SKILLS AND COMPETENCIES NEEDED IN THE RESEARCH FIELD OBJECTIVES 2020

The framework employment studies - November 2010

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Apec

Skills and competencies needed in the research field objectives 2020

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OBJECTIVES

Research policies are central to domestic growth and international competitive strategies. From "Lisbon" to "Bologna" and throughout the construction of the European Research Area, the knowledge economy and the knowledge society have repeatedly been cited as major challenges for the coming years. Politicians, business leaders and unions in all countries are unanimous in pointing to research, and the issues of how to fuel it and how to resource it, as make or break challenges.

If national and/or international research policies together with skills and competencies management strategies are to succeed, they must first be reconciled. Other issues, key to predicting the outcome of current changes in the needs of the research world, include changes in education systems and increasing professionalization of research work, job appeal, and mobility and career management.

In this context, APEC (Management Jobs Association) and Deloitte Consulting decided to conduct a joint international survey on the skills and competencies needed in research-related jobs within the next 10 years. For the first time, a forward-looking international study presents the vision and expectations of researchers and research managers with regard to skills and competencies.

This study addresses six key questions: What are the main trends in the changing organisation of research? What skills and competencies are currently sought after in a researcher? Which are specific to a junior researcher and which to an experienced researcher? How will they change over the next 10 years? What is the current degree of proficiency of these skills? What actions and strategies have been introduced or are planned to produce, attract and retain researchers?

This study therefore addresses a wide audience: PhD students, researchers and research personnel, recruitment and career management professionals in every type of organisation (laboratory, business, university department, etc.), professors, newly qualified researchers, and executives keen to exercise their talents in the research world.

METHODOLOGY

The APEC / Deloitte Consulting study was conducted between May and October 2010 in eight countries, six of them in Europe: France, Germany, Finland, Netherlands, the United Kingdom, Switzerland, Japan and the United States. These countries were chosen for the scale of their research as measured by two indicators: R&D spending as a percentage of GDP, and the number of researchers per capita. The scope of the study covers the profession of researcher, in the public sector as well as in the private sector. After initial documentary research, 80 interviews were conducted[1] in the 8 countries with major players in the field, both private and public sector research managers (laboratory directors, HR managers, University deans or rectors, ministerial representatives...) in order to gather their views on the study's issues.

A committee of experts selected and led by APEC and Deloitte Consulting validated the study's main interim and final results.

A final study report plus an appendix consisting of eight individual country reports expands upon this study summary by providing a detailed analysis of the study's findings and a comparative analysis of the macro-economic, demographic and political data relating to recent developments in the research world.

[1] 45 interviews were conducted in the public sector (higher education institutions, national research institutes, ministries, bodies providing research funding, etc.) and 35 in the private sector (businesses and heads of competitive hubs).

MAIN LESSONS

DEVELOPMENTS IN THE ORGANISATION OF RESEARCH, THE RESEARCH PROFESSIONS AND ASSOCIATED COMPETENCES: MAIN TRENDS

The interviewed individuals all emphasised a number of common factors in the changing landscape of research and the organisation of research activities. These fall into three categories: structural, cultural or related to new ways of carrying out research.

Structural developments

A significant increase of investments and government budgets:
All the countries studied, with the exception of Japan, make research and higher education an investment priority, with substantial increases of government spending.
On the one hand, national and European strategies are setting priorities for research topics. Private sector firms, on the other hand, are tending to reorganise their research activities (specialisation, outsourcing).

Closer ties between public / private sector research are driving innovation: All the countries covered in the study have created links to encourage closer ties between private sector and public sector research, through initiatives such as competitive hubs, joint public / private research centres, and Open Innovation partnerships (a system for opening up innovation processes that has been operating in northern Europe for the past 30 years).

"One of the common characteristics of research in the various countries is the desire to grow, either alone or by joining forces. This has resulted in a concentration of the research environment." (Research director of a large group - France)

Cultural developments

Awareness by all involved in research of the importance of markets and the need for strict controls on spending:
The tendency is more pronounced in some countries than in others, and also depends on the nature of the research (public or private) but is inevitably accompanied by:
The need for regular "evaluation / approval" stages for on-going research (and also for researchers),
• The need, on the national level, to develop a higher education system that aims, beyond excellence per se, at performance as a means of winning new markets,
• The need for researchers, over and above their scientific expertise, to be familiar with and adept at finding funding sources for their projects, and able to adapt to sometimes abrupt shifts in research priorities.

Continued internationalisation of the scientific market (and, in parallel, a keen desire in each country to attract high-level researchers). This development, chosen by the actors as well as forced upon them, has led them to market the attractiveness factors of the country, institution, laboratory, etc. in the broadest possible sense (from remuneration to the working environment).

"Researchers will have to be able to "think globally" and be open to the rest of the world...They will need to be increasingly multicultural, as agile in the academic world as in business, and able to engage in dialogue with teams in countries all over the world." (Research director of a large group - France)

New ways of conducting research

Reinforcing multidisciplinary and interdisciplinary approaches:
Everywhere, the emphasis is on the need to innovate. Multidisciplinary approaches encourage research at the interfaces between disciplines, ideal breeding grounds for new ideas. The key factors applied consist of funding for multi- and interdisciplinary projects and a greater awareness of the expectations of civil society.

The growing importance of issues of intellectual property, regulation and ethics:
These issues feed into the conduct of research work, from initial training to the commercial exploitation of research work.

Development of new tools influencing how research is done:
Breakthrough innovations in technology (the latest generation of gene sequencers, for example) and in IT capacity (modelling and simulation tools, Web-based collaboration tools, open source software) are changing the face of research in certain disciplines.

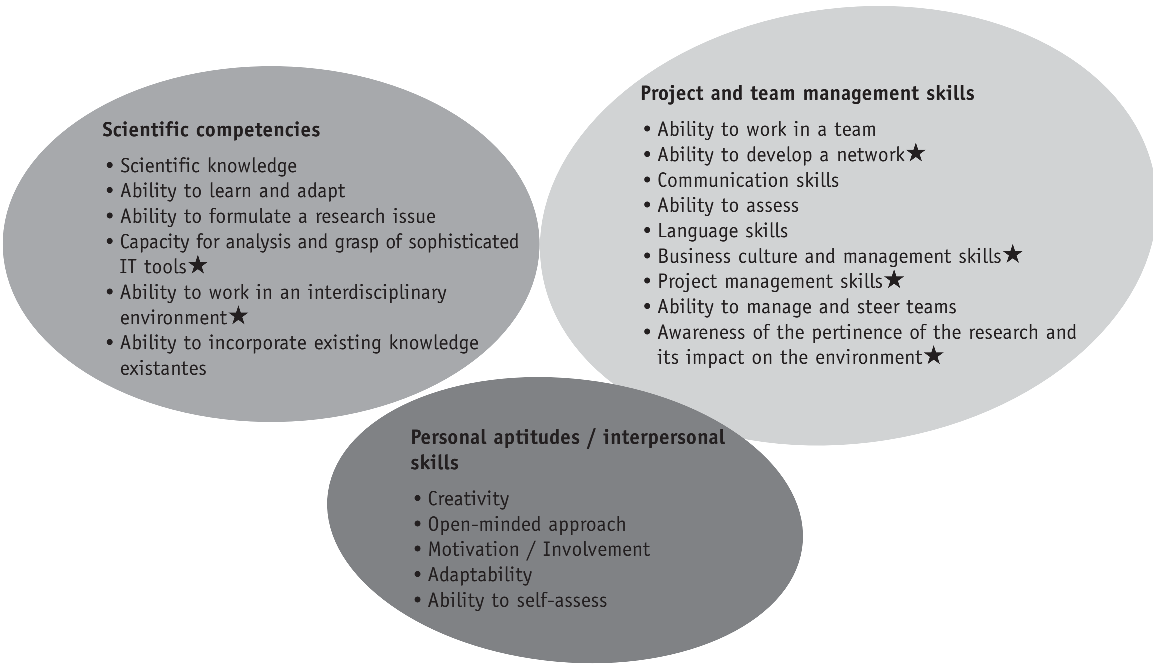
"The latest developments in technology have totally changed the way researchers investigate compounds... the possibilities offered by simulation have expanded enormously. IT has made a big contribution to reducing testing in humans and replacing it with simulations. The impact on fundamental research is limited; the changes are much more apparent on the development level." (Research director of a pharmaceutical group - Switzerland)

THE COMPETENCES NEEDED IN A RESEARCHER TODAY AND BY 2020

The needs for public / private research regarding experienced researchers are fairly uniform in all countries.

20 competencies expected by everyone involved in research in all of the studied countries, in both private and public sectors:

THE IDEAL EXPERIENCED RESEARCHER: THE TWENTY KEY COMPETENCES EXPECTED NOW AND IN THE FUTURE BY RESEARCH ORGANISATIONS*



★ Key competencies required for the future
* In the 8 studied countries (France, Germany, Finland, Netherlands, the United Kingdom, Switzerland, Japan and the United States)

Source: APEC/DELOITTE Study 2010

A greater demand for six competencies in the years ahead: These six competencies will become decisive as foreseeable changes in the research world become reality. For many of those interviewed, the ability to take into account the pertinence of research and its impact on society is now the most important of all the competencies.

"R&D cycles in the pharmaceutical sector have grown even longer in recent years, due to the complexity of the regulations governing the industry. Researchers must therefore be capable of understanding what the market demands, focusing on the research the market wants, and translating the commercial potential of the molecules they study into products. This will minimise the time spent on research and maximise the efficiency of the R&D cycle. This competence is thus a key factor for the efficiency of this industry, but for many others, too. The more a scientist is business-oriented, the more he is aware of the potential for applying his research, and the greater his future career opportunities will be. The researcher of tomorrow will need to retain all of his scientific excellence while also being able to think in terms of market potential." (HR manager of a pharmaceutical company - Switzerland)

Research organisations find that most young scientists share this concern for the impact of their research on society and on the environment, and have therefore successfully incorporated it into their choice of research priorities.

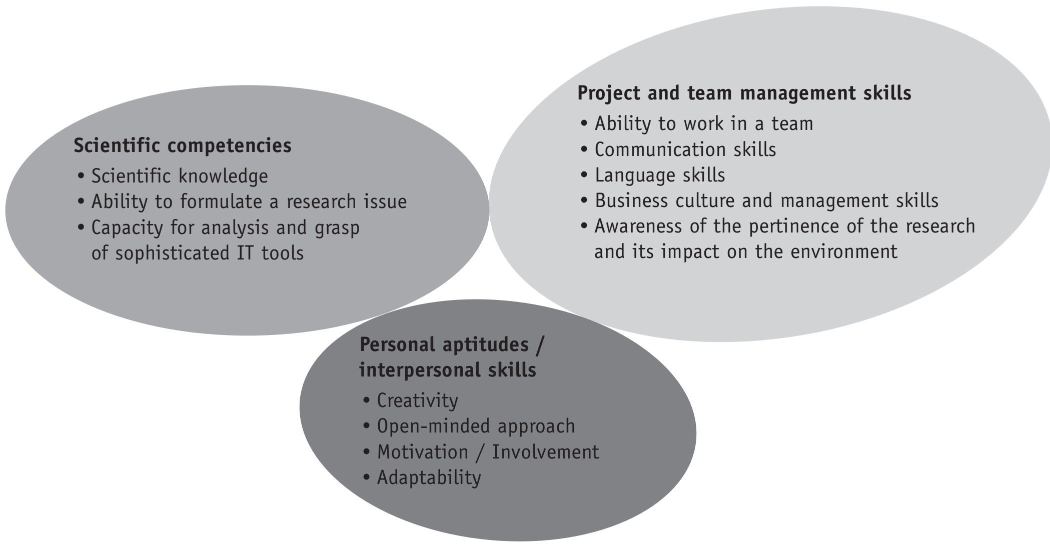
"While avoiding the trap of automatically assuming that the "bandwagon effect" often leads to research with little pertinence for society, today's students want to know what the benefits of a research subject will be to society. This concern has gained ground with the current economic crisis and is currently one of the main factors driving changes in university education." (Research director of a large company - France)

The majority of research managers, however, feel that this competence is not as yet sufficiently developed in the research world.

Competencies very much dependent on the nature of the structure in which the researcher works:
The more developed an organisation's research support structures, the more its expectations regarding the competencies of its researchers are precise and focused on specific areas of expertise. In large structures, support and back-up functions allow the researcher to focus on his/her core activity.

When recruiting a newly qualified researcher, twelve competencies are currently decisive for all research organisations and will remain so in the years ahead.

THE 12 COMPETENCES EXPECTED BY RESEARCH ORGANISATIONS WHEN RECRUITING A YOUNG RESEARCHER*



* In the 8 studied countries (France, Germany, Finland, Netherlands, the United Kingdom, Switzerland, Japan and the United States)

Source: APEC / DELOITTE Study 2010

There are currently real differences between private and public sector when it comes to the recruitment of young researchers: in the public sector, they are recruited almost exclusively on the basis of scientific excellence, whereas the private sector tends to look for a broader range of competencies (communication skills, languages, etc.). The stated aim of many public sector recruiters nowadays, however, is to develop recruitment practices that cover all of the listed competencies.

Levels of competence currently vary widely from one country to another

According to all of the queried research organisations, there is a disparity in the current levels of eleven decisive researcher competencies amongst countries and in particular amongst European countries (see table below). The overall perceptions of the various interviewed organisations about the level of researcher competencies in each country do not allow conclusions to be drawn regarding the level of research performance, which is altogether separate from the number of mastered competencies. Most countries need to make improvements in order to reach a high degree of proficiency of the six key competencies required for the future. Furthermore, the diversity of the competencies mastered, as perceived by research organisations in certain countries, is indicative of an efficient learning system, particularly in the case of newly qualified researchers.
Finally, a high degree of proficiency of certain scientific competencies coupled with a lower level of proficiency in other competencies, as is the case in France and Germany, reflects philosophies of higher education that differ from those of other countries, such as the USA and Switzerland.

Level of researcher competencies by country: perceptions of all those interviewed

	discriminating competencies	Germany	United States	Finland	France	Japan	Netherlands	United Kingdom	Switzerland
Scientific	Capacity for analysis★ and grasp of sophisticated IT tools	Well mastered	Relatively mastered	Well mastered	Well mastered	Relatively mastered	Well mastered	Well mastered	Relatively mastered
	Ability to work in an★ interdisciplinary environment	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered
Project / team management	Ability to work in a team	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Well mastered	Relatively mastered	Well mastered	Well mastered
	Ability to develop★ a network	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Relatively mastered	Well mastered	Well mastered	Well mastered
	Communication skills	Relatively mastered	Well mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Well mastered	Relatively mastered
	Language skills	Relatively mastered	Poorly mastered *	Well mastered	Poorly mastered	Poorly mastered	Well mastered	Poorly mastered *	Well mastered
	Business culture★ and management skills	Relatively mastered	Well mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Well mastered	Relatively mastered
	Project management★ skills	Relatively mastered	Well mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Poorly mastered
	Ability to manage and steer teams	Poorly mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered
Aptitudes	Awareness of the★ pertinence of the research and its impact on the environment	Relatively mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered
	Creativity	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Poorly mastered	Relatively mastered	Well mastered	Well mastered

Non-discriminating competencies: *Scientific knowledge, ability to learn and adapt, ability to formulate a research issue, ability to incorporate existing knowledge, ability to assess, open-minded approach, motivation / involvement, adaptability, ability to self-assess*

Source: APEC/DELOITTE Study 2010

Well mastered *Relatively mastered* *Poorly mastered*

★ *Key competence in coming years*
* *Language skills: Poor foreign language skills are less of a handicap here than in other countries, since a grasp of English is a considerable advantage in the research world.*

Examples of how to read the table: For everyone involved in research, the broadest range of competencies mastered is found amongst US and UK researchers, and the narrowest range amongst French and Japanese ones. Of the eleven discriminating competencies, all of the interviewees identified two that are no more than adequately or even poorly grasped in all of the countries studied: the ability to manage and steer teams, and the ability to take into account the environment and its development.

The remaining 9 competencies are described as non-discriminating in two situations:

- Perceived as well mastered in all of the countries: scientific knowledge, open-minded approach, motivation / involvement, ability to formulate a research issue,
- Perceived as poorly mastered in all of the countries: Ability to learn and adapt, ability to incorporate existing research, ability to assess, adaptability, ability to self-assess.

Paradoxes in the world of research professions:
Research professions have undergone many changes in recent years. The competencies required to succeed, whether scientific knowledge, project management skills or personal characteristics, are first and foremost those expected and stated by employers, and may sometimes seem paradoxical in many respects:
• Share and protect the fruits of your research,
• Maintain your level of expertise and become a good manager,
• Stay focused on your research project and be constantly open to the rest of the world,
• Be determined to reach your objectives and ready at any time to abandon a research project if it is not “profitable”.

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

Higher education systems are not all equally responsive and geared to producing the competencies employers expect

Philosophies regarding the development of competencies differ widely from one country to another, with the transformation of higher education systems proceeding at very different paces:
Some countries, such as the USA and the UK, are very advanced. The UK has produced the Researcher Development Framework, the work of a British organisation championing researcher competencies. It sets out the expected competencies of researchers at different stages in their career development. Finland, Germany and the Netherlands have also made considerable progress and are gradually introducing training in fields other than the purely scientific. In France and Switzerland, the organisation of higher education is more complex to grasp as a whole. Japan lags behind in awareness of this issue.

Market awareness varies widely from country to country...
Across the eight countries studied, higher education institutions are forging closer ties with businesses and listening more closely to their needs, some with more success than others (USA, Finland, Switzerland).
It is difficult, however, for universities to follow changing needs at the pace desired / desirable from a business point of view.

... resulting in real changes in higher education systems, but again at a pace that varies from one country to another:

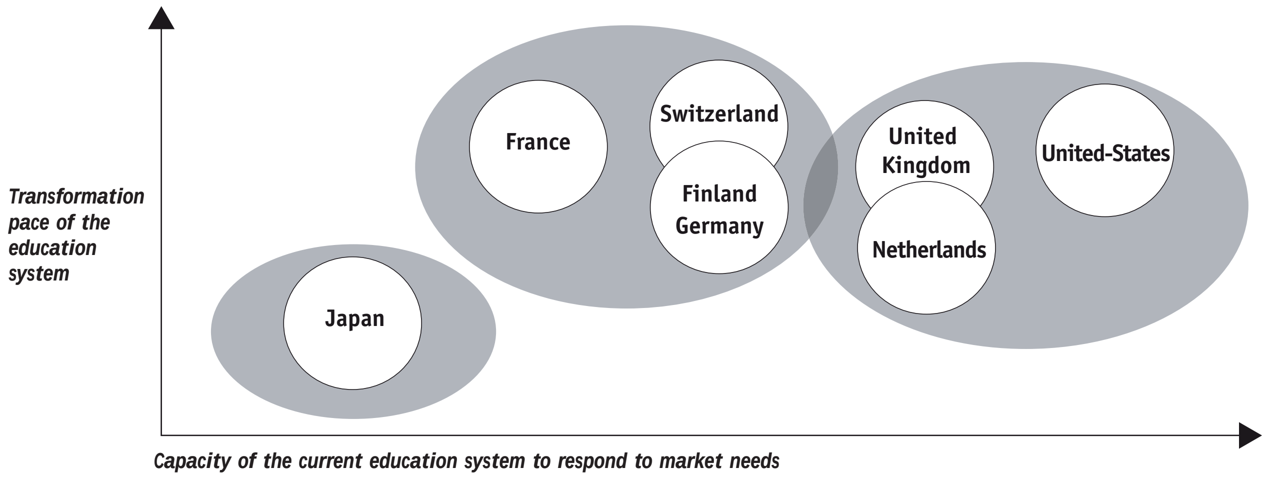
A number of symbolic actions have been undertaken by governments to change higher education systems:
• Initiative for excellence, campus operation, national research hubs, etc. (Germany, Switzerland, France),
• Development of the training role of competitive hubs (Germany, France, Finland),
• Selection criteria in calls for projects (all countries),
• Influence over doctoral school programmes (all countries).
There has also been a widespread change in curricula (content and methods):
• Bringing teaching staff with a background in industry,
• Strengthening links with companies during higher education,
• Including non-scientific competencies in curricula, to varying degrees.

Strategies designed to adapt to the “recruitment market” that vary between countries:
To meet present and future needs for competencies, countries are implementing strategies to produce, attract and retain sought-after competencies. Each country is responding to the demands of the “competencies market” in its own way and at its own pace, however.

“If France wants to keep its researchers, it will have to offer recruitment and working conditions that will allow them to give of their best. France will have to make an effort to offer an attractive package.” (Public sector research director - France)

The chart below plots the position of each country against two axes:
• The first plots the perception that key research players (HR managers and laboratory directors) have of the education system's capacity to respond to market needs,
• The second plots the perception of those interviewed for the study as to the pace of transformation of education systems, backed up by documentary research. There are two components to the pace of transformation: the ability of universities to adapt their courses to meet the needs of employers (institutional strategy) and the pace of change driven by governments (national strategy).

PERCEPTION OF THE ABILITY OF COUNTRIES TO RESPOND AND ADAPT TO MARKET NEEDS



Source: APEC / DELOITTE Study 2010

This analysis identifies three main groups:
• Japan appears to be isolated. The interviewed research managers were able to identify and point to the risk factors for Japan falling irretrievably behind. One of the challenges is to reinforce dialogue between businesses and universities.
• The European countries have embarked on in-depth reforms, highlighting considerable potential for catching
• up with the leader.
An "Anglo-Saxon" model appears to be more effective and better suited to constant adaptation.

What is the competition in the search for talented researchers?

For large companies and certain universities, the recruitment pool for researchers is now global:
Companies and universities able to do so now recruit the best profiles irrespective of country of origin. For these employers, the search for talent cannot be confined to a single country and the diversification of their teams in terms of nationality is seen as a positive factor for innovation.

"We recruit researchers wherever they may be, as long as they're the best. It doesn't matter where they come from. The only condition is a willingness to move to where the research is being done." (Research director of a large company - United States)

The driving considerations behind this international recruitment, according to those interviewed, are excellence, diversity as a factor for innovation and getting closer to markets.
There are also certain factors holding back the mobility of competencies, in particular:
• Restrictions associated with the company's activity (the nuclear industry and the defence sector, for example),
• Language problems,
• Administrative barriers.
Some of these barriers have been removed at the European level, but language remains a real obstacle in many cases.

Governments, universities and research centres are therefore embarking on a range of actions to boost their ability to attract talent, in particular:
• Grants for foreign students aimed at encouraging them to take up residence in the country,
• Streamlined administrative procedures,
• Attractive packages: remuneration and working conditions.
The aim of these policies is to attract the top talents in a globalised market.

Despite the recent transformations, the researcher recruitment market remains primarily national, with limited recourse to an international market for research competencies:
Recruiters do not always find the supply of researchers to match their needs and are obliged to tailor their recruitments accordingly. This mechanism is not confined to the research world, but plays a significant role given the very high level of qualification of the profiles in question.
The competencies available on the national market do not always satisfy demand:
• The "competencies markets" may be limited, the demographics unfavourable (particularly in Switzerland and Japan),
• The available profiles do not necessarily match the needs of recruiters:
Doctorates versus master's degree or engineering diploma: the profiles required are not the same in all of the countries studied. In France and Japan, recruiters place little weight on doctorates, for example.
The search for experienced profiles is often a delicate matter,
Certain disciplines suffer from a lack of trained profiles.
Some companies and higher education institutions still have difficulties attracting the best researchers in their field, for reasons of image: the image of research in that particular country (less attractive than professions such as finance, for example), the image of the organisation concerned or of the field of activity.
"The company has trouble finding engineers in Europe because today, sectors like the automotive industry and even finance represent massive competition when it comes to recruiting engineers." (Research director of a large company - Netherlands)

What strategies are there for retaining them?

In the private sector (in larger companies in particular), career development management is a reality:
Several types of careers are possible in major groups.

"There are three kinds of career paths in business: management (managing and developing a team, managing a strategy), project management (cross-disciplinary management, no management involved but rather the supply of resources and competencies, with objectives and landmarks to be respected in terms of cost, quality, deadline), as well as expertise (an individual who is an authority to be consulted in a certain field)."
(Research director of a major group - Japan)

Those interviewed found that mobility amongst researchers is much higher now than it was ten years ago. Some companies strongly encourage this mobility as a source of new ideas and knowledge and as a means of maintaining the momentum of innovation.

Fairly extensive training programmes have been set up. In some groups, these courses include cross-disciplinary competencies in addition to the scientific competencies specific to researchers.

"There are several different types of training. Some are general in scope:
• Managing interviews with colleagues: how to give feedback, particularly to underperforming colleagues
• Leadership: for employees and project managers
Concept of "leading through others", for managers
How to develop a "winner's mentality" and learn from setbacks.
• Some are highly specific to the field of research. The most important course for researchers at the moment is "Managing a global project", which delivers the tools and strategies for managing complex projects. (Research HR manager of a large group - Switzerland)

Public sector career management, a change in the making:
This covers a number of realities:
• Offering the young researcher more opportunities without waiting for a certain degree of seniority to be reached,
• Offering the young researcher greater visibility regarding possible careers, including "mixed" careers, more an objective for the future than a reality at present,
• Introducing continuing education policies in the public sector.

AVENUES TO BE EXPLORED

The results of the APEC / Deloitte Consulting study suggest four avenues that could usefully be explored:

• A structured strategy for managing researcher competencies appears to be essential. No country has really developed such a strategy yet. Nevertheless, a number of initiatives have emerged. Europe's higher education institutions should provide the necessary impetus, building on the Bologna process, the Lisbon strategy and the definition of a common core of key competencies.

• Higher education systems have a key role to play in training young researchers and equipping them to adapt to the globalised expectations of their future employers. Clearly, there are sharp disparities in the level of researchers' mastery of competencies across the countries studied. In order to fill these gaps, best practices should be adopted as a model, and not only in the so-called "Anglo-Saxon" model.

• Research has become globalised and research projects involve increasing numbers of multidisciplinary and international teams of researchers. The challenge is not to plug a mythical "brain drain", but to facilitate the international mobility of researchers in all its forms, in particular by the adoption of policies to train and attract competencies.

• All those involved in research, in private and public sectors alike, expressed the same expectations in terms of competencies required for the research professions. A similar approach to the management of competencies is therefore required. Building bridges between public sector and private sector research would benefit all concerned.

DEVELOPMENTS IN THE ORGANISATION OF RESEARCH,THE RESEARCH PROFESSIONS AND ASSOCIATED COMPETENCES: MAIN TRENDS

The interviewed individuals all emphasised a number of common factors in the changing landscape of research and the organisation of research activities. These fall into three categories: structural, cultural or related to new ways of carrying out research.

STRUCTURAL DEVELOPMENTS

Evolving national policies and strategies regarding research

The desire shared by all countries to promote growth by creating added value is driving the development of national policies and strategies in favour of research, both public and private.

• Research that benefits from a significant increase of investment and government budgets, and raised to the status of a societal question

All the countries studied, with the exception of Japan, make research and higher education an investment priority, with substantial increases of government spending. This increase is being accompanied by the definition of national and European strategies that are establishing priority research topics, as well as by the creation of various tools in support of these strategies.

In France, the set-up of the research tax credit (providing companies with a 30% tax deduction on the volume of R&D expenses with a ceiling of 100 million euros), the creation of competitive hubs and the passing of laws relative to the freedoms and responsibilities of universities, have brought about a profound change in the research landscape, by placing research at the forefront of the political scene. The same movement can be seen in the study's other countries, notably including the German federal government's launch of a national programme in favour of research and innovation[2], the set-up of an Innovation Strategy in Finland[3] , or even the new impetus given to research after Barack Obama's election. Also, all European countries are reasserting their determination for research to become a national and European priority (cf. the diagram on the Lisbon Strategy in the appendix).

"Research has become a societal question, with visibility provided by political declarations. Companies (small and big) have taken hold of innovation and are looking to the long term and medium term..." (Public sector research director - France)

The Japanese government is an exception amongst the studied countries, with stagnating and even declining budgets for higher education and research[4].

• National strategies promoting applied research to the detriment of fundamental research

In all of the countries studied, public policies have provided innovation with a new impetus. The general trend is to increase budgets dedicated to development, sometimes with a new balance between research and development.

In Finland, this orientation has led to an increase of the budgets of the TEKES, the main organisation for funding applied research and development, which are even greater than those of the Academy of Finland that focuses more on fundamental research. Also, the innovation potential of research projects has been included in the selection criteria for projects financed by the Academy of Finland. This has led to public research financing being re-balanced in favour of applied research.

Applied research is therefore often favoured to the detriment of fundamental research, according to certain research directors, who fear that the latter could suffer from lower budgets.

"Traditionally, German universities focused more on fundamental research, rather than applied research. Today, however, university budgets are not enough to support fundamental research, the quality of which runs the risk of being strongly affected." (Director of a competitive hub - Germany)

[2] For more details on this programme, refer to the Germany country report in the appendix.
[3] For more details on this national strategy, refer to the Finland country report in the appendix.
[4] OECD data

• Polarisation of research

Under the influence of national strategies and of new means for funding research, the research landscape has been transformed in the direction of greater polarisation (cooperation between research institutes and universities, concentration of competencies on very precise domains, grouping around research platforms, clusters, etc.). These groupings result both from national policies and from a virtually spontaneous adaptation by all involved in research.

"The concentration of efforts on very precise domains for each university is not a process that is being directly driven by the Ministry for research, though it does correspond with the Ministry's wishes." (Public sector research director - Netherlands)

In Germany, the increased overall funding for research and the set-up of university excellence hubs as part of the Excellence initiative programme has transformed the research landscape[5]. Cooperation between universities and research centres has been enhanced. An illustration of this renewal of the German research landscape is the creation of the Karlsruhe Institute of Technology, one of the largest German institutes with an annual budget of 650 million euros, which resulted from the merger of a university in Karlsruhe with the local research centre; this is emblematic of the Excellence initiative programme. The closer tie between universities and research centres (such as the Max Planck, Helmholtz or Leibniz) is also an indication of this evolution.

This movement is also affecting the private sector, either via mergers or via cooperation between private companies and public sector research actors.

"One of the great constants of research in the various countries is the desire to grow, either alone or by joining forces. This has resulted in a concentration of the research environment ». (Research director of a large group - France)

The other side of this polarisation is the sometimes negative outcome for actors whose research fields do not fall within the adopted priorities. As such, in Germany, the universities not selected to be one of the excellence campuses as part of the Excellence initiative consider that they are at a disadvantage since they will not be able to obtain government support.

"The federal government's excellence initiative has had counterproductive effects on research since, despite their great potential, universities that were not selected to be one of the 10 excellence campuses will be unable to benefit from government support. They will have considerable trouble catching up with the 10 selected universities." (Director of a research institute – Germany)

• The outsourcing of research

The movement to outsource R&D activities as mentioned by a certain number of contacts, notably within major pharmaceutical companies, has two main reasons. The first is access to skills that are not available in-house, or at a lower cost. The second is to generate new ideas with high added value.

"Within my unit, collaboration is more the order of the day, but within the company, there is certainly considerable outsourcing, notably for the activities that are very regulated such as molecule test phases. This part can be outsourced." (Director of a large company's laboratory - France)

"All pharmaceutical companies are taking part in this evolution. External biotechnology companies are therefore necessary so that companies like ours can outsource. This provides access to differing profiles that specialise in different domains.
The main thing is that they provide the pharmaceutical industry with added value." (Research director of a large pharmaceutical company - France)

• Increasingly autonomous universities, leading to the financing of research by private funds

In almost all of the countries in the study, the current trend in the evolution of the status of universities is in the direction of greater autonomy. The outcome is an increase of the pool of potential funding sources for a university.
In France, the adoption relative to the freedoms and responsibilities of universities is a step in this direction. In the Netherlands, budget autonomy also exists, whereas in Germany, the repealing of the "framework law", one of the last ramparts holding back the total autonomy of universities, will soon be discussed in the parliamentary assembly[6]. In January 2010, Finland also experienced a major change in the status of its Universities[7].

[5] *For more details on this programme, refer to the Germany country report in the appendix.*
[6] *http://www.lepoint.fr/archives/article.php/193881*
[7] *For more details on this national strategy, refer to the Finland country report in the appendix.*

"The major change to the status of Universities that took effect in January 2010 has made universities independent. They negotiate funding with the Ministry for education, but can also seek other funding sources." (Public sector research director - Finland)

• For research, the future is closely tied to the continuation of the implemented measures

While the implemented strategies are indicative of the growing concern of the governments of the studied countries to make research a priority, the future of research will depend on the continuation of the initiated measures.

As such, research in France partly depends on the continuation of the research tax credit, in the sense that its withdrawal could prompt research laboratory located in France to move elsewhere. Similarly, in the United States, research is strongly dependent on the continuing inflow of funding that universities have enjoyed up to the present.

"The developments will depend greatly on what the politicians do: the future of the research tax credit, other economic and legislative measures. If the research tax credits are reduced, some research laboratories will leave. The political choices will not fail to have a weight.
Companies will remain aware of the importance of innovation, and therefore of research. But there could be disengagement thresholds, at which point the impact of the austerity plan, of the loans and credits will have an effect on corporate investments. Certainly it has been a wrinkle for companies, but the question is to figure out where these disengagement thresholds are located." (Public sector research director - France)

Closer ties between "public / private sector research" are driving innovation

These closer ties are resulting from two converging movements: the first initiated by governments and higher education establishments, the other initiated by companies. In both cases, the objective is to reach a critical size in terms of competencies and funding.

"One of the common characteristics of research in the various countries is the desire to grow, either alone or by joining forces. This has resulted in a concentration of the research environment". (Research director of a large group - France)

• Closer ties resulting from the public sphere...

The boundaries between public / private research and industrial / research settings are becoming increasingly porous. In France, these closer ties have primarily resulted in the creation of competitive hubs, in which projects are carried out through a collaboration between companies, laboratories and academics. The State invests in these closer ties between public research and private research. In Germany, the Kompetenznetze Deutschland initiative is comparable to the French competitive hubs. Its purpose is to support the industry-research partnership and to encourage the networking and regional anchoring of competencies in Germany.

Government initiatives in this direction have been launched in Japan[8], notably via calls for projects managed by the NEDO (New Energy and Industrial Technology Development Organisation) that finances finalised research programmes in collaboration between the public sector (universities and research centres) and companies.

• ... and from the private sphere

While research is currently helping to bring companies and universities closer together, it is also because a certain number of companies, notably technology companies, are making the effort to draw closer to university campuses. As such, the eleven Nokia research centres around the world have ties with local universities (Stanford, MIT, Berkeley, EPLF, establishments in China, Kenya and in Bangalore). The teams working there include both Nokia personnel and researchers from academic institutions. The interaction with representatives of the academic world, as desired by the company, has been made possible thanks to this geographical proximity. This cooperation is justified by the access to a vast range of competencies and to the innovative capacity of the university members.

Through Open Innovation, the Phillips Research entity has cooperated with universities in more than 60% of its research projects. These academic partners must be at the leading edge of science and able to work together with its research teams. The collaboration of Phillips Research with universities firstly allows Phillips to influence the development of new technologies right from the fundamental research phase, and secondly allows its partners to implement these collaborative research programmes in their own names. Also, it's a way for Phillips to develop its competencies by working alongside highly qualified and very competent people, since the company

[8] For more details on the government initiatives in favour of closer ties between universities and companies, refer to the Japan country report found in the appendix.

has access to virtually the same competencies as the ones that might be found in a university setting. As such, it is sometimes perceived as a large private university.

In general terms, company / university partnerships can be of three types. Firstly there are isolated operations, with the company having the objective of communication targeting the students. Secondly, partnerships can be part of the performance of specific projects on a regional or European level. In this configuration, the partners remain bound for the duration of the project. Finally, these partnerships can take the shape of a longer term collaboration with sharing of the risks and intellectual / industrial property rights (examples for EADS on the Nantes Technocampus or of the EADS Innovation Centre in Munich,...).

"A company's collaborative model distinguishes several types of collaboration: collaboration between peers, and a more formal collaboration that requires collaboration agreements. The collaboration can be plotted using the XYZ model:
• The X indicates the collaboration between two researchers. The agreement can take place between a scientist in a company research centre and a university scientist.
• The letter Y designates the collaboration between the personnel of these two organisations. Academics take part in corporate research programmes, and use the equipment provided by the latter.
• The letter Z relates to cases in which the entire organisations cooperate with one another after signing a contract. This is on a more strategic level."
(Research director of a large company - the Netherlands)

OPEN INNOVATION

In the developed countries, innovation has become a key economic growth factor. Innovating and developing new goods and services have become essential objectives for organisations. New approaches and strategies have been developed in pursuit of this aim. Open Innovation is one of them.

Until the end of the 1970s, research and innovation were primarily developed in a "closed" setting, i.e. internally within a company. R&D work was confidential and covered by blanket secrecy. As such, R&D was carried out exclusively within the carefully partitioned world of the company.

Since the 1980s, both within universities and in companies themselves, Open Innovation has been at the core of the questions that are being asked. Formalized by Henry Chesbrough, professor and director of the Berkeley open innovation centre, Open Innovation allows people involved in R&D to spark up their innovations by going beyond the confines of the university or entrepreneurial structure. The principle behind Open Innovation is to extend the frontiers of research and development, and therefore its innovation processes, to a variety of partners: public or private structures, companies, customers, suppliers... Building on the exchanges between the various involved partners, the innovations will be a source of added value. This de-partitioning of innovation processes allows the people involved in R&D to attain a greater degree of effectiveness and efficiency in their research. Open Innovation therefore allows companies to respond to market demands more quickly and with greater flexibility.

Open Innovation also makes it possible to develop innovations that will be used not only by the partners themselves, but also by other structures within the market (notably through licences and patents, while internal inventions that are not used can be outsourced). As such, Open Innovation makes it possible to develop innovations that involve not only internal and external R&D actors, but that also result in both internal and external usage of the innovations. a l'externe.

Open Innovation offers many benefits.

• The flexibility provided by Open Innovation provides companies with productivity gains and therefore market shares in a context of ever shorter time-to-market timeframes.

• In this context of openness to new resources, Open Innovation offers a universe of unlimited innovation possibilities. Building on collaboration between researchers, such synergy and integration of many sources of knowledge make it possible to reach a common aim. Open Innovation provides for a better control of the costs and financial risks that are intrinsically linked to R&D activities. Also, by involving suppliers as true partners (vertical collaboration), Open Innovation provides for unquestionable productivity gains (throughout the supply chain, for example), while optimising processes. This is the case of carmakers that involve equipment manufacturers in the product design phases.

• Open Innovation provides for better usage of all of the patents and technologies that are sometimes not used or underused by companies.

Overall, Open Innovation contributes to a general lowering of innovation costs.

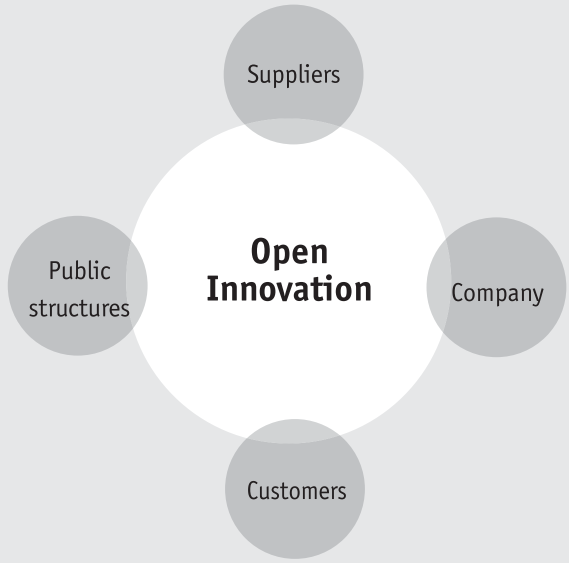
Several factors are part of the recourse to Open Innovation. First of all, professional mobility of the researchers and the dispersal of knowledge have prompted companies to call on existing resources outside of the often partitioned confines of the company; as such, to develop innovations, they must work with competent researchers from outside the company. Secondly, a company's internal resources can be insufficient to carry out a research project. According to the [French] Economic Analysis Council[9], Open Innovation "is based on the fact that the internal resources of companies may not be enough in today's world to allow them to recognise and grasp opportunities that are useful to them"; as such, researchers develop their skills while contributing their respective knowledge and know-how to the realisation of a common project. This is a true opportunity.

Many companies have adopted Open Innovation. Amongst the best-known examples,
Procter&Gamble has developed more than a thousand innovation partnerships through its "Connect + Develop" programme[10]. By creating the "Studio SFR", the telecommunications company SFR offers a participatory approach, that gives consumers a chance to be heard with regard to new concepts, services and products, and that proposes "shared construction of the innovations that resemble them the most."[11]

Though a factor in many advances, Open Innovation is unquestionably a challenge for the companies that use it. True efforts to develop an open-minded approach must therefore be undertaken and the structure must adopt a partnership culture in order to promote openness to a new venue that, until this point, had to be kept away from R&D secrets. The cultural dimension is a key success factor in the application of Open Innovation. As such, wiping away the veil of secrecy and de-mythologizing the impenetrable notion of innovation is a true issue for structures. Working on creation as part of a network is a true challenge. However, the governance of projects must be clearly established right from the start of R&D activities. The sharing of value creation, the complex management of human resources, preserving intellectual property and releasing control are all delicate but essential subjects.

[9] Innovation and competitiveness of the regions, CAE, http://www.cae.gouv.fr/IMG/pdf/077.pdf
[10] https://secure3.veticali.net/pg-connection-portal/ctx/noaoth/PortalHome.do
[11] http://atelier.sfr.fr/quest-ce-que-latelier

Today, companies no longer innovate only in isolation, and innovations are increasingly produced via networks. According to the OECD, 40% of French companies use Open Innovation. 65% indicated having contacts with their suppliers, 50% with their customers, 36% with their competitors, 26% with higher education structures and 18% with public sector research. Despite these encouraging figures, France is lagging behind the other European countries in the study. Finnish companies, that appear to be best performers in terms of Open Innovation, generate nearly 93% of innovations in a network with their customers, and 77% with their competitors. German companies collaborate with higher education structures in more than 50% of the cases (versus 26% in France). Finally, France is in last position with regard to the exchanges with public sector research structures, behind Finland (59%), Germany (26%), the United Kingdom (25%) and the Netherlands (18%).



