companies as the United States, a market that provides investors with an appropriate "exit": indeed, the most promising or most successful companies are floated on the stock exchange (or acquired by another company).

In the mid-1990s, several reports called for the creation of a specific stock market for innovative high-growth companies, along the lines of the NASDAQ in the United States. This market was intended to foster the development of venture capital, which is being hampered in Europe by the fact that holdings in new innovative companies cannot be liquidated. It was also supposed to help the most promising companies raise the funds needed for their development. These new markets proliferated throughout Europe; over a dozen were established, including the Alternative Investment Market (AIM) in the United Kingdom in 1995, the *Nouveau Marché* in France in 1996 and the *Neuer Markt* in Germany in 1997. At the initiative of the European Commission and the EVCA, the EADASQ was established in 1996 at the European level. Apart from the British AIM, however, these other markets – whose lack of selectiveness, liquidity and transparency were particularly criticised – ultimately failed and were shut down. The creation of a specific market for high-growth companies is a regular topic of discussion: the recent *Assises de l'Entrepreneuriat* entrepreuneurship congress (April 2013) proposed "establishing a stock market for SMEs-ISEs", taking up a proposal made by Gérard Rameix and Thierry Giami in their 2011 report on the financing of SMEs-ISEs by the financial market. The report commented that "the total capitalisation of the 574 SMEs-ISEs quoted represents less than the capitalisation of France's leader in market value".

Investment outcomes

Ultimately, France has a venture capital industry composed of small teams investing small amounts in a large number of companies. How well are they doing?

Venture capital is an industry which is characterised by very disparate performance levels worldwide: some funds under-perform, while the majority fail to reimburse their limited partners.

In France, the overall performance of these teams is negative. A recent study by AFIC and Ernst & Young (4 July 2013)[6] looks at the net performance of French private equity firms. It shows that the net performance of venture capital over 10 years is 0.05% – the internal rate of return (IRR) being calculated for the period 2003-12 – compared with 4.88% for growth capital and 17.6% for buyout capital. While the IRR on the investments made by venture capital has been negative on average in France for ten years, some funds have performed well and some FCPIs with a negative IRR have posted a positive return after taxation.

These results – and this is another feature of French funds – mean that they are no longer attracting investment from their traditional limited partners (funds of funds, insurance companies, banks, pension funds, etc.), some of which have also been hit by the prudential rules (Solvency II in the case of insurance companies). Where does their money come from? Who invests in venture capital funds? As mentioned above, the French State and public authorities account for a substantial share of the funds raised by French players, as do large companies (corporate venture capital) and private individuals who are over-represented compared with other European countries. For the last few years, it is essentially the State and private individuals, via the FCPIs (products subject to specific tax rules), that have carried the sector.

In contrast to other European countries or the United States, France does not have immense pension funds making long-term investments in listed and unlisted securities. In France, household savings are placed in life insurance funds, which also finance companies. The European Solvency II Directive covering insurance companies is having an effect in France that it does not have in other countries: it imposes reserve and equity requirements that mechanically force insurance companies to cut down on their investments. As a result, insurers are providing less financing for business – and in particular for venture capital funds. Solvency II does not pose this problem in countries with pension funds.

Conclusion

Investments by French venture capital companies are well above the European average (0.042% of GDP in 2010) and on a par with investments by their British counterparts. However, l the venture capital investment actually received by French firms only represents 0.038% of GDP (far behind the United Kingdom). This difference is explained by the fact that new French companies are not successful at attracting foreign venture capital investment and that French venture capital companies themselves invest a significant proportion of their funds abroad.

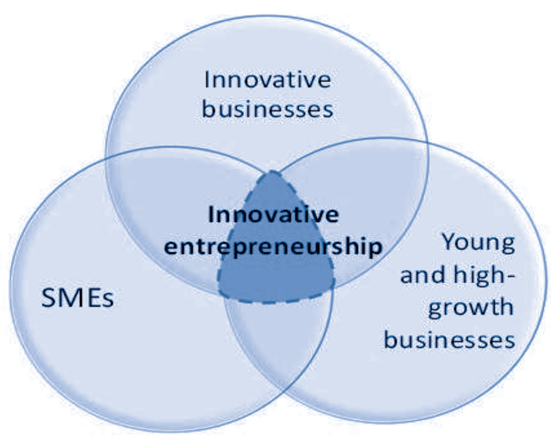
Looking at investments made at the different stages of company development, France is notable for the relative importance of its later-stage venture financing (during the second round, expansion) compared with the seed and start-up stages. In other words, those that receive capital are overwhelmingly mature companies that have already received financial backing; those receiving capital for the first time are a minority. France is also notable for the weakness – compared with other countries – of its seed financing. This is problematic, as there are few business angels who take on seed financing, as they do in the United Kingdom. It is too early to judge what effect the National Seed Fund (FNA) established under the Investments for the Future Programme (PIA) will have, but it would appear from initial interviews that more companies are starting to be financed at the seed stage.

Another weakness of the French financing system for new companies is the small number of business angels and their still low investment levels.

Policies supporting innovative entrepreneurship

Innovative entrepreneurship can play a key role in economic growth, job creation and poverty alleviation, and may help overcome key social challenges. Innovative entrepreneurship is synonymous neither with SMEs nor with business creation, but can be viewed as the intersection of three different areas: *i)* innovative companies; *ii)* young and high-growth companies; *iii)* SMEs.

Figure 7.7. Innovative entrepreneurship



Source: OECD, Innovation Policy Platform, www.innovationpolicyplatform.org/

The following policy dimensions (some of which are examined in other chapters of this report) are particularly important in promoting a dynamic and innovative ecosystem: access to knowledge, entrepreneurial capacity and culture, access to markets and administrative framework, access to finance and access to skilled workers.

Access to knowledge is essential for innovative entrepreneurship, since it is a major source of innovation-based entrepreneurial opportunities. "Access to knowledge" refers to the links with private, public and academic sources of knowledge that nourish innovative entrepreneurial activity. Technological co-operation between companies, the inter-face between universities and industry, investment in R&D, intellectual property systems and access to information and communication technologies (ICTs) all have a part to play.

Entrepreneurial capacity and culture are closely linked to social and cultural traditions ("entrepreneurial spirit"), competences and experience in running companies, and business support infrastructure. Entrepreneurial capacity is key to the success of new companies, as it makes it possible to identify opportunities, manage new companies, put innovations into practice, learn, and adapt to changing circumstances.

"Market access" refers to regulations for product markets, competition and public procurement rules. These factors have even more impact on growth than on new business creation, as it is the stage where companies need customers not just to raise income, but also to finalise their products and establish their reputation.

Establishing and growing a company requires access to financing. This may take the form of debt, venture capital, private equity capital (business angels) and, in the case of more mature companies, market financing.

"Access to skilled labour" refers to the conditions surrounding the employment of highly skilled human resources by entrepreneurs. It includes policies that have an impact on the cost of recruitment/dismissal, the availability of skilled labour and immigration rules (e.g. rules governing visas for highly skilled foreigners). Compared with more conventional companies, these companies generally have a greater need for versatile and adaptable skills: they appreciate a multinational workforce and require much more flexible hiring conditions.

Support for ventures and companies

France's innovation policy strongly emphasised entrepreneurship in the late 1990s: entrepreneurship, particularly the creation of spin-offs from public research, was regarded as a prime means of generating knowledge-based growth, as exemplified by US models such as the Massachusetts Institute of Technology and Stanford University. Until then, France's innovation policy had centred on defence and large-scale civil programmes in areas such as space and telecommunications, chiefly benefitting large corporations. The new approach gradually placed entrepreneurship at the heart of intervention by the State, which put into play its (fiscal or economic) instruments and methodology. The 1999 Innovation Act, the focus of the CIR and OSEO aid on JETIs and the creation of the JEI status helped construct an innovation policy focusing on the creation and growth of young technology companies.

A turning point in the late 1990s in public support for large and small enterprises

The policy developed in the late 1990s marked a turning point: the demise of the two main methods of State intervention in research and technology, i.e. the large-scale civil technology programmes – which, with the exception of the space programme, disappeared or were scaled down – and public spending on defence R&D – which was regularly and progressively cut. One consequence was that the State stopped financing R&D in large industrial companies (for a detailed analysis, see Mustar and Laredo, 2002). Public action was geared towards supporting new small companies (Le Plan, 2005). Creating new innovative companies, chiefly from public research, became an objective of public action and in turn mobilised other instruments to encourage entrepreneurs and their ventures (aid for innovation and CIR), as well as develop and focus venture capital on new innovative companies (creation of public funds and funds of funds).

In the mid-2000s, large companies with over 2 000 employees continued to be "favoured" by what was left of the large-scale programmes: they accounted for 55% of industrial research expenditure and received 72% of direct public grants – excluding the CIR, but including military programmes and local authority expenditure (DGRI-MESR, 2008). Companies with fewer than 250 employees received more than in the past, accounting for 20% of total business R&D expenditure and received nearly 13% of public support for industrial R&D). The companies receiving the least support were those with 250 to 1 000 employees, representing 18% of R&D expenditure but receiving only 7% of public financing (MESR, 2008).

A review of the CIR (rather than direct public grants, detailed above) shows that it favours small companies even more. In 2005, for instance, companies with fewer than 250 employees, accounting for 19% of R&D expenditure, received 46% of the total CIR. Companies with over 2 000 employees, accounting for 48% of R&D expenditure, received only 14% (MESR, 2008).

Technology SMEs started to occupy much more of a place in public financing as a result of the combined effect of this scaling down of the major civil and military programmes – which largely benefitted large companies – and the rise of the CIR, which favoured small companies. In other words, public support was allocated disproportionately to smaller and larger companies, while ISEs received less support proportionally to their economic weight (Mustar and Wright, 2010).

The 1999 Innovation Act and its impact

The 1999 Innovation and Research Act ("Loi Allègre", after the minister in office at the time) was designed to promote the creation of technologically innovative business spin-offs from public research by making it easier for researchers to move into industry-related fields and creating commercialisation structures in the public research system.

The US ability to transform the results of research into new high technology and high-growth companies is cited as a model that France should imitate by fostering links between public research and business, making venture capital available and introducing policies to stimulate business creation and develop spin-offs from public research. These three points have been central to many policy measures since the late 1990s and are at the core of the PIA.