Source:
• OPEN INNOVATION, The New Imperative for Creating and Profiting from Technology H. Chesbrough
• OECD, Open innovation in global networks, http://www.oecd.org/dataoecd/30/27/41843115.pdf
• Innovation et compétitivité des régions, CAE, http://www.cae.gouv.fr/IMG/pdf/077.pdf
• www.openinnovation.eu
• www.openinnovation.net

CULTURAL DEVELOPMENTS

Awareness by all involved in research of the importance of markets and the need for strict controls on spending

In both private and public research, the question of a research project's funding has become decisive.

• A question of public research funding that is becoming essential

In terms of public research, the days of State subsidies are virtually over. State allocations increasingly focus on calls for projects, in which competition between laboratories and even between research teams within a given laboratory, together with the demand for excellence, are more important than ever.

"20 years ago, State allocations made it possible to carry out research. They now focus much more on calls for projects. The outcome is:
- a demand for excellence since in order to secure projects, one must be able to prove excellence on an international level;
- a multidisciplinary requirement: these days, leading-edge projects in a single discipline are seldom favoured;
increasing pressure from the public authorities in order to bridge the gap between excellence in research and economic development" (Director of a public sector research centre - France)

Regular "evaluation / approval" stages in on-going research (and also for researchers) are often used in a context of increased competition in the research world.

Also, researchers are sometimes transformed into "funding hunters". They must therefore be well informed regarding any available aid. Over and above their scientific expertise, researchers must be adept at finding funding sources for their projects, and able to adapt to sometimes abrupt shifts in research priorities.

"The federal laboratories are no longer managed by the government. Researchers have to go in search of funds in the same way as in other laboratories. And even within the laboratory, there's competition between the various research teams in order to obtain part of the financing granted as a subsidy by the Energy Department." (Researcher in a federal research centre - United States)

• Private research funding must make sense to shareholders in response to their demands for a return on investment: more than ever, the research world must "listen to the market"

For its part, private R&D requires shareholder backing, and it's easier to direct major investments into finalised research when there is no doubt that the market will absorb the newly developed innovative product.

"Today, major investments are difficult to direct towards non-finalised research, which has led to the creation of clusters in many countries. Private R&D doesn't have the financial wherewithal to contribute efficiently to the development of non-finalised research."

It is certain that researchers must understand the market's demands, they must focus on these demands and be able to translate them into finished products. The idea is not to integrate marketing into R&D, but on the contrary, for researchers to be listening to the market.

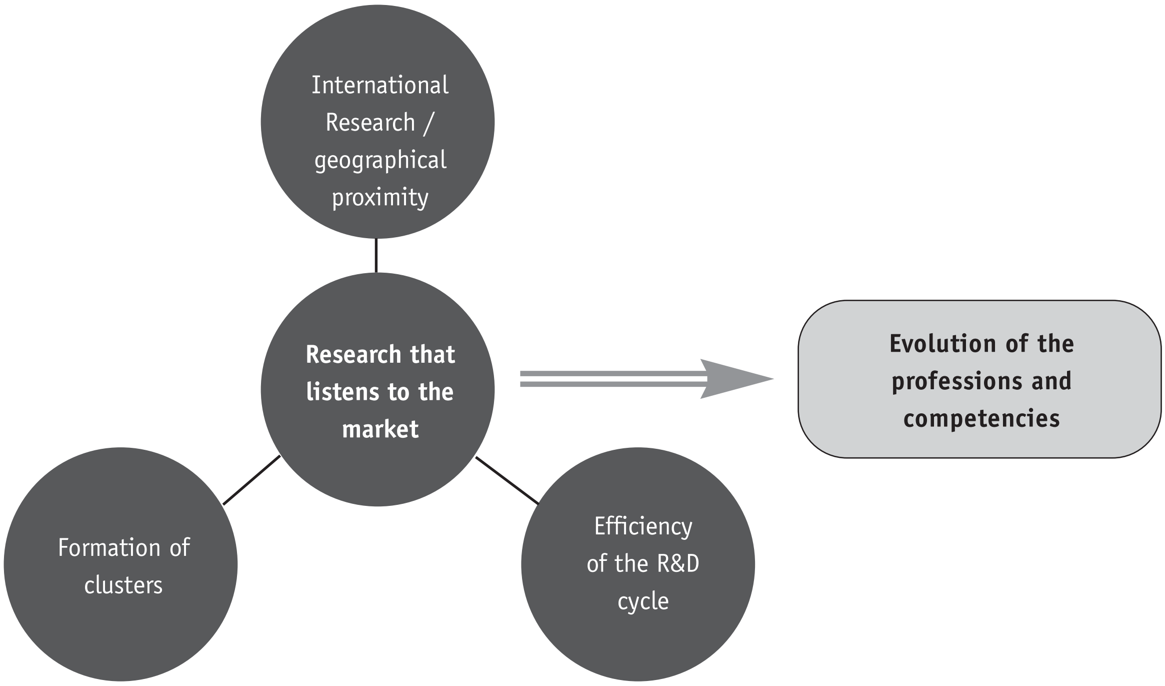
"Research serves the market." (Research manager of a large company - France)

• Importance of the markets that translates into geographical terms, with set-up choices renewed according to growth opportunities

Research that stays close to market demands also requires geographical proximity between R&D research centres and markets. As such, major companies often choose to develop research sites internationally, such as to cultivate this proximity with the markets that are essential for commercial success. The people interviewed as part of the study feel that this strategy of establishing product development sites as close to the markets as possible will continue in the future. In response to the demands of the host countries, to benefit from their strong points in terms of competencies and/or in order to be credible relative to the market, companies on these sites recruit both national and foreign researchers.

"Japan is at the leading edge in the development of new production techniques. It's therefore worthwhile for the company to develop its research activity in this country. Indeed, this presence allows the company to have access to new technical competencies." (HR manager of a large company - Japan)

LISTENING TO THE MARKET: IMPLICATIONS FOR PRIVATE RESEARCH



Continued internationalisation of the scientific market (and, in parallel, a keen desire in each country to attract high-level researchers)

• Increased internationalisation of the scientific market made possible by the development of new communication technologies...

For most of the interviewed key research players, researchers must now consider their research works in a global manner, or in other words, so that their research makes sense in international terms, as has already been the case in certain domains, primarily "hard" sciences. Researchers are now part of a community and of an international scientific market. In this context, the fact of being a multicultural person open to the world is a strength.

"Researchers will have to be able to "think globally" and be open to the rest of the world... They will need to be increasingly multicultural, as agile in the academic world as in business, and able to engage in dialogue with teams in countries all over the world". (Research director of a large group - France)

The internationalisation of the scientific market has been made possible by the development of technological tools, such as videoconferencing or Internet-based exchanges of large files, which make it possible to work remotely with international research teams.

"Our company has many partnerships in Japan and abroad, notably with Tokyo and Stanford universities, in areas of both fundamental and applied research. These partnerships take the form of donations or common research on a given topic, resulting in the awarding of a common patent. It also happens that the company sends employees to give courses at the university." (Research director of a large group - Japan)

Some key research players consider that the benefits derived from such collaboration are very great, notably given that these exchanges, carried out over a limited time, are extremely constructive.

"International collaboration requires that you devote some time to it, but the benefits are significant. Quite paradoxically, we note that it's difficult to create such links with researchers within one's own institution. Indeed, researchers within a given organisation have a tendency to overlook what they could learn from their peers, with the belief that there is no urgency since these people are always present within the organisation, and that there is therefore no limit on the time that they could spend exchanging with them. As such, there is no pressure to reflect on how they could work together. Researchers are more productive as part of international collaboration since they're more focused on what we can do together in a limited period of time." (Director of a university laboratory - United States)

• ... and this implies, in each country, the need to be as attractive as possible for high level researchers.

The internationalisation of the scientific market raises the question of the appeal of each country's scientific market. For the interviewed key research players, as the international mobility of researchers is developing, the concern on the national level becomes one of retaining or attracting researchers. They consider that knowledge of the expectations and motivations of researchers is therefore essential.

"Our country still doesn't know how to correctly analyse the expectations of its researchers, and what really motivates them. The offered salary is not the only element that motivates young researchers, especially ones who want to work in public sector research.

If France wants to keep its researchers, it will have to offer recruitment and working conditions that will allow them to give of their best. France will have to make an effort to offer an attractive package." (Public sector research director - France)

Up to now, there is no doubt that the international mobility of researchers is still not very widespread, however extensively it may be envisaged. (cf. part III-2 of the study)

NEW WAYS OF CONDUCTING RESEARCH

Reinforcing multidisciplinary and interdisciplinary approaches

Everywhere, the emphasis is on the need to innovate. According to all of the interviewed key research players, multidisciplinary approaches encourage research at the interfaces between disciplines, ideal breeding grounds for new ideas. The key factors applied consist of funding for multi- and interdisciplinary projects and a greater awareness of the expectations of civil society.

• Multidisciplinary approaches, that have led to the design of innovative products that are very popular with the general public, and that are behind major progress in the world of medicine.

The need to innovate has encouraged the development of multidisciplinary and interdisciplinary research.

"When a researcher is able to work with an ergonomist, a sociologist or a physician, the outcome of the research can be something very powerful." (Director of a competitive hub - France)

Innovative products known to the general public illustrate the benefits of interdisciplinary efforts, such as the Nintendo Wii and the Apple iPhone.

"The Wii is characteristic of man-machine interaction, and is proof of the successful integration of technologies into daily life. Similarly, the iPhone's commercial success is much more the consequence of a design based on the combination of several disciplines, rather than a particular technological development. It's not the best product in terms of technological development, but it's the interface and interaction with the user that has made its success." (Director of a competitive hub - France)

Another example is the micro-cameras used in medicine. This idea was born when an engineer met up with a physician.

For example, these days, one of the world's major problems is obesity. Having obese people go on a diet isn't enough, since it's obvious that these people need to be coached in order to avoid slipping back into obesity. But it's impossible to "measure" coaching, given that it involves a relationship between two people.
That being the case, what can be done so that this coaching will be based on computerized solutions? Resolving this problem will require collaborative efforts between professionals in various disciplinary fields: medicine, computer sciences, social sciences... More than ever, it's necessary to combine these various competencies from different disciplines in order to reach the right solution. In order for this collaboration to work, it's necessary to present the question in the right way to each member of the research

[12] *See part II.1 for a definition of the multidisciplinary and interdisciplinary approach.*

team, so that each person will be able to contribute to resolving the issue at hand while providing his own solutions. Studied in this way, the question then relates to all of the involved disciplines, and it can be understood by all of the representatives of the disciplines in question." (Research director of a large company - Netherlands)

• Projects and even multidisciplinary structures that are taking shape in both the public and private sectors.
In France, this development is confirmed by the number of human sciences researchers subsidized by the ANRT (Association Nationale de la Recherche et de la Technologie) as part of CIFRE (Industrial Research Training Agreements) contracts. The number is clearly climbing, since research projects are increasingly combining human sciences with "hard" sciences.

In the public sector, the project supported by the University of Lausanne in 2007 is particularly emblematic. Entitled "Vivre Ensemble dans l'Incertain" (Living Together in Uncertainty)[13], it began with a survey carried out by the University in order to determine whether or not research was meeting the general public's expectations. At the end of this survey, six research projects were initiated, including both professional researchers and people from outside the University in order to take "daily life" aspects into account. The research subjects are diversified:
"transplant medicine", "the benefit of age" as well as "2030, what horizons for agricultural lands?".

The German Bayer group also created a structure to promote innovation and to encourage the creation of joint projects between the various business lines existing within the group[14]. As such, interesting cooperative efforts have been implemented, such as research projects on medications designed from plants, that build on the group's competencies in chemistry and botany.

Aware of the decisive importance of multidisciplinary and interdisciplinary projects, governments are increasingly encouraging research of this type. As such, the Academy of Finland devotes 10% of its funding to projects identified as multidisciplinary.

The growing importance of issues of intellectual property, regulation and ethics.
These issues feed into the conduct of research work, from initial training to the commercial exploitation of research work.

• Increasingly important intellectual property involving innovations, in a context of globalisation and cooperation between several research entities.
While the question of intellectual property is clearly dealt with in some disciplines and countries, it remains largely ignored in others. However, it is central to two parallel movements: the internationalisation of research and the increasing partnerships and cooperation between research entities. The two following examples illustrate the importance of this aspect and the difficulties that are encountered.

For a long time in Japan, the question of protecting intellectual data was not a priority for many of the key research players. Today, in a context of growing competition with developing countries, notably involving high tech products, the government is attempting to increase the awareness of everyone involved in research, whether public or private, with regard to these aspects.

"With regard to intellectual law, there is significant concern. The idea is not to be copied by developing countries. However, this can happen very quickly if the researchers don't pay attention. The NEDO is therefore raising the awareness of research projects on the need to protect their work right from the start." (Public sector research director - Japan)

In the United Kingdom, it would seem that British universities are having trouble efficiently managing issues surrounding intellectual property. This matter is all the more problematic as the evolution towards Open Innovation is "blurring" the frontiers of intellectual property.

• The growing importance of international outlets, which is making it imperative for technological innovations to be in compliance with international regulations.
In a context in which research is waiting on the market, the adaptation of technological innovations to international regulations is an imperative condition for finding commercial outlets on the international markets.

[13] *http://www.unil.ch/vei*
[14] *www.Bayer-innovation.de*

"Japanese cell phones, for example, are full of innovations and interesting functions, but ones that can't be exported since they still don't meet international standards. Japanese technology is often good but must adapt to the world, since the Japanese market is extremely limited; hence the need to take international standards into account in order to be able to sell in China, in Europe... This aspect is important as of the start of the research project." (Public sector research director - Japan)

• Current research very strongly imbued with ethical considerations.

All of the interviewed managers unanimously pointed out that ethical issues have taken hold in the research world, and that researchers must integrate this new element. In France, there is a national ethics consultative committee that gives "opinions on ethical problems and societal questions brought to light by the advance of knowledge in the fields of biology, medicine and health". The establishment of many constraints weighing on delicate research topics can serve to slow research in certain domains such as bioethics, given the many procedures that have to be followed (authorisations, samples...)

"Exacerbated public attention to issues surrounding biological war and biological defence has resulted in negative effects on this research field. In fact, very strict regulations have been implemented within laboratories, which has a not insignificant impact on the work of researchers. As such, obtaining samples - for example samples of potentially pathogenic agents - is becoming difficult. This bureaucracy complicates but does not prevent the work of researchers. Also, when a researcher applies for a research allowance, he must first demonstrate having properly undertaken a bioethics authorisation procedure relative to this subject's study. If not, the research allowance will not be provided. If a researcher works on animals, the constraint is the same. When a researcher publishes a research article, he must precisely indicate all of the aspects relative to bioethics and biological security. On the other hand, the procedure is much less demanding when the research subject has already been studied." (Director of a university laboratory - United States)

For companies, the question is twofold. Firstly, once convinced of a research project's benefits relative to a sensitive topic, lobbying efforts are often necessary in order to convince public opinion (government, academia, religious groups...) of the benefits of this research.

"In terms of ethics, as a result of the strong moral implications of the genomics field, the company is very attentive to this subject and has undertaken significant lobbying efforts to convince public opinion of the benefits of genomic research." (Research director of a large company - United States)

Also, companies are increasing their efforts to protect themselves against any attack relative to their "ethical behaviour", and to ensure a good image.

"Similarly, because of the toxicity of the materials with which they're working, and in order to maintain its good image on questions of ethics, the company is obliged to spend a lot of money on waste treatment." (Research director of a large company - United States)

New tools in the development stage

For many researchers interviewed as part of this study, "the biggest changes are technological" (Director of a university laboratory - United States). Breakthrough innovations in technology (the latest generation of gene sequencers , for example) and in IT capacity (modelling and simulation tools, Web-based collaboration tools, open source software) are changing the face of research in certain disciplines.

• Exponentially increasing data volumes having to be processed.

Researchers now have access to a phenomenal quantity of data at an identical cost. For researchers, the processing and analysis of such data is a growing challenge.

"Starting in 2006, research work began to rely on the use of "new generation sequencers". This quadrupled the quantity of data that could be obtained at an identical cost. The gathered data has become so inexpensive that a large part of the research budget is now devoted to data analysis. As such, in many laboratories, whether at the University or elsewhere, researchers are often limited by their data processing abilities. As such, an exacerbated need for statistical analyses has emerged. In biology, data have assumed considerable importance in the last 6 or 7 years. Researchers now have far more information to take into consideration when carrying out their research. They therefore need specialists to analyse the data produced by sequencing. To deal with this, in my laboratory, we often teach computer programming to biologists, or biology to mathematicians." (Director of a university laboratory - United States)

DEVELOPMENTS IN THE ORGANISATION OF RESEARCH, THE RESEARCH PROFESSIONS AND ASSOCIATED COMPETENCES: MAIN TRENDS

• Quickly developing simulation and modelling possibilities that are more efficient than ever.

The computerized simulation possibilities available to researchers have developed tremendously and offer many advantages, notably on the level of applied research. Recourse to simulation serves to decrease the number of tests performed on patients or animals.

Research is increasingly relying on the computerized modelling of processes, the main benefits of which are speed and processing of a very great quantity of information at a lower cost.

"In the ten coming years, the most important thing for us will be the ability to carry out computerized modelling of chemical processes, since this avoids wasted verification time that would be required in real experiments. For example, thanks to computerized modelling, we've increased from 2000 molecules sorted per year to 1 million. This screening is faster than experimentation, less expensive, etc." (Research director of a large company - France)

• Omnipresence of the Web and its applications as well as the development of open source software programs, that constitute new sources of innovation in all research disciplines.

Many technologies coming from the world of the Web and of open source software (i.e. independent developers producing software programs themselves) constitute a true hub of innovations, all the more so as these technologies are evolving very quickly.

"One mustn't look down on these technologies, but rather know how to use and transform them for the benefit of industry." (Research director of a large group - France)

However, it is necessary to bear in mind that the consequences of the usage of such technologies can have, notably in strategic domains such as aeronautics or defence.

THE COMPETENCES NEEDED IN A RESEARCHER TODAY AND BY 2020

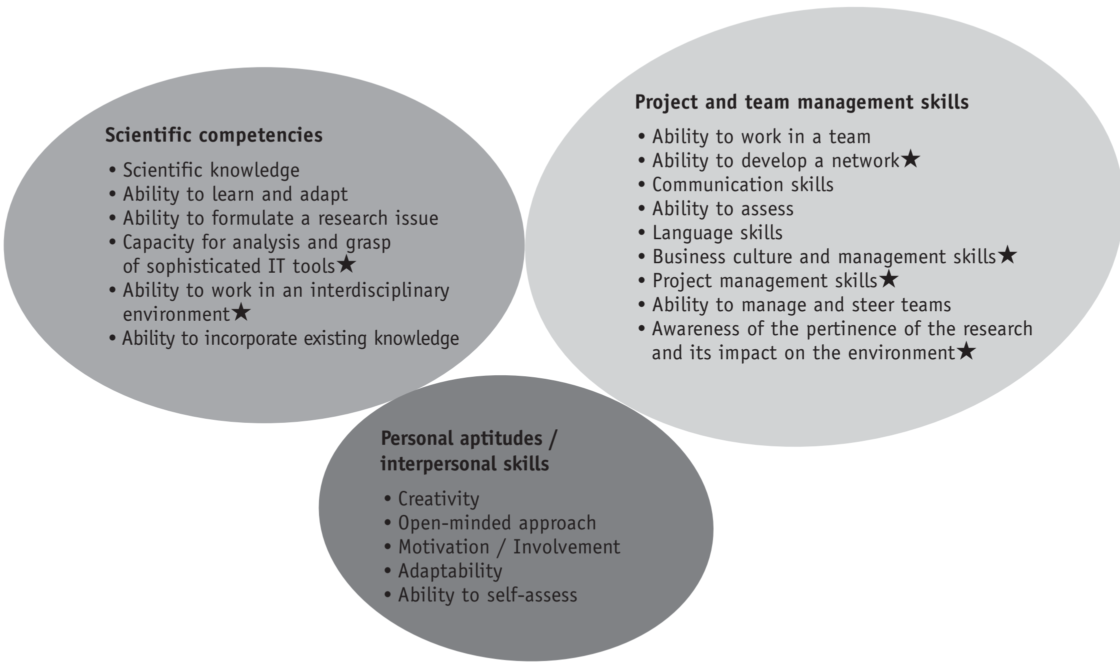
UNIFORM NEEDS IN ALL COUNTRIES FOR AN EXPERIENCED RESEARCHER'S PROFILE - BUT VARIABLE EXPECTATIONS FOR A YOUNG RESEARCHER'S PROFILE DEPENDING ON WHERE THE RESEARCHER IS WORKING (UNIVERSITY, PUBLIC OR PRIVATE LABORATORY, COMPANY...)

In the research field, as in many fields, the competencies that are being sought by the main private and public sector actors around the world are becoming increasingly extended, more complex and uniform irrespective of the country. However, there are some differences in all of the countries when it comes to a researcher, depending on the type of desired profile (junior or senior), the sector (public or private) and the discipline.

Today, for the research professions, there is clearly an internationalisation of the required competencies.

20 competencies are expected by all research organisations in all eight countries studied, in both private and public sectors:

THE IDEAL EXPERIENCED RESEARCHER: THE TWENTY KEY COMPETENCES EXPECTED NOW AND IN THE FUTURE BY RESEARCH ORGANISATIONS*



★ Key competencies required for the future
* In the 8 studied countries (France, Germany, Finland, Netherlands, the United Kingdom, Switzerland, Japan and the United States)

Source: APEC / DELOITTE Study 2010

A greater demand for six competencies will come to light in the years ahead.
These six competencies will become decisive as foreseeable changes in the research world become reality. This involves a capacity for analysis and a grasp of sophisticated IT tools, the ability to develop a network, company culture and management skills, project management skills and an awareness of the pertinence of the research and its impact on the environment.

The competencies of a researcher as described below include traditional and even structural competencies, as well as new competencies that are emerging and that could become essential in the coming years.

A basis of unanimously expected scientific competencies

According to all of the interviewed directors, scientific competencies form the basic kernel of the competencies that the research world expects from any researcher, whether working in a public or private sector environment, and whether a junior or senior researcher. The expectations are very close within the studied countries, even though the importance assigned to a given competence can sometimes vary.

• Traditional or structural needs

These structural needs relate to scientific knowledge, i.e. the ability to learn and to renew one's approaches throughout the professional career, as well as an ability to formulate a pertinent research issue.
These are not expected to change in the coming years and should continue to be structural needs.

i. Scientific knowledge

Independently of the scientific domain or business sector, everyone in the research world considers that a researcher's scientific bases are the sine qua non condition for success in the area of research.

"Scientific success is always based on the in-depth expertise of very high level specialists." (University director - France)

The research world has great expectations in terms of scientific knowledge.

- Theoretical knowledge versus practical knowledge:

The expression "scientific knowledge" takes in both purely theoretical knowledge and practical knowledge. Irrespective of the research domain, such knowledge is based on a mastery of experimentation protocols. While the queried key research players continue to express a strong need for theoretical knowledge, certain domains require more experimental practice than others. The interviewed research directors in the studied countries pointed out efforts to strengthen the "practical" aspect of research.

"Chemistry has a significant manual component. Practical work and the performance of experiments are extremely important, since they allow the researcher to better understand and better interpret the results produced by new experimentation techniques. Researchers in this discipline therefore need to develop this "traditional" side. However, universities still devote insufficient attention to practical work, and students often only experiment with a few reactions during their studies, instead of the several hundred that they would otherwise need." (Director of a laboratory for an industrial chemical group - Germany)

"Of course, students in a DUT (University technology degree) programme, bachelor's programme or professional master's programme carry out significant numbers of practical tasks as well as work experience. Similarly, the growing number of apprenticeship-based Master's programmes points to the development of experimental competencies amongst university students,... but these efforts are still insufficient." (Director of a competitive hub - France)

The needs for proficiency with the physical actions associated with research work are even greater in the public sector, given the lower numbers of research support personnel, notably laboratory technicians, than in the private sector.
In Germany, the R&D personnel is therefore comprised of 35% technicians and other support personnel in the public sector, versus 46% in the private sector[15]. The gap is even greater in the United Kingdom, with 11% technicians and other support personnel in the public sector, versus 44% for the private sector[16]. Under these conditions, the researchers in public organisations must handle the instruments themselves.

- Basic techniques versus cutting-edge techniques:

The major development of technologies in recent years has facilitated the work of researchers in all fields. For people in the research world, a knowledge and mastery of these technologies is essential, notably amongst the young researchers hired by a research laboratory. These researchers are also expected to provide the teams with new scientific knowledge.

[15] Source: OECD, and for more details, refer to the Germany country report in the appendix.
[16] Source: OECD, and for more details, refer to the United Kingdom country report in the appendix.

However, despite these developments, solid training in the basic techniques remains essential. Moreover, some people feel that today's scientific training focuses too much on new technologies, to the detriment of basic scientific knowledge.
Overall, when a researcher is being hired in any of the countries or sectors, the recruiter pays great attention to the quality of the basic stock of scientific competencies mastered by this young researcher.

"Though theoretical knowledge and a grasp of new technologies are important, the company wants to hire young people who have lots of practical experience and who have familiarised themselves with how to carry out simple chemical reactions during their education. In other companies, recruiters look for graduates who are at the leading edge of the latest technologies, with a more expert profile." (Laboratory director in a large group - Germany)

For the interviewed directors, this basis of scientific knowledge is the easiest element to assess during the hiring process. Indeed, it is certified by a diploma and recruiters can easily ask candidates about their research projects and the disciplines at their command. In the public sector, scientific excellence is virtually the only selection criterion for a position. Researchers are often selected on the basis of their academic excellence, before or even excluding any other criterion. Moreover, this skill can prove to be decisive and even discriminating in the career development of researchers in this sector.

"In the public sector, the most brilliant researchers are often later asked to become laboratory directors." (Director of a competitive hub - France).

ii. Ability to learn, to identify the relevant information and to adapt in order to maintain a level of scientific excellence.

By definition, a researcher is open to and curious about scientific progress. Also, it is a unanimous view within the research world that a researcher is constantly learning throughout his career. Nevertheless, the ability to learn goes beyond the discovery and integration of new knowledge. Indeed, the interviewees indicated that the researcher must be able to find new ways of carrying out his research. He must be able to identify new information sources and to apply new methodologies. These qualities are necessary for research if there is to be any innovation.

With regard to updating one's knowledge, research executives, just like those in other positions within the company, undergo continuing training in order to update their knowledge. However, within companies at the cutting edge of technology, and sometimes the worldwide leaders in certain domains, the problem is to find suitable training possibilities. For these companies, recourse to "self-training" is often the only available solution. The researcher then takes the initiative to acquire new competencies on his own. As in the academic world, private sector research professionals are in a constant state of monitoring, and they constantly use their network in order to refine their knowledge and/or to acquire new knowledge.

Over and above an ability to learn, the interviewed research directors also mentioned the need for the researcher to know how to renew his methods and techniques. Certain interview subjects noted significant gaps in this area.

"Some researchers always use the same scientific methodology or have a tendency to always ask themselves the same questions throughout their career. That isn't a good thing. A researcher must be able to renew his approaches and his research issues. He must demonstrate adaptability in a world where everything can change very quickly." (Public sector research director - Finland)

iii. Ability to formulate innovative research issues

For the research world, one of the main dimensions of the research activity is to provide solutions to problems that have been identified as such and clearly expressed. Over and above this ability to resolve problems, however, researchers must also be able to identify and formulate, in a pertinent manner, research issues in known as well as new domains. In the eyes of certain interviewed experts, this skill is often not well grasped. They also note that researchers are more comfortable looking for a solution than with formulating a pertinent question.

"In the era of multidisciplinary research, when a new domain is being explored, it's important to be able to say: What questions should we be asking ourselves in order to become the leaders in a certain domain?
What must be done so that this issue will be clear and pertinent for all of the disciplines touching on this subject? Is this an issue that can lead to technological solutions?"
(Research director of a large group - Netherlands)

For the interviewed directors, knowing how to mobilise researchers from all of the disciplines concerned by the research project makes it possible, in the end, to formulate questions in a manner that is relevant and understandable to everyone.
As such, they can all contribute to finding solutions or to formulating new questions. According to certain interviewees, this skill is still under-represented within research teams, and universities have insufficiently integrated this type of concern into the curricula followed by researchers.

Scientific competencies, an ability to learn (to maintain a level of expertise and adapt to changes) and an ability to formulate a research issue in an innovative manner are some of the skills that people in the research world expect from all researchers. This should continue to be the case going forward, barring major developments.

• The new or emerging needs that are developing quickly.

These new needs only partially cover the range of key competencies for the future, as identified by the interviewed research directors. Indeed, a key competence is not necessarily synonymous with a new need. Certain competencies traditionally applicable to research professions will take on growing importance, such as the ability to analyse, and proficiency with highly sophisticated IT tools.

i. Capacity for analysis and grasp of sophisticated IT tools

In human and social sciences, just as in the “hard” sciences, new technologies have exponentially increased the ability to produce raw data and the volume of information having to be processed. The scientific professions now require an ability to produce and analyse unprecedented volumes of information, often with the help of very complex computerized tools. Whether determining a genetic sequence in biology or studying data in a sociological investigation, a researcher’s ability to analyse is now closely tied in with IT skills and a very good grasp of IT tools and concepts.

“Major technological evolutions are making it possible to obtain constantly increasing amounts of information at rapidly falling costs. The issue of processing this information is becoming key” (University researcher - United States)

Depending on the studied disciplines, a very great mastery of IT tools can prove to be necessary. In certain disciplines, research is now very dependent on the capacity for computerized data analysis, thereby requiring in-depth knowledge of IT hardware and of certain software programs.

“Biologists must be given computer training in order to allow them to reach the required level of scientific excellence. In their laboratories, researchers need to learn computer programming languages, to develop their ability to analyse very extensive databases, and to use very specialised software programs.” (Director of a high technology SME - United States)

In other fields, researchers consider that it’s best not to spend too much time developing these IT competencies. They consider it more worthwhile to have trained IT specialists to support the researchers, rather than ask a researcher to become an IT specialist. In this situation, without an advanced degree of mastery of the IT tools, a researcher must be able to discuss with the IT specialist in order to communicate with the IT teams, and to know how to interpret the information provided to him by the latter.

In short, when it comes to hiring, a mastery of IT skills is either an indispensable prerequisite, or merely a strength. Whatever the importance of the need, many interviewed research managers point out a sometimes insufficient grasp of IT competencies amongst researchers, especially amongst the most senior researchers. To overcome these gaps, some would like to see the acquisition of computer skills be more systematically integrated into the new academic curricula, such as to improve the analytical abilities of young scientists.

“This results from a failing on the level of the university training. Researchers are then forced to learn these new techniques as part of their professional experience, or through continuing education.” (Director of a university laboratory - United States)

ii. Ability to work in an interdisciplinary or multidisciplinary environment

A large part of the international research community shares the idea that the scientific progress of tomorrow will often be found at the intersection and interfaces of various disciplines. However, according to the interviewed research experts, the need to integrate differing disciplines into a research project is recent and difficult to implement.

This requires researchers to have an ability to work with specialists from different disciplines, in domains that are sometimes far removed from one another. As such, researchers must give increasing thought to how the results of their research may be used. They must also at least be familiar with the scientific methodologies and procedures of the specialists in other disciplines, with whom they will be working as part of a team.

Usual and commonly shared definitions

Multidisciplinarity (or pluridisciplinarity)[17]: is the fact of involving several disciplines in a given research project or within a given team.
Multidisciplinarity is expressed through teamwork. It generally has more to do with the team and not the isolated researcher. Within the team, "Each person retains the specific nature of his concepts and methods. These are parallel approaches targeting a common aim through the addition of specific contributions".
For example, nanotechnology researchers are working with researchers specialising in the fields of health or textiles.

Interdisciplinarity: the researcher's ability to work at the interfaces of several disciplines, notably thanks to a strategic research committee or external contributions of expertise, or even the existence of a forward-looking administrative structure.
"Interdisciplinarity presupposes a dialogue and the exchange of knowledge, analyses and methods between two or more distinct disciplines. It implies the need for interaction and mutual enhancement between several specialists. A recent example can be found in the human ethology resulting from the meeting between animal behavioural studies and child psychology."[19]

Multidisciplinarity encourages the emergence of innovation. Indeed, the integration of the question of the usages and contributions of human and social sciences within science and technology have resulted in many recent inventions seeing the light of day, some with remarkable success. This is notably the case of the Nintendo Wii or of the Apple iPhone. These two products were able to successfully integrate the expectations of potential users. This recognition led to the success that we have all seen. In the eyes of many interviewed experts, interaction between distinct disciplines is therefore more than a necessity in the research world, and is even becoming inescapable.

"In the telecommunications field, technicians have trouble explaining that telecommunication antennas are not harmful to one's health... Also, researchers in social sciences do not have the necessary technical knowledge to properly understand the results of the research by the engineers, and therefore to express themselves clearly in terms of societal stakes." (Director of a competitive hub - France)

The interviewed research directors differentiate between two types of multidisciplinarity:
- Multidisciplinarity between hard sciences: for example, certain research projects in the aeronautics field require cooperation with mechanical, thermal and electromagnetic experts.
- The multidisciplinarity of certain projects (notably within the framework of medical / psychological research), that bring together experts in hard sciences and experts in human and social sciences. Many examples of their importance can be found in the research world[20].

[17] The two terms can be used interchangeably [primarily in French - transl.]. In the remainder of the report, only the term multidisciplinarity will be used for greater clarity.
[18] [19] National pedagogical documentation centre. Academy of Grenoble. http://www.crdp.ac-grenoble.fr/tpe/selecdoc/methodo/inter.htm
[20] See Part 1

For the research world, the key to the success of any multidisciplinary or interdisciplinary work resides primarily in each specialist's ability to communicate clearly with the other specialists in other disciplines. Researchers are sometimes asked to be able to translate technical language into language that can be understood by non-scientists, as in the previously mentioned example on telecommunication antennas.

"The researchers from different disciplines must establish a common language that will allow them to work together. This language will allow them to discuss the progress and limits of their common research programme." (Director of a private sector laboratory - United States)

Also, according to some of the interviewed research directors, a young researcher must first and foremost become an expert in a given discipline before worrying about multidisciplinarity or interdisciplinarity.

"To be able to include interdisciplinary questions into research projects, a senior researcher must already be highly specialised in a precise scientific domain. Young researchers must first acquire a solid scientific basis in their domain, while maintaining the open mind that they will need in order to communicate with other disciplines. It's on these solid bases that cooperation between hard sciences and human and social sciences will make sense." (University director - Switzerland)

While the benefits of interdisciplinarity have now been clearly identified by everyone involved in research, many point out the difficulties with implementing it. Indeed, most scientists are trained to become experts in their disciplines, and they logically adopt its philosophy and methodological bias. According to the interviewed research directors, it is especially researchers who must be convinced of the added value of multidisciplinarity.

"It's unfortunate that there is a lack of interdisciplinary cooperation in all countries." (Director of a public sector laboratory - United States)
"For this approach to function, the effort must continue in time and must not be limited to the duration of a specific research programme. Having specialists in evolutionary biology work together with specialists in social sciences is of major interest, but is not self-evident. It will take time for collaboration to take shape and to produce powerful results. However, the funding is sometimes too short, and doesn't allow the interdisciplinary collaboration to take root in order to produce all of its effects." (Director of a research centre - Switzerland)

Moreover, the difficulty with interdisciplinary cooperation also comes down to the fact of very different ways of conceiving experimentation in each domain. Certain interviewed researchers have the distorted view that human sciences are more interpretive, that few mathematical models exist to carry out simulations, and that experiments are sometimes more expensive. On the contrary, in their view, engineers only worry about the sturdiness of their results. When several disciplines try to work together, these methodological differences and the associated "images" are very significant and can complicate the collaboration.

The general perception of the key research players is that cooperation between disciplines is much less developed in the public sector than in the private sector. However, there are differing opinions. For example, some private sector representatives feel that the single-discipline traditions of universities prevent young students from developing the multidisciplinary knowledge and approaches that are expected in the private sector. Others from the private sector point out that universities are in a better position than private laboratories when it comes to studying interdisciplinary issues.
They point to the coexistence of several scientific domains and to the universal character of universities, while private laboratories are often limited in terms of research personnel. Thanks to the presence of specialists from several domains within university campuses, they also feel that the interdisciplinary dialogue is more dynamic than would be the case in a private laboratory.

Finally, multidisciplinary and interdisciplinary works are even more of a problem for researchers when they involve publishing, receiving a promotion or being recognised by their peers (especially for ones working in the academic world). While researchers are asked to work on projects that are common to various disciplines, all of the best-known academic journals are generally discipline-specific. The publication of works is therefore complicated, and a researcher will hesitate to compromise his academic renown by working on a multidisciplinary project.

iii. Ability to incorporate existing research, technologies and knowledge

For many interviewed research directors, researchers (independently of their level or profile) often tend to "plunge headfirst" into a research issue, without drawing lessons from projects that have already been studied, whether to completion or not. In a limiting economic context, more reliance on what already exists can generate significant savings for the company.

"Researchers very often forget to study existing solutions in order to see if they can be improved or adapted to new issues." (Scientific director of a large group - Netherlands)

"This "company memory" has become a key factor. It's therefore important for scientists to be aware of what has come before in their fields. A researcher capable of performing this task as a "scientific explorer" would undoubtedly be much appreciated within a research team, and would be able to more easily advance with his research projects." (Researcher in a private sector laboratory - United Kingdom)

Also, for the key research players, this awareness of what already exists has a twofold interest. It allows a true spirit of innovation to come out, either by avoiding going over ideas that may appear to be innovative but that in reality have already been worked upon, or on the contrary by going back to older innovative ideas that had not been completely exploited.

"My organisation understands "innovation" to mean both the discovery of new knowledge and the discovery of new applications for pre-existing knowledge. To manage that, a researcher must be capable of integrating knowledge and technologies that exist in other countries, something that is often neglected in the research world." (Public sector research director - Finland)

The competencies expected from research professionals therefore go beyond technical competencies, since these days, research professions also require a very significant non-scientific component. Amongst the non-scientific competencies, the interviewed directors point to interpersonal skills, as well as competence in company, project and team management.

Increasingly necessary non-scientific cross-functional competencies, primarily in the field of interpersonal relations and project and team management.

In all countries, research work is always carried out as part of a team. Using communication technologies, there are more possibilities for interaction and cooperation between the various actors in the scientific world. The paradigm of the solitary scientist really no longer exists in the Internet era, and today, all research professionals have adopted the networking method. Also, for people in the research world, a researcher must, in a context of multidisciplinary research and scientific cooperation between the public and private sectors, serve as both negotiator and conflict mediator, which had not previously been the case.

Furthermore, a researcher is not only a member of a laboratory. All of the key research players are unanimous in saying that a scientist these days must master new competencies outside of his purely scientific domain, in order to be connected with the world and to meet the expectations of society.

The key research players therefore insist on the growing importance of these cross-disciplinary competencies, while also noting a lack of mastery of certain of them.

• Interpersonal capacities

i. Ability to work in a team

Very often mentioned by the people in the research world, the ability to work in a team can be translated in different ways. A research professional must be able to cooperate with other professionals, whether in scientific professions or in research management professions. Also, as part of research collaboration projects, professionals must develop an understanding of the motivations of the various involved actors, such as to ensure the project's proper conduct.

The laboratory and the organisation of which it is a part constitute the first environment for working as a team. A researcher's ability to work in a team is fundamental, all the more so as research these days is first and foremost considered to be a team effort. Everyone in the research world describes the benefits resulting from the interactions within a research team, in particular between differing profiles. This difference can be disciplinary or cultural. The ability to work in a multicultural environment is a requirement that is very closely tied with teamwork in the research world. While this need for teamwork is older in certain disciplines, it is more recent in social sciences, for example.

Within companies, researchers must also be able to work with other departments, notably marketing. To stimulate this ability, some large companies systematically send young, newly recruited researchers to spend a certain amount of time in the marketing teams, and vice versa.

"Upon joining the company, young hires in marketing are trained to be able to understand the research constraints, safety standards, etc. Newly required researchers also spend some time in marketing." (HR manager of a large company - Japan)

Collaboration with other research organisations represents another teamwork environment. As part of cooperation between the public and private sectors, the private sector professional must make sure that the academic teams understand the benefits of such cooperation, if he is to gain their confidence. This means considerable interaction between the professional and his partners, and an awareness of how the latter operate.

"Since industry and academia have differing interests, research professionals must establish a climate of understanding between the two worlds, if the collaborative projects are to succeed." (Director of a group's research centre - Finland)

ii. "Networking" or an ability to work in a network

In the opinion of all of the interviewed directors, a researcher's ability to work as part of a network is now another key competence at the heart of research, both in the public and private sectors.

"The ability to develop a network is a key competence. Five years ago, Networking wasn't viewed as important, but now the entire scientific community understand its importance." (University researcher - Germany)

As the number of researchers is often limited, research teams are no longer able to undertake very large research projects, and therefore need to turn to external human resources, or to outsource. There is thus a growing need to develop and maintain a scientific network upon which the researcher will be able to call with regard to collaborating.

"This competence can be described as an ability to "work in the ecosystem", which means an ability to identify key partners for a research project." (Director of a private sector research laboratory - Finland)

In the public sector, a good network allows researchers to remain informed about the various funding mechanisms existing in the domain. Moreover, "networking" allows research teams to respond to multidisciplinary calls for projects, and therefore to reach new funding sources.

Also, when the private sector is faced with the delocalization of certain research activities, the private sector researcher must be able to identify reliable partners and to control the risks of any collaboration.

"In the private sector, "networking" is more difficult to implement, since the research must simultaneously protect itself relative to the competition." (Director of an industrial chemistry laboratory - Germany)

For all of the interviewed directors, scientific networks are essential both outside of the research institution, and within it.

"The group assesses the ability of its researchers to create links with colleagues within the company. As a result of the long R&D cycles in aeronautics, it is indeed essential for a researcher to pass his knowledge on to the other team members so that the projects will be able to continue even if the researcher retires or changes positions." (Scientific director of a large group - Netherlands)

With regard to developing the capacities for promoting the ability of young researchers to work in a team or network, several figures in the research world insist on the need to go further with the cooperation between departments and disciplines within universities.

"Up to now, interpersonal skills were developed primarily in the workplace, since the universities did not particularly stimulate teamwork during the education of young scientists. Nevertheless, in the last few years, several establishments have understood this need for competencies and have begun to encourage networking between research teams." (Research director for a private sector laboratory - Finland)

"The department has set up a special budget to allow researchers to attend scientific conferences and events, and to co-finance post-doctoral programmes with American universities. It is therefore important to stimulate networking right from the young researcher's formative years, since this network will be useful throughout his career." (University professor - Germany)

iii. Communication skills

For most people in the research world, research professions include a significant "communication" component on all levels. The researcher must be able to communicate with his peers, with his team and with the public at large. As previously indicated, the researcher must be able to exchange and to communicate with professionals in different disciplines, such as to take part in collaborative research projects.

This ability to communicate is also decisive for project promotion and for attracting the funding needed for its realisation.
This is particularly true in the public sector, notably after the many reforms that have provided universities with more autonomy in several European countries and in Japan. It is also true in the private sector, in which one must be able to "sell" a research project to one's non-scientific colleagues so that the company will validate and support it. However, whether in the public or private sectors, there is a virtually unanimous finding that there is a considerable lack of communication skills.

"In the public sector, many team members have trouble correctly drafting a scientific article." (Director of a university laboratory - United States)

"Most researchers don't know how the draft responses to calls for projects, which can then prevent them from obtaining funding for their research." (Public sector research director - Finland)

Even though several public and private sector research organisations have programmes intended to enhance the communication skills of their personnel, most of the people involved in both sectors agree that the best way to develop such skills would be to include them in the university curricula.

"University programmes do not do enough to develop the oral and written communication capacities of young researchers. It's therefore indispensable for higher education establishments to include communication training, as some of them have already done." (Director of a private sector laboratory - United States)

"My university offers workshops for students so that they can practice their communication skills by role-playing interviews in front of a camera, or simulating academic presentations. While some students do not see the point of such training, many of them make extraordinary progress, even without realising it. This was notably the case of a student in physical sciences who, after this training, was able to convey her academic excellence to specialists in other disciplines, leading to her being accepted in a post-doctoral programme in a medical school." (Director of a university guidance department - United Kingdom)

iv. Language skills

In a context of the internationalisation of the needs for researcher competencies, research projects are increasingly involving teams of researchers of different nationalities. Whether within a private company that has research centres in different countries, or as part of an integrated university laboratory where foreign researchers are working, everyone in the research world agrees that researchers must communicate in a clear and fluent manner. As such, in their view, a mastery of English is inescapable for anyone working in the research world.
In addition to being a communication tool, fluency in a foreign language is also indicative of the researcher's openness to the world, and of his "multicultural posture". For that reason, "Anglo-Saxon" and American research structures require their researchers to also be fluent in a foreign language.
In the research professions, language skills are often a hiring prerequisite. In some cases, fluency in a foreign language can be a key success factor in a research position. This is true for English, and sometimes for other languages as well.

"The required level varies according to the position's level: on the executive level, all communications within the group are in English, and on the non-executive level, this requirement can nevertheless be adapted." (HRD of a SME - Switzerland)

"In a globalised scientific world, a company present in China can easily find a Chinese professional who speaks English, in order to direct a research centre in China. This means that British research professionals who can only speak English and who apply for a management position are sometimes disadvantaged relative to foreign professionals who speak another language in addition to English. Independently of the omnipresence of English in the research world, knowledge of a foreign language is therefore always a strength for a research professional." (Public sector research director - United Kingdom)

The various key research players agree that it would be very useful for university education to include foreign language courses. If some people at times seem reticent, it's because of the difficulties that this can mean for students. Nevertheless, the countries traditionally open to foreign languages and that have introduced foreign language courses in their university curricula have increased the ability of their researchers to work with foreign partners. This is the case of Switzerland, the Netherlands and Finland.

v. Ability to assess

In the industrial world and in the academic world, an ability to assess the work of others is an essential competence for scientific progress. Though a pillar of academic work, this competence is also very important in the private sector, in which researchers have to give their opinion on the research undertaken by colleagues, and must obtain feedback on their own research. With this outlook, some companies are stimulating the ability of their research personnel to provide and to come to terms with feedback.

"Our researchers receive training on how to carry out an interview, in which their task is to provide feedback to team members, notably ones whose performances are not considered to be satisfactory." (HR manager of a large company - Switzerland)

The ability to critically review the work of others is well-established in the private sector, but is also becoming very important in the public sector, according to the interviewed directors. This assessment, based solely on criteria of excellence, allows researchers to compare the progress of their research relative to the project's objectives. Moreover, several private sector research groups regularly publish their results in academic journals.

• Management competencies

The ongoing developments in the research world are strengthening the needs for project management and team management competencies. Indeed, whether in the public or private sectors, researchers must increasingly manage their work within a "project" setting, and provide reports on it.
Also, as a result of the various career pathways that the scientific world now offers to research professionals[21], a certain number of researchers are likely to evolve towards other professions that will take them further away from their pure research function. Through his career, a researcher may have to choose between a position as a scientific expert, or a management position within his organisation.

"In general, companies assess the ability to assume positions of responsibility when hiring scientific profiles." (Scientific director of a large group - Netherlands)

Indeed, there is an entire range of research professions that do not exclusively require scientific knowledge, notably ones surrounding research management. To succeed in these professions, scientists need certain competencies that are not traditionally associated with research professions.
In the private sector, administration and management have always been part of the competencies expected from research professionals. Today, in the context of the transformation of public sector research, research professionals are also being called on to become managers. According to all of the key research players, the need for management skills is now a reality, irrespective of the sector.

"The private sector's requirements remain higher in terms of management capacities. Unlike in the academic world, if the research project doesn't reach 100% of its objectives, it's considered to be a failure. Private sector research is answerable to its investors, whereas this isn't always the case in the public sector." (Director of a private sector laboratory - United States)

i. Business culture and management skills

Today, and even more so in the future, according to everyone from the research world, a researcher must necessarily be able to understand how the company operates, irrespective of the passion that drives him and notwithstanding the project. As such, any notion of budget and accounting management is desirable. Also, the researcher must have a minimum amount of corporate culture and economic culture.

"Science isn't possible without the management of science" (Director of a public sector research centre - France)

On top of these expectations are ones involving basic knowledge regarding intellectual property. Though obviously without expecting the researcher to become an expert in intellectual property law, everyone interviewed as part of the study mentioned the need to grasp at least the basic context and the stakes, so as then to have the right reflexes and to be able to protect the fruits of one's efforts.

[21] *On this point, see part III.2 of the management report on researcher careers*

"Developing basic notions of industrial property is indispensable. Young researchers don't know these principles. This topic should be part of the education, since it's a common competence to all industries and is particularly necessary in the pharmaceutical industry, where the development times are long." (Researcher in a large group - Finland)

ii. Project management skills

Under the umbrella of these competencies, we can also add an ability to put together research projects (establishing a consortium, by gathering the necessary competencies, drafting an application while presenting a convincing project, securing funding) as well as managing these projects once they have been launched.
Relative to these two aspects, the interviewed directors indicate that project management competencies are becoming a key competence for the researcher's profession, and that this will increase in the coming years,.

- Ability to put together research projects and to "secure" funding:

This competence includes an ability to find pertinent partnerships, means for cooperating within a common team, the identification of possible funding sources and the presentation of critical applications.

"The system and legal framework surrounding research have changed a lot in the last 15 years, in all countries. Consequently, researchers are increasingly asked to find funding for their research, both in the public and private sectors. This had already been the case in disciplines such as biology and medicine, but the trend is becoming more widespread now in all scientific domains, including human sciences. Scientists must therefore come to grips with new competencies, since these days, they're being asked not only to be good scientists but, later on, to become good project managers, team coordinators and even company directors". (University director - Switzerland)

- Knowledge and experience in project management methods (including budget management and "reporting"):

Once the projects have been put together and the consortia formed, the people looking after the project management must steer the analysis of the costs, budgets and schedules needed for the proper realisation of the research objectives, but also develop partnerships or exchanges with other teams working on similar subjects, manage the mobilisation of resources throughout the life of the project, monitor its progress and report at the various steps in the project's life. Finally, they are expected to provide the scientific communication and to see to the project's intellectual protection.
In reality, and all of the interviewed directors confirm this, all of these missions are most often looked after by researchers. These researchers can sometimes rely on support functions, and even dedicated project management support teams within large groups, certain universities or public sector research centres. Over the course of their careers, researchers must therefore be able to progressively assume this project management.
Over and above these project management skills, some people feel that it is necessary to improve the understanding and ability to create research-specific "business models".

"In my industrial sector, in addition to leading-edge technical knowledge, the key to success is often having a good business model." (Research director of a large group - Netherlands)

"In the development of new technologies, it's often the formulation of a solid business model that will mean a scientific discovery's success." (Scientific director of a large group - France)

"When working on innovative products, there aren't any existing business models, so you need to create them." (Public sector research director - Finland)

But while there is currently a growing awareness of the need to develop management competencies amongst research professionals, the professionals who have these same competencies are few in number and therefore very quickly come to be prized in the research world.

"In my company, the most sought-after profiles are now the ones that have a double background in science and management, for example scientists who also have a MBA." (Laboratory director in a large group - France)

iii. Ability to manage and steer teams

Even though the ability to steer a research team has always been one of the expectations facing a researcher during the course of his career, this element is becoming key in a quickly developing research world, in the opinion of the directors interviewed during this study.

"Finally, more than ever, research teams need and will increasingly need managers capable of recognising and taking into account the constraints and dynamics of the researchers. In return, the latter must recognise and understand the constraints of the managers: constraints of the company employing them, constraints of the target market, constraint of the return on investment that is indispensable in order to keep going..." (University director - France)

- Ability to steer and coordinate the teams in the direction of a research objective:

A research manager must be able to guide his team's members towards reaching the objectives of a research programme, while also supporting them at the various key moments in the realisation of this same programme. This obviously includes the ability to manage various personnel categories within a given team.

"Managers have to be able to say "I have to help my team evolve in the direction of the research field that my group needs". Similarly, within the company, it's often difficult for teams to accept that the subject of their current study may well not be very innovative and that it may not elicit great interest from academic publications, but that it's nevertheless important for them to continue the research given that the subject is of interest to the group." (Scientific director of an industrial group - France)

"It's too bad that young doctors have no notion of personnel management and therefore, for example, don't understand the motivation of the technicians working in their laboratory. In the absence of particular attention devoted to the various personnel categories, the turnover amongst technicians was very high and represented a considerable waste of energy on the level of the laboratory, since new personnel constantly needed to be trained." (Director of a research centre - United States)

More globally, the key research players now find that researchers, scientists in particular, often have trouble grasping the skills that are needed to serve as a manager.

"A very good researcher isn't necessarily a good manager. A manager has to focus mostly on managing the projects and teams, and can't devote as much time to research. Research and management involve very different states of mind." (Director of a competitive hub - France)

While several of the interviewed research directors stressed that management competencies are not indispensable for young researchers, they recognise that the latter must at least have some basic notions such as to be able to speak a common language. Even if still not in a supervisory position, it's important for a scientist to understand the management codes, since this will facilitate communications between the supervisor and the supervised, as well as strengthen cohesion within the team.

- Management of risk-taking:

For the participants in the research world, the research manager, and even the researcher himself, must also develop a risk-taking culture that is currently not very widespread within the scientific community.

"A culture of risk-taking is an essential element of the competencies of a research professional. Professionals cannot be content with simply receiving instructions all the time. As the research professional assumes managerial responsibilities, he must understand that risk-taking is important, and that it must be managed and controlled." (Research director - United Kingdom)

"The ability to take risks is often linked to cultural factors." (Director of a scientific campus - Netherlands)

"Though management competencies are difficult to assess during an interview, it's nonetheless possible to assess a candidate's ability to overcome a risky situation, by putting this person in a difficult position during the interview." (Research director for a group - Japan)

- Leadership / Ability to drive and motivate:

The ability to drive and motivate a team presupposes an ability to overcome setbacks. This latter competence is regularly mentioned by figures in the research world, as one of a researcher's indispensable attributes. In management terms, the team manager must be able to manage setbacks, and if there is a setback, to re-motivate, redirect and support the team after the setback. This is even more important in the research field, where uncertainty is the order of the day and setbacks are more frequent than elsewhere.

In the eyes of laboratory directors, especially in the private sector, leadership is crucial. Some laboratory directors feel that no training can provide this leadership ability. It is first and foremost a behavioural competence, one that is inseparable from scientific competence. However, most of them feel that it is not a great obstacle for a scientist to be "somewhat lacking in performance terms" if this person has the necessary human skills to be a team leader and if, otherwise, the team is scientifically very strong.

"Leadership is an area in which work is still needed. For years, researchers are trained to concentrate on the science, they have no team responsibilities, even when part of a team. They therefore assume these responsibilities for the first time within the company, which is a challenge. They're therefore provided with support through management and leadership training, so as to be able to acquire these competencies." (HR manager of a large group - Switzerland)

"No university teaches one how to be a leader. In the scientific world, it's a quality that comes from a mixture of respect relative to scientific skills and more innate human skills. For us, it's better to be a somewhat less brilliant scientist but to have the necessary human skills to be a team leader. People who don't have human skills also have a place within the company, but it's not the best thing. If people don't communicate with the team, the whole team suffers and deteriorates." (Director of a large company's laboratory - France)

- Ability to build a powerful team:

For the people in the research world, a manager who knows how to put together a powerful research team must be able to identify and develop the necessary competencies. To this end, he must take the necessary time to learn about and develop the potential of the professionals working with him.

"To work efficiently within a team, the research manager must understand the competencies needed for each research project and be able to identify the people who have them within the team." (Public sector research director - Finland)

"In terms of the development of team management competencies, there are management concepts that are specific to the research world, even though the principles are the same as for the management of other activities. The general basics must be learned while at university, in order to then continue developing specific management skills during the research carried out in the workplace. The important thing is to acquire these principles before entering the labour market." (Research director - United Kingdom)

In the private sector, and notably in large groups, there is also a concern to set up a talent incubator of researchers who have managerial skills, as well as a good understanding of the "stakes of the professions".

iv. Awareness of the pertinence of the research and its impact on the environment.

- Considering the pertinence of the research:

Most of the interviewees insisted on the fact that all properly thought-out research begins with an understanding of its commercial and financial stakes. In an economic context in which it is difficult to find research funding, this applies to both the private and public sectors, and all scientific disciplines, both in fundamental research and in applied research.

"Even in fundamental research, it's crucial to be able to convince industry that the research could later lead to applied research." (University professor - Germany)

"Within companies specialising in applied research, the research must lead the development of a project or product. It's therefore important to always have an idea of the pertinence of one's research, in terms of commercial and financial stakes, independently of the type of research or business sector." (HRD of a large company - Japan)

This requirement is very pronounced in the private sector, primarily as a result of economic and financial constraints, but less so in the public sector.

"It's important for a research professional to keep in mind that his research fits into a business context. Every researcher must give some thought to the cost of his research, with attention to the quality of the products that will stem from the research." (Research director for a group - Japan)

"Research professionals must now have notions of marketing, notably in order to understand what makes a product attractive for the end-customer." (Researcher in a private laboratory - France)

"Unlike in the academic world, one of the main objectives of any research in industry is to generate profitability for the shareholders. No researcher can get away from this notion. The return on investment and profitability aspect must be clear in all research." (Director of a private sector laboratory - United States)

For many of those interviewed, the ability to take into account the pertinence of research is now the most important of all the competencies.

"R&D cycles in the pharmaceutical sector have grown even longer in recent years, due to the complexity of the regulations governing the industry. Researchers must therefore be capable of understanding what the market demands, focusing on the research the market wants, and translating the commercial potential of the molecules they study into products. This will minimise the time spent on research and maximise the efficiency of the R&D cycle. This competence is thus a key factor for the efficiency of this industry, but for many others, too. The more a scientist is business-oriented, the more he is aware of the potential for applying his research, and the greater his future career opportunities will be. The researcher of tomorrow will need to retain all of his scientific excellence while also being able to think in terms of market potential". (HR manager of a pharmaceutical company - Switzerland)

The majority of research managers feel that this competence is not sufficiently developed in the research world.

"Researchers don't sufficiently consider the pertinence of their works in terms of industrial or market development. This is because most university professors come from a purely academic background. Attention to industrial development and the securing of markets should be included right from the school years." (Director of a private sector laboratory - Finland)

- Considering the consequences of the research on overall society:

Over and above its commercial and financial objectives, science these days has a very important responsibility to society as a whole. Modern science provides not only consumer products, it also proposes solutions to social problems such as improving the quality of fruits and vegetables or combating climatic warming or even in order to combat the propagation of infectious illnesses. New competencies are therefore expected from research professionals since, on all levels and in all countries, societal stakes have led to an in-depth change in how research is carried out.
Research professionals are also obliged to consider the social implications of their research.

"Our organisation assesses the social pertinence of all projects that it finances, on the basis of the impacts that these projects could have on society and on the country's economic development." (Public sector research director - Finland)

"Our company develops its research subjects on the basis of societal questions such as mobility, sustainable development and urban planning, while always asking to what extent technical progress could help to resolve these social problems. This awareness is therefore closely linked to the ability to formulate new scientific issues." (Scientific director of a large group - Netherlands)

"In our company, the bonuses for senior executives depend on the success of their research in terms of reducing the group's ecological impact." (Director of a research campus - Netherlands)

Queried in this regard, the people involved in research find that most young scientists share the social concerns, and have therefore thoroughly integrated them into the choice of their research priorities.

"While avoiding the trap of automatically assuming that the "bandwagon effect" often leads to research with little pertinence for society, today's students want to know what the benefits of a research subject will be to society. Certain actors point out that this concern has gained ground with the current economic crisis and is currently one of the main factors driving changes in university education." (Research director - France)

Personal aptitudes that are equally decisive amongst the expected competencies

Over and above scientific and management competencies, other characteristics are expected of the future researcher. These are personal characteristics and everything having to do with life skills.

i. Creativity

Together with scientific knowledge, creativity is at the core of a researcher's profession. All of the other competencies would lose their interest value without the researcher's ability to go beyond what is already known and to head towards new horizons. To this end, a researcher's ability to be creative by imagining new solutions, but also new questions and new research techniques, is considered to be a key element by all of the interviewed key research players.

"What makes the difference between a research professional and a professional in another profession has a lot to do with creativity. Companies want motivated researchers who are able to innovate." (Public sector research director - United Kingdom)

"We devote considerable attention to the extracurricular activities of candidates and to the initiatives taken during their university years. This allows us to assess the candidate's creativity." (Laboratory director for a large group - Japan)

ii. Open-minded approach

Another factor often studied by employers is the open-minded approach. This open-mindedness is in part tied in with the creativity (in terms of an ability to move beyond the familiar), and in part to an ability to work in a team, particularly within multicultural teams.

"We look for professionals who have a range of interests. If we have to recruit a mathematician, we prefer to hire a mathematician who plays music in his spare time, rather than a mathematician who spends his evenings studying the theories of his discipline." (Scientific director of a large group - Netherlands)

iii. Motivation and involvement

Motivation and involvement are not attributes specific to the researcher. The expectations in this regard are similar, irrespective of the profession. However, these competencies were clearly mentioned by the interviewed key research players as being decisive elements for a researcher.

"In our company, recruiters look for professionals who can make an impact on the organisation and provide something to the company's life." (Laboratory director in a large group - Germany)

"The most interesting profiles are the ones that are motivated by the research itself and by the possibility of its success, which is indicative of their degree of curiosity." (Scientific director of a large group - Netherlands)

iv. Adaptability

Given the new horizons for research and the economic constraints, scientists are expected to be able to demonstrate adaptability.

Researchers are sometimes required to assume responsibilities that they had not envisaged, for example as laboratory manager or in the event of expatriation to a foreign research centre. After a periodic assessment, they may have to change fields and research projects. They can also be required to broaden the field of their research.

"Research professionals very often have trouble adapting to extended responsibilities, even though the ability to change positions as part of the career development is a strong expectation amongst recruiters." (Director of a competitive hub - France)

However, as a result of the great specialisation required for their scientific training, research professionals naturally have trouble changing fields of study or broadening the scope of their research when they arrive on the labour market. It is nevertheless true that an ability to regularly reappraise one's research programme and to judiciously abandon certain projects is now considered to be a great strength for a research professional.

"Faced with the uncertainty and instability that characterizes the overall world and the research world in particular, new ways of doing things are being imposed, every researcher must now do what he was trained for, but also be ready to change fields and research projects if necessary. More than ever, researchers must be adaptable and able to "re-learn", while still maintaining their very high level of sophistication in a cutting-edge domain". (University director - France)

v. Ability to self-assess: properly knowing and appraising oneself, and knowing what one is worth

At the end of his education, a young doctor is a professional with a high potential based on academic competencies. He has very precious scientific expertise and an ability to analyse that are both of interest in the eyes of a future employer. However, employers don't always understand a young doctor's added value. Similarly, the young doctors - often extremely focused on their research work - have trouble promoting themselves to their future employer. A research professional must therefore thoroughly "know himself" and know how to highlight the skills in his possession.

For young researcher, this awareness of "what he's worth" involves a prior analysis of his path up to that point and of his own competencies. He must also be able to understand his potential role within the organisation that he wishes to join. This will be indicative of his motivation and desire to get involved. In a particularly difficult economic context, a professional must be able to stand before his future employer and explain what he can do for the latter. In other words, it isn't enough for him to know what he can do, he must be able to position his abilities relative to the employer's expectations, and to grasp to what degree they correspond with what the employer is seeking. According to several interviewees in the study, this competence is seldom grasped well.

In order to stimulate an awareness of their own skills, certain people met as part of the study propose that a feedback culture should be promoted within the scientific community.

"A professional who gets regular feedback on his work becomes aware of his own abilities. Consequently, he'll be better able to draft a CV, to apply for a position and to get through a hiring interview." (Scientific director of a large company - Netherlands)

Expectations that vary according to the research structure (public or private) and the researcher's profile (junior / senior)

i. Competences very much dependent on the nature and composition of the structure's teams in which the researcher works

The more developed an organisation's research support structures, the more its expectations regarding the competencies of its researchers are precise and focused on specific areas of expertise. In large structures, support and back-up functions allow the researcher to focus on his/her core activity.

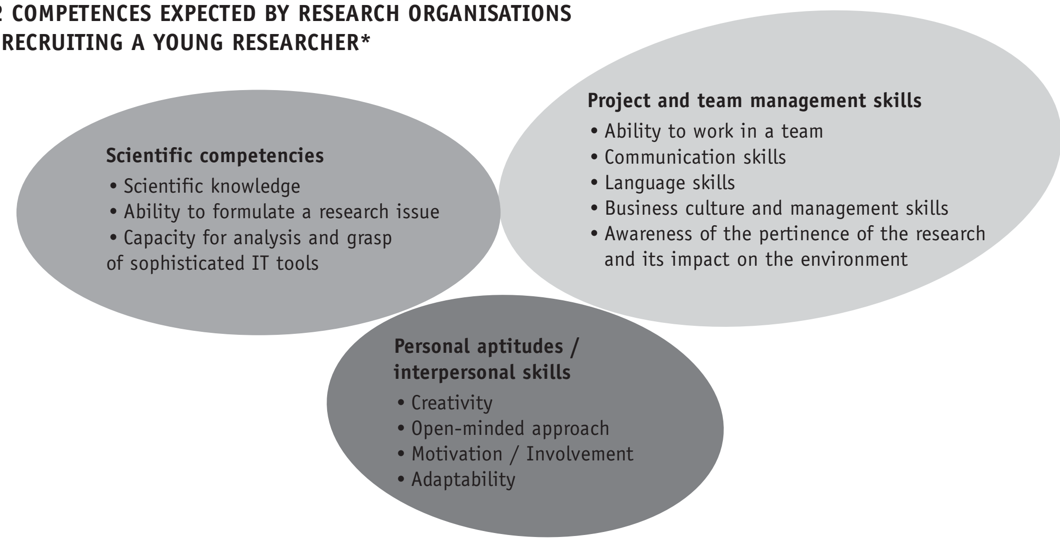
"We want to keep marketing apart from science. We don't want the marketing people to dictate the research programme for the researchers. Consequently, it isn't essential for researchers to have any notions of marketing." (HR manager of a large group - Switzerland)

ii. Specific expectations when recruiting a young researcher, depending on whether he will be joining a public or private structure

THE COMPETENCES NEEDED IN A RESEARCHER TODAY AND BY 2020

For all of those interviewed, twelve competencies are currently decisive and will remain so in the years ahead, when recruiting a newly qualified researcher.

THE 12 COMPETENCES EXPECTED BY RESEARCH ORGANISATIONS WHEN RECRUITING A YOUNG RESEARCHER*



* In the 8 studied countries (France, Germany, Finland, Netherlands, the United Kingdom, Switzerland, Japan and the United States)

Source: APEC / DELOITTE Study 2010

There are currently real differences between private and public sector when it comes to the recruitment of young researchers: in the public sector, they are recruited almost exclusively on the basis of scientific excellence, whereas the private sector tends to look for a broader range of competencies (communication skills, languages, etc.). The stated aim of many public sector recruiters nowadays, however, is to develop recruitment practices that cover all of the listed competencies.

"We ask a young researcher to have a good level of scientific knowledge, as well as of oral and written communication." (Director of a research centre - Switzerland)

"The fact of being multilingual is key." (HRD of a SME - Switzerland)

"When recruiting, the following are necessary: creativity, in-depth scientific competencies, communication and team spirit." (R&D director for a large group - Japan)

"Scientific knowledge is key in a young researcher. We first of all look at his list of publications. Also, the ability to formulate a research issue is decisive. In fact, during the competition, we ask the candidates to formulate a research subject. The first indicators when recruiting are therefore an ability to publish, and an ability to formulate a research issue. Two other aspects are important: communication and a grasp of foreign languages." (Director of a public sector research centre - France)

"To succeed in R&D in the United States, you have to have some notions of management and marketing. But when it comes to hiring, the attention is primarily focused on scientific competencies. Management skills can then be acquired within the companies." (Research director of a large group - United States)

"When I'm interviewing a young graduate, the competencies that I look for first of all are scientific and technical, and interpersonal skills thereafter. If a student has managed to obtain a doctorate, he'll be able to learn management skills, and that's part of the training when joining the company. The company can train its young researchers in these aspects, so it doesn't give them much priority." (Research director of a large group - United States)

"It would be nice if scientists had management skills, but when they arrive as newcomers, it's not expected that young hires will have any. In the middle of their career, yes. But they can develop them." (Research director of a large group - United States)

"The expectations in terms of management competencies depend on the researcher's level. Networking, an ability to learn and to assess, these are things that can be developed once they've joined the company." (Research HR manager of a large group - Switzerland)

"We don't expect newly hired young researchers to have competencies in intellectual property." (Research HR manager of a large group - Switzerland)

FOR 11 SKILLS CONSIDERED TO BE “DISCRIMINATING”, THE PERCEPTION OF THE LEVEL OF CURRENT PROFICIENCY VARIES CONSIDERABLY FROM ONE COUNTRY TO THE NEXT

According to all the research organisations questioned, there is a disparity in the current levels of eleven decisive researcher competencies among countries and in particular among European countries (see table below). The overall perceptions of the various interviewed organisations about the level of researcher competencies in each country do not allow conclusions to be drawn regarding the level of research performance, which is altogether separate from the number of mastered competencies.

Most countries need to make improvements in order to reach a high degree of proficiency of the six key competencies required for the future. Furthermore, the diversity of the competencies mastered, as perceived by research organisations in certain countries, is indicative of an efficient learning system, particularly in the case of newly qualified researchers.

Finally, a high degree of proficiency of certain scientific competencies coupled with a lower level of proficiency in other competencies, as is the case in France and Germany, reflects philosophies of higher education that differ from those of other countries, such as the USA and Switzerland.

Level of researcher competencies by country: perceptions of all those interviewed

	discriminating competencies	Germany	United States	Finland	France	Japan	Netherlands	United Kingdom	Switzerland
Scientific	Capacity for analysis★ and grasp of sophisticated IT tools	Well mastered	Relatively mastered	Well mastered	Well mastered	Relatively mastered	Well mastered	Well mastered	Relatively mastered
Scientific	Ability to work in an★ interdisciplinary environment	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered
Project / team management	Ability to work in a team	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Well mastered	Relatively mastered	Well mastered	Well mastered
Project / team management	Ability to develop★ a network	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Relatively mastered	Well mastered	Well mastered	Well mastered
Project / team management	Communication skills	Relatively mastered	Well mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Well mastered	Relatively mastered
Project / team management	Language skills	Relatively mastered	Poorly mastered *	Well mastered	Poorly mastered	Poorly mastered	Well mastered	Poorly mastered *	Well mastered
Project / team management	Business culture★ and management skills	Relatively mastered	Well mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Well mastered	Relatively mastered
Project / team management	Project management★ skills	Relatively mastered	Well mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered	Poorly mastered
Project / team management	Ability to manage and steer teams	Poorly mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered
Aptitudes	Awareness of the★ pertinence of the research and its impact on the environment	Relatively mastered	Relatively mastered	Poorly mastered	Poorly mastered	Relatively mastered	Relatively mastered	Relatively mastered	Relatively mastered
Aptitudes	Creativity	Relatively mastered	Well mastered	Relatively mastered	Relatively mastered	Poorly mastered	Relatively mastered	Well mastered	Well mastered

Non-discriminating competencies: *Scientific knowledge, ability to learn and adapt, ability to formulate a research issue, ability to incorporate existing knowledge, ability to assess, open-minded approach, motivation / involvement, adaptability, ability to self-assess*

Source: APEC/DELOITTE Study 2010

Well mastered *Relatively mastered* *Poorly mastered*

★ *Key competence in coming years*
* *Language skills: Poor foreign language skills are less of a handicap here than in other countries, since a grasp of English is a considerable advantage in the research world.*

Examples of how to read the table: For everyone involved in research, the broadest range of competencies mastered is found amongst US and UK researchers, and the narrowest range amongst French and Japanese ones. Of the eleven discriminating competencies, all of the interviewees identified two that are no more than adequately or even poorly grasped in all of the countries studied: the ability to manage and steer teams, and the ability to take into account the environment and its development.

The remaining 9 competencies are described as non-discriminating in two situations:

- Perceived as well mastered in all of the countries: scientific knowledge, open-minded approach, motivation / involvement, ability to formulate a research issue,
- Perceived as poorly mastered in all of the countries: Ability to learn and adapt, ability to incorporate existing research, ability to assess, adaptability, ability to self-assess.

Two so-called "discriminating" scientific competencies that are "well mastered" or "relatively mastered" in all studied countries.

• A capacity for analysis and a grasp of sophisticated IT tools"

With regard to the researchers in five of the eight studied countries, all of the interviewees considered this competence as "well mastered". This is truly a strong point for Germany, France and Finland.

"IT competencies have been well integrated on the level of the current university educational programmes." (HR manager of a pharmaceutical company - Switzerland)

"Young researchers who are working on their thesis or masters degree arrive on the market with these competencies. These people have good IT training." (HR manager of a public sector research centre - France)

"The IT skills have been very well developed, the people feel comfortable using IT tools. In general, scientists expect to have access to advanced machines and techniques when they join us, since their work is very dependent on this type of analysis." (Private sector research director - United States)

"German students constantly work with complex software programs, even on the master's level. There's good familiarity with the tools." (University director - Germany)

• Ability to work in an interdisciplinary or multidisciplinary environment

Of the eight countries studied, Dutch researchers are the ones perceived by all of the interviewees to have mastered this competence "well", with researchers from the other countries mastering it "relatively".

"Delft University in the Netherlands has integrated the question of multidisciplinarity into its programmes by eliminating single-discipline faculties and diplomas." (Former researcher in a non-university institute - Germany)

"Multidisciplinarity is a true false problem. It's better to have solid specialisation. You can't do otherwise. A researcher who hasn't specialised will never produce publications, but he must be able to communicate with other disciplines." (HR manager of a public sector research centre - France)

"It's a big problem in Germany because of the high level of specialisation of both faculties and research projects." (University director - Germany)

"In Europe, universities are not accustomed to interdisciplinary work. American universities have developed this type of model to a much greater degree. Many high-level European universities are motivated to begin this type of work, but in this regard, there's a more long-standing tradition than in the United States." (Director of a research centre - Finland)

"In Dutch universities, there have been quite a few developments to make students work with students in other disciplines. It's taking on scope, but it's not yet fully in place. Relative to other countries, the ability of Dutch students to work with interdisciplinarity is good." (Ministry for research - Netherlands)

More uneven levels of mastery for project and team management competencies

• Ability to work in a team

In all of these to the countries, there is little to discriminate how the level of mastery of this competence is perceived:"well" or "relatively" mastered.

"There's very good potential for engineer profiles. One of their main strengths is their ability to work well as part of a team." (R&D director for an international group - Japan)

"Young researchers think that in practice, everyone works on their own, and that it's individual excellence that leads to success in research. The research context in France is not favourable to teamwork since the system recognises the individual, not the collective." (Director of a public sector research centre - France)

"The reputation of the Netherlands is good in terms of teamwork." (Ministry for research - Netherlands)

"In Germany, the ability to work as part of a team is developed well as part of the programmes on the master's level, through various team projects. It's less developed on the doctoral level, there's more of an individual relationship with the thesis supervisor. As such, this competence is not sufficiently developed during the doctoral training." (University director - Germany)

• Ability to develop a network

As with the previous aspect, this competence has little to discriminate how the level of mastery is perceived by the interviewees from all of the countries:"well" or "relatively" mastered.

"Dutch scientists are very good at networking. It's tied in with their good mastery of several languages. The large number of articles co-written by Dutch and foreign researchers is a good indicator of this ability." (Public sector research director - Netherlands)

"The ability to develop a network depends on personal strategies and the ability of the researchers to manage their time, as well as their mastery of foreign languages. Some manage to publish, communicate and develop a network. Others over-protect themselves, and stay too isolated." (Director of a public sector research centre - France)

"Networking is not as well developed in Germany as it is in France. In France, doctoral students are more connected with one another. In Germany, they're dependent on their faculty rather than on a university, so they don't know one another." (University director - Germany)

• Communication competencies

All of the interviewees perceive the researchers in the studied countries as not having a similar level of mastery of communication competencies. At the two extremes, on the one hand are English and American researchers (with a well mastered level), and on the other hand are French and Japanese researchers (with a poorly mastered level).

"With regard to communication competencies, "Anglo-Saxon" university traditions were already very advanced 20 years ago. In Europe, communication competencies were not very widespread. It's progressing now, but they're still far behind the level of "Anglo-Saxon" universities." (Public sector research director - Switzerland)

"It's one of the weakest competencies today in the research world. Significant progress has been made thanks to the integration of communication techniques into programmes, but scientists are still weak in this area." (HR manager of a pharmaceutical company - Switzerland)

"As part of their doctorates, German students work with companies and have to give a report and oral presentation every six months. This builds strong communication competence." (University director - Germany)

"Dutch researchers have some weaknesses with this competence. This is seen during international scientific conferences, in which the Dutch don't present as well as the Americans or British." (Public sector research director - Netherlands)

"Communication is considered as something implicit by US and UK researchers, whereas French researchers consider communicating with society as something "unclean". In the science - society dialogue, a lot of progress is still needed, but it's evolving." (Director of a public sector research centre - France)

"French researchers lack communication competencies. In France, young scientists are taught to work alone, whereas it's the opposite in the United States." (Research director of a large group - Netherlands)

"Japanese students are very weak in written communications." (Director of a university research laboratory - Japan)

• Language skills

Two countries, France and Japan, will have to make considerable efforts in the coming years to improve how the proficiency level of the language skills of their researchers is perceived by all of the interviewees. On the other hand, the handicap is not so great in the United Kingdom and the United States, as mastery of English is a considerable advantage in the research world.

"The fact of being multilingual is key." (HR manager of a pharmaceutical company - Switzerland)

"The mastery of foreign languages in the Netherlands is excellent, almost perfect." (University director - Netherlands)

"Company directors can easily hire foreigners who speak English and another language. The British aren't so good at foreign languages, and that hurts them when it comes to interesting positions abroad." (Public sector research director - United Kingdom)

• Business culture and management skills

In parallel with language skills, the level of mastery of business culture and of management skills amongst French and Japanese researchers was perceived as being the lowest by the key research players. Nevertheless, in these two countries as in all of the studied countries, everyone considers these competencies as essential in the coming years.

"Management competencies are not developed at all. Very few researchers would be ready to take up the management of a research institute." (Director of a research centre - Switzerland)

"Basics in economics and management should be taught at university, so that people know the meaning of a profit and loss statement, they understand why growth is important... There is a significant shortfall in these aspects within academic curricula." (R&D director of a large pharmaceutical company - Germany)

• Project management skills

The level of mastery of project management skills by Finnish and Swiss researchers is perceived as being the lowest by the key research players. Nevertheless, in these two countries as in all of the studied countries, everyone considers these competencies as essential in the coming years.

"There are more and more researchers for whom science and administration are diametrically opposed. A young researcher is very well-trained in science, but will soon have to deal with project management. The "Anglo-Saxons" are better prepared for project management than the French." (Director of a public sector research centre - France)

"Researchers must now have management competencies. The problem is that there is a lack of competencies when it comes to applying for research projects, writing progress reports, and negotiating with backers and industry." (Public sector research director - Finland)

"During their education, German students have to carry out a big project in the last year of their master's degree. Project management skills are therefore well-developed." (University director - Germany)

"Project management is an area that could be better developed." (Research HR manager of a large group - Switzerland)

"Japanese students are very weak in project management." (Director of a university research laboratory - Japan)

• Ability to manage and steer teams

This competence is perceived as "well mastered" by all of the queried key research players, with regard to the researchers in five countries (United States, Japan, Netherlands, United Kingdom and Switzerland). Some countries also recognise their weakness in this regard.

"Team management is one of the areas in which the researchers are very weak. The university doesn't pay enough attention to this competence, the people are more involved in their scientific success, though the coaching of young researchers is essential." (University director - Switzerland)

"The managers at universities become managers because they're the best on a scientific level, not because they're good at managing. However, these people don't have the necessary competencies to steer teams. It's difficult to find scientists qualified in team management." (University director - Netherlands)

"On average, researchers aren't very good in this area, but that's because they're scientists." (Public sector research director - Netherlands)

"Leadership is also an area in which efforts are necessary. For years, researchers are trained to focus only on scientific matters. As such, even if they're part of a university team, they aren't responsible for other people. It's often only when these researchers join a company that they have to deal with this type of responsibility, which is a real challenge for them. It's often difficult for a researcher to assess the performance of people working for him. However, in-house training on management techniques and leadership have been set up within the company and are intended for them, which could help these researchers to acquire management and leadership competencies." (HR manager of a large group - Switzerland)

Two discriminating aptitudes

• The ability to take into account the environment and its development

In all of these to the countries, there is little to discriminate how the level of mastery of this competence is perceived:"well" or "relatively" mastered. In their view, researchers from all of the studied countries could improve.

"Young students expect science and research to be pertinent. They want to know what are the benefits of their research subjects." (Private sector technical director - Netherlands)

"Projects are assessed on the basis of the impact that they will have on society and on the economy. The scientific work must be excellent and pertinent at the same time." (Public sector research director - Finland)

"Scientists should be in contact with the business world and understand how it works. This should be taught as part of the programme, so that researchers will know the meaning of a profit and loss statement, and understand why growth is important. There's a dramatic lack of this type of learning in university education." (Research director of a large pharmaceutical group - Germany)

"The ability to take the research environment into account is well-developed, notably amongst doctoral students in engineering, that carry out their doctorates in cooperation with a company." (University director - Germany)
Creativity

Of all of the countries, in the opinion of the key research players, only the Japanese researchers "poorly master" this competence. Inversely, researchers in the United States, the United Kingdom and Switzerland have "good mastery" of this competence.

"The recruiting of international profile serves to mitigate some creativity shortcomings on the part of Japanese engineers at the time of hiring." (R&D director for an international group - Japan)

"The current education system does not promote creativity. There are no very creative people, and nothing encourages creativity." (Director of a public sector research centre - France)

"In France, young researchers coming from the university are often lacking in personality, creativity and autonomy." (Director of a biotechnology SME - France)

"Creativity is well-developed overall, that isn't a problem. The researchers have very good ideas." (Director of a public sector research centre - United States)

"One of the reasons that has prompted the government to modify its research funding method (by more extensively funding individuals rather than institutions) has to do with the desire to encourage creativity, the freedom to decide on one's research subjects..." (Public sector research director - Netherlands)

Paradoxes in the world of research professions:

Research professions have undergone many changes in recent years. The competencies required to succeed, whether scientific knowledge, project management skills or personal characteristics, are first and foremost those expected and stated by employers, and may sometimes seem paradoxical in many respects.

Share and protect the fruits of your research:
The advent of the knowledge economy means that, these days, research professionals are asked to both share and protect their research work. A researcher within a German group explains that, for example, even though collaboration with external partners is officially encouraged within his company, in reality, collaborative projects are difficult to implement for reasons having to do with protecting the group's industrial property.

Maintain your level of expertise and become a good manager:
Similarly, while researchers are now asked to become managers and to spend less time on research, they are also being asked to maintain their constant level of expertise and credibility.

Stay focused on your research project and be constantly open to the rest of the world:
On a scientific level, a research professional must remain focused on his research subject, but while being open to other disciplines. As explained by the director of a research centre in Germany, the current doctoral programmes require a very great deal of concentration on a research subject. However, it is required that research professionals should be able to work on different disciplines from time to time. Moreover, a researcher must be able to consider existing research surrounding his topic, but also be able to wipe the slate clean in order to innovate. A public sector research director in Finland indicates, for example, that within his organisation, innovation involves equally invention and the discovery of new knowledge, as well as the innovative application of pre-existing knowledge.

Be determined to reach your objectives and ready at any time to abandon a research project if it is not "profitable" Finally, amongst the human skills, a research professional must demonstrate great determination for reaching his objectives but, at the same time, he must be able to abandon his projects or change directions in order to adjust to his organisation's objectives. Today, this implies that a research professional must, over and above his love for science, demonstrate pragmatism in order to succeed in his professional career while responding to the expectations of the scientific community and, more broadly, of society.