The Innovation and Research Act of 12 July 1999 was intended to promote the creation of companies from research. It amended the status of researchers and teaching researchers as public servants, allowing them to participate in creating a private company based on their research work. It established incubators in universities and research bodies. It launched a national competition for technologically innovative business creation, as well as a dozen seed funds geared to financing the early stages of ventures stemming from public research.

In 2006, the General Inspectorate of Finance (IGF) and the General Inspectorate of the Administration of National Education and Research (IGAENR) undertook a critical assessment of this law, underlining that the commercialisation of research had not progressed, that companies created as a result of public research were not growing and that the mechanisms for incubators and seed funds "had become too complex and largely unsuitable for the pursuit of the primary objectives of rapid technology transfer from laboratories to the market and private sector involvement" (IGF and IGAENR, 2006).

The annual data collected by the MESR also allow a quantitative appraisal of the 1999 Act ten years after its introduction (SETTAR 2008 review, published in September 2009[7]).

Between 1999 and 2008, the net balance is 2 060 companies created, over 45% of which – i.e. 950 – stemmed from public research projects or researchers – i.e. fewer than 100 companies per year. Studies conducted between the end of the 1980s and the end of the 1990s on business creation by researchers (Mustar, 1988 and 1994) indicated around 40 such companies. They showed that contrary to the belief of many observers, the 1999 Act neither boosted nor increased business creation from public research to an unprecedented level. Rather, *a longstanding trend had simply intensified.*

Did these companies create jobs? On the basis of studies of companies established by researchers during the 1990s, the answer to this question is no. Ministry data for the 10 years following the introduction of the Innovation Act give the same result: overall, the companies that benefitted from the above 4 measures – i.e. nearly 2 000 companies – created nearly 11 000 jobs in 10 years (SETTAR, 2008 and 2009). These were small companies: technology companies tend not to grow, and success stories are few and far between – especially if those companies were spin-offs from public research.

Studies undertaken prior to the 1999 Act did see one positive element, to wit, the high rate of survival of these companies: six years after their creation, over eight out of ten companies stemming from or associated with public research were still active (Mustar, 1995). MESR surveys show that between seven and four years after their creation, most companies taking part in the national competition or hosted by incubators had an average of four or five employees.

Overall, the 1999 Innovation Act had disappointing results.

The research tax credit (CIR) and its 2008 reform

The CIR has played an important role in the movement that placed JETIs at the core of public policy on innovation. Between 1994 and 2003, the average annual volume of the CIR was EUR 465 million. In 2004, this volume doubled to EUR 890 million, reaching EUR 1.4 billion in 2006. In 2005, for the first time, the total amount of the CIR exceeded direct support for industrial R&D (excluding defence). This was due to the combined effect of cuts to the budgets of large-scale programmes and the rise of the CIR. Proportionally, the CIR was at that time highly concentrated on small and very small companies. In 2006, companies with fewer than 50 employees, accounting for less than 10% of total industrial R&D expenditure, received nearly 32% of the CIR. Proportionally, the CIR fell sharply above the threshold of 50 employees (MESR, 2008).

From the end of the 1990s to 2008, the CIR favoured new small technology companies (which, by definition, were incurring growing R&D expenditure). Other measures, in particular OSEO aid schemes (see below), also focused on these JETIs (sometimes to the detriment of more "traditional" SMEs, which represented their core customer base).

All that changed at the end of the 2000s. The 2008 Finance Law radically reformed the CIR and made it the main instrument of public support for business R&D (see the chapter on business innovation). Between 2007 and 2011, the cost of the CIR to the State rose from EUR 1.7 billion to EUR 5.1 billion.

In 2010, companies with fewer than 250 employees accounted for 28.8% of the CIR, companies with 250 to 4 999 employees for 37.4% and companies with 5 000 or more employees for 32.1%. The scheme, which was enforced fully until 2004, then in a hybrid manner until 2007, was incremental in nature, granting a tax reduction proportional to the company's increase in R&D (compared with the average of the two preceding years). Such a system favoured growing companies, and many JEIs matched this description.

Between 2006 and 2010, the amount of the CIR granted to companies with fewer than 50 employees increased from EUR 477 million to EUR 823 million (OECD calculations), i.e. an increase of 73%. At the same time, however, the amount granted to companies with 5 000 or more employees rose from EUR 213 million to EUR 1.62 billion, i.e. an increase of 660%. The drastic increase in the overall generosity of the CIR made it possible to increase the amount received by small companies, even though their share of the total fell.

ANVAR-OSEO-Bpifrance financing

OSEO is the government agency responsible for implementing policy on innovation and growth for SMEs. It was established in 2005 following the merger of the French Innovation Agency (ANVAR), the Bank for Small and Medium-Sized Enterprise Development (BDPME) and the Sofaris fund. In 2013, Bpifrance was created from the merger of OSEO, CDC Entreprises (a branch of the Deposits and Consignments Fund [CDC]) and the Strategic Investment Fund (FSI).

During the 2000s, the ANVAR-OSEO target shifted away from innovative SMEs "as a whole" (including traditional yet innovative SMEs) and focused more on young and small technologically innovative companies, which became the core target of OSEO.

Since the mid-1980s, support by ANVAR has helped many SMEs engaged in R&D to expand gradually. ANVAR became the "French Innovation Agency". Every year, over 2 000 SMEs received a repayable innovation grant. ANVAR also financed the recruitment of doctoral candidates and skilled engineers by SMEs. During the 1990s, ANVAR shifted its focus to young SMEs (active less than three years); in mid-2005, it became known as OSEO Innovation, financing over 750 new innovative companies per year.

At the time, the OSEO annual report (OSEO, 2006) shows that nearly 60% of the grant amount (totalling EUR 257 million) went to companies that had been active for under 8 years (and 35% to companies active for under 3 years); it also shows that over 72% of the grant amount went to companies with fewer than 50 employees (and 43% to companies with fewer than 10 employees). That year, 2 high technology sectors alone accounted for nearly 51% of the aid paid out by OSEO Innovation: life sciences and ICTs. By 2008, that figure had increased to 55%.

"Young innovative enterprise" (JEI) status

The JEI status was introduced in 2004. Companies must satisfy five main conditions in order to be eligible for this status:

- They must be SMEs employing fewer than 250 people, with a turnover of less than EUR 50 million.
- They must have been in business for less than eight years.
- Their expenditure on research must represent at least 15% of their tax-deductible expenditure.

- They must be independent: at least 50% of their capital must be held by natural persons or indirectly by an SME in which natural persons have a 50% holding (excluding holdings by investment funds).
- They must be genuinely new: they cannot have been established as a result of a concentration, restructuring, extension of an existing activity or resumption of activity.

This status offers exemptions from social security contributions for all employees engaged in research and an exemption from corporation tax for the first 3 years of operation, with a 50% reduction over the next 2 years (up to a ceiling of EUR 200 000 over 3 years) and from property taxes for 8 years.

On 1 January 2012, the corporation tax exemption was changed to 100% in the first year only and 50% in the second year. Thereafter, the JEI is not eligible for this exemption (which therefore no longer covers 5 fiscal years with full exemption from corporation tax for the first 3 years and partial exemption of 50% for the following 2 years). The exemption from social security contributions was also amended.

Between 2004 and 2011, 5 200 companies benefitted from this scheme (OSEO, 2013). After a few hiccups during the first few years following its introduction, 600 companies now join this scheme every year, 60% to 80% of which are under two years old, In recent years, between 360 and 560 companies have exited the scheme; almost half of them are more than 8 years old, which is the eligibility ceiling for the JEI scheme. In 2011, 2 800 companies had this status. Incoming companies accounted for nearly 21% (i.e. 578) of JEIs and outgoing companies for nearly 20% (i.e. 561).

The business services sector (information technology, scientific and technical activities) accounts for 86% and the industrial sector (electrical, electronic and pharmaceutical industries) for 10% of JEIs. JEIs are small structures with an average of 6.6 employees (and a median of 4 employees). They have limited own funds. Only 41% of JEIs turn a profit from their activities (the average deficit per business is EUR 130 000).

Compared with companies that are similar by size and sector, the JEIs catch up with their counterparts after a few years in terms of value added and turnover (even though both of these indicators were considerably lower at the outset for JEIs). However, they generally continue to post a deficit, whereas their counterparts turn small deficits into small profits (OSEO, 2012).

This measure bolsters support for very small technology companies with fewer than 20 employees (which are the main beneficiaries of this status). Both the creation of this status and an analysis of its impact strengthen the argument that innovation policy focused during the 2000s on young and technologically innovative companies.

Legislation on bankruptcy

Establishing an innovative company is highly risky, and most innovative companies end in bankruptcy. This is natural for an exploratory activity where the only way of finding out whether an idea actually works is to put it in practice and therefore put in play the resources and energy required to do so. The law on bankruptcy decides on the allocation of losses among the different types of creditors when a company files for bankruptcy. The law also governs the legal consequences for the company officers. A legal system favouring entrepreneurship would ensure that a failure does not deter entrepreneurs from starting up again. In practice, failure is a learning experience, and countries in which there is active entrepreneurship also have a population of "serial entrepreneurs" who rack up as many failures as successes.

In France, entrepreneurs subject to a court liquidation order are identified by the indicator 040 in the database of senior executives held by the Banque de France. This indicator is an obstacle for anyone wishing to establish another company after an initial failure, particularly by limiting their access to credit. According to the *Assises de l'Entrepreneuriat* in March 2013, it takes nine years to recover from a bankruptcy, whereas in some northern European countries such as Denmark or Norway, it takes only a year. Nearly 150 000 directors are affected by this measure.

Entrepreneurial attitude training

A country's entrepreneurial activity depends on many factors, particularly formal rules (laws, intellectual property rights, etc.) and informal rules (traditions, codes of conduct, attitude to risk, etc.). The Global Entrepreneurship Monitor is an international study conducted in parallel in 69 countries focusing on these questions and in particular on the population's attitudes, aspirations and intentions with regard to entrepreneurship, as well as their business creation practices. The study on France (Nziali and Fayolle, 2013) provides information on entrepreneurial potential, entrepreneurial activity and the framework conditions for entrepreneurship.