A research professional must therefore be capable of flexibility, which is quite new.

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

HIGHER EDUCATION SYSTEMS ARE NOT ALL EQUALLY RESPONSIVE AND GEARED TO PRODUCING THE COMPETENCES EMPLOYERS EXPECT

The gaps relative to the mastery of the previously described competencies result directly from very differing philosophies and development notions for these competencies within the studied countries. While all of the countries have very developed higher education systems, the ideas differ as to what should be learnt at university and regarding the links between higher education and companies.

"In the end, the developed range of competencies is very different." (Director of a research centre - Switzerland)

The development rhythms also differ, which indicate either a need for some catching up or, in certain cases, growing gaps in terms of the produced competencies.

Philosophies and strategies regarding the development of competencies differ widely from one country to another, with the transformation of higher education systems proceeding at very different paces.

• Two countries far in advance: the United States and the United Kingdom

The United Kingdom and the United States have no qualms when it comes to tackling the question of non-scientific competencies and personal development, within doctoral institutes and more broadly as part of secondary and higher education. Reflections are underway in order to integrate these subjects into the educational offer.

"The universities are good in the United States and United Kingdom because they have a more entrepreneurial approach to education." (Research director in a private sector group - Netherlands)

i. In the United States, the learning of "soft skills*" is an integral part of the educational system, well before university.

"Soft skills" are very developed within American engineers, right from secondary school. On the other hand, in Europe, education focuses primarily on the intellectual development of individuals." (Director of a research centre - Switzerland)

Also in the United States, training modules have been developed on subjects ranging from "networking**" to project management. However, a strong distinction must be made between the major research universities (Harvard, University of California...) and establishments of lesser size in research terms. The former adapt better to the needs of research in terms of education.

"The programmes adapt well to transformations and to the needs. Universities propose courses in order to stimulate multidisciplinarity as of the bachelor's level." (Director of a research centre - United States)

"In the major American research universities, the needs are rapidly transformed into new courses so that the new generations will be well trained. (University researcher - United States)

* *"Soft skills" include both personal and interpersonal qualities, as well as human and relational skills.*
** *Ability to put together a network of contacts and knowledge within a professional setting.*

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ii. In the United Kingdom, there is a natural connection between universities and companies

"Universities contact the company on a regular basis in order to ask its opinion on the construction of their pedagogical models, particularly in the event of very specific scientific domains." (Research director in a private sector group - United Kingdom).

A national impetus was provided by the Joint Skills Statement. In 2001, the entire university system in Great Britain developed this common document that lists the standards and competencies expected from a university researcher.
Whether acquired by the researcher before his education, transmitted during the programme or developed personally, these competencies must be mastered by the end of the education period. They fall into seven categories: technical research competencies, the research environment, research management, personal efficiency, communication skills, the ability to work in a team and career management.
Prepared in collaboration with the Research Councils UK and the entire university system in Great Britain, the Joint Skills Statement was a true innovation as a result of its unifying character. Keeping very close to reality in the field, this theoretical construction has proven to be a useful tool for assessing the development of personal and professional competencies amongst post-doctoral researchers, and for developing the educational system.

Companies also expected universities to teach what they refer to as "transferable skills", namely relational competencies such as project management and team management. Within this framework companies provided support, including financial, for training programmes in doctoral institutes relative to non-scientific competencies, referred to as "transferable skills" in the United Kingdom.

The aim of such training is to develop generic personal, professional and research competencies. These competencies will be useful both during the PhD's research project and beyond, from the viewpoint of personal development and career management. Several objectives were targeted:
- supporting personal development,
- improving the ability to carry out a research project and to present one's work to a wide range of audiences,
- helping to improve the role of science within society,
- tackling aspects surrounding the appreciation of research, while presenting the commercial opportunities that could result from a research project,
- introducing / increasing awareness of ethics.
These courses also provide an opportunity to interact with students in other departments.

Financed by the government via the Research Councils and by companies, these courses have progressively spread throughout British universities within the last 5 years or so.

Example of courses available at the Imperial College
Designed to complete the teachings obtained within the departments, the courses cover the following subjects:
- Personal efficiency (notably including self-confidence, creativity, communication, Myers Briggs, "networking", stress management, time management),
- Presentation and communication competencies,
- Research efficiency (project management, negotiation, ethics),
- Statistics,
- Writing,
- Commercial and management competencies (entrepreneurship, intellectual property, introduction to accounting, introduction to marketing, introduction to organisations, introduction to strategy),
- Career management,
- Motivation,
- Interpersonal skills.

Students are required to pass a certain number of courses, the format of which varies from 1 hour classes to 3-day workshops. Online courses are also available.

Source: http://www3.imperial.ac.uk/graduateschools/transferableskilltraining

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While it is still too early to assess the impact of these courses on students, the overall assessment would seem to be rather positive. As such, 91.5 of the students who took these courses at the Imperial College indicated that they understood the benefits of such classes[22]. According to them, there are many benefits:
- the courses have a true impact on their behaviour,
- the programmes correspond well with their changing needs over the course of their doctorate, as they progress from the status of a young researcher to that of a doctor looking for work,
- taking these courses allows them to meet other young researchers, to share their experiences, to reduce their feeling of isolation and to increase their confidence in their ability to succeed.

Despite the national impetus, the reluctance within the ranks of professors can sometimes be considerable.

"Even in the United Kingdom, several department heads who have developed these competencies on their own feel that soft skills training is not necessary,
since the young people can develop them on their own. University education is therefore adapting very slowly." (Director of a university training programme on non-scientific competencies - United Kingdom)

It is once again worth noting the interest value of the work carried out by the Vitae association to precisely describe the competencies expected of a researcher, and to bring together many actors around these questions.

Along the lines of the Joint Skills Statement, Vitae carried out in-depth work to describe the competencies of researchers, in collaboration with higher education institutions. The initial objective of the Researcher Development Framework is the promotion of researchers and of university research. Several methods were used in order to produce this tool: querying of many researchers in order to identify the characteristics of excellence within their profession, magazines... The Researcher Development Framework also naturally includes many elements from the Joint Skills Statement (cf. appendix n°4).

• Three countries out in front: Germany, Finland and the Netherlands

In these three countries, the question of training researchers in areas that are not purely scientific has been extensively discussed even though, in reality, training in these areas is less widespread than in the United States and the United Kingdom.

i. Germany is quite active in the area of structuring and strengthening its doctoral institutes

In Germany, universities with the critical size have set up doctoral institutes that bring together young researchers from various disciplines, to allow them to benefit from the sharing of mutual competencies as well as from a broad range of study subjects. This also allows these young researchers to look ahead to various career possibilities.

"The DFG[23] supports programmes of this kind. As part of the High tech strategy[24], some universities have set up their own doctoral institutes with specific courses relating to cross-disciplinary competencies, but they have sometimes done so primarily in order to obtain better funding, without a true desire to develop these competencies within their doctoral students." (Public sector research director - Germany)

ii. In Finland, the government encourages universities to train doctoral students in "soft skills"

The Academy of Finland plays an important role in promoting the training of doctoral students in management, ethics, communication techniques...

"The various academic departments within universities should ideally look after these courses together, since these competencies are independent of scientific disciplines." (Public sector research director - Finland)

iii. In the Netherlands, the government expects universities and research centres to provide themselves with the means to develop "soft skills".

In the Netherlands, there is no national programme to develop non-scientific competencies within universities.

[22] WALSH,E (2010), Evaluation of a programme of transferable skills development within the PhD: views of late stage students, International Journal for Researcher Development, Volume 1, Number 3 (2010)
[22] Deutsche Forschungsgemeinschaft, resource agency for German research
[22] Deutsche Forschungsgemeinschaft, resource agency for German research
** Law on the freedoms and responsibilities of universities*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

"The subject is in their hands, since universities are very autonomous. They're doing things in this area, but without having been required by the government." (Public sector research director).

In fact, universities have certainly taken on this subject and have integrated a certain number of non-scientific courses into the educational curricula for doctoral students.

"Technical universities in the Netherlands have integrated soft skills and ethics into their programmes." (Director of a private sector research campus - Netherlands)

"Delft University in the Netherlands has integrated the question of multidisciplinarity into its programmes by eliminating single-discipline faculties and diplomas." (Director of a public research laboratory - Germany)

"Industry is very satisfied with regard to the competencies of scientists educated in the Netherlands." (Public sector research director - Netherlands)

• France and Switzerland, two countries in which the organisation of higher education is more complex to grasp as a whole

In these two countries, the situation can be described as a "hybrid", with a gap between the grandes écoles / polytechnical institutes and universities, even though this gap is shrinking.

i. In France, there is a difference between the grandes écoles and universities

Even though the situation is evolving, the general perception of the interviewed research directors is that in France, there is a great difference between the competencies produced by the grandes écoles and those produced by universities: according to large companies, the former correspond better with their expectations than the latter.

"We continue to be keen on engineers, since they think that they've been trained on the basis of experience, and that they have a desire to build". (Research director of a large private sector group - France)

"What has evolved is the perception and awareness of a researcher's competencies. We had never before asked so much about the researcher's karyotype, and that's a good point." (Public sector research director - France)

"Engineers are better trained in personal aptitudes than university graduates." (HR manager of a public sector research centre - France)

While France is universally recognised for the excellence of its scientific education, the French educational system is often reproached for not developing non-scientific competencies. While the criticism from the directors interviewed for the study most often targets universities more so than the grandes écoles, certain reproaches are common.

"In France, students aren't pushed enough. The US / UK educational system operates much more on the basis of positive reinforcement. This is extremely profound and changes both the way of teaching and the way of being." (Director of a high technology SME - France)

"In terms of personal competencies, the current system does not really promote creativity." (Director of a public sector research centre - France)

"In France, young researchers coming from the university are often lacking in personality, creativity and autonomy. However, to do your research, you have to learn to think, and to accept that what has been learnt is not necessarily true. Ideas have to circulate, and we shouldn't be afraid to express them. This kind of ferment of ideas must be promoted, but we don't know how to do that in France." (Director of a high technology SME - France)

"I'm convinced of the fact that doctoral students have to be trained in "soft skills". In this sense, there are schools that have evolved and others that have done nothing." (HR manager of a public sector research centre - France)

"France doesn't know how to bring out the gifts in people. Our educational system does a good job training people on a purely educational level. We don't worry enough about their personality, their gifts, their ability to communicate, etc." (Director of a high technology SME - France)

Certain research directors also find that the university system is paradoxical. Interdisciplinarity is desired, but channels of excellence and ultra-specialisation are encouraged. Much is also said about project management and other relational competencies, but without providing the means to develop these competencies.

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"Paradox: there is a growing requirement for integrators, people capable of working with a sense of interdisciplinarity, but in parallel, the educational system is increasingly targeted in terms of discipline against a backdrop of scientific excellence. The channels of excellence are increasingly targeted and narrow, with doctoral students being very specialised in a given domain, but not necessarily capable of integrating knowledge or working in a multidisciplinary manner. There's a paradox between what they would like to get from researchers and what the academic world is bringing them." (Director of a public sector research centre - France)

"More and more is said about project management, but yet project management courses are not becoming more widespread. They're excessively viewed as management and not science, whereas a scientist needs these competencies. Researchers find that science and administration are diametrically opposed." (Director of a public sector research centre - France)

It's important to emphasise the growing awareness that is developing within many French universities, even though it seems to be much less advanced than in United Kingdom when it comes to implementation, and with a less pragmatic approach.

"There's work to be done on the coherence of the competencies. The researchers in universities or grandes écoles are different, since they don't have the same educational path, and didn't originally have the same desires. But one doesn't become a doctor by accident, there's an initial karyotype. For example, you have to like adventure, not be afraid of the unknown, of the interface." (Public sector research director - France)

ii. In Switzerland, the difference between the grandes écoles and universities is different from the one seen in France

In Switzerland, there are currently 10 universities, two federal polytechnical institutes, and several specialised higher institutes, all of which make up the higher learning institutes. Universities and polytechnical institutes perform fundamental research. The specialised higher institutes perform applied research and development. The key research players interviewed as part of the study feel that the polytechnical institutes have better grasped the issues surrounding interdisciplinarity and the needs for non-scientific competencies. They now ask engineers to take courses in, amongst other things, communications, management, etc., whereas this is less the case in universities.

• Japan: the work on competencies has only just begun

The situation in Japan is fairly atypical compared with the other countries in the study. In this country, companies give preference to scientific competencies over other competencies, that the beginner researchers will acquire once integrated.

"Companies need students who are blank pages, in order to mould them according to their needs, while inculcating them with the company culture." (Laboratory director at the Tokyo Institute Technology Japan)

University is only one step in the training of researchers, that will continue within the company, in a much more intensive manner that may exist in western countries.

All of the interviewed directors agree that, while basic scientific competencies are well taught at university, the other competencies needed by a researcher are not particularly developed during the educational programmes followed by students (whether on the master's level or the doctorate level). Also, foreign companies present in Japan have expressed doubts with regard to the ability of universities to produce operational students. However, Japanese companies have totally integrated the need to train their young researchers, while still having questions about a possible transfer of the burden from the State to the private sector.

"In terms of technical competencies, young Japanese researchers have no problems. They're very good. However, more than elsewhere, there is a shortfall in communications and management aptitudes that is even greater than in France, as well as over-specialisation that may be a great strength when beginning but there can be a handicap when we [...] and we want to have these people work in other professions." (HR manager of a large company - Japan)

"At university, basic research competencies are taught, but creativity and project management are not." (HR manager of a large company - Japan)

"In Japan, students do what the professor tells them. When they join a company, they're taught to look after themselves, since they haven't done any training within companies before arriving. They aren't autonomous. However, they have other qualities: teamwork, strong capacity to listen. Also, once a person is brought up to speed, his performance is very good. Culturally, the Japanese expect strong supervision for six months to one year. They have to find out how to behave within the company." (Research manager of a large company - Japan)

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"There is no communication course or project management within the scientific department. That's up to other departments. Courses in these subjects exist and can be taken by the students, but they're optional. As such, only the most motivated students take them." (Director of a university laboratory - Japan)

Recognising the disparity between what companies want and what universities "produce" as profiles, the government has initiated, via the Education Council, work on university training programmes that could meet the expectations of companies. The idea would be to not only educate experts, but also students with more cross-disciplinary competencies. This work should notably involve a formulation of the expected competencies, with a precise definition of each of these competencies. The first step in this project was the passing of a law in 2010 that obliges universities to publish their educational programmes, in order to provide a certain degree of transparency, which the system is currently lacking.

• Focus: the European model for acquiring a basic set of competencies

On the European level, there is a model for acquiring a basic set of competencies, that defines levels of mastery that are to be attained. Set up in 2004, this skills repository is common to all of the educational and higher education systems in Europe, though it has not been specifically put together to focus on competencies in the research field.

This European repository should have a not insignificant impact on European university curricula in the coming years. Indeed, one of the main challenges for universities will be to identify, for each programme, the level of competencies expected by the future graduates, and to define the conditions for acquiring and processing these competencies. "Soft skills" or relational and personal competencies are some of the shortfalls that must be overcome.
"In Europe, the focus is put on knowledge, but the learning of "soft skills" should begin as soon as possible. At 25 years of age, it's already too late." (Director of a public sector research centre - Switzerland)

THE EIGHT KEY COMPETENCES DEFINED ON THE EUROPEAN LEVEL ARE SUMMARIZED BELOW

Key competence	Definition
Communication in the mother tongue	Ability to express and interpret thoughts, feelings and facts in both oral and written form (listening, speaking, reading and writing) and to interact linguistically in an appropriate way in the full range of societal and cultural contexts - education and training, work, home and leisure.
Communication in a foreign language	Communication in a foreign language broadly shares the main skill dimensions of communication in the mother tongue: it is based on the ability to understand, express and interpret thoughts, feelings and facts in oral and written form (listening, speaking, reading and writing) in an appropriate range of societal contexts - work, home, leisure, education and training - according to one's wants or needs. It also calls for skills such as mediation and intercultural understanding. The degree of proficiency will vary according between the four dimensions, between the different languages and according to the individual's linguistic environment and heritage.
Mathematical literacy and basic competencies in science and technology	Mathematical literacy is the ability to use addition, subtraction, multiplication, division and ratios in mental and written computation to solve a range of problems in everyday situations. The emphasis is on process rather than output, on activity rather than knowledge. Scientific literacy refers to the ability and willingness to use the body of knowledge and methodology employed to explain the natural world. Competence in technology is viewed as the understanding and application of that knowledge and methodology in order to modify the natural environment in response to perceived human wants or needs.

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

THE EIGHT KEY COMPETENCES DEFINED ON THE EUROPEAN LEVEL ARE SUMMARIZED BELOW

Key competence	Definition
Digital competence	Digital competence involves the confident and critical use of electronic media for work, leisure and communication. These competencies are related to logical and critical thinking, to high-level information management skills, and to well-developed communication skills. At the most basic level, ICT skills comprise the use of multimedia technology to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in networks via the Internet.
Interpersonal and civic competencies	Interpersonal competencies comprise all forms of behaviour that must be mastered in order for an individual to be able to participate in an efficient and constructive way in social life, and to resolve conflict where necessary. Interpersonal skills are necessary for effective interaction on a one-to-one basis or in groups, and are employed in both the public and private domains.
Learning to learn	“Learning to learn” compromises the disposition and ability to organise and regulate one’s own learning, both individually and in groups. It includes the ability to manage one’s time effectively, to solve problems, to acquire, process, evaluate and assimilate new knowledge, and to apply new knowledge and skills in a variety of contexts - at home, at work, in education and in training. In more general terms, learning to learn contributes strongly to managing one’s own career path.
Entrepreneurship	Entrepreneurship has an active and a passive component: it comprises both the propensity to induce changes oneself and the ability to welcome, support and adapt to innovation brought about by external factors, taking responsibility for one’s actions, positive or negative, developing a strategic vision, setting objectives and meeting them, and being motivated to succeed.
Cultural expression	Cultural expression comprises an appreciation of the importance of the creative expression of ideas, experiences and emotions in a range of media, including music, corporal expression, literature and plastic arts.

Source: http://ec.europa.eu/education/policies/2010/doc/basicframe_fr.pdf

Market awareness varies widely from country to country

• Stronger or weaker proximity between universities and companies, according to the countries

For the interviewees, universities in the United States and United Kingdom are close to companies. The dialogue is on-going, and it allows them to identify the expectations in terms of training for students, and notably researchers. The result is an ability to adapt to the needs of the market to a much greater extent than in many countries.

“A distinction has to be made between the establishments. At the top end of the scale are universities that perform research (Harvard, University of California,...), then universities that do little research, then colleges. In the large universities that perform research, the curricula adapt very quickly to the research needs, while the other types of establishments are less responsive.” (University researcher - United States)

“The university is in contact with employers and professional associations, notably the Confederation of British Industries.” (University professor - United Kingdom)

In Germany, Finland, the Netherlands and Switzerland, the links between companies and universities are also fairly strong. In many companies, notably industrial ones, laboratory directors are generally professors and may teach at university. There are also student sponsorship programmes.

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"In Switzerland, companies participate considerably in the follow-up of the various establishments. A school that doesn't produce what companies are looking for in terms of competencies will have trouble surviving. Also, in Switzerland, we expect that SMEs will participate in the life of universities through consultative roles. This involvement is very strong." (Public sector research director - Switzerland)

The objective of student sponsorship programmes is to provide targeted encouragement to young university students in all faculties (the mentees) and to make them aware of all of the options available to them within the private economy. The programme lasts for one year, during which the "mentees" can individually benefit from the experience and advice of a director or a specialist (mentor). This programme, developed on the university's initiative, involves other companies. Regular meetings are organised in order to discuss career opportunities. There's also a reverse mentoring programme, in which scientists from Novartis are sponsored by university professors. (Research director of a large company - Switzerland)

In the Netherlands, universities seek the opinion of companies for the development of their curricula.

"In Germany, companies have been advising universities for a few years. Almost half of the people in university boards come from the professional world. Those people are very competent in their fields, and think in a very different way than is the case in the academic world." (University director - Germany)

The links are also very strong between industry and non-university research centres (Institut Fraunhofer, Leibniz company, Max-Planck company, etc.)
In Finland, *"In the countries where it's present, the company works with universities so that they'll train the profiles needed by them. This cooperation between academia and industry is very strong in Finland, relative to other countries. Universities in other countries are often afraid of losing their academic freedom, but in Finland, they see this cooperation as something positive."* (Research director for an industrial group - Finland)

In France, for all of the interviewees, universities are progressively strengthening their links with companies, but the grandes écoles are clearly further ahead in this regard. Very close to companies, when necessary they create chairs or "tailor-made" training programmes in response to the precise needs of large companies. This is the case of THALES, which, with the Supélec engineering institute, created appropriate training programmes in order to deal with a shortage and to better anticipate the needs in the domain of analogue technologies.

On the university side, competitive hubs have contributed to these closer ties, as has the importance assumed by the topic of research development. The creation of the SATT (French for "Technology Transfer Acceleration Companies") as part of the investments in the future, the reform of the governance of universities with the LRU* (whereby boards of directors have been tightened up and more place has been made for external actors), and the development of university foundations and of partnership foundations in order to strengthen corporate / university links are some of the decisions that have been made as an indication of the major developments that are in progress.

In Japan, for the interviewees, companies are not very connected with universities. They have few direct relations that would allow them to influence the content of programmes. On the other hand, they act more as a group, through the associations in which they are members. As such, the Jeita association of high-technology companies carries out certain actions in order to increase the quality of educational programmes.

"The company has no contact with universities in order to develop the curricula. Its researchers also don't give courses at the university. However, through JEITA (sector-specific association), it can happen that the company will send someone to a university in order to talk about a research success, to disseminate his experience regarding how to overcome difficulties, assume leadership, etc." (Research director of a large high technology company - Japan)

"The company is part of the JEITA group (with several manufacturers in the sector), that notably undertakes activities in order to increase the quality of educational programmes. Personnel members went to Keio University in May 2010 to take part in a symposium as part of the cooperation between industry and academia, with the idea of training the students who are needed in one domain or another. In this way, companies had an opportunity to inform the university of their needs." (Research director of a large high technology company - Japan)

* *Loi relative aux libertés et responsabilités des universités*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

• However, changing needs of companies are only followed with difficulty by universities

Listening to the market inevitably has a deferred impact on the development of educational programmes, and the time needed for the implementation of new modules can vary considerably.

Companies often feel that universities do not adapt quickly enough.

"Universities try to adapt their curricula to the expectations of companies, but their success in doing so depends on the country. They make a lot of effort in the United States, but in France, for example, they don't adapt quickly enough." (Research director of a large company - Netherlands)

"There's always a significant offset between the science reality and the education of doctors and engineers. The academic world is not up to the level of current technologies; this isn't new, but it's more strongly perceived in the face of fast developments." (Director of a large company's laboratory - France)

"Higher education institutions don't adapt quickly enough. Some institutes have an interdisciplinary approach, but it isn't widespread." (Company research director - Netherlands)

In response, the queried university representatives indicate that companies are not always capable of expressing their needs with sufficient clarity or sufficiently in advance for universities to be able to adapt their curricula.

"The major manufacturers were unable to state the names of the professions that they needed. The unit therefore tried to figure them out, and a few educational guidelines were then envisaged." (Director of a competitive hub - France)

"It takes about 3 years for a proposed programme to become a reality. The first graduates from this stream only make it to the labour market 6-7 years after the programme's design, at a time when there have already been many technological breakthroughs." (Director of a competitive hub - France)

"Despite the involvement of companies in university boards, setting up an educational programme takes time, and the market therefore evolves more quickly than the programmes proposed by universities. It's difficult for them to keep pace with the market. The behaviour of the academic world is anti-cyclical, which is hard to explain to the corporate world. It isn't easy to explain to them that programmes can't change from one day to the next in order to produce the competencies that they need." (University vice-president - Germany)

"The system takes time to adapt. But these are institutions, so it's normal that they should protect their values. Given their status, they adapt in a fairly satisfactory manner." (Public sector research director - Netherlands)

... resulting in real changes in higher education systems, but again at a pace that varies from one country to another

Recognising the gaps that exist between the competencies acquired by students during their education and the expectations of employers (public or private), governments have taken a certain number of measures so that the supply and demand of competencies will coincide better. Whether prompted by their governments or on their own initiative, higher education institutions are developing their curricula from various points of view.

A number of symbolic actions taken by governments to change higher education systems

The following presentation is not intended to list all of the measures taken by governments, recently or in the more distant past, in order to drive the development of higher education systems. The aim is to illustrate, notably through various quotations taken from the interviews, the various facets of the true movement that is in progress within higher education. Today's researcher leaving the classroom and amphitheatre is not the same one who stepped through those doors 10 or 20 years ago, and tomorrow's researcher will also be very different.

i. The consideration of professional insertion within the missions of universities in France

Article 1 of the LRU* in France included professional insertion within the missions of universities, alongside research.

"The missions of the higher education public service are:
1° Initial and continuing training;
2° Scientific and technological research, the dissemination and development of its results;
3° Guidance and professional insertion;
4° The dissemination of culture and of scientific and technical information;
5° Participation in the construction of the European Higher Education and Research Area;
6° International cooperation."[25]

[25] *[French] Education Code, article L123-3*

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ii. Support for the scientific excellence initiative, technology transfer and closer ties between public research and private research in several European countries

These initiatives now exist, in one form or another, in all of the studied countries: excellence initiatives in Germany, Campus Plan in France, National research poles in Switzerland...

iii. The training component of the competitive hubs in Germany

Even though this is not necessarily the most developed component, all of the competitive hubs have a training component and are intended to foster closer ties between "academics" and "companies / private investors".

Example of the Optonet cluster in Germany: every two years, the cluster carries out a very precise study with companies, research centres and educational institutions. Performed by the Jena Social Sciences Institute, this study is disseminated to the Cluster members in order to mobilise them around the measures having to be taken in the area of training, in order to ensure the perpetuity and development of the regional optical activities. This work takes place in three phases:
- Drafting of a quantitative and qualitative assessment of the employment situation in the optical industry in Thuringia,
- Quantifying and qualifying the competence needs of companies,
- Mobilising universities and companies regarding the stakes surrounding training"[26].
This study led to the finding that competencies in project management, management and administrative management are indispensable, notably within SMEs. Also, they are often lacking in the young researchers leaving universities. One of the projects undertaken by Optonet was to develop the managerial skills of young researchers by setting up specific management courses in order to overcome these shortcomings. Within the cluster, industry and the universities are quite familiar with one another. The university can then adapt its programmes, with an awareness of the medium-term needs of companies.

"The cluster has estimated the number of researchers that industry will need in the next 5 years: around 1000 engineers, researchers and technicians in all. As such, they note that the number of students in the optical sector will be insufficient to cover the needs of companies." (Director of a research institute within a cluster – Germany)

iv. The competitive hubs programme in Finland

In the last three years, the Finnish government has undertaken initiatives in order to bring universities and companies closer together. It has notably created strategic centres for research, technology and innovation, which receive significant funding from the government via TEKES[27]. These centres are clusters along the lines of the French competitive hubs. There are six of them.

"The research programmes carried out within the centres are very industry oriented, but both universities and companies are well intermixed." (Research director for an industrial group - Finland)

Other types of closer ties, such as the Instituts Carnot in France or the Cambridge campus, all provide occasions to connect higher education institutes and laboratories, so that adequate competencies will be developed.

v. Selection criteria in calls for projects in several countries

Through their criteria for selecting funded research projects, research funding agencies also exert indirect influence. As such, in Finland, the Academy of Finland devotes 10% of its funding to projects clearly identified as multidisciplinary, and Tekes, the funding agency for applied research, includes selection criteria involving ethics in its calls for projects.

"The selection criteria during calls for projects include interdisciplinary cooperation. For example, as part of the project on childhood, they don't want only doctors to present the project, they want to see the involvement of social science researchers." (Public sector research director - Finland)

[26] *APEC, Analysis of clusters in three European countries, 2008*
[27] *For more information on the organisation of research in Finland, see the Finland country report in the appendix.*

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"Ethical questions are integrated at the highest level. When examining candidacies during a call for projects, the agency's teams devote particular attention to ethical questions, irrespective of the study's domain (social sciences, biology, medical research, etc.). Ethics must be taken into account in terms of the way that information is gathered, processed, how the research is performed, etc." (Public sector research director - Finland)

vi. Influence over doctoral school programmes

In the 1990s, doctoral schools in Finland focused on scientific and procedural competencies. Today, they ask researchers to develop their competencies in project management, marketing, communication...
"Universities are independent, but the government can ask them to organise programmes such as additional courses on research administration. The government asks the Academy of Finland, which validates the content of doctoral programmes, to see to it that courses on "soft skills" and ethics are included in the curricula." (Public sector research director - Finland)

Tekes also discusses with the Finnish Ministry for education and other stakeholders in order to contribute to developing the competencies required by companies. However, the power of influence is limited.

"Universities are under no obligation to follow the recommendations that may be made by TEKES, there is no formalised process and in reality, the organisation really only has a limited capacity to make itself heard by universities." (Public sector research director - Finland)

However, in all of the studied countries, the progressively increasing autonomy of universities is encouraging their (re-)connection with society. The ties between industry and universities are improving. While losing a certain degree of control, governments nevertheless hope that this movement will help to bring university programmes closer into line with the needs of employers.

"Of the 20 university in Finland, a certain number of them are involved in a real dialogue with companies. And institutional actors are counting on the continuation of this movement, given the ongoing changes in the status of universities." (Public sector research director - Finland)

In this regard, the Finnish university of Aalto is a good example of the ongoing changes. The birth of this university is the result of the merger of technical, business and design competencies. This was possible because companies were in favour of this merger, and injected money.

• A widespread change in curricula (content and methods)

In the Netherlands, certain large companies are pleased to note that many universities have changed their attitudes regarding how science is taught. They're now trying to integrate notions of management, multidisciplinarity, effects and intellectual property into their programmes. In their view, the fact of bringing science closer to society is a major subject. The universities also seem more willing than previously to put scientific effort in the service of the public. There is less satisfaction in other countries, but there is a general finding of a significant change in the research training programmes in recent years, whether in terms of subject matter (introduction of instruction on non-scientific knowledge), or of teaching methods (involvement of professors coming from industry), or of connections with non-academic settings.

i. Bringing teaching staff with a background in industry

This integration is favoured by everyone queried as part of the study and in all of the countries, especially by the private sector research managers. There are several objectives: to provide students with field experience, to introduce them to possibilities beyond academic careers, to make them aware of certain requirements and certain necessary competencies (for example company culture, project management, the question of the relevance of research).

"Professionals from industry give courses at universities quite regularly. The problem is managing to get people from industry to accept permanent positions as professors, since the public sector can't compete with the private sector in terms of salaries. That's why Germany is attempting to give more autonomy and flexibility to research centres, in order to give them the means to implement an attractive HR policy." (Public sector research director - Germany)

"To a certain degree, universities bring in teaching staff with a background in industry, but it's difficult because of the reluctance on the part of companies. Indeed, some wonder what benefit they would derive from the letting their key resources take up another activity. The government would like to encourage some horizontal mobility between the private and public sectors, but it isn't easy to implement." (Public sector research director - Finland)

However, this integration comes up against two major obstacles: the ability of university to pay these non-academic professors (for those people that become full-time professors) and the reluctance of companies to let them go (for researchers who give courses in parallel with their private careers).

"It's rare to have people from the business world giving courses at university. This is difficult to implement, notably in terms of compensation." (University professor - United Kingdom)

"In the doctoral programmes relative to "transferable skills", the courses are given by faculty members or private sector representatives, when many people with very precise expertise are needed. The university is trying to find a balance since the use of external people is more expensive, meaning that it's reserved for subjects that can provide a real added value." (University professor - United Kingdom)

ii. Strengthening links with companies during higher education

Several structures have developed in Europe, some of which are long-standing, to help doctoral students remain connected with the corporate world during doctoral studies. As such, in France, the CIFRE (Conventions Industrielles de Formation par la Recherche) structure subsidizes any company operating under French law that hires a doctoral student for placement at the heart of a research collaboration with a public sector laboratory. This structure has existed for 30 years.
The ANRT (Association Nationale de la Recherche et de la Technologie) distinguishes three integration levels[28]:
- "complete integration with, as in the case of the CIFRE, the doctoral student being hired by the partner companies that co-directs the research project"
- "Moderate integration based on a partnership with the company involved in the research work and supervision, which accommodates the doctoral student for a work experience period that varies in length from 3 to 18 months according to the structures" (examples: EPRSC industrial CASE studentships in the United Kingdom, Graduate-Cluster for Industrial Biotechnology in Germany)
- "a desire to increase the pertinence of doctoral works by relating them to concrete issues, but with no direct partnership with a company".

"There's a strong tendency to see to it that students spend a considerable part of their time within a company and not in an academic environment during their doctorate." (CIHE - United Kingdom)

"Many work experience possibilities are available in Germany, which is a good way to help students to develop all of the required competencies." (Research director in a private sector group - Netherlands)

iii. Including non-scientific competencies in curricula

In Switzerland, the University of Lausanne is making efforts to promote the competencies acquired by researchers "without knowing it". These non-scientific competencies (ability to manage projects, to manage setbacks and to work in a team), of which the young researchers have not yet become aware, are particularly important when looking to the possibility of career development outside of the academic world.
This work notably involves a significant reflection on the format of a doctorate, which is shifting from an experienced researcher / student relationship to a relationship that is accompanied by socialisation through the scientific community. In this case, emphasis is placed on the development of "soft skills", most notably communication. This recent development is expected to continue. It involves putting young researchers in contact with the community of researchers on an international level, notably through summer programmes.

Other countries such as Germany, or in a more isolated manner, certain establishments in Japan, have also undertaken such developments.

In all of the countries, the integration of the teaching of non-scientific competencies into the educational programmes of researchers is not a given. Moreover, there is debate around the provisions for learning to apply interdisciplinarity in a work situation, with questions such as:
- What balance can be found between the development of a solid scientific basis and interdisciplinarity "training"?
Is the university the setting for the development of this ability to work in an interdisciplinary environment?

[28] *http://www.anrt.asso.fr/fr/pdf/comparaison-europeenne_formation-doctorale_11.11.09.pdf*

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"It's necessary to develop "soft skills", but these skills shouldn't be acquired through courses given by specialists from other disciplinary fields or departments, but during the time spent within a research team in one's own discipline. For this reason, it would be best for students to join research teams as soon as possible. It's the idea of learning while doing." (Director of a public sector research centre - Germany)

"The best way to promote interdisciplinarity is scientific competition. If multidisciplinary projects are more ingenious because they combine several disciplines in order to present the subject with a better approach, they'll be more successful during calls for projects and will result in more publications. He doesn't believe that there will be more interdisciplinary cooperation by forcing it." (Public sector research director - Germany)

"In the United Kingdom, a certain number of people in the academic world feel that the role of higher education is to deliver knowledge and values, and not to put people into the labour market." (Director of a university training programme on non-scientific competencies - United Kingdom)

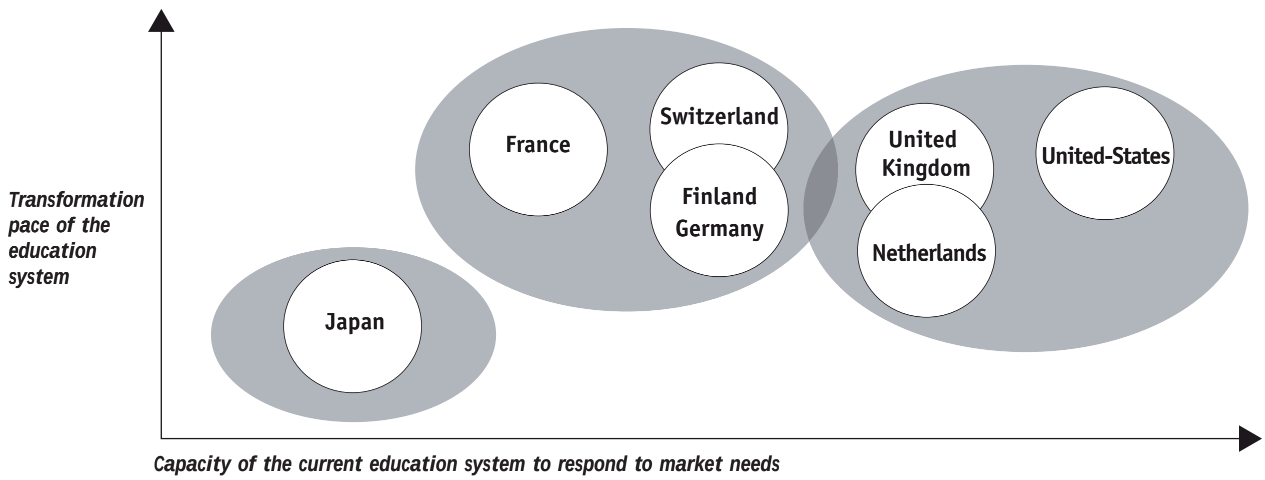
Strategies designed to adapt to the "recruitment market" that vary between countries

To meet present and future needs for competencies, countries are implementing strategies to produce, attract and retain sought-after competencies . Each country is responding to the demands of the "competencies market" in its own way and at its own pace, however.

"If France wants to keep its researchers, it will have to offer recruitment and working conditions that will allow them to give of their best. France will have to make an effort to offer an attractive package." (Public sector research director - France)

The chart below plots the position of each country against two axes:
- The first plots the perception that key research players (HR managers and laboratory directors) have of the education system's capacity to respond to market needs.
- The second plots the perception of those interviewed for the study as to the pace of transformation of education systems, backed up by documentary research. There are two components to the pace of transformation: the ability of universities to adapt their courses to meet the needs of employers (institutional strategy) and the pace of change driven by governments (national strategy).

PERCEPTION OF THE ABILITY OF COUNTRIES TO RESPOND AND ADAPT TO MARKET NEEDS



Source: APEC / DELOITTE Study 2010

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This analysis identifies three main groups:
- Japan appears to be isolated. The interviewed research managers were able to identify and point to the risk factors for Japan falling irretrievably behind. One of the challenges is to reinforce dialogue between businesses and universities.
- The European countries have embarked on in-depth reforms, highlighting considerable potential for catching up with the leader.
- An "Anglo-Saxon" model appears to be more effective and better suited to constant adaptation.

WHAT IS THE COMPETITION IN THE SEARCH FOR TALENTED RESEARCHERS?

What do the various observed countries do in order to attract talents and to find the expected competencies?

The internationalisation of the "needs for competencies" does not necessarily mean an internationalisation of the "markets" for these same competencies.

• For large companies and certain universities, the recruitment perimeter for researchers is now global.

There is clearly an international researcher profile, and companies and universities able to do so now recruit the best profiles irrespective of country of origin. For these employers, the search for talent cannot be confined to a single country and the diversification of their teams in terms of nationality is seen as a positive factor for innovation.

"We recruit researchers wherever they may be, as long as they're the best. It doesn't matter where they come from. The only condition is a willingness to move to where the research is being done." (Research director of a large company - United States)

"When a company such as ours is looking for talents, it can't be content just looking within one country, that would be too limited, it must think globally." (Research director of a large company - Germany)

"There are very interesting scientific developments in countries such as China, Brazil, etc. If we want scientific excellence within our country, we have to take these developments into account. Public sector institutions must therefore attract these talents by becoming more attractive themselves." (Public sector research director - Germany)

"The company hires globally. It's good to be familiar with the local markets, but recruiting is carried out worldwide, with no preference in terms of nationalities. The fact of having different cultures provides the team with very beneficial diversity." (Research director of a large company - Netherlands)

"The group is present worldwide, with a strong presence in Brazil, India, China and the United States. There aren't necessarily R&D activities in all of these countries, but these activities stay as close to the markets as possible in order to know them and to adapt to them. Also, it's important for the company to integrate people coming from these different countries, so as to be credible within these markets over the long term. This demonstrates a willingness to understand the markets. Sometimes, it's also easier to find certain competencies within these countries." (Research director of a large company - Finland)

"There is a desire for openness. We communicate in the direction of the breeding grounds of foreign researchers in order to attract them, through an Internet site in English, advertisements in international scientific journals and major foreign institutes. The application file has also been modified so that someone who is not familiar with the laboratory can apply, without being placed in an unfavourable position relative to the researchers who gravitate around the institute. Also, the network of partner laboratories makes it possible to disseminate information quite broadly." (Director of a public sector research centre - France)

• However, significant barriers limit the mobility of competencies, and the "markets" very often remain national

i. Restrictions regarding company activities

For security reasons, as a result of the sensitive nature of an organisation's research subjects, it is not always possible for an organisation to hire foreign researchers. This is notably the case in the defence sector, in certain domains in chemistry or the nuclear sector.

"As a result of security restrictions in the defence field, the company can only recruit British scientists." (Director of relations with higher education for a company - United Kingdom)

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"In terms of recruiting, we make no distinctions between European countries. However, given the research subjects at hand, recruiting profiles from outside the European Union is problematic." (Research director of a large company - France)

Moreover, in some countries, the authorities require that companies wishing to set up shop must employ a significant share of local manpower, in particular in research, to ensure a technology transfer. Under these conditions, the nature of recruiting with regard to nationality is partly dictated by these requirements.

"The company's objective is more to find local researchers and to have them stay in their country of origin. This is notably the case of sites outside of the European Union, where the host countries require local researchers in order to guarantee a technology transfer. The international mobility of researchers is therefore very rare. Also, the research projects are carried out individually by each site, and not between different sites in different countries. Any internationalisation is therefore only on the management level." (Research director of a large company - Netherlands)

ii. Problems related to language proficiency

In some countries such as Japan, France or Germany, the work environment requires proficiency in the country's language, since the researchers are in contact with various types of contact people, who often only speak the national language. Foreign researchers must therefore speak it fluently in order to potentially be hired.