The study shows that a great many French people are keen and intend to establish a company and are increasingly aware of business creation opportunities. French entrepreneurial potential is increasing, but the problem in France is turning this potential into reality. Two factors seem to explain this: socio-cultural norms –especially the French relationship with failure and the small social return from entrepreneurial activity – and the fact that French people's belief that they lack the skills required for entrepreneurship. The study also stresses that entrepreneurial activity is largely concentrated in the service sector, does not feature very innovative content and is carried by entrepreneurs with limited ambitions for growth. Women's entrepreneurship is on the increase. Experts consider that the teaching of entrepreneurship prior to the baccalaureate level and the dissemination of business creation skills are the most significant obstacles to entrepreneurial activity in France.

Over the past 20 years or so, many French engineering and management colleges have devised training programmes which – more than in the past – include entrepreneurship and innovation in their curricula. The public authorities have also supported programmes to raise awareness and provide training in entrepreneurship to young people, and a number of universities now offer structured business creation and entrepreneurship departments.

In 2001, an Observatory of Teaching Practices in Entrepreneurship was established by the Ministry of Research, the Ministry of Industry, the Business Creation Agency and the Entrepreneurship Academy (an academic association working in the field of entrepreneurship).

By 2004, six *Maisons de l'Entrepreunariat* ("houses of entrepeneurship") had been set up in six universities and higher education institutions. They offer courses, entrepreneurship clubs for students, resource centres, business plan competitions, business forums and guides for student entrepreneurs, develop partnerships with local economic players and involve them in the ventures.

Box 7.1. Entrepreneurship training in Sweden and Australia

Sweden has done a great deal to promote entrepreneurship by trying to improve social perceptions of entrepreneurial activity. In 2009, the Ministry of Education and Research and the Ministry of Enterprise, Energy and Communications published its "Strategy for Entrepreneurship in Education". This document shows that the Government considers that teaching of entrepreneurship in the education system is essential.

The Australian Junior Achievement Company Programme (JACP) is a national entrepreneurship training initiative at the secondary level designed to improve practical understanding of how to establish and manage a company. Elert et al. (2012) analysed the effects of participation in the JACP, by comparing companies established by JACP graduates with a similar sample of companies in the same industry established by people of the same age, gender and education. The study shows that the likelihood of creating a company, and that the company will survive and create jobs, is higher among graduates of the JACP programme. These effects are particularly marked among women.

Government agencies in Sweden, such as the Nyföretagar Centrum, coach young entrepreneurs and support entrepreneurship though seminars, exhibitions and conferences. An annual exhibition, *Eget Företa*g, brings together young entrepreneurs, start-ups, web development service providers, coaching companies, representatives of government bodies, etc. a chance to meet one another. Start-up competitions, such as the Venture Cup, are also held. Universities have also introduced new entrepreneurship programmes. The Stockholm School of Entrepreneurship s, for example, is managed by five Stockholm universities. It provides training in entrepreneurship, workshops, conferences and networking events for Swedish and international students.

Australian universities have also launched a number of initiatives to develop entrepreneurship skills (for instance, the University of Adelaide launched the master's degree in applied innovation and entrepreneurship in 2013 and the University of Sydney began to offer a graduate certificate in innovation and enterprise in 2012). Under the new university system introduced on 1 January 2012, universities have much more freedom to develop new certificates or to develop existing certificates in response to industry and student demand for degrees incorporating entrepreneurial skills.

In 2009, a plan to develop entrepreneurship in higher education institutions was launched. Its goal was to raise students' awareness of business culture in order to promote innovation and bolster their integration into the world of work. The aim is to include entrepreneurship in the curricula of future higher education graduates – no matter what subject they are studying – and to promote the awareness, training and mentoring that enhance it. About 20 student entrepreneurship hubs were selected after a call for projects by the Ministry of Industry and the MESR, with financial support from the CDC. Their mission is to offer innovative mentoring to students and young graduates interested in entrepreneurship. An "entrepreneurship mentor" is appointed in every higher education establishment and is responsible for informing students about the grants available to support their ventures.

According to a report published at the end of 2011, all of France's *grandes écoles* (elite universities) were engaged in innovation and entrepreneurship (Bécard, 2011). Despite all the talk, however, "a structured entrepreneurship option is to be found in only a few *grandes écoles* for business and engineering… With a few exceptions, entrepreneurship is still not being taught in universities…" (Hayat, 2012). Since 94% of innovative business creators have studied in higher education institutions, teaching entrepreneurship in those institutions is crucial (OSEO, 2012). Only 30% of French entrepreneurs say that they benefitted from a programme to promote entrepreneurship during their higher education, compared with 62% in the United States, 70% in Brazil, 64% in Canada and 50% in Germany (Ernst & Young Barometer, October 2011; Hayat, 2012).

Innovation policies of local authorities and in particular cities

Innovation is not just a priority for national governments; it is also a priority for regions and states, as well as many large cities. New York, London, Berlin and Paris have introduced policies to support innovative business creation and development. In France, the City of Paris has, in recent years, launched a raft of schemes "to foster and promote innovation in all fields in Paris" (see Box 7.2).

Box 7.2. Measures taken by the City of Paris to promote innovative entrepreneurship

- A property policy provides business creators with high-quality premises at competitive prices. In 2002, 5 000 square metres (m^2) of business incubators and business centres were available for start-ups. Ten years later, 78 000 m^2 were available and a further 25 000 m^2 were being developed. Thus, 17 incubators are managed by Paris Incubateurs. They are mostly thematic, focusing on digital technologies, video games, digital publishing, cleantechs, design, e-health, tomorrow's city and the Welcome City Lab (dedicated to tourism). Some have been established in partnership with corporations, such as "Connected Services for Mobility" with Renault, "Virtual Urban Services" with JCDecaux, "Connected Traveller" with the SNCF, and "Mobile Technologies" with Alcatel One Touch. As well as premises, start-up creators can rely on logistical services, help with developing their market and fundraising, and contacts with the Parisian innovation ecosystem.
- The financial support policy resulted in the creation in 2009 of the Paris Seed Innovation Fund (which has financed over 400 ventures), in partnership with OSEO.
- A policy of establishing closer links between entrepreneurs and research is reflected in the creation of scientific and technological facilities within research and higher education institutes (Vision Institute, Brain and Spine Institute, ESPCI (Higher College for Industrial Physics and Chemistry) and the Langevin "Waves and Images" Institute.
- The Innovation *Grands Prix* of the City of Paris are a major showcase for the approximately 40 start-up finalists and eight winners (over 400 start-ups apply every year).
- Paris Région Lab has established an Open Innovation Club, which meets every two months to discuss a particular topic and gives 20 or so start-ups an opportunity to present their products and services to 30 or so large groups.
- The City of Paris itself has been transformed into a laboratory for experimentation: start-ups can try out their solutions or their innovative products – on a real scale – throughout the Île-de-France region. Experiments are taking place in the areas of intelligent street furniture, energy-efficient buildings, home services for the elderly, innovative revegetation, etc.

Sources: City of Paris and Paris Région Lab documents and websites.

Public support for the supply of capital

Significant direct and indirect action to make venture capital and private equity more available to new companies has been an important strand of public action on innovation, starting with the CDC and its subsidiary CDC Entreprises and then the FSI, both of which have now come under the umbrella of Bpifrance.

Indirect action involves the partial financing of funds administered by private management companies, which are often independent and combine public and private funds. A large majority of French venture capital companies have received funds from CDC Entreprises, which has thus become one of the main players in venture capital in France. This is also the mechanism used by the PIA, in particular for the FNA.

Since the late 1990s, the CDC has established various funds of funds in order to develop a venture capital industry in France. Following are a few examples:

- The Public Venture Capital Fund, financed by the State and the European Investment Fund (EIF) and managed by the CDC, was launched in 1998, with EUR 150 million marshalled "to increase the supply of venture capital to young innovative companies". A total of 21 funds have been financed, which have in turn invested EUR 700 million in 400 companies (most of which were less than 3 years old).
- The Venture Capital Promotion Fund, sponsored by the State, the EIF and the CDC, was launched in 2000, with a budget of EUR 150 million. Ten funds have been financed and have in turn invested EUR 351 million in companies (most of which were less than three years old).
- The Technology Fund of Funds, sponsored by the State, the EIF and the CDC, was created in 2005, again with a budget of EUR 150 million earmarked for venture capital funds investing in technology companies with strong growth potential.
- France Investissement was born in 2006, with a budget of EUR 2 billion over six years (i.e. over EUR 300 million per year) to bolster the equity of innovative SMEs. France Investissement invests in funds of funds and venture capital funds, but also co-invests directly in innovative companies.

This direct intervention in companies grew following the creation of the FSI in 2008. The FSI uses "its own funds to take minority holdings" in order to support the development of promising SMEs ("industrial business ventures creating value and competitiveness for the economy"[8]) that do not have access to financing. The FSI has own funds of EUR 20 billion and its main missions are to contribute to the equity of companies whose growth ambitions are likely to make France more competitive, promote eco-investment, mentor companies in the medium and long term and examine shareholder stability and reorganisation when deciding on an exit strategy.

Building on the action of CDC Entreprises, the France Investissement initiative was largely intended to establish funds of funds in partnership with institutional investors and thus to combine public and private investment in venture capital funds. The fact that insurance companies and banks have stopped investing in this type of fund of funds (5.1% contributed by insurance companies and 12.3 by banks to the funds raised in 2012, according to the EVCA) has turned the FSI and the CDC into the main players in the sector – players who find it difficult to locate private co-investors.

The FNA is part of the PIA. A fund of funds endowed with EUR 600 million, it invests in seed funds investing in young innovative companies at the seed and start-up stages (in the fields of health, food, biotechnology, ICTs, nanotechnology and ecotechnology). By June 2013, it had invested in 13 funds. It is administered by Bpifrance, which is responsible for selecting the funds and associated management teams.

Although past CDC intervention in funds of funds alongside private institutional investors, or in funds managed by private venture capital associations, has generally been welcomed by private equity players, many argue that direct interventions – which grew following the creation of France Investissement and became more widespread with the FSI – are sometimes in competition with venture capital funds and are not always transparent. The role of equity investors is not simply to provide funds, but also to play an active part in the business venture (see e.g. Lerner, 2009). This is a very pertinent question since in 2010 (and in the following years), venture capital funds located in France raised EUR 100 million more than they invested in France (net flows based on gross flows which are undoubtedly higher).