"It's hard to recruit researchers if they don't speak Japanese, since all of the work is done in the local language." (Research director of a large group - Japan)

"In Thuringia, the level of English amongst young people is not as good as in other regions. During the years of the GDR, researchers in this region had more contact with Chinese and Vietnamese people, so there's no tradition of speaking English. This hasn't changed very much, even though students now have more contact with the rest of the world." (Director of a research institute within a competitive hub - Germany)

"In most of the major public sector research centres, the working environment is in French. This is an obstacle to the arrival of foreign researchers, as opposed to the countries in Northern Europe, for example, where the countries are more bilingual and English-speaking. Language-related constraints must not be neglected." (Director of a public sector research centre - France)

"It's indispensable for recruited researchers to speak German. This requirement constitutes a true filter for candidates, since in reality, very few come from countries other than Germany. But if a researcher doesn't speak German fluently, problems will arise since he's going to be in contact with ethical committees, physicians, nurses, etc., who don't necessarily speak any languages other than German." (Research director of a large pharmaceutical group - Germany)

This is less of a problem for researchers in the United Kingdom, the United States, Switzerland, Finland and the Netherlands, as a result of the proficiency in English or in several foreign languages in these countries.

iii. Administrative barriers

The complexity and cost of the administrative procedures for bringing in a foreign researcher can sometimes be an obstacle. Faced with these obstacles, recruiters are not always "playing on equal terms". As such, large companies generally have legal departments able to look after a certain number of aspects. Similarly, major universities, notably American ones, are particularly experienced in dealing with such questions. Inversely, SMEs are generally fairly ill-equipped, which provides them with a major roadblock for the recruiting of foreign researchers. The situation also differs from one country to the next, as the formalities can be more or less complex.

"It's sometimes difficult to have a foreign scientist come to the United States because of the complexity of the immigration and administration procedures. We have a legal department that looks after that, so we can generally bring in foreign researchers without too much trouble." (Research director - United States)

"The administrative formalities complicate the hiring of young foreign graduates, since they're obliged to leave the country immediately upon obtaining the diploma and they can't wait for an opportunity to arise a few months later." (University researcher / Professor - United States)

"The company would like to hire foreign researchers, but that would require material support that's quite difficult for a SME: visa application, looking for an apartment. Companies don't always have the means or the time to do that. In the United States, the universities look after everything: everything is organised so that the researcher only has to work." (Director of a high technology SME - France)

• Governments, universities and research centres are therefore embarking on a range of actions to boost their ability to attract talent

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

The resources employed by governments and public sector research institutions combine sovereign leverage (easing of immigration procedures) and the classical HR attractiveness levers used by the private sector (compensation, installation conditions...).

i. Grants for foreign students aimed at encouraging them to take up residence in the country

"There are specific programmes for students from outside of the European Union. These international programmes are financed by the federal government and half by local industry, with the idea being to train the young researchers and to have them work in the local optical industry thereafter." (Director of a Competitive hub - Germany)

ii. Streamlined administrative procedures and efforts focusing on the researcher's environment

"The Alexander von Humboldt programme attempts to attract professors from around the world, so that they will teach in Germany. It notably includes assistance with receiving foreign scientists, such as at the University of Aachen, where the immigration authorities have an office on the university campus in order to facilitate the procedures." (Public sector research director - Germany)

"Scientists no longer have to speak German in order to work in Germany. Except in certain disciplines, it's accepted and even desired to have professors who teach in English." (Public sector research director - Germany)

"The Ministry of foreign affairs has taken measures to make it easier for foreign researchers to come. The procedure for obtaining work permits has been accelerated and is less expensive. The administrative procedures for scientists have been streamlined." (Public sector research director - Netherlands)

The characteristics of the "market for competencies" oblige recruiters to constantly adapt to the existing offer.

Recruiters do not always find the demand for researchers to match their needs and are obliged to tailor their recruitments accordingly. This mechanism is not confined to the research world, but plays a significant role given the very high level of qualification of the profiles in question.

• The competencies available on the national market do not always satisfy demand

Quite naturally, and as a result of the reasons mentioned above, for all of the directors interviewed during the study, the national perimeter generally remains the first to be explored by recruiters looking for competencies. It's the most easily accessible. But, depending on each organisation's specific needs, the availability of competencies within this talent incubator may or may not prove to be satisfactory.

i. The "markets for competencies" can be limited, and the demographics unfavourable

The supply of researchers may be insufficient within a country, such as in Switzerland or Japan.

"From the Swiss viewpoint, the hiring of foreign researchers is explained by the fact that Switzerland is a small country, and does not produce all of the required profiles. They turned to other countries since they can't find the profiles that they're looking for in Switzerland. They tend to look more in Europe for questions of work permits. Also, having multicultural teams has a positive impact on innovation." (Research HR manager of a large group - Switzerland)

ii. The available profiles do not necessarily match the needs of recruiters

Doctorates versus master's degree or engineering diploma, the profiles required are not the same in all the countries studied:

In France, despite an often visible preference within companies for engineers from institutes, some recruiters recognise that doctors are the best trained professionals for research positions. Some organisations only accept doctors in these positions.

"By definition, we don't hire engineers. Our few existing engineer positions correspond with technicians who have developed. [...] Researchers must at least have a thesis, i.e. a PhD (8 years of post-secondary), and one or two post-doctoral years." (Director of a large company's research centre - France)

But in other countries or types of organisations, for most of the key research players, a doctorate is much less valued and therefore less sought-after by recruiters. This is notably the case in Japan and France (notwithstanding the example mentioned above).

In France, engineers hold higher positions than doctoral students. Indeed, even in the event of recruiting for research positions, companies prefer engineer profiles over doctors. According to the Centre d'Analyse Stratégique, the latter only represent 14% of researchers in companies, versus more than 50% for engineers.[29]" In a higher education system marked by dichotomy and the negative image of the university system, a doctor's diploma seems to be less valued in France than an engineer's diploma or one from a grande école.

In Japan, companies prefer to look for people with masters degrees rather than doctorates, for various reasons.
The first has to do with the training tradition within Japanese companies. Companies train their young researchers internally, after having hired them. They therefore don't look for hyper-specialists, who will be less flexible and more expensive.

"Japanese companies don't like doctoral students. It has to do with how they recruit. They look for students who are blank pages, in order to mould them according to their needs, while inculcating them with the company culture. The salary is very low in the early part of the career, but companies train young researchers (who therefore receive free education while receiving a salary). At the end of the training period, the young hire will then receive a bonus and his salary will climb until the age of around 40, before stabilising." (Director of a university laboratory - Japan)

"Young graduates with a doctorate are often older than people with a master's or bachelor's degree. Companies therefore have to pay them more. However, Japanese companies don't know how to make the most of their potential and of their expertise. Also, the labour market is quite rigid in Japan, such that it is difficult to dismiss someone. Companies therefore hesitate to invest in a very specialised profile that they will be unable to get rid of, all the more so since these profiles are viewed as rather inflexible." (Director of a university laboratory - Japan)

The second has to do with the current orientations of Japanese R&D, which, according to the people interviewed as part of the study, is more inclined to the development of pure research. In this context, the competencies of Japanese doctors are viewed as unsuitable.

"Most Japanese companies import new technologies and adapt them to the Asian market. They therefore need researchers who can adapt these new technologies, rather than invent new ones. However, this is not the leading quality of researchers who focus more on discovery. Their profile does not perfectly correspond with Japanese R&D which is more D than R." (Director of a university laboratory - Japan)

"The company hires few doctors since they've often stayed somewhat too long at university and have "fallen asleep". Someone coming from the university world and who is now confronted with milestones and deadlines is destabilised: people no longer know how to work with this intensity. However, the ability to do things on time is decisive within a company." (Research director of a large group - Japan)

This lack of prospects generates a loss of interest amongst students, who are less and less inclined to undertake doctoral programmes. The interviewed universities consider this to be a threat to the strength of Japanese research.

- Moreover, the search for senior profiles is often a delicate matter:

The range of competencies requested from confirmed researchers is broad, and people who have it are very often "hunted" by companies. Their "rarity" in the market partly explains the recruiting difficulties.
The second difficulty has to do with the fact that, in certain disciplines, the "top" specialists have not all been trained for the profession of a "confirmed researcher".

"Physicians trained in France are sometimes reluctant to work in pharmaceutical laboratories. Trained to heal, they have trouble leaving behind this initial motivation." (Director of a large company's research centre - France)

[29] *Les difficultés d'insertion professionnelle des docteurs: les raisons d'une "exception française", Rapport du Centre d'Analyse Stratégique, July 2010*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

- Certain disciplines suffer from a lack of trained profiles:

The key research players interviewed as part of the study mentioned a lack of training in certain domains and countries.
These are generally recently developed domains or ones with a “bad image”, or even that have a strong multidisciplinary dimension: specialists in environmental chemistry, the nuclear sector, agro-food (research on GMOs), pharmacokinetics...

“In France, there’s little training in pharmacokinetics and drug metabolism (DMPK, a profession specific to the pharmaceutical industry); whereas it’s easy to find people trained in this domain in the United States and United Kingdom, since the programmes exist.” (Research director of a large group - France)

“It is difficult to find bio-technologists in the United States, and hard to recruit scientists who are familiar with the technologies that we use, since they’re very advanced.” (Director of a SME - United States)

Lacking an ability to be quantifiable, some disciplines will experience tension in the coming years. This is already prompting recruiters, when possible, to recruit profiles close to the desired ones in order to train them once they’ve been integrated.

“Each year, the head office systematically defines the number of researchers to be recruited (distributed by speciality), on the basis of the needs expressed by the business units and the R&D departments. If they don’t manage to find someone with the required specialty, they’ll go for a close profile. Only doctors are chosen specifically relative to their research topic. If this topic doesn’t correspond with the company’s needs, the person isn’t hired.” (Research director of a large group - Japan)

“Few companies have a background in our domain. But the newly hired young doctors will learn within the company. It’s difficult to find very advanced profiles that correspond with the company’s research domains, but we can find people who’ve done fluid mechanics, for example, who will be easily able to shift into the domain of noise research. The specialty isn’t really an obstacle for us, provided that the domains are close.” (Research director of a large group - Japan)

• The organisation’s ability to attract talents can be a problem

Another factor that will determine the recruiting behaviour of organisations is their ability to attract the type of profile that they’re looking for, in other words their ability to make researchers want to join the organisation.

Some companies indicate that they have difficulties attracting the best researchers in their field, for reasons having either to do with the image of research in that particular country (less attractive than professions such as finance, for example), the image of the organisation itself or of the field of activity.

“Few people want to work in a laboratory that belongs to the Defence Department.” (Researcher in a federal research institute - United States)

“The market for qualified scientists is very tight. It isn’t easy to find qualified people. This is partly because they’re attracted to other types of jobs, and have other opportunities. Hard-line researchers don’t necessarily want to go into development activities. Most scientists want the freedom that they can obtain in an academic setting or within small biotechnology companies.” (Research director of a large company - Germany)

“The company has trouble finding engineers in Europe because today, sectors like the automotive industry and even finance represent massive competition when it comes to recruiting engineers”. (Research director of a large company - Netherlands)

“Today, the research professions, and more generally the expert professions, are not necessarily popular within French civil society. Major companies are realising this and are in the process of revaluing the professions of experts and researchers in order to be able to keep them. This includes revaluing the salaries and the creation of senior grades, a certain international recognition via the valuation of the parts of research (encouragement for the publishing of articles, etc.).” (Public sector research director - France)

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

In Japan, the interviewed high technology companies point out the recruiting difficulties in the area of research. The recruiting primarily involves people newly leaving university. Each year, the major companies announce the number of persons sought in each domain. This offer includes several domains: communication, research...

"The company regrets that it does not have more opportunities to meet with students having the specialities that are of interest to it. As the director of a research institute, I have very precise needs in certain domains, and I have trouble finding students who meet my needs. The fact of carrying out common searches with universities can be a true help when it comes to recruiting, by making it possible to detect people who have the expected skills. We try to identify the students using various means." Research director of a large group - Japan)

To explain these difficulties, the contacts interviewed during the study mentioned, on the one hand, a problem with university education.

"Japanese universities do not sufficiently push students to specialise, to have big visions or the spirit of an entrepreneur. In the United States, research specialities are more advanced." (Research director of a large group - Japan)

Also, the problem of attractiveness is mentioned.

"The excellent students aren't interested in working on products for end-consumers. They're more interested in big infrastructures. Electricity companies, industry (Mitsubishi) are more attractive than companies that produce small products for consumers. The best IT students want to go into consulting or finance, rather than work for us. When the young students are excellent and have potential, their interests cover many areas. How can we attract their interest? It's a big challenge today." (Research director of a large group - Japan)

The same difficulty is encountered by these companies in Japanese research bases abroad, for example in China, Germany and the United States. However, the difficulties are also due to the general recruiting situation in each country.

"In Germany, for example, Bosch is a major competitor in terms of recruiting. The fact of whether or not a company like Bosch is part of the landscape changes many things." (Research director of a large group - Japan)

In this context, organisations implement recruiting strategies in the face of competing recruiters that include not only other organisations involved in research, but also globally ones that attract the same types of profiles, doctoral students and engineers.

"The laboratory has a recruiting strategy at the post-doc level that includes attractive salaries and the possibility of devoting 25% of their time to personal projects. The objective of this is to attract talents in a competitive context. Also, the post-docs are paid more than post-docs in University." (Researcher in a federal laboratory - United States)

"The laboratory environment and living framework count for a lot when trying to attract a scientist. People are looking for things other than just a career. This trend has become more prominent in recent years. It helps the university with its recruiting if it can offer a pleasant living framework or if it has good working groups. These two aspects are very attractive in the eyes of researchers." (Director of a University research laboratory - United States)

WHAT STRATEGIES ARE THERE FOR RETAINING THEM?

In the private sector (in larger companies in particular), career management is a reality

In the private sector and primarily in large companies, there are many practices.

• Several types of careers are possible in major groups

"There are three kinds of career paths in business: management (managing and developing a team, managing a strategy), project management (cross-disciplinary management, no management involved but rather the supply of resources and competencies, with objectives and landmarks to be respected in terms of cost, quality, deadline), as well as expertise (an individual who is an authority to be consulted in a certain field)." (Research director of a large group - Japan)

"When hiring, the idea is that the recruited people will make a career within the company." (Director of a large company's research centre - France)

"Several years ago, a scientist's career within the company was designed so that they would evolve from researcher to manager. Today, there are two possibilities: a purely research career and a manager track. The choice depends on the person's skills." (Researcher for a large company - Finland)

"The structure is very hierarchical: research officer, manager of the research group (around 200 people on that level), head of the research laboratory (30-40 people),
director of a research institute (6 or 7 people within the R&D head office), head office director (1 person). Everyone starts at the bottom, not everyone makes it to manager. You can spend your entire career within the company as a research officer. Everyone knows that only one person will make it to the very top." (Research director of a large group - Japan)

In SMEs, career paths are emerging that could provide researchers with development prospects, but they remain insufficient.

"The employees naturally evolve towards management professions. In the past, there was external recruiting for positions of this type, but today, they try to have people evolve as part of their career development. Someone who works in research can, for example, shift into development, project management, quality control, etc. There are also some people who've evolved towards marketing or sales functions." (HRD of a SME - Switzerland)

• Mobility between groups is encouraged

The people interviewed as part of the study generally found that mobility among researchers is much higher now than it was ten years ago. Some companies strongly encourage this mobility as a source of new ideas and knowledge and as a means of maintaining the momentum of innovation.

"People applying for a post-doc position must draft a research project. The hiring decisions will be made on this basis. If the applicant receives a position, he'll work in the company for two or three years, though this doesn't mean that he'll necessarily have a position within the company thereafter. This is often unclear for researchers, who don't always understand why they aren't hired at the end of their contracts. These post-docs, trained by the company, will go to the competition. Similarly, the company tries to hire post-docs away from its competitors, since it's healthy to have exchanges of this type. All companies need these contributions of new knowledge." (Research HR manager of a large group - Switzerland)

"The company doesn't offer lifetime positions in research; they prefer for researchers to leave after a few years in order to guarantee a renewal of the teams and ideas. This is mentioned during the annual interviews, during which researchers are asked to envisage their career development within other departments of the company, with partners or even as part of universities. As such, when a research subject becomes commercially exploitable, the researcher is encouraged to continue with his idea's life cycle and to move on to business development." (Research director of a large group - Netherlands)

• The special features of the Japanese model deserve to be mentioned

"A manager first of all joins the company without a doctorate, and then becomes an expert. Japanese companies invest tremendously in the development of their personnel. They must rotate through several departments: A few months in the laboratory, a few months in marketing, some time in production, then a return to the laboratory. When he returns to the laboratory, he'll have a point of view and competencies that are totally different from someone who completed a doctorate. He has a much more complete vision. This rotation within the company's various departments is demanding in terms of the company's organisation, but it's a very efficient way to develop the competencies of the researchers." (Director of a public research laboratory - Switzerland)

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

"When being hired, researchers don't know where they're going to go work." (Research director of a large group - Japan)

Fairly extensive training programmes have been set up in order to encourage mobility and the career management of researchers. In some groups, these courses include cross-disciplinary competencies in addition to the scientific competencies specific to researchers.

"In general, the people working at the head of research laboratories know that they could do better if they had knowledge regarding the commercial side. Some of them take marketing courses in parallel with their activities. As such, the company has a corporate finance programme provided by Harvard." (Research HR manager of a large group - Switzerland)

"The company has two departments that look after training: the HR department and a scientific department, that look after scientific training. The Harvard Business Programs are dedicated to researchers, but not all of them. They're essentially intended for directors of units with 40 to 50 people, that have a budget of a few million. These training courses are therefore for a targeted group. If they want to acquire these competencies, these people must take the training." (Research HR manager of a large group - Switzerland)

"There are several different types of training. Some are general in scope:
- Managing interviews with colleagues: how to give feedback, particularly to underperforming colleagues
- Leadership: for employees and project managers Concept of "leading through others", for managers
- How to develop a "winner's mentality"

"Some are highly specific to the field of research. The most important course for researchers at the moment is "Managing a global project", which delivers the tools and strategies for managing complex projects. Important training is also provided in the area of research management, specifically with regard to change management. One of the company's main objectives right now is to help researchers move from an individual work environment to a teamwork environment. Researchers must leave behind one way of doing things, and adopt a new one." (Research HR manager of a large group - Switzerland)

In others, the training programmes focus on non-scientific competencies.

"At each important step in the researcher's career, there's a skills development programme. The training relates to the expected competencies for assuming each position, teamwork, communication, etc. However, there's no continuing training in terms of technology, including upon arrival (only non-scientific profiles not involved in research receive scientific training, introduction to the company's various areas of competence). The company specialises in advanced technologies, so no one is more on the leading edge." (Research director of a large group - Japan)

The management of public sector careers: a revolution in progress

The management of the public sector careers of researchers is characterized by attempts to structure their professional experience as well as possible, and the development of continuing training. Unfortunately, these developments often result in a trend towards reduced job security, changes of status, and many positions with fixed term contracts, etc.

"A major evolution is underway in terms of the types of careers of researchers in the public sector. Previously, promotions were virtually automatic, but this is no longer the case. Job security is in the process of disappearing." (Director of a university laboratory - Japan)

• Offering the young researcher more opportunities without waiting for a certain degree of seniority to be reached

This concern for anticipation is relatively recent, and conditions every success in terms of career development management.

"Every non-university research institution makes special efforts in order to attract young researchers. In particular, efforts are made in all such institutions in order to give researchers, even young ones, more responsibilities." (Public sector research director - Germany)

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

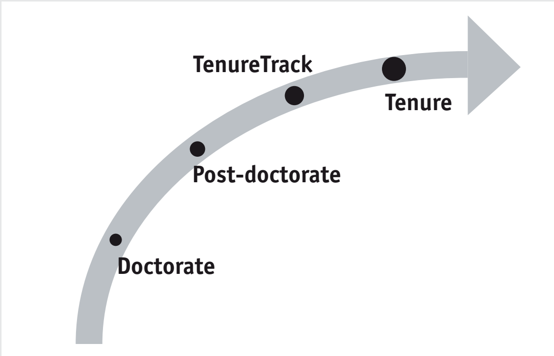
• Providing a young researcher with more visibility regarding possible careers

In certain countries, the aim is to inform young researchers of all possible career options open to them, so that they can make relevant choices.

The "tenure track" system (position with possibility of obtaining tenure), that originated with American universities, is in the process of being adopted and adapted in a certain number of countries.

THE "TENURE TRACK" SYSTEM IN THE UNITED STATES

An American university researcher's career follows a precise course, consisting of four steps: doctorate (writing the thesis), post-doctorate (fixed-term contracts for non-tenured doctor researchers, Tenure Track (period during which the researcher is an assistant professor) and Tenure. This model is the typical path for anyone aspiring to a tenured researcher's position.



Tenure Track is a contract between the university and the researcher: the researcher enjoys research autonomy and resources made available by the university, but must prove himself in order to reach the tenure objective.

A Tenure Track researcher's aim is to convince with regard to his abilities, in order to obtain tenure. For 6 years (maximum Tenure Track duration), the beginner researcher must prove his abilities in the area of research, publications, team management and teaching. His aptitude for generating external funding, on the basis of his projects, will also be assessed.
In exchange for these demands, Tenure Track researchers enjoy academic freedom for their research on an equal footing with tenured professors, which leaves them with considerable manoeuvring room.

At the end of the Tenure Track period, the researcher is assessed by a committee that involves external experts, that will judge his work and research capacities on the basis of criteria clearly defined in the university contract. This committee will or will not grant his tenure. If successful, the researcher becomes a tenured associate professor; otherwise, he must leave the university to once again join the Tenure Track in another university, or move into another sector. Though there is no American national database with regard to tenure, the success rate for researchers obtaining Tenure after Tenure Track is in the area of 50%[30]. The tenure for researchers is therefore conditional since it depends on the researcher's performances during the term of his contract.

Tenure Track is a means for bringing together research competitiveness, professional stability and intellectual demand, which are often difficult to reconcile.

[30] *Tenure Achievement Rates At Research Universities*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

In Germany, the progressive introduction of “tenure track” should have a significant impact on the careers of researchers.

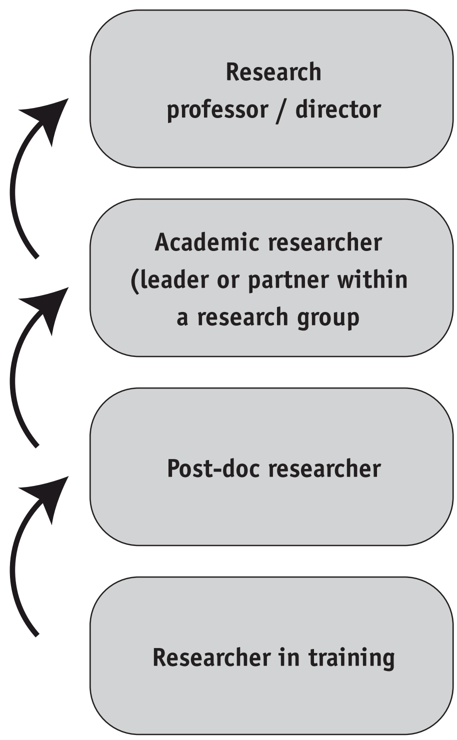
“Germany is making efforts to provide young researchers with more visibility regarding their career, along the lines of the tenure track model in United States. This concept is difficult to implement in Germany since researchers generally have much more rigid open-ended contracts than in the American system. Understanding and integrating the tenure track concept is therefore not obvious for most organisations. However, it’s currently being introduced in Germany and should have a major impact on careers in German public sector research institutions in the coming years.” (Public sector research director - Germany)

Other countries are following this path, such as Finland (example of the University of Aalto) and Switzerland (example of the EPLF).

The 4 steps in the career of a Finnish researcher

The Academy of Finland has set up a 4-step career management system in order to facilitate and support the development of professional careers in the world of science and research.

A researcher will evolve within this 4-step system in keeping with his experience and the development of his skills.



• Researchers reaching this step in the system are leaders in their domain of competence and considered to be accomplished scientists. They actively participate in the scientific progress within their discipline.

• À ce niveau, les chercheurs participent à des projets de recherche, assumant des postes de leader ou partenaire de recherche au sein d’un groupe.

• Researchers have completed their doctorates and, at this level in the system, enjoy research independence.

• Often with a master’s degree, researchers in training focus their efforts as researchers on their doctoral research.

This model has three main objectives:
The first aim is to provide visibility on the various possible career trajectories. Researchers are therefore more likely to plan their careers upstream.
Also, at each step, the system identifies the necessary qualifications and the possible funding sources. The calls for projects launched by the Academy of Finland are therefore specific to each level, thereby resulting in competition between researchers on the same level. The idea is to encourage researchers, irrespective of their levels, to develop a series of competencies, both scientific and "transferable", which means competencies acquired in one domain but applicable in others (for example, teamwork, public commitment, communication...).
The ambition is also to apply this model not only for the university research work of researchers but also outside of an academic setting, in order to facilitate exchanges with the private sector, research institutes and other figures involved in research. However, the public sector has not adopted this model for now.

Sources: • Get ahead in research, Academy of Finland,
http://www.aka.fi/Tiedostot/Tiedostot/Julkaisut/tutkijanura_pdf_en.pdf
• Research Career - Researcher? You decide
http://www.aka.fi/Tiedostot/Tiedostot/TUTURA/Research%20Career%20-%20an%20Opportunity.pdf
• Interviews with the Academy of Finland, Tekes ...

Finland is also considering possible modifications to the status of a researcher, who would no longer be only a researcher as is currently the case, but also have a teaching assignment.

"For now, in Finnish universities, there's a separation between researchers and professors. Some thought is being given to mixed career paths, such that no professor is exclusively devoted to teaching for 30 years. The idea is that they should all be able to go back and forth between research and teaching." (Public sector research director - Finland)

• Introducing continuing education policies in the public sector

In recent years, significant efforts have been devoted to designing continuing education programmes for public sector researchers (research institute or university). Germany and Switzerland provide good examples.

In Germany, significant efforts are being made by research institutes, that are setting up continuing education programmes for their researchers. As such, the Helmholtz association has developed a programme on the management of young scientists and researchers. It has been implemented and is partially funded by the Initiative and Networking Fund. The Helmholtz Management Academy was launched in 2007. The programme offers courses to young researchers, young managers, but also to members of the executive board, institute directors, etc. It is being supervised by the Malik Management Zentrum St. Gallen, which is responsible for the training content and methodology. The training covers the managerial responsibility of researchers, particularly specific to managerial competencies when working in research sectors, as well as management and leadership tools. The programme involves one and a half years of seminars, courses, tutoring and workshops. Since July 2009, it has been open to researchers from other research institutes and universities[31].

In Switzerland, the University of Lausanne has set up a teaching support centre. Its aim is to provide skills to all recruited scientific personnel (for example through workshops on "how to give a presentation", "how to manage a team").

• Mixed public and private sector research careers: an objective more than the reality

In all countries, major developments have occurred in recent years, under the strong impetus given by governments. But this desire to encourage mixed careers (particularly expressed by governments and companies) is running up against major reticence.

In Germany, the government wishes to encourage mobility between private and public sectors, but considerable resistance remains.

[31] *Source: http://www.helmholtz.de/en/research/promoting_research/promoting_young_academics/*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

• In Germany, two research institutes have a strong mobility policy for their personnel, such that researchers leave after a certain amount of time.

"The Institut Max Planck primarily recruits young researchers who can contribute their knowledge regarding new technologies, as well as new ideas. After joining this organisation, researchers generally leave it quite early in order to take up positions in universities or other research institutes.
Regarding the Fraunhofer company, the researchers who leave from there generally head into industry, since the institute has many innovation-oriented researchers who are amongst the most qualified that can be found on the market. This contributes to the appeal of the Fraunhofer institutes amongst young researchers: they know that they'll then be able to find very interesting positions in industry. Another interesting thing is that people don't burn their bridges with the institute one setting moved into industry, which is later good for collaboration." (Public sector research director - Germany)

The possibility of personnel exchanges between the public and private sectors for limited periods has been debated for years. Many programmes have been implemented, but the directors interviewed for the study indicated that the results were not very convincing for the moment.

"One of the reasons for this failure is the salary gap between the public and private sectors, that they're going to try to deal with. A second reason is cultural: it isn't easy to move from the public sector to the private sector. There's no culture for the development of the exchanges from this double experience. These exchanges worked when there wasn't an excessive geographical distance between the original research institute and the company. There could then be daily exchanges with the original institute." (Public sector research director - Germany)

"Mobility between companies and universities is encouraged and supported by the government, but little practiced within the cluster. It may mainly be a question of mentality, but there are also obstacles having to do with intellectual property management." (Director of a competitive hub - Germany)

• In the United States, mixed career paths are rather rare.

"Mixed career paths that include various periods in a federal laboratory and in other laboratories are rare. However, researchers can have double assignments: university and federal research centre." (Researcher in a public sector research centre - United States)

"If mixed careers exist in Europe, they're rather rare in the United States. In my own case, for example, I taught in the United Kingdom, but now that I'm in the United States, I don't anymore." (Laboratory director of a large private sector company - United States)

"It's fairly common to go from university to biotechnology companies, at least in San Diego. That's what most people do. But it's then hard to come back to the university. That isn't frequent. There's no barrier, but people just don't do it often." (Director of a university laboratory - United States)

"In United States, the choice is clear; if you start with an academic career and then you move into industry, it will be very difficult and even impossible to return to an academic career (because you aren't publishing and aren't working in your research structure). However, it's possible to cooperate with industry while remaining in an academic career, in project mode, through:
A contribution of expertise on a particular subject (very frequent) A technology transfer to an industry (with the support of the university office in charge of these subjects). Also, the university provides its support to researchers who want to demonstrate their initiative." (Researcher in a university laboratory - United States)

• Less resistance in Finland?

"A researcher in the pharmaceutical industry can have a mixed public-private career. If he has several publications, he can give university courses. He can also be a thesis director for young doctoral students working in the company." (Researcher for a large company - Finland)

• In France, some examples of mobility within competitive hubs, as a result of the crisis major developments given by the government, but much resistance remains.

"From 2006 delay 2008, the hub's members fought to attract the competencies that they needed. Consequently, the competitive hubs are now becoming hubs of attractiveness. However, at the high point of the crisis in 2009, hiring was frozen, with companies also not wanting to part with employees after all the trouble that they had overcome in order to attract them.

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

It was within this context of crisis and cooperation between HR managers that the idea of making personnel available within the hub was born. This mechanism had three objectives:
- Short-term objective: to protect the "cash" of companies
- To provide companies (especially SMEs) with the human resources that they needed in order to start projects
- To promote transfers of public research to companies and SMEs

"So far, 52 employees have been made available to other organisations. The interest value of the 2006 law on making personnel available is that it allows these transfers in every direction: public-private, public-public, private-public, etc. It should be noted that research has been affected in different ways by the crisis. The research programmes at public sector research centres have not really been affected, with no one calling strategic research projects into question because of the crisis. Consequently, there have been more transfers from the private sector to the public sector, since companies were most affected. The question now is whether it's going to work in the opposite direction after the recovery." (Director of a competitive hub - France)

"Researchers are afraid to go into the private sector because they're afraid of job instability. However, when some researchers leave their laboratories to go work for six months in a SME or a private laboratory, they realise that, in the end, the private sector isn't so bad. They like that." (Director of a competitive hub - France)

"Despite favourable regulations, mobility is uncommon between the public and private sectors, since researchers don't view it as an experience but rather as an abandonment, a risk of losing one's benefits and of being badly viewed by one's peers." (Public sector research director - France)

"Public-private mobility is always criticized from one direction or another. However, innovations are born from the intimate mixture of fundamental research and applied research. That's what it means to be innovative." (Director of a biotechnology SME - France) "The main roadblock is mentalities. The regulatory bridges are there, but people don't take them because they aren't shown the way. The people who receive students at university aren't familiar with the various career opportunities." (Director of a biotechnology SME - France)

• In the Netherlands, companies open to double assignments and a public-private mobility programme within the framework of an innovation support policy

In some large companies, there have been mixed career possibilities for 30 years.

"Many researchers teach at university, in addition to working within the company's Research department. The typical example is that of a researcher who teaches one day per week and works at the company for the other four days of the week. There are other possible combinations and these situations can last over a long period, not only for a few weeks.
This double assignment of researchers has several objectives. Firstly, it broadens the career prospects of the researchers involved. At the same time, it allows researchers to have access to new domains, which sometimes prompts them to redirect their research work. In most cases, the researchers consider this to be an enhancement of their professional activity. It's also a means for enhancing their technical leadership, since they must demonstrate it not only within the company, but also at the university. It also allows the company to serve as a role model in the research domain, since many researchers cooperate in projects carried out on the European level, which allows them to demonstrate the company's research excellence on an international stage." (Research director of a large company - Netherlands)

In the Netherlands, having people with an industry background teaching at university is infrequent. However, to deal with the crisis, the government implemented a very important support programme for high technology companies. The Knowledge Workers Scheme (KWR)[32] therefore allowed researchers working in private companies for which the budgets had fallen sharply as a result of the crisis, and whose jobs were threatened, to work in an employment research institute for a period of a year and a half. The researcher in question remained an employee of the company. A request had to be submitted by the company in question and by the public sector research laboratory. The government covered the bulk of the researcher's salary (75%).

[32] *Innovation Policy Progress Report, The Netherlands, European Commission, 2009*

WHAT ACTIONS AND STRATEGIES HAVE BEEN INTRODUCED OR ARE PLANNED IN THE VARIOUS COUNTRIES IN ORDER TO PRODUCE, ATTRACT OR RETAIN THESE COMPETENCES?

The budget allocated to this measure was 180 million for 2009 and 2010.

"The objective was to allow them to continue their research in their domain, but as part of a project defined by the host institution. More than 2000 researchers were accommodated in this matter. The programme has worked well, but is drawing to an end. The idea is now for the researchers to return to their original companies. At the end of the programme, the hope is for intensified contacts between the public and private sectors. This will be evaluated in 2011, but satisfaction has already been expressed by the companies and research institutes, as well as by the government. It was the public sector research institutes that proposed this cooperative structure at the start of the crisis. To prevent recently graduating doctors from moving abroad, the government had also made provisions for the creation of post-doc positions within research institutes, as part of this programme. This involved 200 post-docs." (Public sector research director - Netherlands)

This measure was implemented by SenterNovem (agency of the Economic affairs ministry - assessment of government policies in the field of technologies, energy and the environment) and the NWO (Netherlands Organisation for Scientific Research)

• In Switzerland, the mixing of researcher careers between the public and private sectors depends a great deal on their disciplines.

"In economic sciences, medicine and law, it's very easy to find a job outside of the university setting. An economics researcher can direct a bank and apply his research. (example of a former University professor who now works at the Swiss National Bank) It also works in the other direction. The University recently hired a management researcher who had worked in the public and private sectors. In labour law, if you want to teach law but have never worked as a lawyer, teaching is too academic. In this case, it's preferable for the teacher-researcher to work on the side as well. In these domains, in fact, the university is having trouble recruiting researchers. However, in domains more focused on human sciences (ancient Greek, for example), it's impossible.
In biology and natural sciences, the direction of the movements is more from the public sector to the private sector." (University director - Switzerland)

APPENDICES

- LIST OF MEMBERS OF THE EXPERTS COMMITTEE
- LIST OF PERSONS INTERVIEWED AS PART OF THE STUDY
- THE LISBON STRATEGY
- FOCUS - RESEARCHER DEVELOPMENT FRAMEWORK
- COUNTRY PROFILE

LIST OF MEMBERS OF THE EXPERTS COMMITTEE

Angelier Clarisse, PhD, Department head at the CIFRE (Convention Industrielle de Formation par la Recherche), Association Nationale de la Recherche et de la Technologie

De Trogoff Hervé, engineer, Worldwide Business Development Director (retired), DuPont Agriculture

Garderet Philippe, ECP Director, Scientific Director, AREVA

Lehmann Jean-Claude, Honorary Chairman, Académie des technologies; Honorary Professor, Pierre et Marie Curie University

Priou Alain, University Professor, Doctor of Science, Manager of the Waves, Materials and Systems Group of the Laboratoire Energie, Mécanique et Electromagnétisme (LEME) de l'UPO and Chairman of the Employment-Training-Research Domain of the ASTECH Cluster, Université Paris Ouest Nanterre la Défense (UPO) and Aeronautics Cluster ASTECH

Valery Philippe, Director of Strategy and Partnerships, Thales Technical Department

LIST OF INTERVIEWED PERSONS

GERMANY
Calarco Tommaso, Professor, Universität Ulm Institut für Quantenphysik
Iancu Otto Theodor, Vice-President, Franco-German University
Kowarschik Richard, Director of the Applied Optics Institute at the Friedrich Schiller University in Jena
Kurmeyer Christine, Soz.-Psych. MA, Diversity Consultant, Charité - Medical University Berlin
Dr Nelle Dietrich, Department of Research Organisations, Federal Ministry for Education and Research
Dr Rodefeld Lars, Head of Chemistry Fungicides Monheim, Bayer CropScience SA Research
Dr Schindler Klaus, CEO, OptoNet e.V
Dr Strohmeyer Torsten, Vice President Medical and Regulatory Affairs, GlaxoSmithKline
Tjin Andy, Director – Ovi Développement, Nokia
Dr Van de Voord Marcel, Professor, Delft University of Technology
Dr Wrachtrup Jörg, Professor, Multidisciplinary University of Stuttgart

UNITED STATES
Aldous David, Senior Director, Sanofi-Aventis
Dertzbaugh Mark, Chief, Business Plans and Programs, USAMRIID
Fenical William, Professor and Director, Marine Research Division tumour growth, invasion and metastasis program, University of California in San Diego; Director of Center for Marine Biotechnology and Biomedicine de Scripps Inst. Oceanography
Gontang Erin, Research Fellow in Microbiology and Molecular Genetics, Harvard Medical School
Mayali Xavier, Post-doc researcher, Lawrence Livermore National Laboratory
Rohwer Forest, Professor, Fellow of the American Academy for the Advancement of Science, San Diego State University
Ruohoniemi J. Michael, Associate Professor, Virginia Tech
Southworth Finis, Chief Technology Officer, Areva USA
Toledo Gerardo, Director, Microbiology, Synthetic Genomics
Wheeler Julia, HR Manager, Crop Protection Products, Dupont de Nemours

FINLAND
Heikinheimo Riikka, Executive Director, TEKES – Finnish Funding Agency for Technology and Innovation
Hiidenmaa Pirjo, Director, Research Council for Culture and Society, Academy of Finland
Lotta Timo, Translational Sciences –R&D, Orion Pharma
Nieminen Risto, Director, National Centre of Excellence for Computational Nanoscience (COMP)
Ylijoki Jukka, Technology Development Manager, METSO

FRANCE
Bariteau Michel, Directeur Centre de Recherche, INRA PACA
Boujard Thierry, Adjoint au DRH, INRA
Cytermann Jean-Richard, Assistant to General Manager for Research and Innovation, Chef de services, Ministry for Higher Education and Research, Research and Innovation General Department
De Marguerye Claire, Chef de la mission for scientific employment, Ministry for Higher Education and Research, Research and Innovation General Department
De Mercey Laurent, Regional delegate for research and technology, DRRT Ile-de-France
Kahn Axel, President, Université Paris-Descartes
Kirilovsky Jorge, Director of the Centre de Recherche des Ulis, GlaxoSmithKline
Leterrier Nicolas, General Manager, MINALOGIC Division
Pinel Michel, Director, VALORIAL Division
Vita Natalio, Researcher, Sanofi-Aventis
Weissmann Dinah, Founding president and General Manager, Biocortech SAS Foundation; member of the Attali Commission

LIST OF INTERVIEWED PERSONS

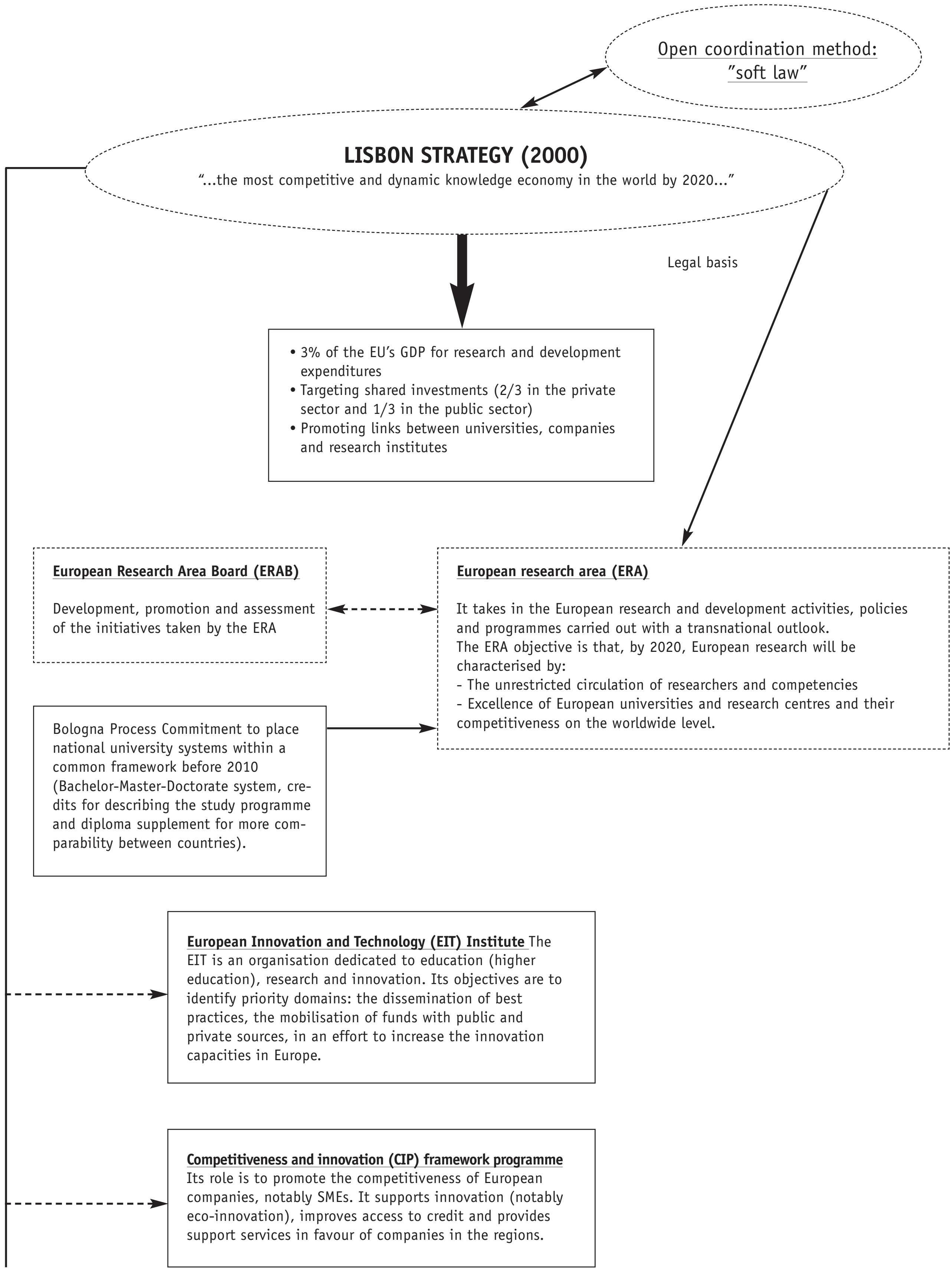
JAPAN
Anzai Yuichiro, Executive Advisor for Academic Affairs, Keio University
Chigusa Yasuhiro, General manager of RES Human Resources, Sony
Fujita Masahiro, Chief of System Technical Research Institute, Sony
Fukushima Takashi, Department General Manager / General Affairs Dept. – Corporate research and development group, Sharp
Hamada Kenji, Partner / Human Capital, Deloitte
Kawakatsu Takaharu, General Manager - Technology Management Department, Murata
Kawashima Hiroyuki, Associate Professor – Department of Global Agricultural Sciences, University of Tokyo
Levy Georges, R&D Manager, Michelin
Lugagne Remi, General Manager – HR Division, L'Oréal
Nakamura Yoshiaki, General Director – Technological Development Promotion Department, Nez Energy and Industrial Technology Development Organization (METI/NEDO)
Nozomu Nishitani, Associate Professor – Solar-Terrestrial Environment Laboratory, Nagoya University
Sato Taisuke, Professor – Department of Computer Science, Tokyo Institute of Technology

NETHERLANDS
Aalders Ferrie, Senior Director Business Excellence, Philips Research
Aarts Emile, Chief Scientific Officer and VP Philips Research, Philips
Botti Jean, Chief Technical Officer, EADS
Huysse Johan, Senior advisor, Vereniging van Universiteiten (VSNU), Association of Dutch Universities
Kirschbaum Robert, Vice President - Open Innovation, Dutch State Mines (DSM)
Van Den Bergh Babs, Director of Research and Science Policy, Ministry of Education, Culture and Science

UNITED KINGDOM
Bennett Sue, Director Student Careers and Skills, University of Warwick
Berry Caroline, Research Manager, UK Commission for Employment and Skills
Docherty David, CEO, Council For Industry and Higher Education
Hockaday Tom, Isis Innovation Ltd
Hodge Alison, Head of the Inter-Company Academic Relations Group, Confederation of British Industry
Dr Hughes Dave, External Partnerships, Syngenta
Jay Michelle, Head of Research, Asset Skills UK
Pr Longhurst Derek, Chief Executive, Foundation Degree Forward
Metcalfe Janet, Chair and Head, Vitae
Rodger Alison, Professor, University of Warwick
Walsh Elaine, Senior Lecturer, Imperial College London

SWITZERLAND
Arlettaz Dominique, Rector, University of Lausanne
Dr Bloemberg Guido, Researcher / Director of the Department of molecular diagnostics for bacterial and fungicidal illnesses, university of Zurich
Bourlard Hervé, Director, IDIAP; Professor, Ecole Polytechnique Fédérale de Lausanne
Haber Mathias, HR Partner for ATI & Dermatology, MSD and Programme Office Basel, Institut Novartis for biomedical research
Haour Georges, Professor Emeritus, Technology & Innovation Management, IMD Lausanne
Kunz Olivier, Director of Human Resources, Ferring
Laurila Juha, Head of the Nokia Research Centre, Nokia Lausanne
Dr Miescher Guido, Dr med. FMH, Scientific advisor for national research, Swiss Ministry for research

THE LISBON STRATEGY



Seventh Framework Programme for Research (2007-2013)
Its aim is to consolidate the ERA, in which it is involved.
It includes many elements from previous programmes that had a positive impact on European research.
The programme is focusing on the long term, since its duration has been increased from four to seven years. The budget dedicated to this programme is €50,521 million (€7,217 million / year), an amount far in excess of the one allocated to the sixth Framework Programme. This increase reflects the importance of research in the relaunch of the Lisbon Strategy. The seventh Framework Programme is subdivided into four specific national programmes: the Cooperation, Ideas, People and Capacities programmes.
The 7th framework programme will finance the direct actions of the Joint Research Centre (JRC) and the actions covered by the Euratom framework programme in the areas of research into fusion energy;
nuclear fission and radiation protection.