The question also arises of whether public intervention tends to evict private financing in some market segments, which is then being invested in other products or countries. The negative return on venture capital invested in France is a further reason for looking into this question. The public authorities need to examine the problem in more detail. Public financing at the seed stage, through the FNA, might well help strike a new balance and activate this market segment, which clearly seems to lack capital. A comparison with support mechanisms implemented in other countries with the same objective might also be useful (Box 7.3).

Box 7.3. Public financing policies for innovative enterprises in OECD countries

The Australian Government is helping innovative entrepreneurs gain access to financing by encouraging Australian business angels, venture capital funds and foreign investors to invest in innovative companies. It is doing so through tax breaks, such as those provided by the Venture Capital Limited Partnerships (VCLP) and the Early Stage Venture Capital Limited Partnerships (ESVCLP) programmes, as well as venture capital co-investment initiatives, such as the Renewable Energy Venture Capital Fund and the Innovation Investment Fund. The VCLP and ESVCLP offer tax breaks on capital gains: eligible investors in the funds are exempted from capital gains on their share of the funds' profits. The particular aim of the VCLP is to increase foreign investment in the Australian venture capital sector. Fund managers are eligible to register a VCLP if they seek to raise new venture capital funds of at least AUD 10 million (Australian dollars) (USD 6.5 million) for investments in Australian companies with assets of up to AUD 250 million (USD 164 million). The ESVCLP programme targets venture capital funds, business angel groups or syndicates and foreign investors investing in companies at the seed stage. The minimum capital commitment of AUD 10 million (USD 6.5 million) for an ESVCLP has been cut to AUD 5 million (USD 3.3 million) in order to make the programme more accessible to business angels. An example of venture capital co-investment is the Innovation Investment Fund. Private sector investors co-invest with the Government in this seed stage fund. Public capital must be matched by private capital at a minimum ratio of 1:1. In addition, states and territories, as well as universities and other research bodies funded by the national government, are also contributing to venture capital. This support may take the form of university commercialisation offices or specific state/provincial funds (e.g. the Biotech Fund in Queensland and ANU Connect Ventures in the Australian Capital Territory), as well as venture capital-based support for the development of technology start-ups (e.g. Uniseed, Uniquest and the Trans Tasman commercialisation fund).

Canada is also trying to improve access to venture capital financing. The Venture Capital Action Plan, published in 2013, will make available CAD 250 million (Canadian dollars) (USD 205 million) to establish a new fund of funds managed by the private sector with interested strategic investors and the provinces concerned. It will invest up to CAD 100 million (USD 82 million) to recapitalise large funds of funds in partnership with the provinces. It will also invest a total of CAD 50 million (USD 41 million) in 3 to 5 high-performing venture capital funds in Canada. Furthermore, the Canadian Business Development Bank, which is fully owned by the Canadian Government, also co-finances ventures alongside Canadian venture capital companies and is investing in venture capital funds of funds. Various Canadian provinces also support venture capital by financing funds (for instance AVAC in Alberta), public-private co-investment funds (Ontario's Emerging Technologies Fund) and funds of funds (e.g. the British Columbia Renaissance Capital Fund in British Columbia and Teralys in Quebec). In addition, Canada is supporting environmental innovation through Sustainable Development Technology Canada, a non-profit foundation that finances and supports the development and demonstration of clean technologies.

…/…

Box 7.3. Public financing policies for innovative enterprises in OECD countries *(continued)*

In Finland, supporting young innovative companies is one of the priorities of the Government's programme for 2011-15 and the Finnish public agency for innovation support TEKES has stepped up its financing for this type of business. FINNVERA is a State body offering financing for business creation, growth and internationalisation. FINNVERA offers loans, domestic guarantees and other services to promote exports. The VIGO accelerator programme was established in 2009 to help start-ups obtain higher investments from public/private venture capital. VIGO has helped finance companies in clean technologies, ICTs, mobile phones, the web and life sciences.

In the Netherlands, the SME + Innovation Fund was established to promote new innovative business creation. It has three main pillars: *i)* the "innovation credit" pillar provides venture capital to innovative SMEs established in the Netherlands, with a minimum investment of EUR 150 000; *ii)* the "seed capital" pillar supports creative entrepreneurs who receive assistance from professional investors, thus improving their chances of attracting investment; and *iii)* the "Dutch Venture Initiative (DVI)" pillar is an investment fund (fund of funds) earmarked for high-growth innovative companies. This fund is administered by the EIF with the regional venture capital company for the eastern regions of the Netherlands.

In Switzerland, the CTI Start-up programme was established in 1996 with a view to increasing the number of start-ups in the country. The programme supports entrepreneurs by offering mentoring and coaching, networking opportunities and a quality label for start-ups. Companies can also call on the extensive network of CTI Start-up experts, other entrepreneurs' experiences, business angels and venture capitalists. CTI Entrepreneurship supports partnerships between companies and higher education institutions. It offers training that helps entrepreneurs develop their business models, business plans and fundraising. CTI Invest offers start-ups a platform for presenting their ideas to a wide public of investors, business angels and national and international venture capital companies. It runs regular networking and matchmaking activities. Venturelab is a training programme developed by Swiss higher education institutions and the CTI in order to promote innovative entrepreneurship among students.

The British Government has set up a number of initiatives to promote entrepreneurship: capital increase for the Enterprise Capital Funds, support for business angel investors through the Regional Growth Funds, reform of tax breaks for investors, ongoing support for the United Kingdom Innovation Investment Fund (investment in life sciences, ICTs, clean technology companies, etc.). It also promotes investment in start-ups by the Seed Enterprise Investment Scheme. The United Kingdom Intellectual Property Office also offers training courses for business trainers and sales advisers.

In Germany, a number of programmes have been set up to support innovation and entrepreneurship. The Federal Research and Innovation Funding Advisory Service is the national contact point for companies looking for support for their research and innovation. The service provides information for potential candidates on the federal research structure, the various funding programmes and the bodies to be contacted depending on needs. It is co-ordinated by several federal ministries: the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Economic Affairs and Technology, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Transport, Construction and Urban Affairs and the Federal Foreign Office. Other initiatives target access to capital for young companies and SMEs. The budget allocated by the various ministries for financing SMEs in technology sectors has increased since 2005. The law modernising the general terms and conditions for capital investment provides for tax breaks for companies investing in technology start-ups and SMEs. The High-Tech Gründerfonds, established initially in 2005 by the Federal Ministry of Economic Affairs and Technology in conjunction with six corporate partners and the KfW banking group, offers seed capital to companies which are not mature enough for venture capital investment. In 2012, the High-Tech Gründerfonds II was launched in partnership with 12 private corporate investors and again the KfW banking group. Other programmes targeting young technology companies are ERP-Startfonds, established in 2005 and offering public co-financing as well as expertise for young companies, and KMU-Innovativ, established in 2007 by the BMBF to promote collaborative research by SMEs and research institutions. KMU-Innovativ's main features include its rapid procedures (two months) and simplified solvency test. Other initiatives seek to promote a culture of innovation in companies: the Innovation Day for SMEs (*Innovationstag Mittelstand*) takes place every year and offers companies and research institutions throughout Germany a platform for exchanging good practice and an opportunity to link up with new networks and obtain information on programmes promoting entrepreneurship.

Sources: Innovation Policy Platform and STI Outlook Policy Database, www.innovationpolicyplatform.org.

Tax schemes for investors

Faced with what it considers as a potential shortage in capital for the risky and not very liquid investments represented by shares in JEIs or venture capital funds, the State has introduced specific tax measures that make these investments more attractive than others, after tax. On the fiscal side, preferential tax treatment has been accorded to investors in small innovative companies, especially since 1999. This can take several forms, the main ones being the FCPIs)and the local investment funds (FIPs).[9] From 1997 to 2008, a total of EUR 5 billion was collected under this scheme by 33 management companies, and over half of the amount was invested in more than 900 innovative companies.

FCPIs are mutual funds created in 1997 which entitle investors to an income tax reduction if at least 60% of the fund's assets are shares in innovative companies in the European Union with fewer than 2 000 employees. These companies must meet one of the following two criteria: they must invest significantly in R&D (10% to 15% of the value of their tax-deductible expenses) or have been certified as an innovative business by OSEO. The tax benefits for individuals consist in a tax reduction of 18% (lowered from 25% in 2012) of the amount invested in an FCPI (up to a ceiling of EUR 24 000 for a couple) and full exemption from capital gains tax if they kept their stake in the FCPI for more than 5 years.

The remaining 40% of the FCPI assets are generally assigned to companies that invest more conventionally in secured collective investment schemes. The performance of FCPIs generally depends on how these 40% are invested combined with the tax reduction, rather than on the performance of the innovative companies, only a few of which will achieve success. Furthermore, funds dissolved after five years are rare, most FCPI lasting between 8 and 10 years; it takes five years for any tax-free capital gains to accrue, although such gains remain subject to 15.5% social security contributions. This somewhat justifies the tax measure, but at the expense of creating a product which is as much a vehicle for tax relief as for investing in JEIs.

French venture capital cannot be understood without reference to the role of these FCPIs (and, to a lesser extent, the role of FIPs, taken together with FCPIs in the following paragraphs), which have doubled their contribution to venture capital financing in France in the space of ten years. In 2000, EUR 256 million were invested in FCPIs. By 2005, the figure had reached EUR 327 million, topping EUR 520 million in 2009. In 2000, FCPIs provided 23% of all investment in venture capital; the figure rose to 50% in 2005 and nearly 60% in 2009 (Chausson Finance, 2010). In other words, FCPI investment in venture capital more than doubled in ten years, both in absolute terms and as a percentage of total investment. FCPIs invested in 183 companies in 2000, 295 in 2005 and 346 companies in 2009, representing an 89% increase in the number of recipient companies over the period.

FCPIs are also playing a crucial role in the initial funding of innovative companies; in 2009, they provided 63% of raised start-up capital. Put another way, not only do FCPIs play a major and crucial role in providing venture capital, they also play an irreplaceable part today in the initial funding of innovative companies (this first injection of venture capital is generally the harder to obtain for an innovative company). Chausson Finance (2010) estimates that between 2000 and 2009, 1 135 companies had access to start-up capital through the intervention of FCPIs (or FIPs).