Cooperation Programme
• Objective: To stimulate cooperation and to strengthen the links between industry and research in a transnational framework focusing on health themes; food, agriculture and biotechnology; information and communication technologies; nanosciences, nanotechnologies, materials and new production technologies; energy; environment (including climate change); transport (including aeronautics); socio-economic sciences and the humanities; security and space.
€32,413 million

Ideas programme
• Objective: Objective: To enhance exploratory research in Europe, i.e. aimed at discovering new fundamental knowledge.
€7,510 million

People programme
• Objective: To harness financial resources that can be used to improve the career prospects of researchers in Europe and attract more high-quality young researchers
€4,750 million

Capacities programme
• Objective: To enhance the quality and competitiveness of European research through more investment in research infrastructure, in the creation of regional research-driven clusters and in research for the benefit of SMEs This programme is also intended to strengthen international cooperation in research
€4,097 million

Funding

Joint Research Centre
• Objective: Provide scientific and technical support for the research policies of the European Union and, more specifically, to promote the transfer of technologies that stem from the results of research in order to create industrial added value and to promote Community policies related to innovation

EURATOM programme
• The actions covered by the EURATOM programme include research activities in the areas of fusion energy, nuclear fission and radiation protection, and the actions of the Joint Research Centre in the area of nuclear energy. The overall ceiling amount for the implementation of the seventh framework programme for the period from 2007 to 2011 is equal to
€2 751 million

European research council
• Objective : Created as part of the Ideas programme, its aim is to support fundamental research projects as part of the scientific excellence criteria and to provide research grants to scientists at the start of their careers (ERC Starting grants) or to experienced scientists (ERC Advanced grants). As part of the seventh Framework Programme, the European research council has a budget of **€7.51 billion**

The European Research Council grants in 2009:
21% in Social Sciences and Humanities
45% Physics, engineering
34% natural sciences

The countries that received the most grants: UK, FR, DE
The fewest: PL, EE, HU

Research Executive Agency
Created with the set-up of the FP7, the agency's aim is to foster excellence in research and innovation. As an executive agency, its actions are concrete: services for researchers, support for the European Commission's services dealing with research and innovation.
The agency manages four programmes of the seventh Framework Programme: Marie Curie Actions, SME Actions, Space Research and Security Research.

Marie Curie Actions: €4.75 billion
Support for training, mobility and career development for researchers on all levels, within the EU and elsewhere.

SME Actions: €1.3 billion
Support for strengthening innovations within SMEs and their contribution to the development of new technologies. Help with making better use of their results, extending their networks, increasing the research capacity of SMEs.

Space Research: €600 million

Security Research: €800 million
Development of technologies / competencies for ensuring security on the European level.

The main trends to come out of the Lisbon Strategy

The European Commission's efforts in the areas of research and innovation have been reinforced, and the allocated budget for the Seventh Framework Programme is higher than that of the Sixth Framework Programme. The EU's actions are intended to strengthen a "market" type approach to research, for which the mobility of researchers is a prerequisite.

Collaborative research has been extensively encouraged by the closer ties between industries and universities, by the training of clusters and by the establishment of networks of excellence.

Considerable weight has been devoted to applied research in general, but that does not mean that fundamental research has been neglected (excellence bursaries). Applied research is also encouraged within SMEs (SME Actions).

European funding is primarily intended for the financing of technological innovations or for subjects involving security / space / nuclear sectors.

The question of sustainable development has now been taken into consideration as part of the European research policy (eco-innovations, etc.).

Sources
http://erc.europa.eu/pdf/Statistics_AdG09.pdf
http://ec.europa.eu/research/rea/index.cfm?pg=fo
http://ec.europa.eu/research/index.cfm?lg=fr
http://ec.europa.eu/research/erab/index_en.html
http://ec.europa.eu/research/era/understanding/what/what_is_era _fr.htm
http://fr.wikipedia.org/wiki/M%C3%A9thode_ouverte_ de_coordination
http://europa.eu/scadplus/glossary/research_and_development_fr.htm
http://europa.eu/legislation_summaries/research_innovation/general_framework/i23032_fr.htm
http://fr.wikipedia.org/wiki/Recherche_europ%C3%A9enne
http://www.touteleurope.eu/fr/actions/economie/politiqueeconomique/presentation/strategie-de-lisbonne-introduction.html
http://erc.europa.eu/pdf/statistics_STG-2_outcome.pdf
http://europa.eu/legislation_summaries/energy/european_energy_policy/i23022_fr.htm

FOCUS – RESEARCHER DEVELOPMENT FRAMEWORK

The Researcher Development Framework is the work of a British organisation championing researcher competencies. It sets out the expected competencies of researchers at different stages in their career development. Five major steps in a researcher's professional life have therefore been distinguished and hierarchically set out.
Researchers progressively advance from one category to the next while developing their aptitudes and performances, that are assessed as they advance.

Along the lines of the Joint Skills Statement, Vitae carried out in-depth work to describe the competencies of researchers, in collaboration with higher education institutions. The initial objective of the Researcher Development Framework is the promotion of researchers and of university research. Several methods were used in order to produce this tool: querying of many researchers in order to identify the characteristics of excellence within their profession, magazines, etc. The Researcher Development Framework also naturally includes many elements from the Joint Skills Statement.

The Researcher Development Framework describes the competencies, knowledge, performances and personal qualities that the researchers must develop in order to attain excellence.
It provides researchers with a new approach to professional and personal development, in order to highlight the competencies of British researchers, and to promote the emergence of world-class researchers. The objective is twofold: to describe the expected behaviours of researchers and to offer them a listing of the knowledge and attitudes that should be developed.

There are nuances to this approach, however; this is not a list of necessary competencies in order to obtain a job (the listed characteristics would not be appropriate, for example, for preparing a job description). As such, the Researcher Development Framework incites researchers to target excellence while encouraging them to improve their competencies. Finally, this approach can contribute to research planning (notably with regard to the preparation of university programmes) and to the definition of training policies.

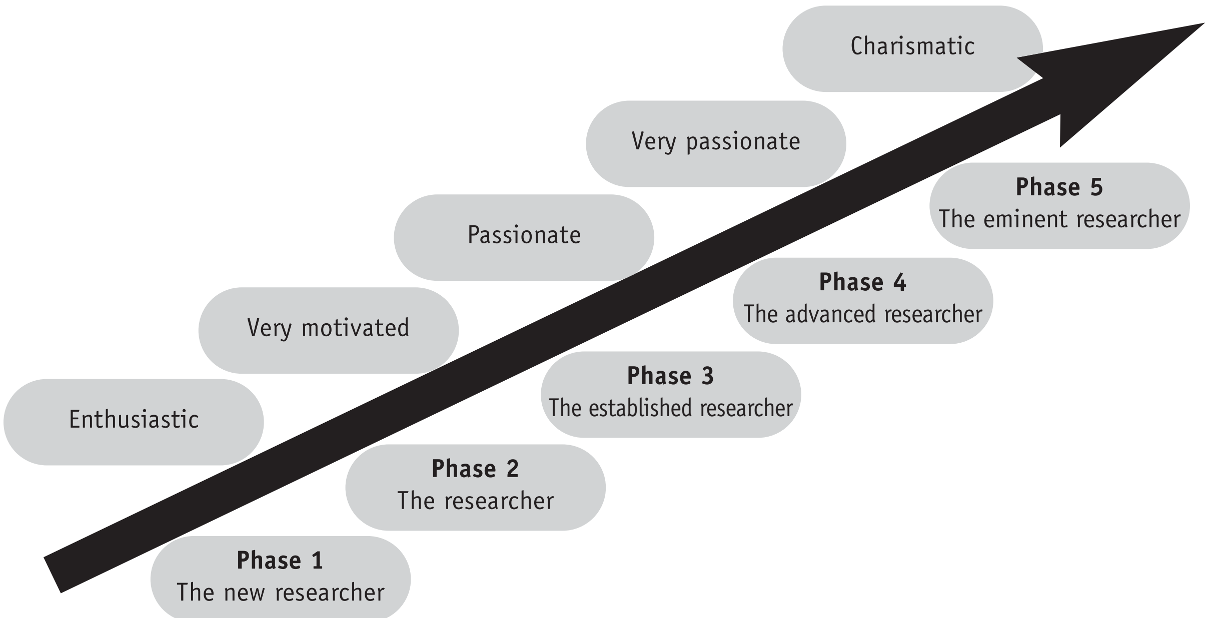
The researcher continuum
The Researcher Development Framework defines five steps in the professional life of a researcher. It's part of a continuum for researchers. Each phase has associated standards that have to be reached, as well as corresponding attributes and types of behaviour. A ranking is therefore created for each step; as such, positive and negative attributes have an impact on the assessment of researchers, while placing them in one category or another.
As the following diagram indicates, the continuum takes in the major steps in a researcher's professional life, from the status of a "new researcher" to that of an "eminent researcher".

The new researcher (phase 1) is a beginning researcher, often still in the process of university education; the researcher (phase 2), for his part, is beginning a career in the research world. The established researcher (phase 3) has a level of research independence as well as a national reputation. The advanced researcher (phase 4) is a leader in a given research domain and has international influence. Finally, the eminent researcher (phase 5) is an expert and international leader in his area of expertise.

By defining these five steps in a researcher's life, the Researcher Development Framework establishes a notion of progress. As such, the researcher gradually develops his competencies in keeping with the development of professional and personal aptitudes.

The four spheres and the assessment criteria

In order to be able to define the competencies expected of researchers, Vitae has established expected levels of competence proficiency for the purpose of assessing the researchers in a given domain. In this way, this expected level increases as the researcher progresses along the continuum. For example, when assessing the enthusiasm (sub-domain of the "personal qualities"), the listing defines various gradual levels for assessing researchers.



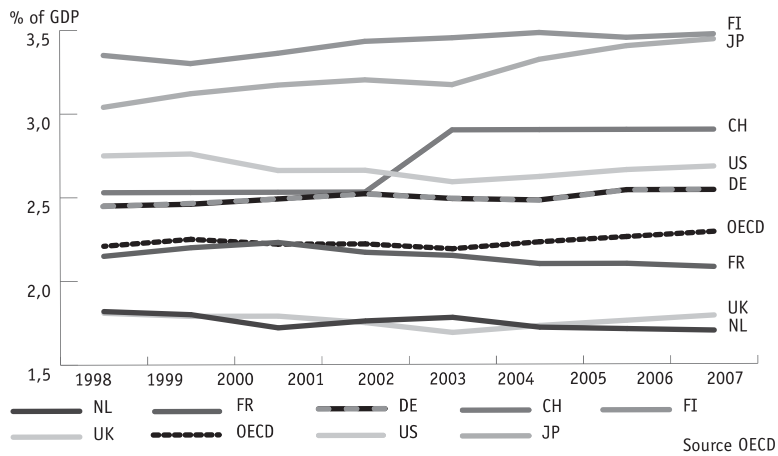
COUNTRY PROFILE:
GERMANY

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[33] (M$ current PPA)	59 409	61 319	64 299	68 515	72 242	76 797
DRDS per capita ($ current PPA)	720	743	780	832	878	935
DRDS (as % of GDP	2,52%	2,49%	2,49%	2,53%	2,53%	2,64%
Including government (as % of GDP)	0,79%	0,76%	0,71%	0,70%	0,70%	n.d.
Including industry (as % of GDP)	1,67%	1,66%	1,68%	1,72%	1,72%	n.d.
Number of FTE researchers	268 942	270 215	272 148	279 822	290 853	301 295
Researchers for 1,000 working people	6,81	6,764	6,649	6,754	6,993	7,229
Estimate of the number of families of triad patents	5 486	5 687	5 812	6 073	6 167	6 027

Source OECD

Chart 1: Growth Of The DRDS: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:
- Automobile equipment
- Chemical industry
- Electrical components and equipment
- Pharmaceutical industry
- Software

Ranking of the key private sector research players in 2008 by total investment:
- Volkswagen (5,926 million euros)
- Daimler (4,442 million euros)
- Robert Bosch (3,916 million euros)
- Siemens (3,836 million euros)
- BMW (2,864 million euros)

Source: IRI - Top R&D companies - Germany

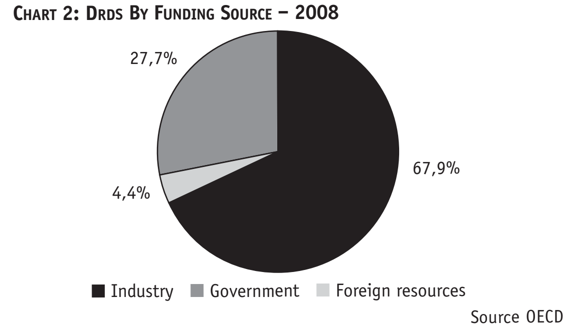
Germany's R&D expenditures fall within the average of the studied countries, but are rising on a constant basis (chart In 2007, research expenditures amounted to **2.53% of the GDP.**

70% of the funds come from industry, i.e. 1.72% of the GDP, versus less than 30% from public financing, i.e. 0.7% as a percentage of the GDP.

The R&D investments in the automobile sector represent nearly 22 billion euros. Four of the five main private research players in 2008 (in terms of total investment) specialise in the automobile industry. **The chemical industry** comes in second place, with nearly 4.8 billion euros.

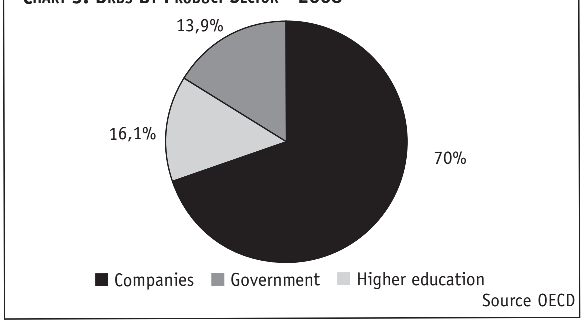
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: DRDS By Funding Source – 2008



Source OECD

Chart 3: DRDS By Product Sector - 2008



Source OECD

Relative to the other European countries in the study, **the share of private R&D funding is high in Germany** (67.9% vs. 50.5% in France, for example), though it remains well below the share in other countries (for example in Japan, where 78% of the research is funded by industry). This importance of the private sector in R&D is also very evident in terms of the R&D product sector.

[33] *DRDS: Domestic research and development spending.*

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

As a **federal country, the research system is Germany is not managed by a central decision-making body**. The Bund and the Länder can establish their own research priorities. As research freedom is included in the German Constitution, each actor is free to determine his own research priorities. The German federal state implements its research policy through the federal Education and research ministry, while the Länder within the federation are active through the Ministries of the Länder that look after research. The necessary dialogue in terms of the governance of public research is carried out within the **Gemeinsame Wissenschaftskonferenz** (Joint scientific conference - GWK) and it relies on the opinions of the **Wissenschaftsrat** (Science council - WR); neither of these organisations is connected to the Bund or the Länder. As such, the German public sector research funding mechanism is a result of this twofold level of governance.

Germany has approximately **750 public sector research units** (laboratories, institutes, centres, etc.) funded by the Bund and the Länder. **The bulk of these units are found in universities,** which therefore concentrate most of the research activities in Germany (fundamental research, but also applied and development research, often carried out in collaboration with research institutes or industrial laboratories, or with SMEs). They receive a large part of their funding from the DFG (Deutsche Forschungsgemeinschaft).

Germany also has **four major non-university research organisations**, which receive joint funding from the federal State / Länder, but that have management autonomy. Their research fields are multidisciplinary, and their missions are complementary in terms of objectives. With their resources and activities, they complete university structures in the various research domains.

- The **Max-Planck** company is an independent public interest organisation that carries out fundamental research work based on scientific excellence in the domains of natural sciences, life sciences, humanities and social sciences; consisting of 80 institutes, it employs around 12,600 people, including 4400 researchers. It accommodates more than 11,000 doctoral students, post-doctoral students, invited scientists and other students. In 2007, the budget of the Max-Planck company amounted to 1.43 billion euros. The Bund and the Länder provide 82% of its funding, with the remaining 18% coming from the financing of contracts for projects signed with the Bund, the Länder or the European Union (13%), contributions from members themselves, donations and its own resources (5%).

- The **Fraunhofer** company is an organisation that specialises in technology transfers, innovation and applied research intended for industry, services and the public sector. It employs approximately 12,500 people in some 50 institutes on 40 sites in Germany. Its annual research volume amounts to 1.2 billion euros.

- **The HGF (Helmholtz community of research centres)** is the largest scientific organisation in Germany. It includes 15 major research structures, has an annual budget of 2.3 billion euros, and it employs 26,500 people. It works in the domains of energy, the Earth, environment, health, key technologies, the structure of matter, transportation and space. The Helmholtz community has adopted the concept of programme-based research funding, resulting in the end of the previously recurring institutional support.

- The **Leibniz** company, for its part, is regionally anchored. Consisting of 86 research institutes, this company is independent on both legal and financial levels, and its actions are primarily regional. Focused on applied research and technology transfer within the Länder, it employs more than 13,000 people and has a total budget of 1.1 billion euros. The range of disciplines within these institutes is very broad, ranging from human and economic sciences to mathematics.

Over and above the university and non-university research structures, German research is funded by agencies and foundations that, on the basis of calls for proposals, support projects that have been assessed and selected by experts. The Deutsche Forschungsgemeinschaft is a resource agency for German research. **The Projektträger** (“ Project carriers”) are the managers of the research programmes of the federal and regional Ministries in charge of implementing research programmes, from the management of calls for projects through to the awarding of financing. Finally, **the A. von Humboldt Foundation**, as well as a large number of powerful foundations, provide research projects with funding.

RECENT DEVELOPMENTS

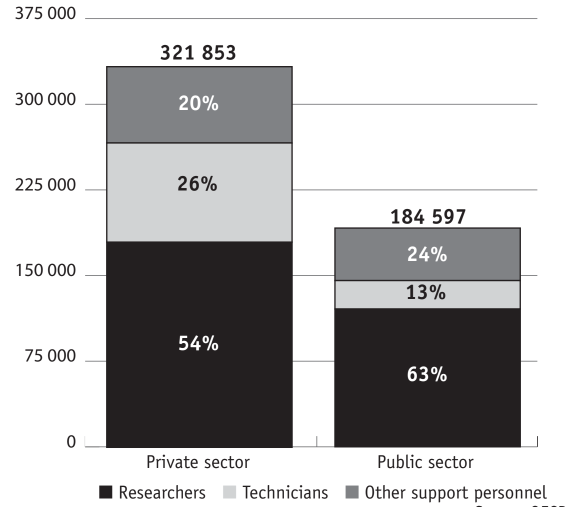
In an effort to increase the flexibility, competitiveness and quality of its research, in 2005 Germany decided to strengthen its university research through the creation of **university excellence clusters**, that have been implemented by means of the **Excellence initiative** programme. It consists of 3 major axes: support for technology transfers, scientific excellence and strategies for the future that target the promotion of leading-edge university research.

Also, in 2006, the federal government launched a national programme in favour of research and innovation, which should help Germany to reach the Lisbon objectives (3% of GDP dedicated to R&D) as of 2010. This is the **High tech strategy**, that has 3 objectives: promoting technology transfers, linking industrial research and industry, and increasing the ability for technological innovation, particularly in the sectors of the future. This strategy has had a major impact on the intensity of the collaboration between universities and non-university research organisations.

2- RESEARCH PERSONNEL

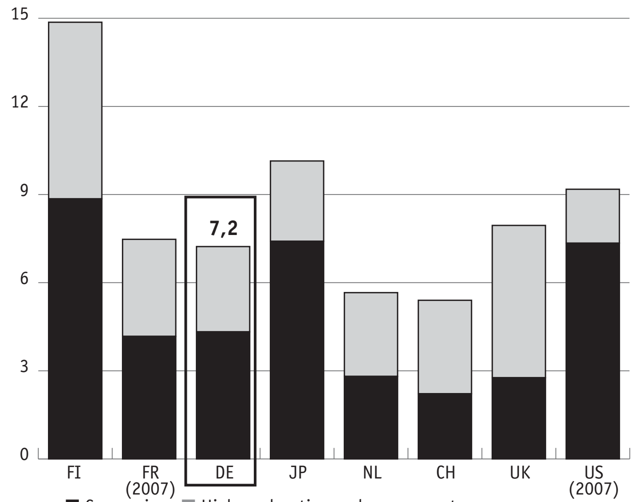
2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2007



Source OECD

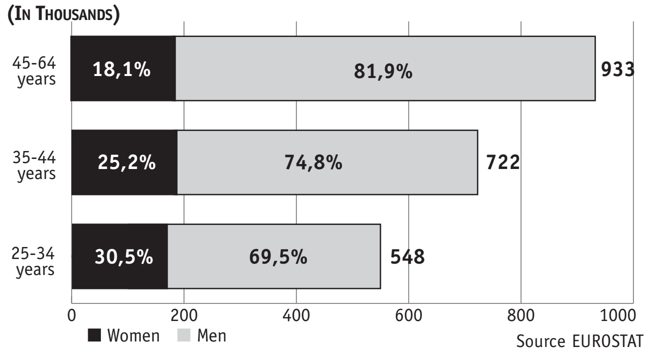
Chart 5: Number Of Researchers / 1000 Working People - 2008



Source OECD

In Germany, research and development involved more than **400,000 people in full-time equivalent positions in 2007 (chart 4)**. 80% of these people were employed in the private sector (321,853 FTE in the private sector versus 184,597 FTE in the public sector) and the share of **technicians involved in research was larger in the private sector** (26% versus 13% in the public sector). In 2008, there were **7.2 researchers for 1000 working people** (chart 5), a rate that is slightly lower than the average of the studied countries **(8.2 researchers per 1000 working people)**.

Chart 6: Age Distribution Of Scientists And Engineers In Germany - 2008 (In Thousands)

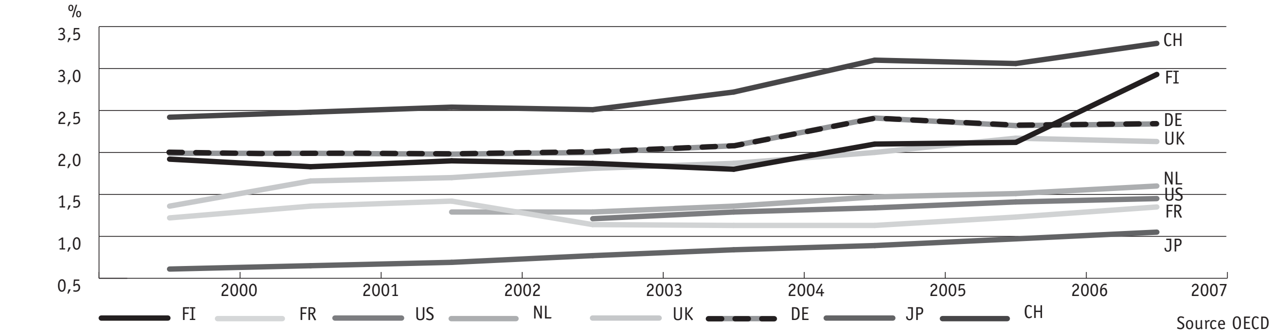


Source EUROSTAT

2.2. GROWTH OF THE POPULATION OF DOCTORS

Along with France, Germany has seen the weakest **growth of the percentage of doctors in the total population of new graduates** (growth of +0.13% for France and 0.34% for Germany). Germany is somewhat behind, with the average growth in the studied countries being +0.74% (chart 7).

Chart 7: Growth Of The Percentage Of Doctors In The Total Population Of New Graduates Between 2000 And 2007



Source OECD

Note: included in the other country profiles, data on the growth of the percentage of foreign doctoral students are not available for Germany.

A few sources:

OECD - Science and Innovation
http://www.oecd.org/topic/0,3373,fr_2649_37417_1_1_1_1_37417,00.html

Berlin Science and Technology Service, Embassy of France in Germany
http://www.science-allemagne.fr/

Research in Germany
http://research-in-germany.de

Deutsche Forschungsgemeinschaft (DFG)
http://www.dfg.de/en/index.jsp

Wissensschaftsrat-Fields of Activity and Results
http://www.wissenschaftsrat.de/1/fields-of-activity/

COUNTRY PROFILE:

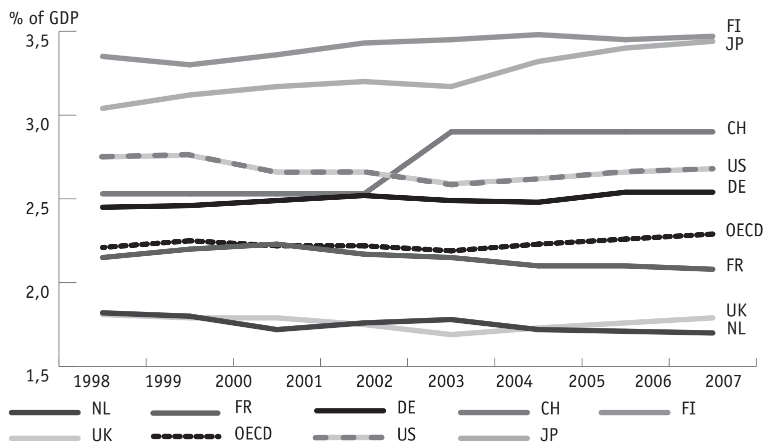
UNITED STATES

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[34] (M$ current PPA)	289 736	300 293	323 047	347 809	373 185	398 194
DRDS per capita ($ current PPA)	997	1 024	1 091	1 164	1 237	1 308
DRDS (as % of GDP	2,61%	2,54%	2,57%	2,61%	2,66%	2,77%
Including government (as % of GDP)	0,79%	0,79%	0,78%	0,76%	0,75%	0,75%
Including industry (as % of GDP)	1,68%	1,62%	1,65%	1,70%	1,76%	1,86%
Number of FTE researchers	1 430 551	1 384 536	1 375 304	1 414 341	1 412 639	n.d.
Researchers for 1,000 working people	9,67	9,299	9,182	9,321	9,18	n.d.
Estimate of the number of families of triad patents	14 834	15 208	15 391	15 217	15 283	14 828

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:

- Pharmaceutical industry
- Semiconductor equipment industry
- IT industry (software programmes)
- Automobile industry
- Telecommunication equipment

Ranking of the key private sector research players in 2008 by total investment:

- Microsoft (6,482 million euros)
- General Motors (5,755 million euros)
- Pfizer (5,715 million euros)
- Johnson & Johnson (5,451 million euros)
- Ford Motor (5,251 million euros)

Source: IRI - Top R&D companies - USA

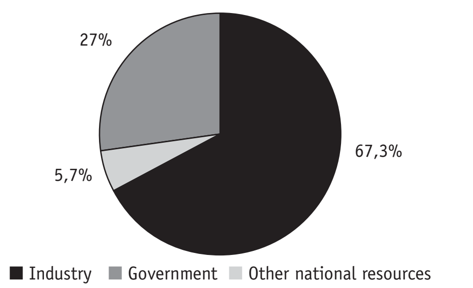
In 2008, **research and development expenditures** were in the area of 400 billion dollars (around 316 billion euros). This sum represented **2.77% of GDP**, which puts the United States in a good position on the international scene, though behind Finland, Japan and Switzerland. Overall, R&D expenditures increased by 37% between 2003 and 2008 (increasing from 290 to 398 billion dollars).

In the United States, **R&D funding comes primarily from the private sector** (private sector expenditures for R&D represented 1.86% of GDP versus 0.75% for the public sector in 2008). Most of the R&D expenditures by companies originate with **manufacturing companies in high technology sectors** (63% of the total R&D in the manufacturing sector involves high technology, versus 47% in the EU and 43% in Japan - source OECD).

Though it only represents 0.75% of GDP, the federal budget dedicated to research and development represents nearly 4% of the American federal budget. While the value of this figure seems low in relative terms, a study of the historical trend for federal R&D indicates that federal investments can increase spectacularly in order to meet national needs, and that they fluctuate with government changes.

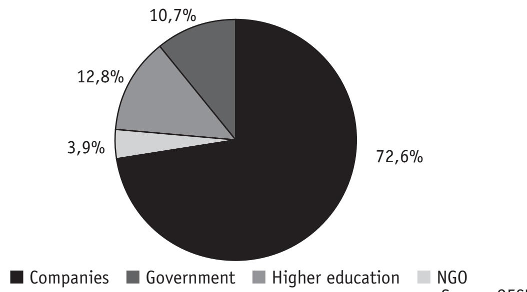
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: Drds By Funding Source – 2008



Source OECD

Chart 3: Drds By Product Sector - 2008



Source OECD

[34] *DRDS: Domestic research and development spending.*

67.3% of research and development is funded by industry, i.e. slightly above the average of the studied countries (approximately 61% of private sector funding). 27.1% of the funds come from the government. Most private sector R&D expenditures originate with high technology industries.

The very weak presence of foreign funds in the financing of R&D in the United States is interesting to note, given that the European countries in the study all have access to foreign funds. It's a characteristic shared by the USA and Japan (in the absence of European Union type funds).

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

The public governance of research in the United States is characterized by two elements:

- **the scale of the effort of the American public sector R&D:** indeed, the federal budget dedicated to research represents more than 140 billion dollars - of which 60% is allocated to defence);

- **the absence of a department of research and higher education, which is indicative of the system's decentralisation.** Of course, there is a federal framework, but its outlines are vague. The definition of the priorities does not follow a purely "top-down" approach (i.e. emanating from a higher entity and disseminated to the lower levels). The research priorities are defined on various levels of the government system, and there is significant interaction between the various actors.

The federal budgets devoted to research and development can vary considerably from one year to the next, and are strongly correlated with the current administration's priorities. On the federal level, the President of the United States takes part in the general orientation of the national R&D policy primarily through the choices that he has had to include in his draft federal budget. The R&D objectives are part of the R&D budget allocations. Various offices and executive committees advise the President relative to the strategic choices for the scientific and technological policy.

Four entities exist in order to advise the administration:

- **the Office of Science and Technology Policy** (OSTP) was created by an act of Congress in 1976;

- **the President's Council of Advisors on Science and Technology** (PCAST) was created by President Bush Sr. in 1990 in order to gather advice from the private sector and the university community with regard to technologies, scientific research priorities, and the teaching of mathematics and sciences;

- the (**National Science and Technology Council** NSTC) serves as a coordination tool within the federal scientific and technological policy;
- **the Office of Management and Budget** (OMB). Their role is important insofar as the credits allocated to research will to a large extent be dependent on the assistance that they provide to the federal government.

After the President's annual budget request to **Congress,** the latter can put forward its own priorities as part of the budget's adoption, provided that these modifications do not result in a presidential veto. The executive agencies and departments (ministries) and to a lesser degree universities and their PIs (principal investigators) also participate in the governance system.

The vast majority of public sector funding for R&D comes from federal government funds (the federal budget allocated 142.7 billion dollars to R&D in 2008 - around 112 billion euros). Over and above this direct financing, there are indirect sources, notably in the form of tax deductions. In particular, in 1981, the government implemented a research and experimentation tax credit.

Eight ministries and agencies share 97% of the federal investment in R&D, and each received more than 1 billion dollars for R&D: the Defence Department, notably with the DARPA (Defence Advanced Research Projects Agency), the Department of Health and Human Services, NASA (National Aeronautics and Space Administration), the Department of Energy (DoE), the Department of Agriculture, the Trade Department and the Department of Homeland Security.

RECENT DEVELOPMENTS

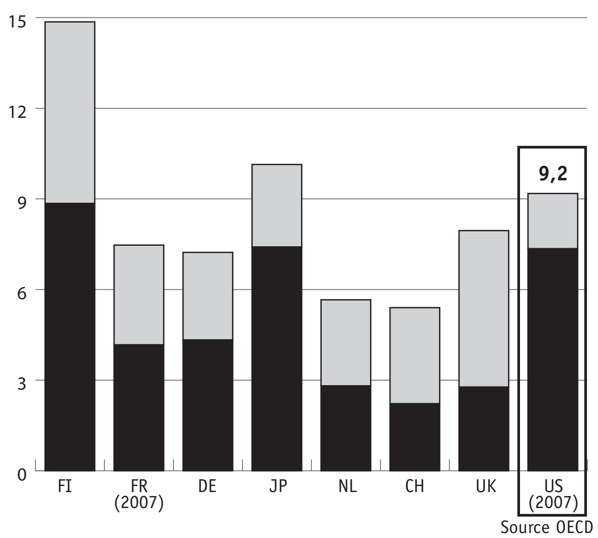
Administration changes can influence the general orientations of R&D policies. Indeed, the president prepares a budget and makes federal budget allocations to R&D at the start of his term.

The **change of Administration at the start of 2009** meant a **reorientation of the federal government's R&D priorities**. Nearly 5 months after the start of the fiscal year, Congress approved a 2009 budget that included 147 billion dollars for R&D, an increase of 3.3 billion dollars or 2.3% relative to 2008. This increased the federal investment in research (fundamental and applied) to 58.6 billion dollars, i.e. the first increase (4.7%) in 4 years, while accounting for inflation.

2- RESEARCH PERSONNEL

2.1. DEMOGRAPHICS AND DISTRIBUTION

CHART 4: NUMBER OF RESEARCHERS / 1000 WORKING PEOPLE - 2008



The United States have 1.4 million researchers, i.e. nearly 10 for 1,000 working people, which puts the United States in third place after Finland and Japan.

American research is also powerful in terms of the patent filings. Indeed, with the filing of nearly 16,000 triad patents in 2006, the United States are the second leading generator of patents in absolute terms. However, by considering the number of patents per million inhabitants, the United States (53.3 patents) are less efficient than Switzerland (114.8 patents), Germany (74.9 patents), Finland (64.7) and the Netherlands (61.5 patents) - 2006 OECD data.

Note: the data regarding the distribution of researchers by age and the distribution of the total FTE personnel in R&D by major sector are not available.

2.2. GROWTH OF THE POPULATION OF DOCTORS

The United States are a host country for foreign researchers. In 2006, more than one doctoral student in 4 came from a foreign country. This figure is slightly higher than it was in 1998.

Regarding the proportion of doctors in the population of graduates, the United States are within the OECD average (chart 4).

CHART 5: PERCENTAGE OF DOCTORAL STUDENTS AMONGST GRADUATES - 2005 AND 2006

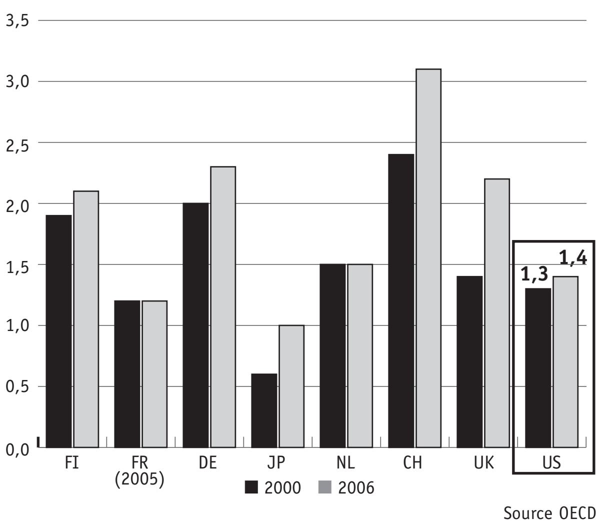
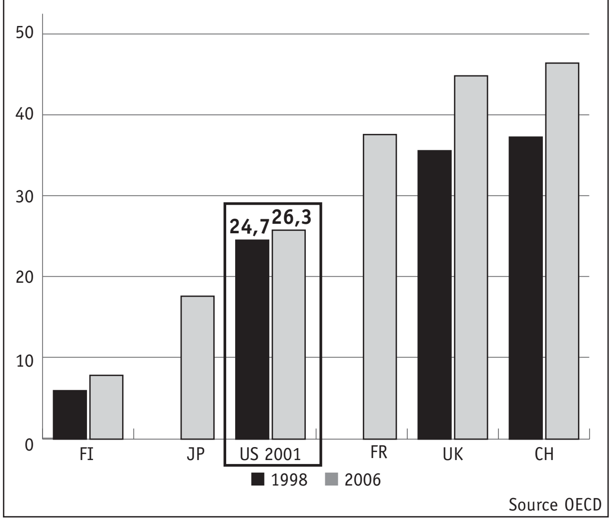


CHART 6: GROWTH OF THE PERCENTAGE OF FOREIGN DOCTORAL STUDENTS



A few sources:

National Patterns of R&D resources, National Science Foundation, Division of Science Resources statistics, http://www.nsf.gov/statistics/pubseri.cfm?seri_id=4

Historical trends and prospects for American federal R&D, Embassy of France in the United States, Responsible for science and technology http://www.france-science.org/spip.php?article1161

R&D and Policy Program, Advancing Sciences, Serving Society http://www.aaas.org/spp/rd/

ERAWATCH - US http://cordis.europa.eu/erawatch/index.cfm

The federal efforts regarding innovation in the United States: realities and trends, Embassy of France in the United States, Mynard Antoine and Charpentier Aline http://www.bulletins-electroniques.com/rapports/smm09_032.htm

The adoption of the federal research and development budget, the Embassy of France in the United States, Science and technology mission, Estelle Bouzat http://www.france-science.org/spip.php?article1155

The public governance of research in the United States, formalisation of national research policies, budget allocations and assessment, Embassy of France in the United States, Estelle Bouzat http://www.bulletins-electroniques.com/rapports/smm08_035.htm

University of California- Technology Transfer http://www.ucop.edu/ott/

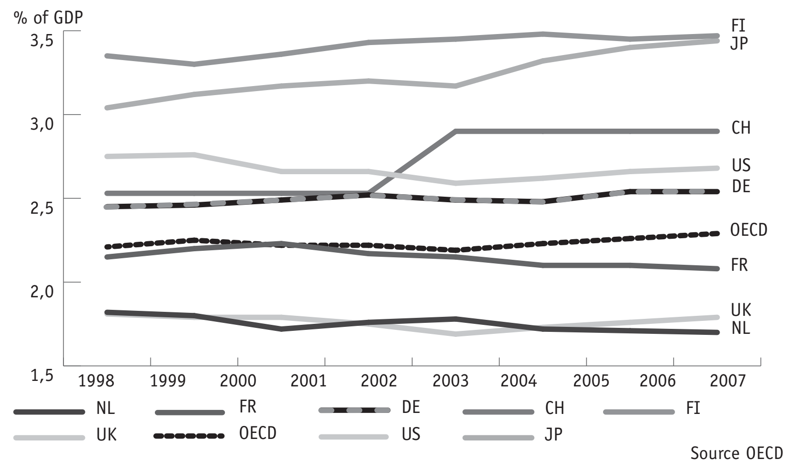
COUNTRY PROFILE:
FINLAND

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[35] (M$ current PPA)	4 950	5 388	5 601	5 920	6 496	7 098
DRDS per capita ($ current PPA)	950	1 031	1 068	1 124	1 228	1 336
DRDS (as % of GDP	3,44%	3,45%	3,48%	3,48%	3,48%	3,75%
Including government (as % of GDP)	0,89%	0,91%	0,89%	0,87%	0,84%	0,82%
Including industry (as % of GDP)	2,41%	2,39%	2,33%	2,32%	2,37%	2,62%
Number of FTE researchers	41 724	41 004	39 582	40 411	39 000	40 879
Researchers for 1,000 working people	15,93	15,678	14,988	15,135	14,471	14,996
Estimate of the number of families of triad patents	302	340	343	352	350	339

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Ranking of the main industrial R&D investment sectors in 2008:

- Telecommunications and associated equipment
- TIndustrial equipment
- TVehicles
- TPharmaceutical
- TAgriculture, hunting and silviculture

Ranking of the key private sector research players in 2008 by total investment:

- Nokia (5 321 million euros)
- Metso (129 million euros)
- Wartsila (121 million euros)
- Orion (96 million euros)
- Stora Enso (80 million euros)

Source: IRI - Top R&D companies Finland

In 2009, **the country's total R&D** expenditures were in the area of **7 billion euros, i.e. 2.62% of GDP**, which places Finland at the head of the studied countries. R&D expenditures increased continuously for around 20 years, before stabilising between 2007 and 2008. **70% of these expenditures emanate from the private sector, and around 25% from the public sector.**

On its own, the **telecommunications and associated equipment** sector accounts for nearly 5.3 billion euros of R&D investments. Indeed, Nokia, the company that dominates the worldwide cellular phone market, plays a decisive role in Finnish R&D.

RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: Drds By Funding Source – 2008

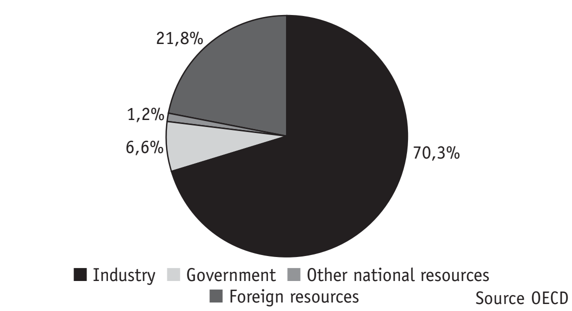
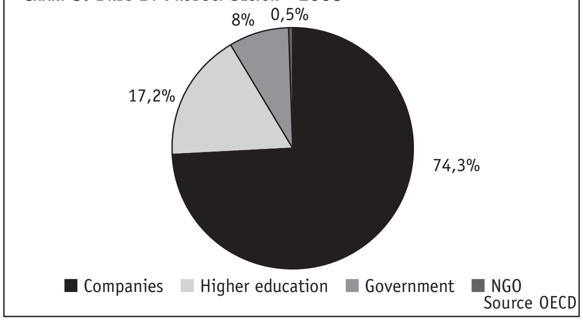


Chart 3: Drds By Product Sector - 2008



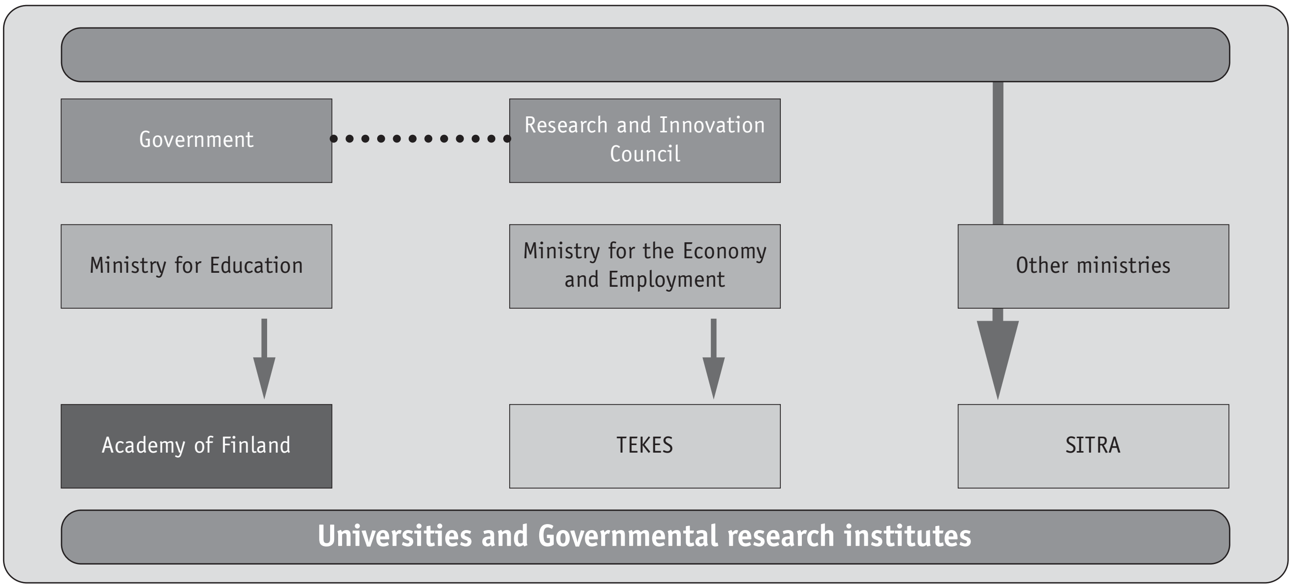
The following charts clearly illustrate the importance of the private sector in the R&D domain. Indeed, **Finland is the country with the highest rate of private funding of all the European countries in the study** (70.3% versus 50% in France, for example), though this figure is still below Japan (nearly 80%).

The private sector is therefore naturally very strongly represented in the performance of research in Finland, once again with a rate that is higher than study's other European countries (nearly 75% versus 53% from the Netherlands).

[35] DRDS: Domestic research and development spending.

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION RECENT

The allocation of public funds follows a precise circuit and is indicative of **the desire not to disperse the country's limited efforts and resources**, but rather to concentrate them on a few target domains. The following diagram illustrates the organisation of the allocation of funds in Finland.



Source : Academy of Finland - Research Funding and expertise

Three institutes are fundamental and receive funds coming from government structures.

- **TEKES** (National technology agency) is the main funding organisation for research and applied development. Its primary mission is to promote Finland's industrial competitiveness and services, through technology. In addition to funding, TEKES provides consulting and establishes cooperative networks between companies, research centres and universities in Finland.

- The function of the **Academy of Finland** is to promote high level scientific research and the exploitation of its results, as well as to develop international cooperation. It reports to the Ministry for Education and provides backing to the Science and Technology Council, which defines the Finnish science policy. It funds researcher positions as well as certain research credits and bursaries.

- The **SITRA** is a national fund for Research and Development, under the responsibility of the Parliament. Its main objectives are to prepare Finnish companies for international competition, as well as to identify and develop the tools capable of improving the country's economic competitiveness. The research projects funded by Sitra must be multidisciplinary but also innovative, and in keeping with the national strategy. The Sitra projects are complementary to the traditional research projects (Universities and Research Institutes).

RECENT DEVELOPMENTS

In order to maintain Finland's performance, the government launched an **Innovation Strategy** in 2008.
With the aim of coordinating the innovation policies and generalising the R&D efforts in all sectors of the economy, this strategy was intended to complete the **Strategic Centres for Excellence**. These centres are intended to promote the emergence of high-level, innovative and efficient knowledge within an environment that supports the development of international research. Four successive programmes of the Strategic Centres for Excellence have been launched since 2000. They targeted 26 research units for the 2000-2005 period, 16 research units for 2002-2007, 23 research units for 2006-2011 and 18 research units for the 2008-2013 period (i.e. a total of 80 research centres in 13 years). The Academy of Finland was the origin of these Strategic Centres for Excellence, and it provides the targeted units with the bulk of their funding (54.9 million euros for the 2000-2005 programme); TEKES also participates actively in the funding of the excellence centres.

A major change to the status of universities occurred in January 2010: universities became independent. They now negotiate funding with the Ministry for education, but can also seek other funding sources. One of the direct consequences of this reform is much greater freedom in terms of HR policy.

Another major development: the growing focus on innovation. The budgets of the institutions that fund innovation (first of all the TEKES) are consequently becoming greater than the ones that finance fundamental research. This orientation is also seen in the consideration of the innovation potential of the research projects as part of the criteria for selecting projects funded by the Academy of Finland.

2- RESEARCH PERSONNEL

2.1. DEMOGRAPHICS AND DISTRIBUTION

CHART 4: TOTAL FTE R&D PERSONNEL IN THE PUBLIC AND PRIVATE SECTORS, BY JOB TYPE - 2008

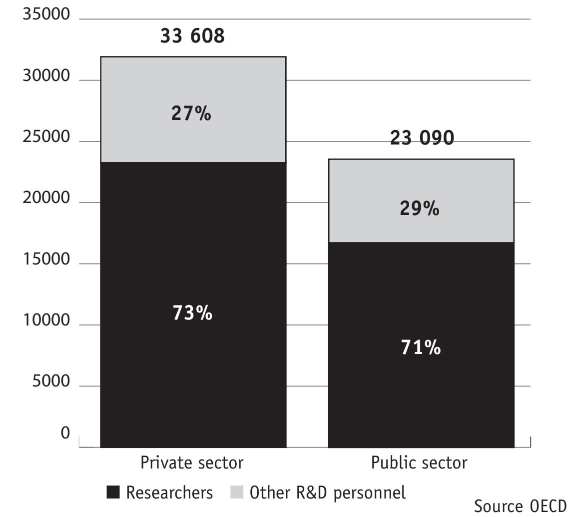
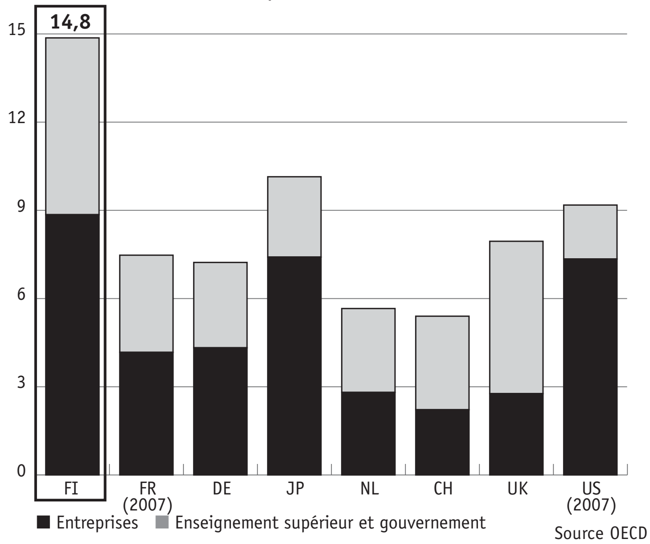


CHART 5: NUMBER OF RESEARCHERS / 1000 WORKING PEOPLE - 2008

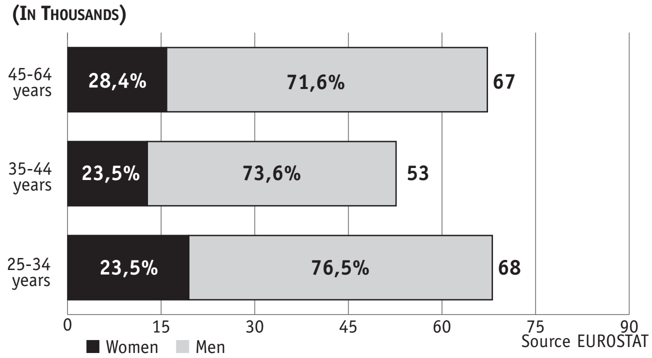


Nearly 40% of the R&D personnel are employed in public sector research, with the remaining 60% working in the private sector.

Finland is the world's leader in terms of the number of researchers as compared with the working population, with nearly 15 out of every 1000 working people dedicated to R&D.

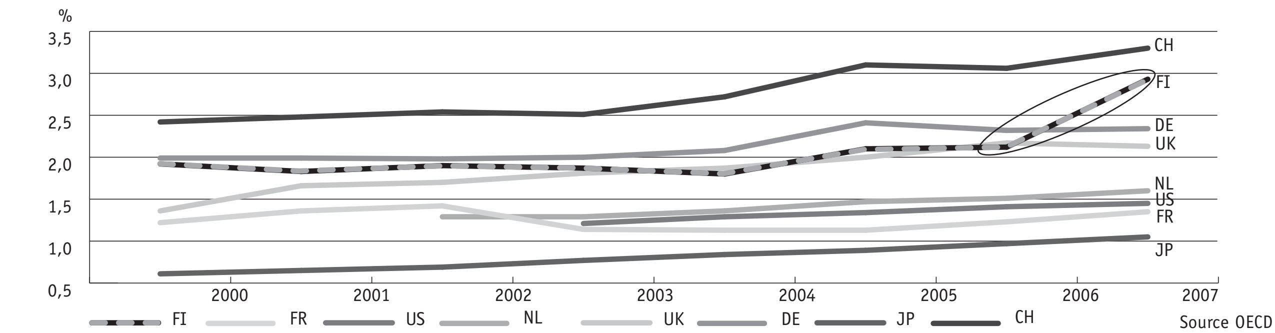
The age pyramid indicates a good renewal of the R&D personnel, with many scientists and engineers in the 25 to 34 years of age bracket.

CHART 6: AGE DISTRIBUTION OF SCIENTISTS AND ENGINEERS IN FINLAND - 2008 (IN THOUSANDS)



2.2. GROWTH OF THE POPULATION OF DOCTORS

CHART 7: GROWTH OF THE PERCENTAGE OF DOCTORS IN THE TOTAL POPULATION OF NEW GRADUATES BETWEEN 2000 AND 2007

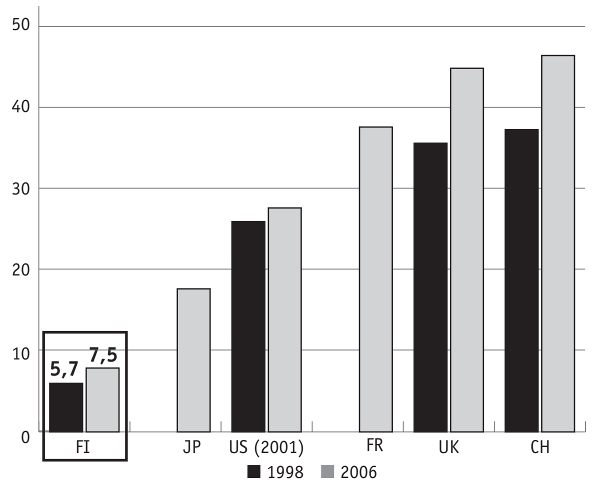


The number of university graduates has more than doubled in 15 years. It increased from 15,229 in 1992 to 39,000 in 2007, i.e. +156%, with a peak in 2003 at nearly 42,000 university graduates.

The growth of the percentage of doctors within the total population of new graduates between 2002 and 2006 followed the trend of all of the presented countries. However, in 2006 / 2007, this growth in Finland exploded and resulted in the greatest increase of the percentage of doctors within the total population. This places Finland in second place amongst the studied countries and is once again indicative of the quality of the research effort in Finland.

As a country with 5 million inhabitants but with some 20 universities, the number of foreign doctoral students in Finland is very low compared with the study's other countries.

Chart 8: Growth Of The Percentage Of Foreign Doctoral Students



Source OECD

Science and Innovation: Country score Finland, 2008 OECD Science, Technology and Industry Outlook

The Evaluation of the National Innovation System - Policy Report, 2009, Ministry of Education, http://www.tem.fi/index.phtml?l=en&s=3161

Academy of Finland
http://www.aka.fi/en-gb/A/Academy-of-Finland/Academy-publications/

Curie File + 2009 Finland Research, Science and Technology Observatory (OST) and Ministry of Foreign and European Affairs.

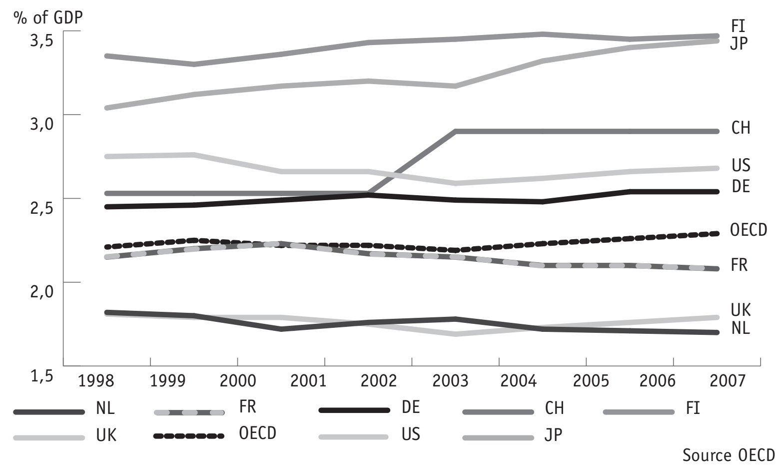
COUNTRY PROFILE:
FRANCE

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[36] (M$ current PPA)	36 840	37 979	39 236	40 988	42 307	42 893
DRDS per capita ($ current PPA)	594	608	623	647	664	669
DRDS (as % of GDP	2,17%	2,15%	2,10%	2,10%	2,04%	2,02%
Including government (as % of GDP)	0,85%	0,83%	0,81%	0,81%	0,78%	0,80%
Including industry (as % of GDP)	1,10%	1,09%	1,09%	1,10%	1,06%	1,02%
Number of FTE researchers	192 790	202 377	202 507	210 591	215 755	n.d.
Researchers for 1,000 working people	6,97	7,277	7,231	7,447	7,591	n.d.
Estimate of the number of families of triad patents	2 288	2 437	2 421	2 465	2 475	2 430

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:
- Automobile equipment
- Pharmaceutical industry
- Telecommunication equipment
- Aerospace and defence
- Electronic components and equipment

Ranking of the key private sector research players in 2008 by total investment:
- Sanofi-Aventis (4,608 million euros)
- Alcatel-Lucent (3,167 million euros)
- Peugeot (PSA) (2,372 million euros)
- Renault (2,235 million euros)
- France Telecom (900 million euros)

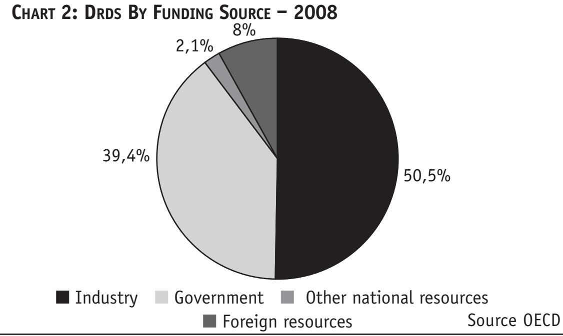
Source: IRI - Top R&D companies – France

With **2.02% of its GDP devoted to R&D in 2008**, France is on the high side of the average within the European Union, but below most of the countries in the study (chart Also, its R&D investments are dropping, with this trend explained by the hesitancy of industry since 2000 and by the slow growth of public sector research.

Private sector investments are relatively low in comparison with the other countries in the study, but nevertheless still very slightly higher than the public sector investments. These private investments originate primarily with the **automobile equipment and pharmaceutical industries**. Indeed, the ranking of the main private sector actors investing in R&D includes two major automobile industry companies (PSA and Renault) and one from the pharmaceutical sector (Sanofi-Aventis).

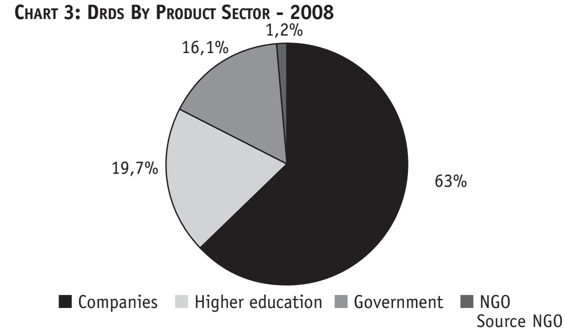
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: Drds By Funding Source – 2008



Source OECD

Chart 3: Drds By Product Sector - 2008



Source NGO

France is one of the countries with the lowest rate of private sector investment amongst the studied countries (50.5% versus 67% for the United States or 70% for Finland, for example). Only the United Kingdom and the Netherlands are lower in the ranking, respectively 45% and 48%. On the other hand, the public sector is more active than in the other countries.

[36] *DRDS: Domestic research and development spending.*

With 39.4% of the funds coming from the government, France is **the study's leading country with regard to the government's financial involvement in R&D**.
With regard to the performance of research and development, the private sector's share is greater as a result of the significant transfers from the public sector to industry (through various subsidies, tax credits, etc.).

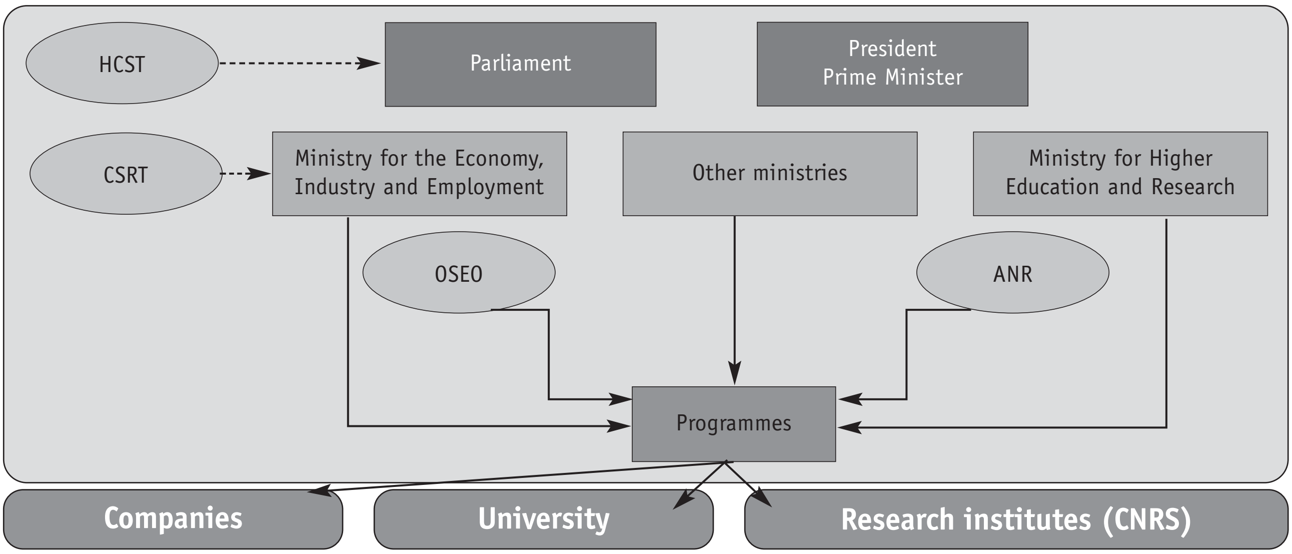
GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

In France, **there are two separate ministries in charge of the organisation of teaching and of R&D**. These two structures are the Ministry of National Education, in charge of primary and secondary education, and the **Ministry for Higher Education and Research**, in charge of higher education, public research and the space policy. These two ministries both report to the Parliament and to the tandem consisting of the President of the Republic and the Prime Minister (advised by the HCST or Haut Conseil de la Science et de la Technologie, in charge of advising the Government relative to all questions regarding the country's major orientations in terms of scientific research policy, technology transfer and innovation[37])

Based on the recommendations from the CSRT (Conseil Supérieur de la Recherche et de la Technologie), **the Ministry for higher education and research (French acronym: MESR) defines and implements the national research and innovation policies**.

The ministry finances innovation, research and development in various organisations. The **ANR** (Agence Nationale de la Recherche) is a **public sector funding agency for research projects**. Its objective is to increase the number of research projects by equally targeting both public sector research establishments and companies, with the aim of producing new knowledge and promoting interaction between public sector laboratories and company laboratories through the development of partnerships. Between 2005 and 2008, the ANR took part in more than 4500 projects (involving nearly 16,000 research teams).

OSEO, a public industrial and commercial corporation, also takes part in the funding of research. The organisation's mission is to **support innovation and the growth of SMEs**. The objective is to ensure continuity in the project funding chain through support for innovation, the funding of investments and the operational cycle in partnership with banks.[38]



Source: The research and innovation system in France, Ministry for Higher Education and Research

The **83 French universities are at the heart of public sector research**. The **"law on the freedoms and responsibilities of universities"** of 10 August 2007 reforms the organisation and operation of universities in order to make them more attractive and more open to the business world. They manage their own scientific policy, budget, human resources policy and real estate assets. As such, they can hire more easily, create new programmes, establish partnerships and tap into funds thanks to the university foundations that they can set up.

The French research landscape also includes **research institutes**.

The **CNRS** (Centre national de la recherche scientifique) is one of the major French research institutions. It consists of a public sector research institution under the responsibility of the Ministry for Higher Education and Research, which produces and disseminates knowledge. The CNRS also serves as an agency for resources, by distributing personnel and financial means to the various university laboratories. The **INSERM** (Institut national de la santé et de la recherche médicale) is another example of a French research institute. It is a public scientific and technological corporation under the double responsibility of the Ministry for Health and of the Ministry for Higher Education and Research. The INSERM is an institute entirely dedicated to health, the mission of which is to ensure the strategic, scientific and operational coordination of biomedical research.

Research centres and universities are undergoing a reform; they are drawing closer to the grandes écoles within **research and higher education clusters** (French acronym: PRES), which are establishing links with industry. This helps them to increase their efficiency, to enhance their international visibility and to better assume their position within worldwide scientific competition.

[37] *http://www.hcst.fr/*
[38] *http://www.oseo.fr/*

Public-private R&D partnerships are developing in France through the "Carnot label", which is awarded to higher education establishments and to research centres that come together in order to undertake research activities for the benefit of the economic world. The 33 Carnot institutes are very much inspired by the German Fraunhofer institutes, they mobilise 12% of the public sector research personnel (12,800 FTE including 6500 doctoral students) and have a budget of 1.3 billion euros.

The government participates actively in the research efforts of industry, through **significant tax incentives**. The **CIR (research tax credit**) is a deduction applicable against corporate tax, for 30% of the volume of R&D expenditures up to 100 million euros. The CIR also encourages the hiring of young doctors. A study by the Observatoire Européen de la Fiscalité des Entreprises, published in March 2009, indicated that the CIR was encouraging 87% of companies to increase their research and development expenditures. In 2006, 6000 companies were able to take advantage of the research tax credit.

In addition, SMEs created within the last 8 years and that devote a significant share of their budget to R&D (at least 15% of expenditures) can obtain tax reductions and be exempted from social levies on the compensation linked to research projects; this is known as the JEI programme (JEI: French for Innovative young company). In 2007, 1930 companies qualified for the "JEI" designation.

In France, there are also organisations in charge of providing specific aid. This is notably the case of the FUI (French for: Single interministerial fund), which allocates subsidies to R&D projects within the competitive hubs as part of calls for projects that are launched twice each year. In 2008, OSEO also worked with more than 5000 innovative companies, providing them with 800 million euros of direct aid. The Agence Nationale de la Recherche financially supports research projects that are jointly presented by public sector laboratories and companies.

RECENT DEVELOPMENTS

In August 2007, the government introduced a restructuring **plan for universities by means of the Law relative to the freedoms and responsibilities of universities (French acronym: LRU)**. This law is primarily intended to provide universities with more autonomy in budget terms.
Also, the January 2008 **Campus Plan** is intended to create 10 university excellence clusters within France, in order to place the country on the highest international level. Amongst the 66 projects presented in 2008, 10 were selected on the basis of scientific and educational criteria. A second call for projects was launched in the summer of 2008. The first projects began in early 2009.

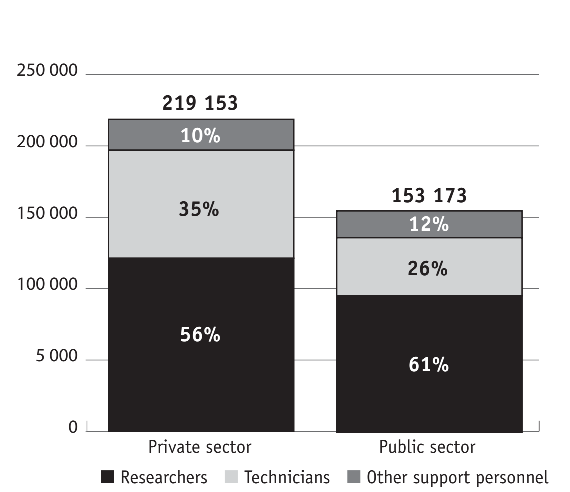
In July 2009, the Minister for Higher Education and research unveiled its **National Research and Innovation Strategy**, the aim of which is to identify the main socio-economic stakes on which French research should focus. The objective of this study is an appraisal of the challenges facing research and innovation, to identify research priorities, to align the efforts of the various actors and to optimise the allocation of public funds for research.

After an assessment of the **competitive hubs** in 2008 (after 3 years of operations), the government decided to continue with the creation of clusters and to renew their support with a contribution of 1.5 million euros for the second stage of its cluster plan.
Finally, as part of the **Programme d'Investissement d'Avenir (Grand Emprunt)**, the government decided, in 2009, to provide 8 billion euros as support for the country's research efforts.

2- RESEARCH PERSONNEL

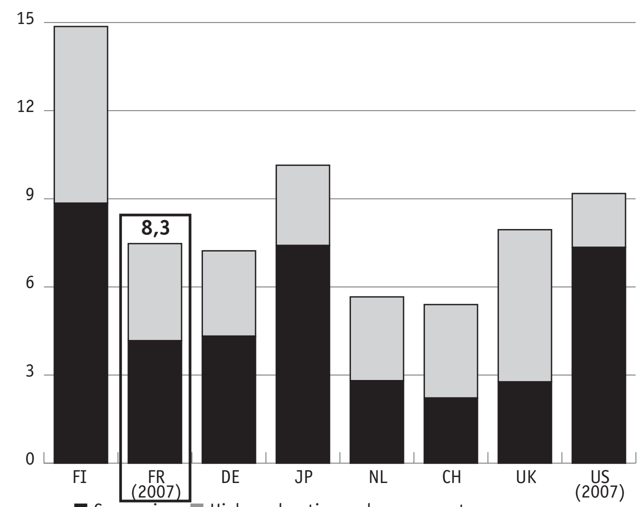
2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2007



Source OECD

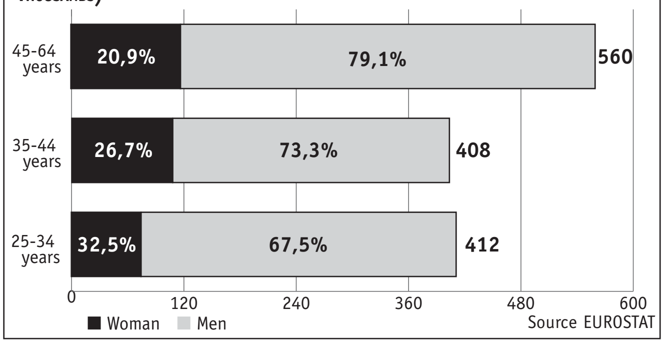
Chart 5: Number Of Researchers / 1000 Working People - 2008



Source OECD

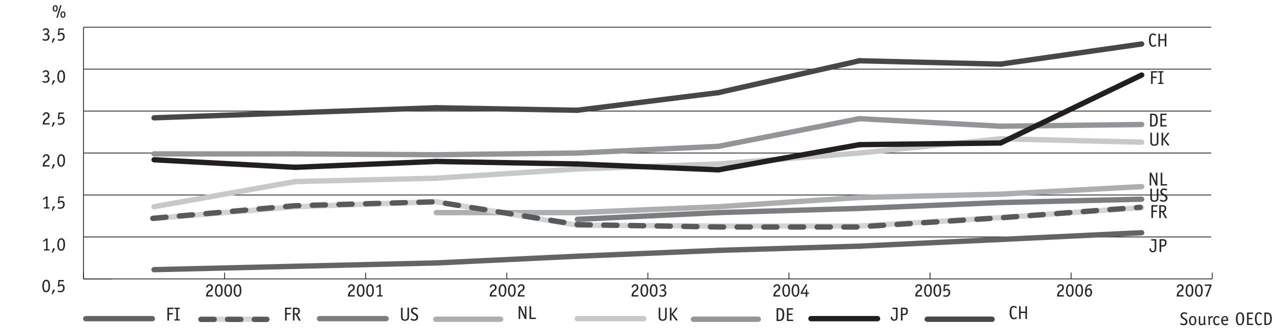
France is within the average of the studied countries with regard to the number of researchers per 1000 working people, with 8.3 researchers per 1,000 working people.
Though the age bracket of 45-64 years is the best-represented, the pyramid of researchers seems to be in the process of renewing itself from the bottom up.
Indeed, there are more people aged 25-34 years than there are in the 35-44 range. The average age of researchers active in the public sector is 47 years, versus 39 years in the private sector.
With regard to business sectors, more than one researcher in two works in one of the following four sectors: Materials and electronic components, automobiles, IT services and the construction of aeronautical and spatial structures.

Chart 6: Age Distribution Of Scientists And Engineers In France - 2008 (In Thousands)



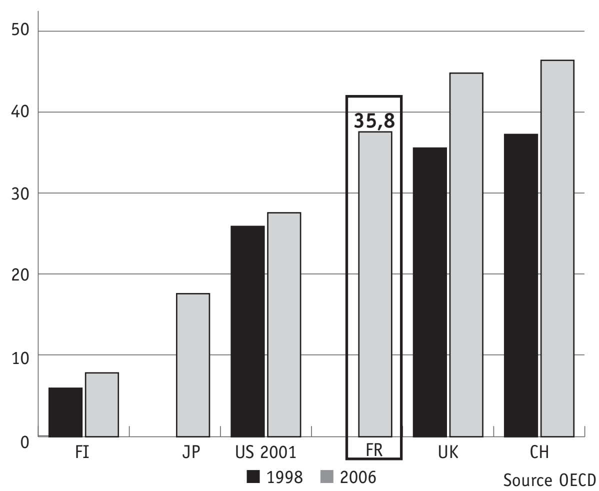
2.2. GROWTH OF THE POPULATION OF DOCTORS

CHART 7: GROWTH OF THE PERCENTAGE OF DOCTORS IN THE TOTAL POPULATION OF NEW GRADUATES BETWEEN 2000 AND 2007



Between 2000 and 2007, **the growth of the percentage of doctors in the total population of new graduates was virtually nil**, despite some minor fluctuations. This rate is low and well below the countries in the study, except for Japan. Similarly, the population of students in a Research Master's programme is in a downward trend. Indeed, there were 6,000 fewer students registered in a Research Master programme in the 2008-2009 year versus 2006-2007 (change partly explainable by diversified educational offerings).
A positive point for the country is that **France accommodates many foreign students**. France appears to be an attractive country for foreign students, since in 2006, more than one third of doctoral students came from foreign countries.

Chart 8: Growth Of The Percentage Of Foreign Doctoral Students



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COUNTRY PROFILE:

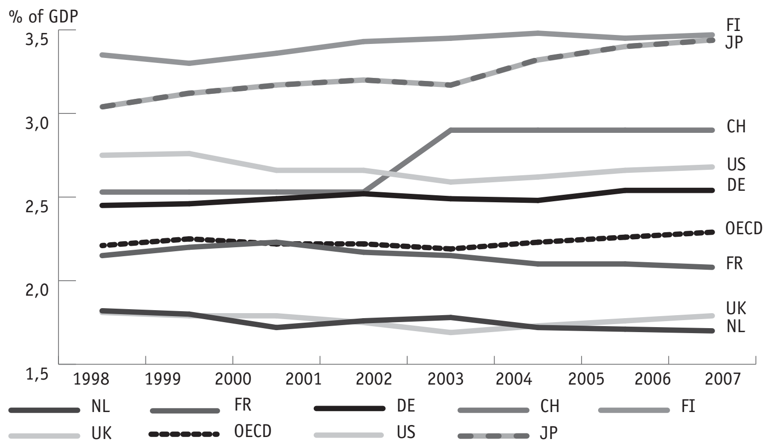
JAPON

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[39] (M$ current PPA)	112 275	117 453	128 695	138 918	147 939	149 213
DRDS per capita ($ current PPA)	879	919	1 007	1 087	1 158	1 169
DRDS (as % of GDP	3,20%	3,17%	3,32%	3,41%	3,44%	3,42%
Including government (as % of GDP)	0,58%	0,57%	0,56%	0,55%	0,54%	0,54%
Including industry (as % of GDP)	2,39%	2,37%	2,53%	2,62%	2,68%	2,68%
Number of FTE researchers	675 330	677 206	704 949	709 691	709 974	682 757
Researchers for 1,000 working people	10,13	10,196	10,601	10,661	10,646	10,267
Estimate of the number of families of triad patents	13 913	13 705	13 899	14 058	14 518	14 126

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:
- Automobile equipment
- Leisure goods
- IT hardware
- Electronic equipment
- Pharmaceutical industry

Ranking of the key private sector research players in 2008 by total investment:
- Toyota Motor (7,610 million euros)
- Honda Motor (4,666 million euros)
- Matsushita Electric (Panasonic) (4,401 million euros)
- Sony (4,132 million euros)
- Nissan Motor (3,631 million euros)

Source: IRI - Top R&D companies Japan

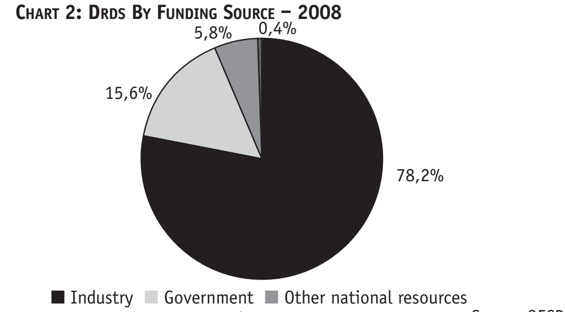
R&D investments are significant in Japan, as they amounted to nearly 150 billion dollars in 2008 (i.e. close to 118 billion euros). **Public and private sector R&D expenditures have increased considerably since 1994**, and amounted to **3.42% of GDP in 2008**: this is the third highest rate in the world (after Sweden and Finland), in a country that is home to the world's second largest economy.

The private sector provides the bulk of the Japanese R&D funding: it accounts for nearly **80% of R&D expenditures**, versus 20% for the public sector. Some companies invest massively in R&D, such as Toyota, for example, which devotes nearly 6 billion euros to R&D each year. There is little collaboration with public sector research, despite increasing encouragement from the government.

Contrary to what is generally thought, high-level fundamental research is carried out in parallel with applied research within Japanese industrial laboratories (Sony, NTT, Fujitsu...). It is estimated that, in 2003, **30% of the Japanese fundamental research efforts were undertaken by private companies.** This effort was particularly significant in the 1980s, but fell during the economic crisis in the 1990s. The trend is once again increasing.

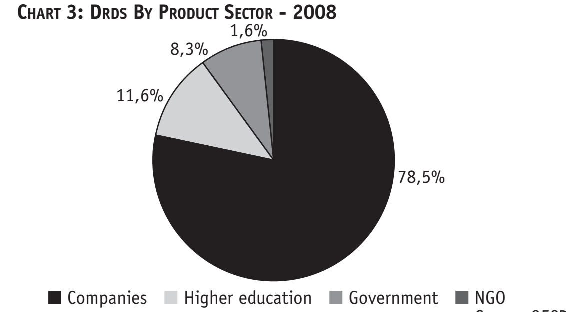
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: Drds By Funding Source – 2008



Source OECD

Chart 3: Drds By Product Sector - 2008



Source OECD

[39] *DRDS: Domestic research and development spending.*

The private sector's massive presence is found both in the funding sources and in the performance of R&D. There is little transfer of public sector funding into private sector research; the private sector's share is therefore identical in both the funding and performance of research.

There is also very limited foreign presence both in the funding and performance of research, which is indicative of the country's low level of openness in this area.

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

The major orientations of the research policy are defined by an interministerial body, the Council for scientific and technological policy (CSTP). This is a limited council chaired by the Prime Minister, that defines scientific policy by means of master plans. The CSTP members include the Cabinet Minister in charge of the Science and Technology Policy, the Minister for Education, Culture, Sport, Science and technologies (MEXT), the Minister for the Economy and Industry (METI), the Minister for Public Administration, Domestic Affairs, Post and Telecommunications and for the Environment, the Cabinet General Secretary, the Chairman of the Science Council, and seven representatives from universities and industry.

This council decides on the government's actions related to science and technology. It determines the actions that will be carried out by the government in fundamental research, in the areas defined as priorities (for example, for 2007: life sciences, information and communication sciences and technologies, the environment, nanotechnologies and materials), the university-industry-government collaboration as well as the reform of the university system.

The research budget is shared between seven ministries, but primarily the MEXT and the METI. The budget is then distributed between the research institutes and universities, either directly or through funding agencies.

There are essentially three such **agencies** (two attached to the MEXT and one to the METI).