From 1 January 2008, the TEPA Law promoting work, employment and purchasing power granted a tax concession to taxpayers subject to the wealth tax (ISF). Under the Law, they could deduct from their ISF 75% or 50% of their direct or indirect investment in an SME with fewer than 250 employees. This supplementary tax concession applies to FCPIs and FIPs provided that they undertake to respect a minimum ratio of companies that fall under the terms of the TEPA Law (including a high percentage of companies less than five years old).Direct investment in the capital of an SME, or indirect investment via an ISF holding underwriting the capital of an SME, results in a 75% reduction of the ISF, up to a ceiling of EUR 50 000. Subscribing to an FCPI or FIP lowers the ISF by 50%, up to a ceiling of EUR 20 000 per year and per taxable household.

In 2008, 73 200 taxpayers invested EUR 1.1 billion directly or indirectly in the capital of SMEs under the TEPA Law. In 2009, this figure increased to EUR 1.5 billion. In October 2010, reduction on the ISF for a direct or indirect holding dropped from 75% to 50% and the reduction ceiling to EUR 45 000.

Taxpayers may combine both benefits (FCPI and/or FIP) and TEPA/ISF, provided they take out separate subscriptions and make separate payments.

Two types of product are concerned:

- Investment mutual funds (FIPs , FCPIs and fiscal venture capital funds [FCPRs], which are not examined here as they are less important: they entitle subscribers to a 25% income tax reduction and 50% ISF reduction.
- Own-fund investment holdings for SMEs: they entitle subscribers to the same tax reductions as direct investments, i.e. 75% of the amounts invested in the case of the ISF.

The report by the General Inspectorate of Finance ([IGF] 2009) in the wake of criticisms of the high management fees and commissions taken by managers and brokers for these products stresses that they entail significant losses of tax revenue: "These two types of vehicles made it possible to raise over EUR 1.2 billion in 2008, largely through funds (fiscal FCPRs, FIPs and FCPIs made it possible to raise EUR 1.1 billion with 145 000 subscribers, compared with EUR 126 million with 6 300 subscribers in the case of holdings) in return for tax expenditure of EUR 500 million (income tax relief of EUR 242 million and ISF relief of EUR 258 million)" (see also the report by the French Court of Auditors on business creation support schemes, 2012).

Ultimately, the main vehicle for investing in venture capital in France is a mainstream fund, the FCPI, supported by individuals whose banks and insurers have supplied them with a tax-deductible savings product.

Finance professionals met during the course of this review have criticised this model for various reasons:

- Traditional investment funds with no fiscal impact see it as distorting competition.
- The fees charged by FCPI managers seem particularly high.
- The pace of investment imposed by law is too fast and does not allow adequately selecting projects.
- The scheme results in a significant loss of tax revenue (EUR 500 million for every EUR 1.1 billion collected in 2009, according to the IGF).

Conclusion: Assessment and recommendations

As far as can be ascertained from the available statistics, innovative entrepreneurship has developed in France at a level comparable with other countries. Business survival rates are high, but few new companies are growing. Success stories exist, but continue to be the exception. The fact that a growing number of French "serial entrepreneurs" are becoming high-profile business angels and that a growing number of French industrial groups have established "venture capital" branches points to an increasingly propitious climate for innovative entrepreneurship in France.

Increasing and stimulating innovative entrepreneurship has gradually become a core objective of French innovation policy. Public intervention is very high at all levels of the chain (training, administrative simplification, business creation, taxation, financing, etc.) and seems to be having a real impact on start-ups (e.g. through Bpifrance aid schemes and the CIR). While there is more government intervention than in other countries, France's performance does not seem to fully reflect this difference: this raises the question of its effectiveness.

What factors hamper the creation and especially the expansion of innovative companies in France? Inadequate capital is often cited – although, as has been shown, that appraisal needs to be qualified. A second factor is a set of framework conditions – especially threshold effects at play in social legislation, taxation, access to some public support schemes, etc. – that deter companies from growing beyond a certain size. A third factor is the organisation of public research, which does not offer many small and young companies sufficient access to the knowledge they need (see the chapter on transfers).

The section below offers a set of recommendations based on the preceding analysis.

1. Developing a culture of innovation and entrepreneurship

Efforts have been made in these areas, especially in management and engineering colleges. Better integration of entrepreneurship in training, especially throughout higher education, is underway and should be pursued.

Mentoring networks for entrepreneurs have also been developed, especially at the regional level. These local networks of business managers play a crucial mentoring and coaching role for new entrepreneurs or young entrepreneurs. The mentored ventures are less likely to fail than those that are not. These mentoring networks should be encouraged and their daily field work promoted. Agencies such as Bpifrance could play a role here.

2. Building a favourable framework for innovative entrepreneurship

A great deal of administrative simplification has taken place to foster the creation of innovative companies, and this trend should be pursued.

The issue of social security and tax thresholds has yet to be dealt with, but seems to be a significant hindrance to the growth of innovative companies, and therefore to the emergence of a larger population of ISEs in France.

The local dimension and stakeholder networks are important: local authorities and cities have launched a range of measures to develop new innovative companies in their areas (see the case of the City of Paris). They offer them working premises and advice. Mixed public-private initiatives – e.g. digital districts, with their start-up incubation and acceleration facilities, and the mixed thematic incubators in Paris – are proliferating throughout France.

3. Taxation

Tax policy must provide incentives for business creation. Taxation and its successive changes have long deterred entrepreneurs, managers and investors. This report has not looked at all aspects of taxation, particularly the rules on capital gains from sales of securities, which have been lightened and simplified by the 2014 Finance Law. Two points are nevertheless worth mentioning:

- Taxation should not deter entrepreneurs, the managers whom they hire and all those (individuals or funds) who invest in these ventures. This is why the rules on capital gains from sales of securities have been lightened and simplified.
- Taxation should be coherent and stable: the Government is moving in this direction with its current consultations on ways of simplifying and making corporate taxation more cost-effective.

4. Adopting a broad definition of innovation

French policy to support the creation of innovative companies continues to be very focused on technological innovation. Although innovation in services has been considered more in recent years (see the chapter on business innovation), the public support system continues to rely on a narrow definition of technological innovation linked chiefly to R&D. The exemption from social security contributions for which JEIs are eligible is therefore limited to research jobs. It has just been extended to innovation-based jobs (such as prototyping or design). This approach should be systematised in public action.

Many start-ups in the digital field are based on new services or new business models rather, than on R&D results. Many of these companies produce significant value, economic activity and jobs. Their subsequent development often requires the use of technologies (particularly algorithms). The public authorities should adopt a broader definition of innovation – especially in the digital field – not as a specific sector, but as a key element of the value chain in many economic sectors.

5. Venture capital financing

Capital shortage is often mentioned and justifies injecting significant public funding into venture capital through funds of funds. Although this shortage is proven in some market segments at the early (seed) stage and sometimes later (third round) stages, it should be noted that France is overall a net exporter of venture capital. This implies that the current shortage is partly linked to a low (generally negative) rate of return, which results in private equity raised in France being invested in ventures located abroad. When injecting capital, the public authorities should consider the possibility of such an eviction effect.

The following points should be considered:

- There are few seed ventures: the FNA should increase their number.
- Many new companies are under-capitalised compared with their North American counterparts.
- Refinancing of companies already backed by venture capital accounts for a larger share than elsewhere.

- Venture capital funds that are large enough to support third rounds geared towards high growth, especially at the international level, are lacking.
- The lack of a specific stock market and of acquisitions by French groups (buyouts by foreigners) is doing little to resolve the exit problem.
- The greater role of the State than in other countries when it comes to fundraising should be examined in the light of the preceding comments, especially with regard to net exports of venture capital.

6. Promoting high-growth enterprises

The lack of selectiveness, as well as the duration, of many public aid schemes raises questions. Various data show that the failure rate among new technology companies or innovative companies is very low. Companies seem to be able to spend many years benefitting from public support schemes even though their ventures are barely progressing. This over-survival of under-performing companies is detrimental to the growth of other companies since they compete with them for public and private financing, as well as access to skilled labour and markets.

While the Government has in the past emphasised business creation, today's financial assistance schemes for innovative companies need to focus more heavily on companies that have proven growth potential after operating for a few years.

France has many assets in high-growth sectors: digital, big data, connected objects, etc. These assets are connected to its education and training system emphasising the mathematical and statistical skills crucial to these fields. Innovation support policy should also include this dimension

7. Internationalisation

Many new companies find it difficult to internationalise, gain access to export markets and establish subsidiaries abroad, all of which often curbs their expansion, and even sometimes their robustness. This often occurs because they engage in these activities too late in their development cycle, whereas these activities should as a rule be materialised from the onset. The public authorities, by mobilising agencies such as Ubifrance, could help these companies anticipate such needs.

Notes

1. Acquisition is defined very flexibly as "acquisition of majority or minority holdings": taking out a very small minority holding and buying out and merging a business (merger-acquisition) are actually very different events that have very little in common and have very different impacts on the business. It would therefore be useful to gain a better idea of the various types of acquisitions in play and the reasons for them (do JETIs sell some of their shares because they need cash or because of technology or market-related strategic agreements?).

2. www.nvca.org/index.php?option=com_content&view=article&id=344&Itemid=103.

3. Seed: financing provided to research, assess and develop an initial concept before a business has reached the start-up phase.

   Start-up: financing provided to companies for product development and initial marketing. Companies may be in the creation process or may have begun operations a short while ago, but they have yet not sold their product commercially.

   Later-stage venture: financing provided to expand an operating company, which may or may not be breaking even or trading profitably. Later-stage venture tends to finance companies that are already backed by venture capital and therefore in the third or fourth round of financing.

   Source: EVCA, Yearbook 2013, Glossary.

4. EVCA defines this term as including country, regional, governmental and European agencies or institutions specialising in innovation and development (e.g. the European Bank for Reconstruction and Development, including the EIF).

5. www.franceangels.org/fr/france-angels/les-chiffres.html.

6. Net performance of French private equity players in late 2012, AFIC-Ernst & Young study, 4 July 2013.

7. A further report adding data for 2009 was published in 2010 but no longer contains an overall review; this report was published by the MESR from 2003 to 2010 (hence, for the years 2002 to 2009); unfortunately, its publication was discontinued.

8. www.fonds-fsi.fr.

9. FIPs, introduced in 2003, operate similarly to FCPIs. The main difference between these two vehicles lies in the type of company in which they must invest 60% of their fund: innovative SMEs in the case of FCPIs, and well-established regional SMEs in the case of FIPs.

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Chapter 8

Governance of research and innovation policies in France

This chapter examines the governance of the French research and innovation system, which strongly influences the general effectiveness of the system and the effectiveness of political interventions. It presents the main institutions responsible for the system and the relationships between them. The ministries chiefly involved are the Ministry of Higher Education and Research and the Ministry of Economy. The General Commission for Investment, which is responsible for the "Investments for the Future" Programme, plays a pivotal role. "Vertical co-ordination" refers to relations between these entities and the research organisations and universities. Evaluation is becoming more and more important. Local and regional authorities are increasingly involved in supporting research and innovation, as are the European institutions, prompting the Government to redefine the scope of its own intervention.

The choice and implementation of a political orientation by the relevant stakeholders take place within the framework of a set of co-ordination methods, rules, etc. These are the instruments of general governance. The challenge for France in this context is two-fold: first, formulate a single strategy for research and innovation adapted to the general conditions analysed in the preceding chapters, then mobilise stakeholders to implement the strategy. The new strategy must be built on cross-cutting objectives related to France's competitiveness and social and environmental challenges. Accordingly, both its formulation and implementation require close co-ordination between operators based, therefore, on a common set of objectives. This chapter will show that the present French research and innovation system (SFRI) does not make it easy for such co-ordination to materialise. It will examine the main aspects of this issue: strategic decision making, interministerial co-ordination, vertical co-ordination with funding and implementing agencies, policy assessment, supranational and infranational tiers (Europe and regions).

What does governance of a scientific and technological system mean?

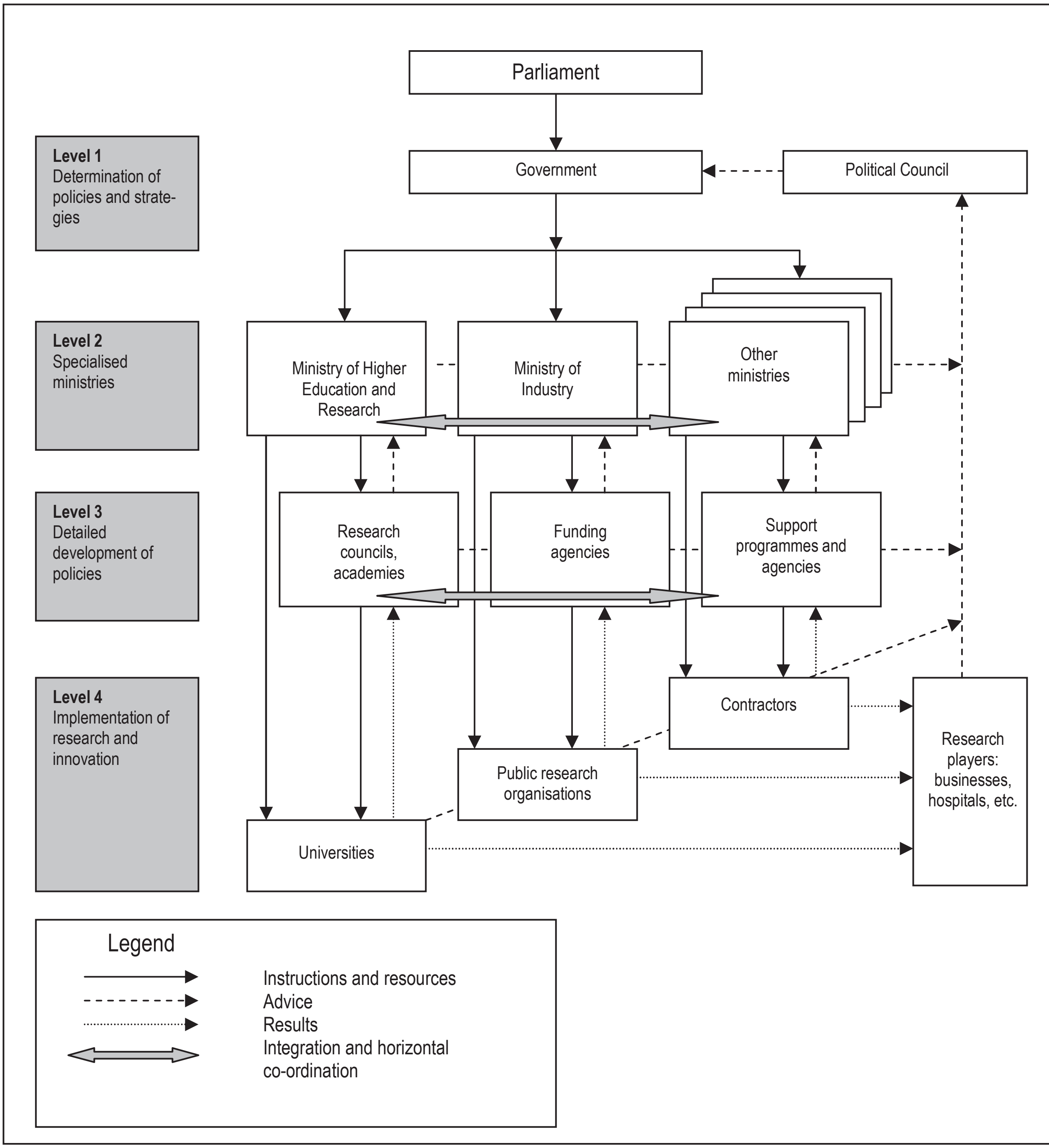
Governance refers to all the mechanisms involved in managing and co-ordinating research and innovation policies, and in particular co-ordinating stakeholder strategies and activities. The main aspects covered by this study cover: setting the main objectives of research and innovation policies; co-ordination between the various political players, particularly ministries and other bodies; supervision of the organisations involved; assessment; and local and regional government.

More specifically, the functions of governance of research and innovation are as follows:

- Establish strategic policy guidelines
- Arbitrate within the policy making structure, for example by reconciling the interests of the various ministries;
- Achieve horizontal co-ordination between the policies and interests of stakeholders in the various parts of the system and between the various government ministries or their agencies;
- Co-ordinate the production of knowledge, providing an appropriate mix of instrument types, of basic and applied research, between different subject areas, etc.;
- Generate and share the strategic intelligence required to design and implement policies and programmes;
- Ensure vertical direction between the "principals" (clients, such as government ministries) and the "agents" (those who implement measures, such as the funding and executive agencies);
- Raise the profile of research and innovation, including promoting understanding of science and an appreciation of the value of research and innovation.

Governance of a research and innovation system generally includes four levels (Figure 8.1):

Figure 8.1. Organisational model for the governance of research and innovation policies



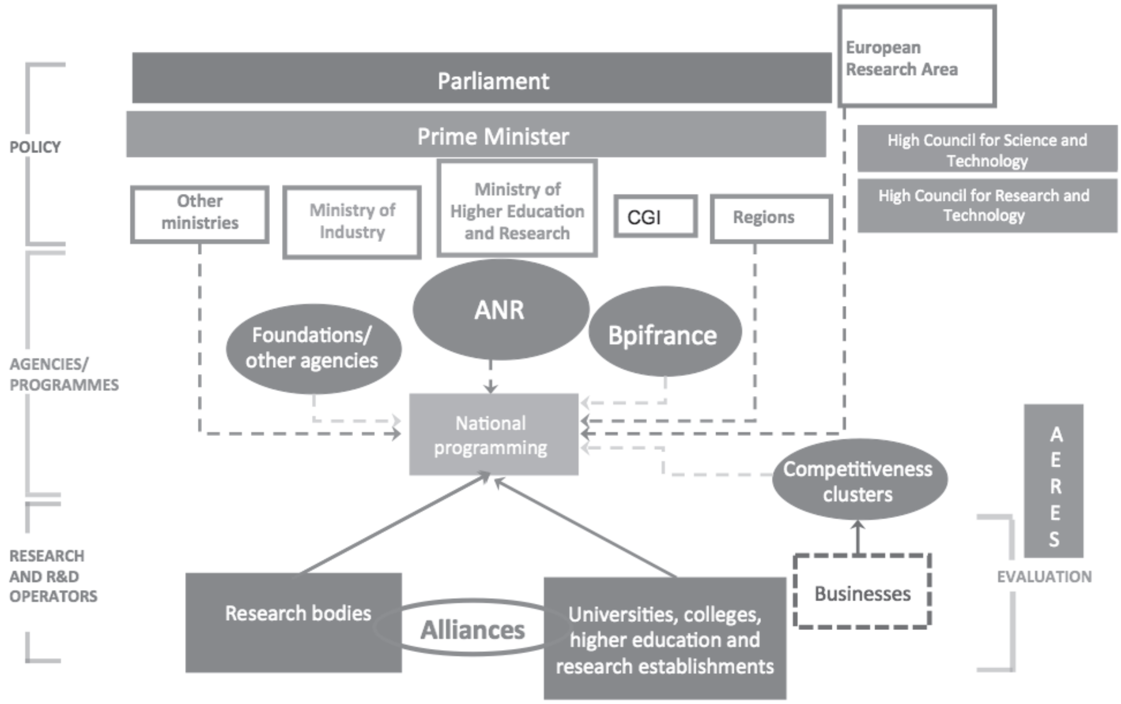
Source: Arnold et al. (2000), "Enhancing policy and institutional support for industrial technology development in Thailand. The overall policy framework and the development of the industrial innovation system", NSTDA, Bangkok.

- Level 1 is the highest level. It is where the general guidelines and priorities are defined for the entire national innovation system. It may entail providing advice to the government or more binding inputs, such as the decisions of an interministerial committee. It must include not only government input, but also input by groups of key contributors, including businesses, researchers, etc. The Finnish Research and Innovation Council, which operates at this level, has been emulated in a number of countries. That model, however, assumes a high level of political commitment to research and innovation. Such conditions do not exist in every system.
- Level 2 is co-ordination between government ministries, whose diverse portfolios incline them to pursue their own discrete policies. In practice, this co-ordination level may include both administrative and political elements. In some instances, an interministerial group also functions as a level 1 co-ordination mechanism. In a number of countries, however, co-ordination at this level is complicated by interministerial rivalries, especially over access to budgetary funds.
- Level 3 is more operational and aims to ensure consistency among the measures taken by the various funding bodies. This level may involve co-ordinating funding activities, e.g. through joint programming. Effective co-ordination requires strategic intelligence and a degree of autonomy at this level – operators without a margin for manoeuvre cannot truly co-ordinate their actions. In some countries – the United Kingdom and the Nordic countries – institutions known as Research Councils are responsible for programming and funding university research.
- Level 4 is where co-ordination takes place between the operators responsible for executing research and innovation (companies, public research organisations [PROs]). At this level, co-ordination tends to be achieved through autonomous organisation rather than formal mechanisms. This is often done through joint funding programmes and public-private partnerships.

Overall governance in France

No country entirely matches this template. France diverges from it by virtue of the fact that levels 1 and 2 on the one hand, and 3 and 4 on the other, are combined to a great extent. Indeed, ministries (level 2) play a key role in the defining the general strategy (level 1), and PROs are both funding agencies (level 3) and implementing agencies (level 4). Figure 8.2 depicts the overall governance of the SFRI in 2014. This system has not really changed since 2010, when the General Commission for Investment (CGI) was created (apart from the creation of Bpifrance as the successor to OSEO and the Strategic Investment Fund.

Figure 8.2. Governance of the SFRI in 2010



Source: Ministry of Higher Education and Research (MESR) adapted and amended by the OECD.

The general research priorities are normally set by the President of France and the prime minister, who avail themselves of various mechanisms for this purpose. Until 2013, they were able to base their decisions on the opinions delivered by the High Council for Science and Technology (HCST). HCST was created by the 2006 Law to succeed a similar body that had never really been effective. It is appointed by the MESR and reports directly to the prime minister. HCST, like the succession of similar committees that preceded it, had a limited impact. Its role was purely advisory, which is not conducive to inspiring active commitment on the part of its members, and the public authorities apparently made little use of its services. It could, for example, have played a key role in the preparation of the National Research and Innovation Strategy (SNRI) in 2008-09, but this was not the case.

The Law on Higher Education and Research of July 2013 heralded the establishment of a new system of strategic governance, comprising a "Strategic Research Council" ([CSR] consisting of leading scientists and parliamentarians and chaired by the prime minister), with a remit to propose strategic and scientific priorities for selection by the Government; an "Operations Committee" (consisting of the directors-general of the ministries involved in research, the heads of research alliances and major research organisations, and research directors from large enterprises), reporting to the CSR and responsible for preparing and implementing the CSR agenda; plus alliances (bringing together the operational stakeholders in the research structure, major research bodies and universities); and the National Centre for Scientific Research (CNRS), which will support the Council and Committee, particularly by informing the agenda. The CSR will propose a strategy to the Government and the President of the Republic, and the PROs will implement it. The purpose of this system is to formulate the strategy required by France. The Law, however, does not specify the new mechanisms that would be created in order to ensure that the PROs actually implement the strategy once it has been developed.

In the light of past experience, it seems that several conditions must be fulfilled if this system is to work properly: the CSR must be vested with its own powers of strategic investigation, so that it is not bound by the strategy devised by the various stakeholders, particularly the ministries and PROs, which have their own vision and their own agenda; the Council must be truly interministerial, meaning that ministries other than the MESR must have real influence on appointments to and the functioning of the Council (see below); lastly, the roles of the various bodies must be clearly delineated, so that there is no confusion between formulation and implementation.

Other bodies represent the scientific community in the political arena. The Academy of Science and the Academy of Technology comprise eminent elected scientists. The National Council of Universities and National Committee for Scientific Research comprise both members appointed by the political authorities and members elected by their respective communities; they seek to communicate their analyses of the higher education and research system and defend their interests.

On several occasions in the past, the Government has carried out wide-ranging consultations involving the scientific community and other operators (businesses, public or private users of science and technology, etc.). This occurred in 2009 with the SNRI, and then again in 2012 with the National Conference on Higher Education and Research. Such consultations create more favourable conditions for building a consensus among interested parties – including individuals, because discussion sites are accessible on the Internet. It should be stressed, however, that research and innovation serve to pursue objectives determined by the French nation and its government, which must have the last word, and that interested parties are involved only in an advisory capacity. It is also important to involve not only producers, but also users of research and innovation – i.e. companies, consumers and citizens.

Interministerial co-ordination

Research and innovation are activities that relate to all of the tasks of government, which means that they in the portfolio of most government ministries. Research centres are attached to the ministries of agriculture, the environment, transport, health, defence, etc. Two ministries, however, have a more important role to play in the realm of research and innovation, namely the MESR and the Ministry of Industry, which has a special interest in innovation. The roles of these ministries reflect the fact that research activity is attached to two sectors, namely universities (link between education and research) and companies (link between industry and research). One of the great difficulties for any government lies in co-ordinating these two sectors and ensuring that research serves both education and science on the one hand and innovation on the other, and that the two are closely linked. In the traditional French model described in the preceding chapters of this study, the various research activities were tightly cloistered between universities and *grandes écoles*, settings of education but not research; the CNRS, the exclusive bastion of basic research; and lastly the major projects, bringing together corporations and specialised research bodies (Alternative Energies and Atomic Energy Commission, French Space Agency [CNES], National Centre for Telecommunication Studies, etc). The separation between education and research on the one hand, and basic research and innovation (applied research) on the other hand, was deeply etched into the system. France was not the only country in such a situation.

In the meantime, however, conditions have changed. Innovation is no longer the preserve of large, closed corporations with links to the Government, but is now more open: it depends on entrepreneurship and requires flexible, close-woven links with the scientific community. Similarly, responses to social and environmental challenges must now be multidisciplinary, mobilising a variety of players and flexible public-private partnerships. In these circumstances, the divide between research and innovation that characterised the previous model is no longer tenable. Likewise, quality higher education is now closely bound to research; educators have a duty to impart the latest knowledge and to imbue students with the same sense of curiosity that drives research. The *grandes écoles* are now awarding numerous doctorates. Against this backdrop, the divide between education and research no longer holds. The French governance system has taken these new trends in stride and evolved as a consequence for several decades. However, this has been only a partial evolution.

Table 8.1. Mission for Research and Higher Education (MIRES) research & development (R&D) programmes, 2012

Programme	Title	Funding ministry
142	Higher education and agricultural research	Ministry of Agriculture, Food and Forestry
186	Cultural research and scientific culture	Ministry of Culture and Communication
190	Research in the fields of sustainable energy, development and planning	Ministry of Ecology, Sustainable Development and Energy
191	Dual-use research	Ministry of Defence
192	Research and higher education in economic and industrial fields	Ministry of Economy and Finance
150	Higher education courses and university research	MESR
172	Multidisciplinary scientific and technological research	MESR
187	Research in environmental and resource management	MESR
231	Student life	MESR
193	Space research	MESR

Source: MESR.

Interministerial efforts have been made in this regard. In 2001, the Organic Law on Financial Legislation created a common system for all budget lines involving higher education and research. The system, the MIRES, aims to co-ordinate the spending of the six ministries working in these fields. MIRES has proven effective, and ten programmes are under its aegis (Table 8.1). The advantage of this arrangement is that it allows integrated monitoring of the various government research programmes, whatever the lead ministry. However, co-ordination seems a weak point. In particular, there is no joint programming, each ministry remaining entirely in charge of its own budget and retaining exclusive control of its own programmes. Yet such joint programming would be useful, at least in areas of shared interest, such as the environment, which is within the remit of the ministries of research, the environment, agriculture and the ministry in charge of industry (if not more). There is, moreover, an instrument that could carry out this joint programming effectively, namely the National Research Agency (ANR), which has already played a similar role in the "Investments for the Future Programme" (PIA), demonstrating its capacity for selective allocation of significant research budgets devoted to predefined subject areas.

In a context in which public-private transfers are seen as having a key role to play in innovation, the ministry in charge of industry and the MESR share many subject areas. Close co-ordination might therefore be expected between these two ministries. It appears, however, that such co-ordination, insofar as it exists at all, is not optimal. Such is the case for the SNRI, which was published in 2009. The SNRI identified the main subjects and areas of research focus over the next four years. A strategic exercise of this type is extremely useful, particularly in aligning the agendas of the players involved in formulating the strategy. The SNRI was not set at an operational level and did not allocate budgets, but it did exert direct influence on the PIA, indicating the thematic areas into which funding could be channelled. Although it includes an innovation component, the SNRI had essentially been prepared by the MESR with a lesser degree of involvement on the part of the ministry in charge of industry.

The MESR is currently preparing a national research strategy (SNR) for the period 2015-20, which is designed to succeed the SNRI. The SNR is to set the thematic research priorities for the coming years (ten "structural challenges" have already been identified) and will guide the allocation of public resources. While the SNR is a necessary building block for France's strategic edifice, it seems astonishing that the "I" (for "innovation") of the SNRI has been dropped: it is difficult today to set thematic priorities for public research – including its social and commercial applications – without explicitly incorporating the innovation aspect. It should also be noted that the interministerial nature of the exercise is limited compared with its ambition, which was to cover all governmental activities with an impact on research and innovation.

The strategic agendas published by the MESR (France Europe 2020, which provides the political framework for the SNR) and by the ministry in charge of industry (the "34 industrial recovery plans") have largely identical aims – to ease the energy transition and restore French competitiveness through innovation – but do not seem to reflect a co-ordinated strategy. The research bodies under the supervision of the MESR could play a very useful role in pursuing the technological development objectives announced in the "34 plans", but there is no evidence that they have ever been consulted or enlisted.

In addition to the ministries responsible for the various tasks related to research and innovation, the CGI reports directly to the Office of the Prime Minister and is responsible for the PIA. The priorities of the PIA were set in the wake of the Juppé-Rocard report, hence outside of the established administrative processes. The ministries were then closely involved in the precise selection of investment targets. A significant share (about EUR 1 billion per year) of government research and innovation expenditure is made within the framework of the PIA framework. A number of PIA programmes interact very closely with programmes run by the two ministries (in charge of research and industry), while remaining separate: the excellence initiatives (Idex) projects relating to university research, the technological research institutes (IRT) and the transfer technology acceleration companies within competitiveness clusters. The CGI reported directly to the prime minister until April 2014 to ensure that its choices were consistent with those of the Government as a whole. Now that the CGI reports to the Ministry of Economy, Productive Recovery and Digital, aims to ensure operational co-operation with the major innovation programmes launched by this ministry, especially "New Industrial France". Nevertheless, care should be taken to strengthen the coherence of the PIA with the stakeholders and programmes linked to the MESR, especially the Idex, which must be co-ordinated with the new "university communities" mentioned in the July 2013 Law.

More generally, there seems to be insufficient co-ordination today of the Government's overall involvement in research and innovation; the establishment of the CSR and its operations committee should serve as an opportunity to establish the supplementary instruments that will foster interministerial co-ordination.

Vertical co-ordination

The major research organisations are linked to their respective supervising ministries by multi-annual target-based contracts, which lay down in some detail the policies they must pursue in the relevant period. Universities negotiate a similar contract with the MESR – their four-year plan (although these have now become five-year plans and raised to the level of the sites), which specify the projects to be implemented and progress to be made over the period in all of the university's areas of activity. The four-year plans are endowed with specific funding over and above the universities' core budgets. In both cases, these are potentially powerful management and incentive tools. Their full implementation, however, requires the ministries to have significant long-term strategic intelligence resources – particularly for supervising the major research organisations, which already possess such resources. The proclaimed intention of the MESR to include in the research organisations' goals the themes featured in the SNR is a step in the right direction. It is vital that these research themes be effectively implemented, in other words that the funding allocated to research organisations be explicitly tied to these themes.

From this point of view, the limited role of competitive mechanisms in public research funding does not make it easy for the political authorities to manage the research. In fact, the political level has not always been able to implement its strategic guidelines. This was the case, for example, with the decision taken in 1999 to emphasise life sciences in public research, which apparently never had any visible effect on the distribution of resources among – and within – research organisations over the next five years (French Court of Auditors, 2007). Government supervision of universities is stronger, because beyond the four-year plans and their increasing autonomy, the universities are subject to a system of national degree accreditations. Better command of the political supervision of operational research choices could be exercised in the new governance framework announced in the "France Europe 2020" strategy. This would entail effectively establishing strategic intelligence capabilities within the MESR, negotiating multi-annual contracts with research organisations as part of the same process in order to guarantee overall consistency of research choices and institutionalised governance of the ANR.

On a more basic level, the effective implementation of the national guidelines by the public research system would be facilitated by an institutional transformation of the system itself. Evolutions such as the full transfer of research unit management to universities (which would be entirely consistent with the current policy of devolved management), the restriction of the scope of the research organisations to activities on a national scale (e.g. the management of major infrastructures or networks) and the full transfer of financing to the ANR would allow forging a more direct link between the national strategy and the units responsible for its implementation.

Policy assessment

Policy assessment within the SFRI has made huge strides in recent years. Policies (e.g. the research tax credit [CIR] and competitiveness clusters) are more frequently subjected to audits, and sometimes to independent assessments. An independent assessment agency covering higher education and research, the Evaluation Agency for Research and Higher Education (AERES) was established in 2006, operating in accordance with the relevant international rules in this field. The novelty of this approach in France posed some problems: it required "on-the-job" learning and gradual methodological adjustments. Effective, independent assessment is necessary to enhance the general quality and relevance of research and higher education. The new High Council for the Evaluation of Research and Higher Education (HCERES), which replaces AERES under the July 2013 Law, should take on this responsibility with a remit extending to all public research. It is important that independent assessment cover all operators, including the research units within organisations and the organisations themselves.

The assessment of innovation policies – as opposed to assessment of the operators themselves – is currently conducted by the competent ministries, which may commission external experts (as the MESR did for the CIR and the Ministry of Industrial Recovery for the competitiveness clusters). This self-assessment is one of the keys to effective policy management. It would also be very useful to establish systematic and independent assessment procedures, which would give the Government and Parliament a more direct overview of public action programmes. Conducting such procedures with the ministries, moreover, would allow an integrated assessment of France's policy mix, which covers programmes under the responsibility of several government ministries.

The French Court of Auditors has developed expertise in this field and has published several reports covering most research and innovation policies (public research, CIR, entrepreneurship, etc.). The detailed analysis of accounts, which is the Court's primary area of expertise, sheds unique light on the evaluated policies. The current initiative for the creation of an assessment group for innovation policies within the General Commission for Strategy and Foresight (CGSP) would dovetail neatly with the Court's activity, since it would adopt a more economic approach. Its impact on policies could be all the greater by virtue of the fact that the CGSP reports directly to the Office of the Prime Minister.

Numerous statistical indicators for monitoring research and innovation policies exist, and efforts have clearly been made to improve their quality and dissemination. There are, however, a number of key policy areas which they do not cover adequately. Specific coordinated efforts could be made by the information departments of various bodies – the HCERES, the statistical services of the relevant ministries and the Observatory of Science and Technology (OST). The aim would be to gather and compile data on key subject areas that are currently not well covered, particularly public-private knowledge transfers, the scientific performance of research organisations, etc. Provided they are not subject to statutory statistical confidentiality, the data in question should be made available for wide and open use by the research community, which would guarantee relevance and methodological progress. The data should be used for more systematic monitoring and assessment in the fields concerned. This is also the gist of the present discussion about a renewal of the OST and its possible affiliation with the HCERES. In particular, it entrusts the OST with collecting, processing and widely disseminating all pertinent data relating to the SFRI.

Several institutions, most notably Bpifrance, have recently taken or announced "open data" initiatives consisting in making available to the public the detailed data they possess by dint of their activity. Some restrictions may occasionally apply, because certain data relating to individuals and businesses are confidential. The development of such initiatives fosters the emergence of a community of analysts who provide open and independent assessment of the activity of the relevant institutions, thereby assisting both the public authorities and the relevant agencies.

Regional and local authorities

Traditionally absent from the field of innovation, the regions have become increasingly involved for the past 20 years or so. R&D expenditure of regional and local authorities amounted to approximately EUR 1.2 billion in 2010, 69% of which was spent by the French regions, 16% by the departments and 15% by the municipalities (French Court of Auditors, 2013). Much of this expenditure relates to real estate. This involvement of the regions, driven by awareness of the importance of knowledge-intensive activities as a means of stimulating local economic life, has proven beneficial to the emergence or enhancement of regional clusters centred on innovation and the implication of a higher number of small and medium-sized enterprises (which are more accessible to the regions than to central government) in innovative activities.

The regions have frequently complemented government measures, particularly in the framework of State-region project contracts, competitiveness clusters, academic research and industrial and commercial activities departments, where regional resources top up government funding. The involvement of regional and local authorities, however, has sometimes increased the complexity of procedures (by adding at least one more intervening body subject to specific constraints, which translate into additional procedural requirements). There is also a risk that national policies will lose coherence if they are crossed with specifically local elements, since location may supersede excellence as the main criterion for selecting projects, particularly in the context of competitiveness clusters. The new "sites policy" announced by the MESR in its "France Europe 2020" strategy document is fully in line with this emphasis on the role of the local authorities. Its effective implementation, however, will require recognising the priority of universities over other national stakeholders when establishing the relevant strategies, without which a coherent local strategy will struggle to emerge.

The European dimension

Europe contributed EUR 694 million to French R&D in 2011, which is equivalent to 4.4% of total public expenditure (government-funded gross domestic expenditure on research and development). Its impact is actually greater than that, however, since a significant proportion of government expenditure is "tied", meaning it covers wages and salaries and other fixed overheads and does not reflect a capacity for targeted allocation, whereas European funding is entirely "project-based", which gives the European Commission leverage and hence a great deal of power to channel national research; indeed, some European projects are carried out by teams that also receive government funding.

Since the middle of the previous decade, France has its national share of funding under the Seventh Framework Programme for Research and Technological Development (FPRTD) decline, which is now significantly lower than its allocation under the 6th FPRTD. One of the reasons put forward for this decline relates to the diverging European and French research agendas, particularly the more targeted and applied nature of European calls for tender compared with French public research. The measures implemented since the end of the 2000s, particularly the PIA, are designed to remedy this situation by emphasising the scientific excellence of funded research and the targeted nature of a number of the projects.

The new European programme "Horizon 2020" gives pride of place to social and economic objectives. In preparing the SNR (2014), the MESR identified thematic priorities that overlap somewhat with those of Horizon 2020. This should help reverse the past divergence, provided that the aims of the SNR are actively implemented by the PROs.

Conversely, it is pertinent to consider the influence of France on the European research agenda. The interviews conducted for this review reflected real scepticism on the part of some interviewees about France's ability to make itself heard by the European Commission in this matter. Some bodies are indeed represented in Brussels, but they have no mandate to put the case for the SNR. Hence, as it enhances its strategic capacity (as proposed above), the MESR could also enhance its European presence.

French integration into Europe on the research and innovation front is more extensive, in that much of France's space policy is pursued through the European Space Agency (ESA). In 2012, France's contribution to the ESA budget amounted to more than 50% of the Government's allocation to the CNES (which is responsible for managing this contribution). In short, a significant share of CNES activity is performed under European programmes.

Conclusion

It goes without saying that the governance of a national system as large and sophisticated as the French system is no simple matter. The diversity of stakeholders, the complexity of the issues raised and problems to be resolved, not to mention the weight of history and geography – all of these factors inevitably lead to complex governance comprising multiple mechanisms and rules that cannot fit easily into a coherent strategy.

On the whole, the governance of the SFRI has considerable proven merits; it has risen to new challenges by creating new institutions and measures (e.g. the ANR and CGI), it has driven reforms designed to adapt the system to a new context (Law on the Freedoms and Responsibilities of Universities) and it has taken the path of rigorous policy assessment. However, it seems that the present governance structure has not succeeded in completing the thorough adaptation of the SFRI required to put France on a new growth trajectory; and that this adaptation remains unfinished business. In light of the analyses presented in this chapter, the main areas of governance that merit special attention are as follows:

- The strategic guidelines must be set at the highest level of government, supported by a High Council. It is important that the latter pay attention to the stakeholders – to all the stakeholders – and that it have at its disposal its own information system for this purpose.
- Co-ordination between ministries seems effective at some levels, but sometimes seems lacking at the strategic level, as each ministry establishes its own positions and sets its own priorities. It must therefore be reinforced.

- Strategies and programmes must not be designed by the institutions responsible for implementing them – the PROs – but by one or more separate agencies, based on guidelines set at the political level.
- The evaluation function – long a weakness in France – has recently progressed thanks to the new mechanisms established to allow the independent assessment of operators and policies. This trend must continue.

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