- **The mission of the Japan Science and Technology Agency (MEXT/JST)** is to help with the emergence of new technologies, from fundamental research through to marketing, by funding a limited number of projects. It is also in charge of promoting scientific culture and technology to the Japanese public (it owns two science museums). It has a budget of approximately 750 million euros. It operates basically on the basis of calls for thematic projects.
- **The New Energy and Industrial Technology Development Organisation (METI/NEDO)** has a budget of 1.5 billion euros, and it funds research programmes finalised in collaboration between the public sector (universities and research centres) and companies.

As these 3 resource agencies sometimes fund common projects, there is currently a reflection on a possible overhaul of this funding system.

Since the 2001 reform (Basic Law on Reforming Government Ministries), **research institutes** have become independent administrative institutions. They cover the bulk of scientific topics. The general policies of research institutes are directed by their supervisory ministries and are intended to motivate the activities of universities (conferences, researcher networks...).

There are **733 universities** in Japan, including 87 national universities (including 7 ex-Imperial), 76 prefectural or municipal universities, and 570 private universities. Most of these establishments have little or no research activities; significant activity is only found within the national universities, a few prefectural or municipal universities and a handful of private universities. Public funding is distributed in a very heterogeneous manner, which some 20 universities receiving a significant share of the research budget.

In the context of decentralisation and deregulation of the Japanese administration, **R&D plays a priority role in the development of the regions, while encouraging closer ties between universities and industry, and the creation of clusters**.

RECENT DEVELOPMENTS

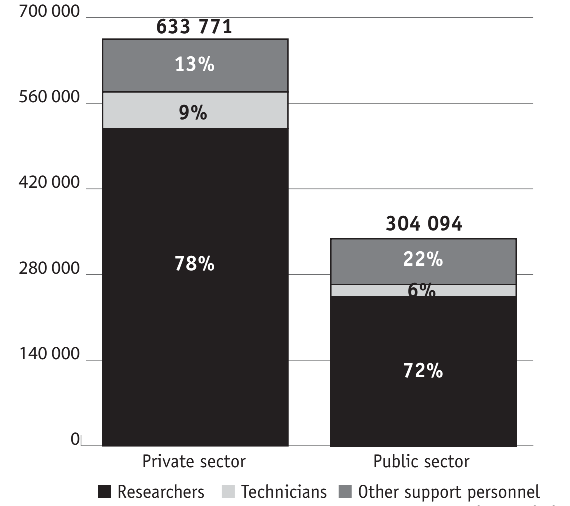
The 2009 budget for the Council for Science and Technology (CSTP) gives some indications of the government's current priorities in terms of science and technology investments. The CSTP's priorities include ecological innovation (385.8 billion yen, i.e. a 20.5% increase relative to 2008), health sciences and technologies (70.9 billion yen, +0.2%), the promotion of science and technology in the regions (71.7 billion yen, +6.8%), and innovative technologies such as new generation robots (215.9 billion yen, +3.7%).

Moreover, a new programme of public sector policies entitled "**New Growth Strategy:** Towards a Radiant Japan" indicates that one of the government's objectives out to 2020 is to increase domestic research and development expenditures up to 4% of GDP. This document, that should be finalised before the end of 2010, also insists on the importance of renewable energies as an engine for the country's growth.

2- RESEARCH PERSONNEL

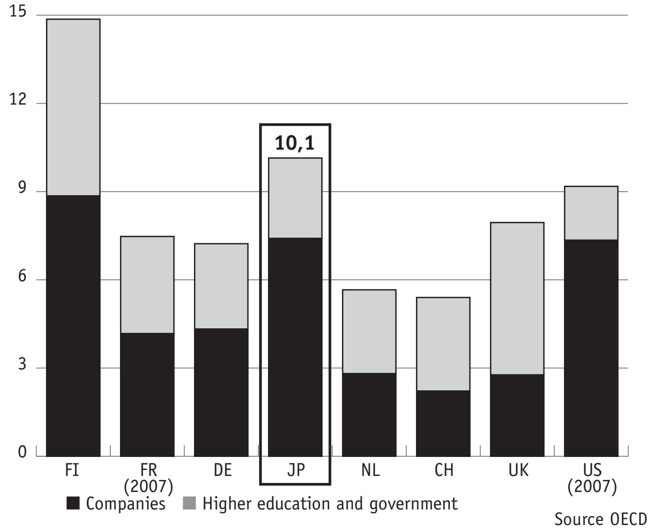
2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2007



Source OECD

Chart 5: Number Of Researchers / 1000 Working People - 2008

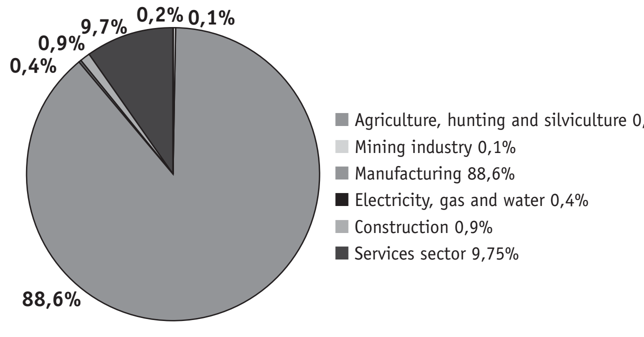


Source OECD

Between 1980 and 2004, Japan doubled its number of researchers, increasing from 0.64% to 1.1% of the working population, primarily by increasing the number of researchers within companies, and to a lesser degree within universities (no significant increase in the national research centres). As such, **Japan is the country in the study with the highest number of FTE researchers**.
Industry employs nearly 2/3 of the FTE R&D personnel (633,771 versus 304,094 FTE - Chart 4).
Nearly 90% of the R&D employees are involved in the manufacturing industry, and 10% in the mining industry.

Note: Data on the age distribution of scientists and engineers in Japan are not available.

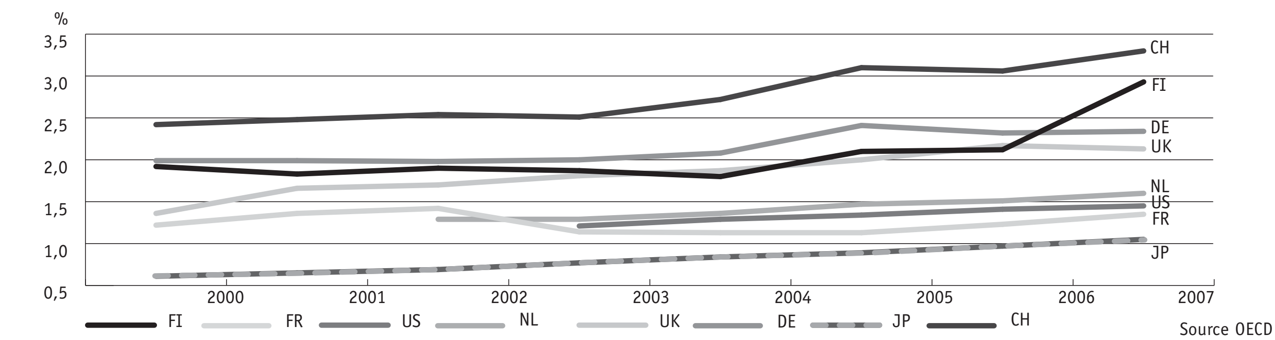
Chart 6: FTE R&D Personnel Within Companies, By Industry - 2007



Source EUROSTAT

2.2. GROWTH OF THE POPULATION OF DOCTORS

Chart 7: Growth Of The Percentage Of Doctors In The Total Population Of New Graduates Between 2000 And 2007

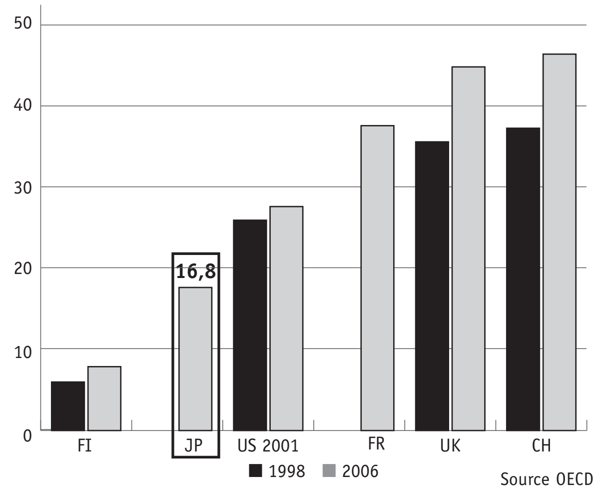


Source OECD

Japan is one of the countries that invests the most in terms of research and development, and one of the best performers in this area. However, it is falling behind somewhat **in terms of the number of doctors**. Indeed, in terms of the percentage of doctoral students in the total population of new graduates, Japan is in last place with a rate in the area of 1% in 2007 (chart 7). This rate is up to three times higher in countries such as Switzerland or Finland. This can partly be explained by the limited **interest of companies in this type of very specialised profile**, since companies prefer to hire new graduates with a master's or bachelor degree.

Japan has few foreign doctoral students. In 2006, only 16.8% of doctoral students were foreigners. Once again, Japan is trailing somewhat behind when compared with countries such as France, the United Kingdom or Switzerland.

Chart 8: Growth Of The Percentage Of Foreign Doctoral Students



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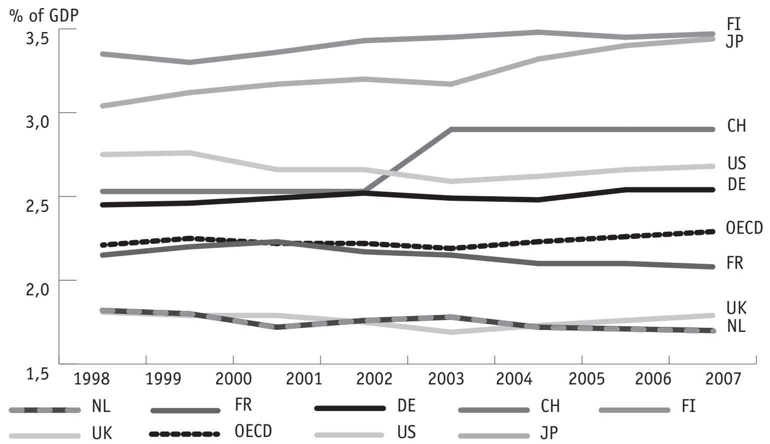
COUNTRY PROFILE:
NETHERLANDS

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[40] (M$ current PPA)	9 031	9 764	10 236	10 789	11 794	11 828
DRDS per capita ($ current PPA)	557	600	627	660	720	719
DRDS (as % of GDP	1,76%	1,81%	1,79%	1,78%	1,82%	1,75%
Including government (as % of GDP)	0,64%	n.d.	n.d.	n.d.	0,67%	n.d.
Including industry (as % of GDP)	0,90%	n.d.	n.d.	n.d.	0,89%	n.d.
Number of FTE researchers	37 282	47 225	46 767	52 039	51 055	50 602
Researchers for 1,000 working people	4,40	5,534	5,47	6,027	5,815	5,661
Estimate of the number of families of triad patents	1 030	1 037	1 037	1 084	1 081	1 080

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:

- Equipment industry (semiconductor)
- Aerospace and defence
- Leisure industry
- Chemical industry
- Electronic equipment

Ranking of the key private sector research players in 2008 by total investment:

- EADS (2,756 million euros)
- Philips Electronics (1,613 million euros)
- STMicroelectronics (1,545 million euros)
- NXP (863 million euros)
- ASML (534 million euros)

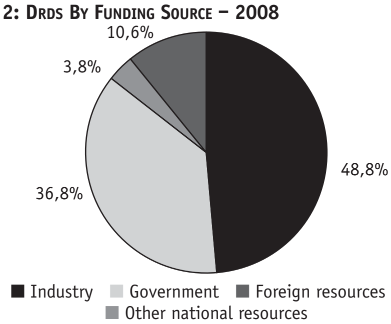
Source: IRI - Top R&D companies Netherlands

Research and development expenditures in the Netherlands are remarkably low when compared with the other countries in the study. They amounted to nearly 12 billion dollars in 2008 (approximately 7.8 billion euros), i.e. 1.75% of GDP, a figure that has dropped appreciably since the start of the 1990s. As such, amongst the studied countries, the Netherlands are the country that invest the least in R&D as a percentage of GDP (chart 1). However, in 2005, the country was **ranked 5th in terms of the number of scientific publications per inhabitant** (amongst OECD countries - OECD data).

Surprisingly, the private sector invests little in research and development when compared with the public sector (the Netherlands are one of the two countries in which the private sector invests the least, together with the United Kingdom). Private expenditures, normally twice as high as public expenditures, in this country are only slightly higher than the funds provided by the public sector (0.89% of GDP in 2007 versus 0.67% of GDP for the public sector). The Netherlands are nevertheless 5th amongst OECD countries in terms of triad patents filed per inhabitant, to a large extent thanks to the innovation efforts of multinationals (2005 OECD figures).

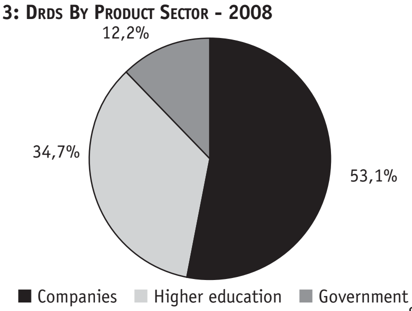
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: Drds By Funding Source – 2008



Source OECD

Chart 3: Drds By Product Sector - 2008

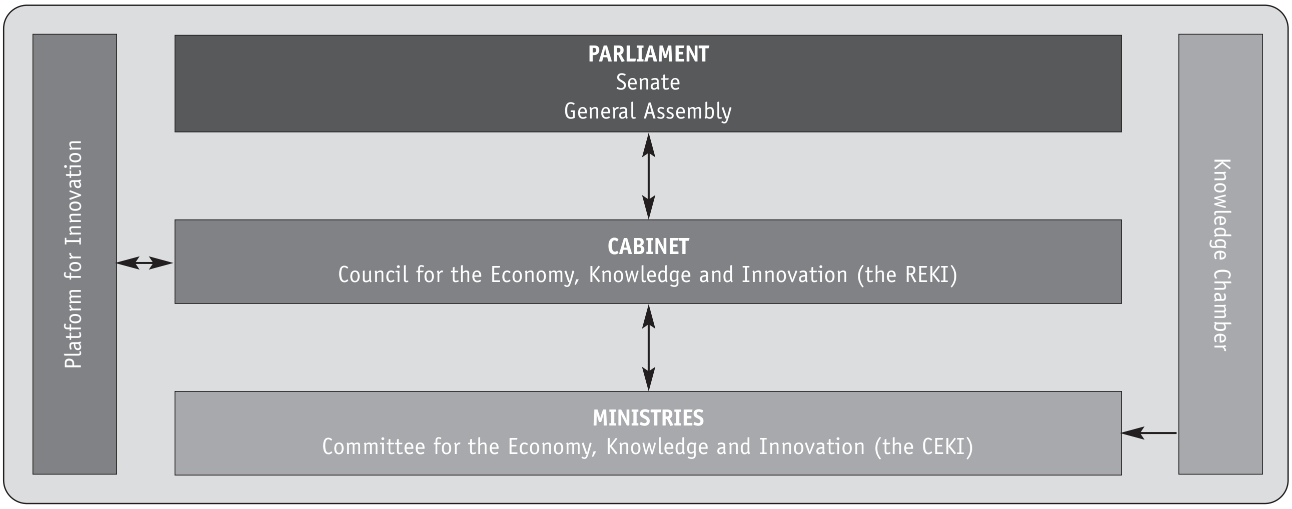


Source OECD

[40] *DRDS: Domestic research and development spending.*

Almost half of the funds financing R&D emanate from private companies (48.8%). Private industries primarily financed their own research (82% of the private sector research is self-funded).
The share of public financing in the Netherlands is relatively high (indeed, the Ministries for Education, Culture and Sciences are in charge of coordinating scientific research and are therefore major funding sources). Only France has a higher public funding rate (39.4%). More unusually, however, more than 10% of the funds come from foreign resources. In recent years, such foreign funding has increased considerably: it increased from 2% in 1990 to nearly 11% in 2007. This foreign funding includes private funds and funds coming from the European Union.
The other national resources are less significant (3.8%). They originate primarily with **charitable institutions**, the presence of which has grown in the Netherlands since the second half of the 19th century. Their financial involvement in research amounts to 80 million euros per year.
In terms of the performance of research, we note a lower private sector involvement in the Netherlands than in the other countries in the study (53.1% versus an average of 68% in the studied countries).

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION



Source: The science system in the Netherlands, an organisational overview, Ministry of Education, Culture and Science [August 2008]

In the Netherlands, questions related to research policies are studied at the highest level, within the Council for the Economy, Knowledge and Innovation (the REKI), that provides the Cabinet with its recommendations (cf. above diagram). However, **decision-making is the remit of the ministries, through the Committee for the Economy, Knowledge and Innovation (the CEKI)**.

The **platform for innovation** was set up by the Cabinet in 2003, and renewed in 2007. Its role is to develop the necessary framework for innovations in the Netherlands (conditions, relations between actors, promotion of innovation...) in order to expand the perimeter of innovation beyond the traditionally powerful multinationals, while involving more SMEs and encouraging collaboration with public sector knowledge institutions. The Prime Minister, as well as the Ministers for Education, Culture, Science and Economy are therefore members of this platform.

Also, **all of the ministries have set up Knowledge Chambers**, the objective of which is to promote interactions between the various levels of the ministries, on the one hand, and research and innovation institutions, on the other hand.
As in the other studied countries, **many organisations are included in the R&D landscape**. Amongst the most influential, the **Advisory Council for Science and Technology Policy (ATW)** is an independent organisation implemented in order to advise the government and Parliament with regard to policies for scientific research, technological development and innovation. In the Netherlands, there are also intermediate organisations that serve as relays for the government, notably in R&D consulting and in higher education, and that very extensively participate in the search for funding in the Netherlands. The most important of these organisations are the NWO, KNAW and SenterNovem.

NWO manages a budget of more than 500 million euros and works to promote the quality and innovation of scientific research, and to disseminate the information and results produced by scientific research. Though an administratively independent organisation, it remains under the responsibility of the Ministry for Education, Culture and Science. The funds are shared between universities and other research institutes, on the basis of projects and programmes proposed by the latter.
The Royal Netherlands Academy of Arts and Sciences (KNAW) advises the government. It can be solicited with regard to specific matters, or freely give its opinion on topics of a scientific nature. The KNAW is chaired by recognised experts, in the fields of sciences, research, development and innovation. It has a budget of 130 million euros, which is virtually exclusively dedicated to scientific research.

Finally, **SenterNovem** is an intermediary between the government, on the one hand, and the private sector and knowledge institutions, on the other hand. The organisation's primary activity is the management of research programmes, the assessment of results and the dissemination of information. SenterNovem can also provide advice regarding research policies. In 2006, the SenterNovem budget amounted to 1.5

billion euros. The bulk of these funds originated with the Ministry for the Economy.
The Netherlands have a large number of organisations that invest in research. 3 activity sectors are generally distinguished: universities, research institutes properly speaking, and the private sector.

The Netherlands are home to **14 public universities** that take part in scientific research projects. The research universities are funded in three ways: funding coming directly from the government, from government funds via the NWO and KNAW and from funding resulting from research contracts. There are various types of **research institutes**: para-university institutions (funded by the NWO and KNAW), TNO (Dutch organisation for research applied to the government and the private sector), GTIs (Large Technological Institutes that carry out research in specialised fields), agriculture research institutes (under the control of the Wageningen University and Research Centre), institutes attached to ministries, sociological research institutes and other research institutes.

Finally, part of the research is carried out by the **private sector** itself. In 2005, 3700 companies carried out R&D, but the activities were very concentrated on a limited number of international companies: primarily Akzo Nobel, ASML, DSM, NXP, Océ, Philips, Shell and Unilever.

RECENT DEVELOPMENTS

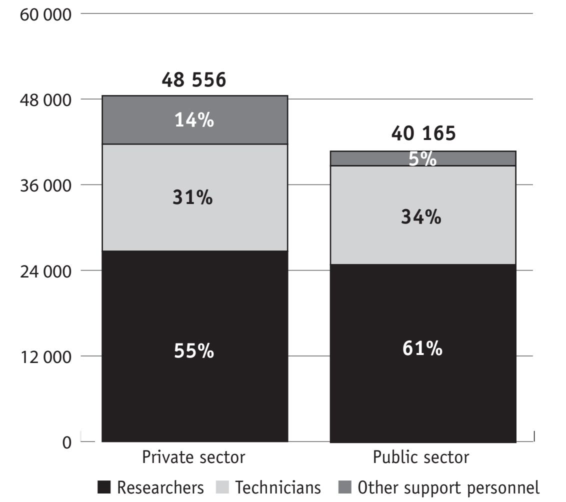
The Dutch government has identified the **main research challenges in the Netherlands, in the 2007-2011 Strategic Agenda for Higher Education, Research and Science Policy**. The starting point of this strategy is that the good current position of Dutch research is indeed good, but fragile. Consequently, in order to maintain its level, the research system must focus its efforts on societal problems such as security, renewable energies, health and education.

Moreover, the Strategic agenda is intended to promote investment in the human capital in order to stimulate innovation and to ensure that Dutch research remains on the highest international level. The strategy therefore focuses on the development of American-style "graduate schools", and on strengthening the integration of women and ethnic priorities into the research world.

2- RESEARCH PERSONNEL

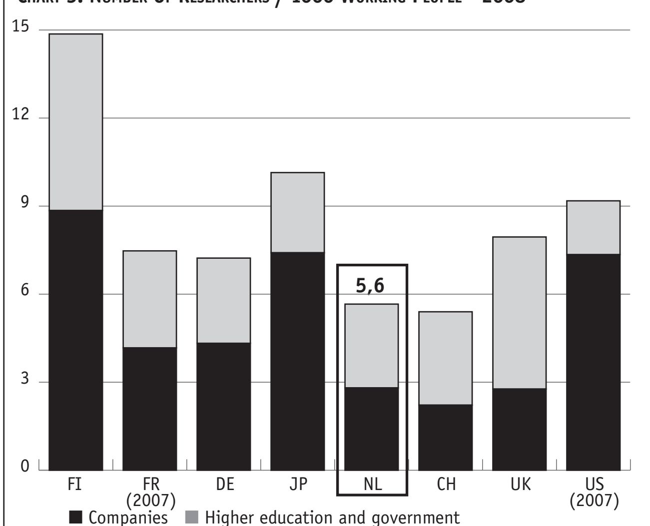
2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2008



Source OECD

Chart 5: Number Of Researchers / 1000 Working People - 2008

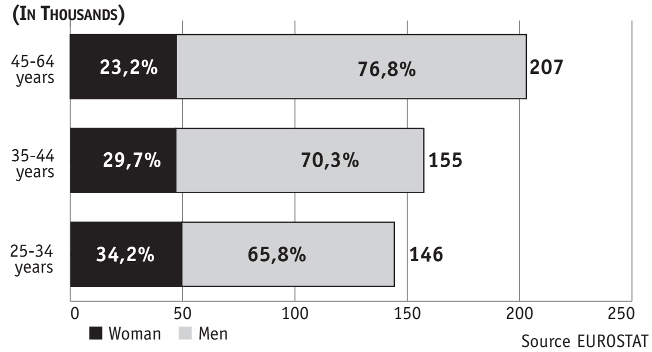


Source OECD

The share of research support personnel and of technicians in the total R&D personnel is significantly higher in the private sector than in the public sector. This characteristic is common to all of the studied countries.
The number of researchers per inhabitant, relatively low compared to the other countries in the study, has to be considered in relation with the low R&D intensity (DRDS as a % of GDP). Like Switzerland (5.3 researchers per 1,000 working people), the Netherlands are somewhat behind in terms of the population of researchers amongst working people.

In terms of age distribution, the bracket from 45-64 years is the largest by far, indicating a certain ageing of the research personnel (chart 6).

Chart 6: Age Distribution Of Scientists And Engineers In The Netherlands - 2008 (In Thousands)



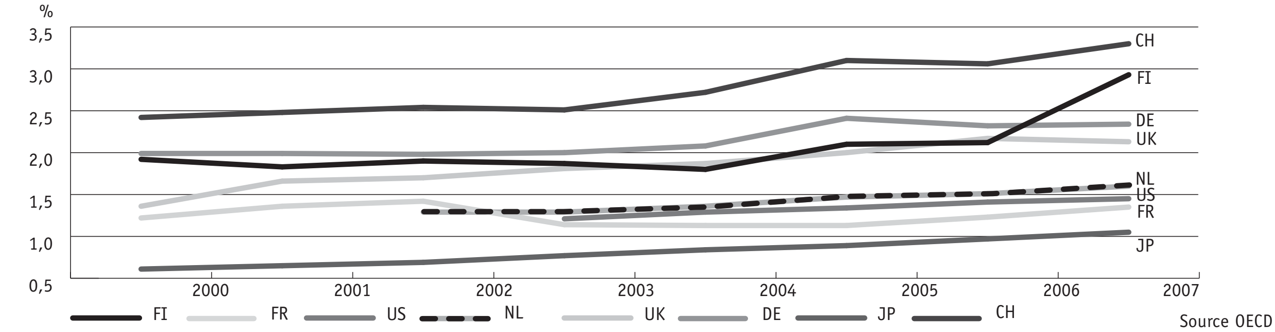
Source EUROSTAT

2.2. GROWTH OF THE POPULATION OF DOCTORS

In terms doctorates obtained, the Netherlands are in the low part of the average relative to the other countries in the study, and the figure has only increased slightly since 2002.

Note: data on the growth of the percentage of foreign doctoral students in the Netherlands are not available.

Chart 7: Growth Of The Percentage Of Doctors In The Total Population Of New Graduates Between 2000 And 2007



Source OECD

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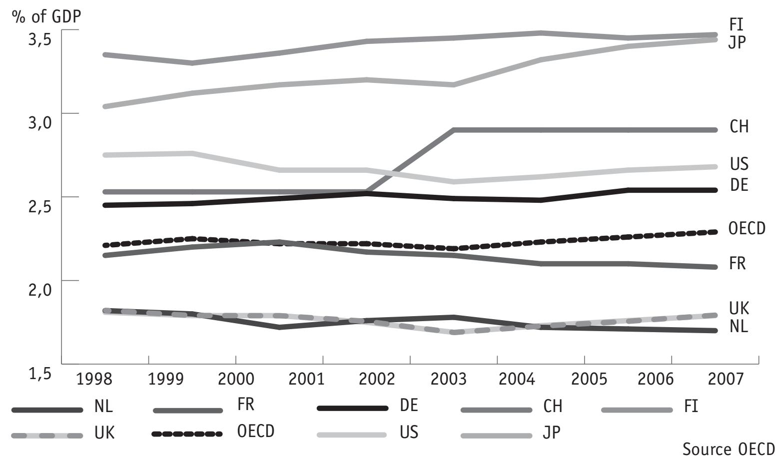
COUNTRY PROFILE:
UNITED KINGDOM

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[41] (M$ current PPA)	31 032	32 018	34 081	36 142	38 088	38 707
DRDS per capita ($ current PPA)	525	535	566	597	625	631
DRDS (as % of GDP	1,75%	1,68%	1,73%	1,75%	1,79%	1,77%
Including government (as % of GDP)	0,55%	0,55%	0,57%	0,56%	0,55%	0,54%
Including industry (as % of GDP)	0,74%	0,74%	0,73%	0,79%	0,82%	0,80%
Number of FTE researchers	216 690	228 969	248 599	254 009	252 651	251 573
Researchers for 1,000 working people	7,41	7,796	8,269	8,308	8,224	8,084
Estimate of the number of families of triad patents	1 664	1 654	1 663	1 694	1 681	1 658

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:
- Pharmaceutical
- Banks
- Oil and gas
- Landline telecommunications
- Agro-food

Ranking of the key private sector research players in 2008 by total investment:
- GlaxoSmithKline (3,835 million euros)
- AstraZeneca (3,622 million euros)
- BT (1,157 million euros)
- Unilever (927 million euros)
- Royal Dutch Shell (910 million euros)

Source: IRI - Top R&D companies - UK

Research and development investment in the United Kingdom is relatively low when compared with the other countries in the study. Industry contributes relatively little to the expenditures, since its investments amount to 0.8% of GDP, whereas the government, on its own, participates for 0.54% of GDP. R&D investments by British companies are lagging somewhat behind as a percentage of GDP when compared with the country's main competitors (United States, Japan, Germany, France). Aware of this, **the government has in recent years set up a certain number of programmes in order to promote collaboration between public research and industry:** 22% of the governmental R&D budget is intended for companies, which represents 11% of the total R&D activity in the private sector.

The two major domains in which public and private sector investments are concentrated are the pharmaceutical industry and biotechnologies, on one hand, and defence and aerospace, on the other hand. Other R&D sectors account for significant investments in comparison with the international average: food (5.5% versus 1%) and oil and gas (3.5% versus 1.4%). On the other hand, the United Kingdom proportionally invests very little in IT (5.7% versus 19.6% internationally), automobiles (6.9% versus 18.8% internationally) and electronics (3.5% versus 10.8% internationally).

The United Kingdom has a **relatively low number of patents per capita** (27 per million inhabitants), when compared with the OECD average (42.4 per million inhabitants). We also note a strong concentration of British patents in the fields of health, the environment, biotechnologies and nanotechnologies.

RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

In the United Kingdom, the private sector makes little contribution to R&D financing (only 45% of the DRDS in 2008). In fact, it is in the United Kingdom that industry participates the least. The participation of the public sector is within the average. However, the share of foreign resources in the R&D financing is rather high when compared with the other studied countries (more than twice as high as in France, and three times as high as in Finland, for example).

[41] *DIRD : Dépense intérieure de recherche et développement.*

The financial transfers from the public sector to companies appear in the R&D performance figures, where the private sector has a much greater presence than in the funding.

Chart 2: DRDS By Funding Source – 2008

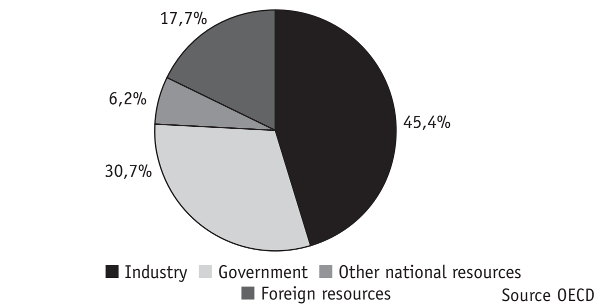
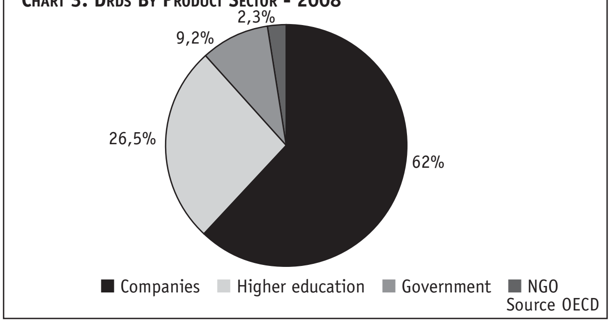


Chart 3: DRDS By Product Sector - 2008



GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

The organisation of British public sector research is based on the "dual support system". The two pillars of this system are the **Funding Councils**, and the **Research Councils**. Research funding emanates primarily from the Department for Innovation, Universities and Skills (DIUS), that distributes the science budget to the Research Councils (which are coordinated and harmonised by the RCUK).
The latter provide funding for research projects on the basis of excellence criteria. The DIUS also allocates part of its budget to the HEFC (Higher Education Funding Councils), which then finance a portion of the university research.

In the United Kingdom, there are **seven councils** on the **basis of research fields**. These **councils are resource agencies** and have variable budgets according to the research topics (increasing in keeping with the importance of the research field). The EPSRC has 25% of the total budget and covers all physical, chemical and engineering sciences. The MRC has 20% of the total budget and covers biomedical research. The STFC finances astronomy, astrophysics and nuclear physics. The BBSRC looks after biomedical and biotechnological research. The NERC covers environmental sciences, the ERSC looks after economic and social sciences, and the AHRC funds research in the fields of arts, history, religion and all of the humanities. The allocation of the budgets from one year to the next serves to bring to light the public sector research priorities.

The British governance system is also distinguished by the size of the organisations that provide advice to the government, and that are involved in the orientation of research. The CST (Council for Science and Technology) is the largest of them; it is made up of eminent researchers and co-chaired by two members: one appointed by the Prime Minister, while the other is a member of the government, with the title of Chief science advisor.

British research activities are assessed by committees on a regular basis, which is known as the RAE (Research Assessment Exercise). These assessments are used to distribute research funding between the various establishments on the basis of assessment criteria that consider more than just the research projects. The funding from the Funding Councils is awarded according to the RAE results of each higher education establishment.

There are two types of British public sector research organisations: research institutes and centres linked to the research councils (14 in all) and universities (170 higher education establishments).

RECENT DEVELOPMENTS

After the global financial and economic crisis that began in 2007, in 2009, the British government published a strategic document entitled **"New Industry, New Jobs - Building Britain's future"**. This document contains the details of an investment plan that is intended to improve the economic competitiveness of the United Kingdom by means of manufacturing, services and creative industry. This strategy's main implications on the research and innovation policy are:
The creation of the "Department for Business, Innovation and Skills", that now manages the skill development policy, the link between industry and higher education, and the research and innovation policy. This umbrella department's objective is to guide economic growth within the framework of the new knowledge economy.

- The **new strategies for the development of competencies and for higher education**, in order to ensure the production of the competencies that the new economic model will need.

Several sector-specific **strategies intended** to strengthen the development of high added value industries, such as biotechnologies.

- The "Low Carbon" industrial strategy, which is intended to support investments in nuclear, wind and marine energy technologies.

- The "Life Sciences Blueprint", that is intended to transform the pharmaceutical industry, medical biotechnology and the medical technologies sector.

- The "Strategic investment fund", that anticipates an investment of £1 billion in projects intended to develop the United Kingdom's comparative advantages in terms of new technologies and capacity for innovation.

2- RESEARCH PERSONNEL

2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2008

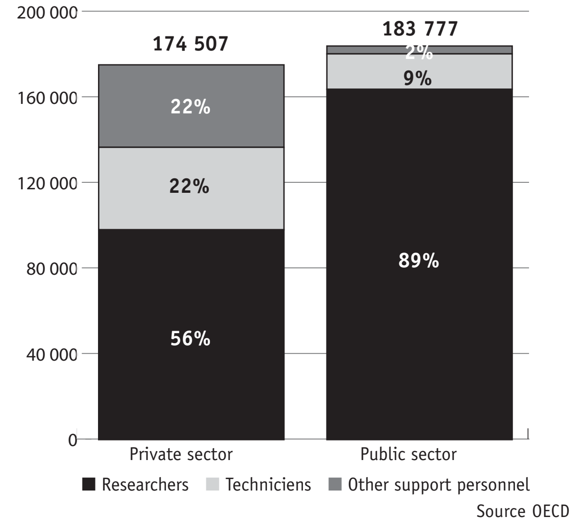
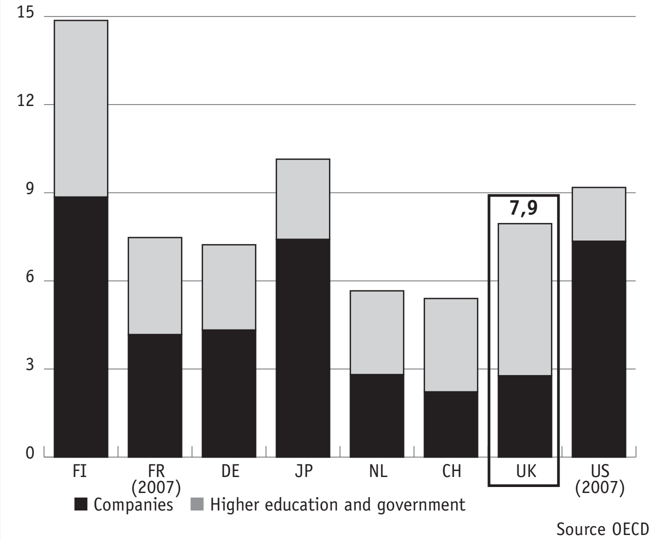


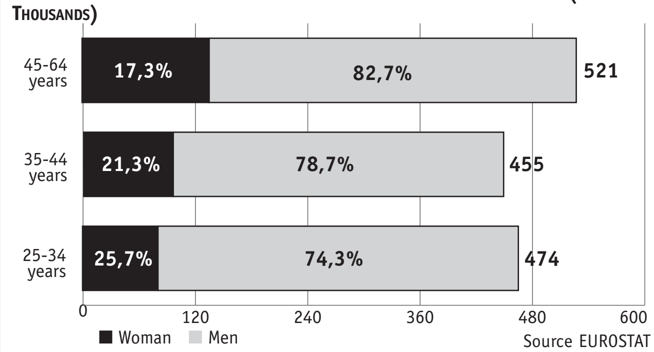
Chart 5: Number Of Researchers / 1000 Working PEOPLE - 2008



In the United Kingdom, the number of researchers per 1000 working people falls within the average of the studied countries (chart 5). More than half of these researchers work in the public sector, and 3.5% of them worked in non-profit organisations in 2008.

The figures for FTE research personnel (researchers and other) **have increased steadily in the last 10 years**, to a level of nearly 360,000 FTE in 2008, which represents a 13.4% increase relative to 2003. **This increase is primarily due to the higher personnel numbers in the private sector**, which have more than compensated for a slight decline of the government's R&D personnel (excluding higher education).

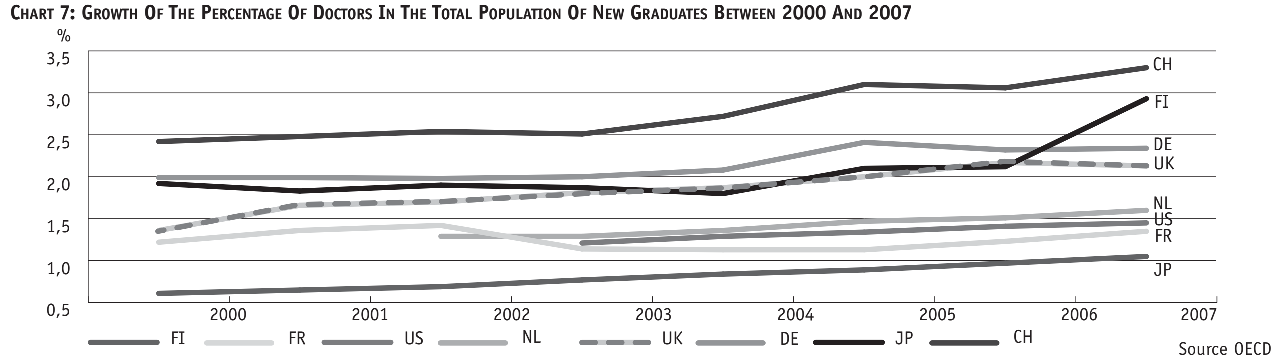
Chart 6: Age Distribution Of Scientists And Engineers In France - 2008 (In Thousands)



As shown in chart 6, the population of scientists and engineers in the United Kingdom is generally balanced, in terms of ages. Though there are many scientists and engineers in the 45-65 years of age bracket, there is a large population of young researchers in order to compensate for the future departures and to renew the scientific efforts. As in many other countries, this is a significant challenge.

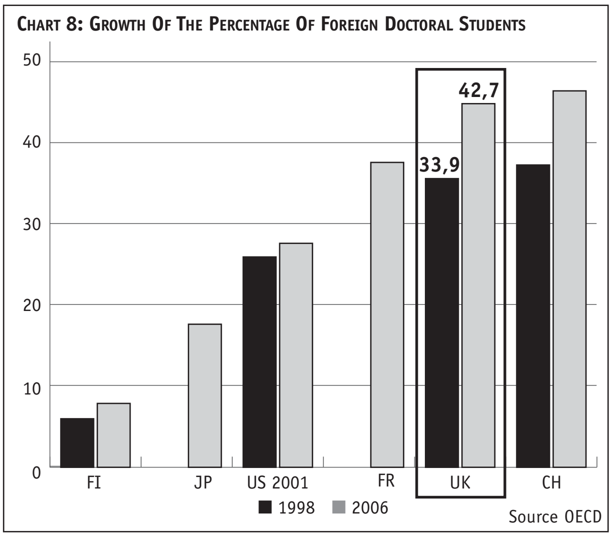
2.2. GROWTH OF THE POPULATION OF DOCTORS

Chart 7: Growth Of The Percentage Of Doctors In The Total Population Of New Graduates Between 2000 And 2007



The United Kingdom is increasingly attractive for foreign students wishing to continue their postgraduate studies. As such, the United Kingdom is experiencing higher growth than the other studied countries in terms of the percentage of foreign doctoral students. Moreover, **the proportion of doctors in the total population of graduates also increased between 2000 and 2007** (chart 7).

Finally, we note a strong presence of foreign doctoral students (42.7%, just behind the 44.2% in Switzerland).



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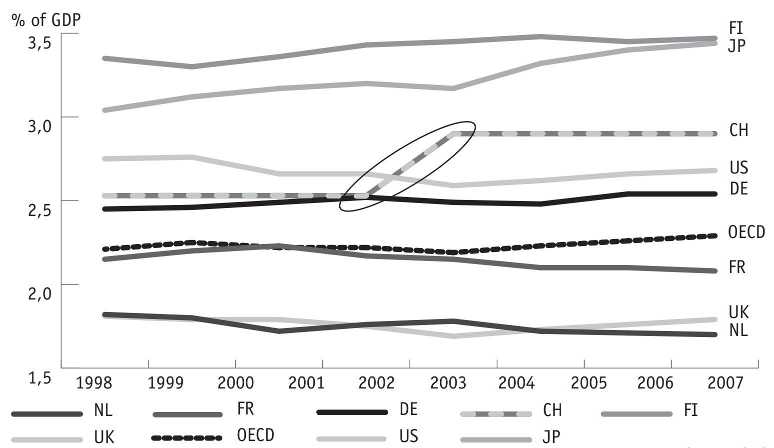
COUNTRY PROFILE:
SWITZERLAND

1- ORGANISATION AND RESEARCH KEY FIGURES

HEADING	2003	2004	2005	2006	2007	2008
DRDS[42] (M$ current PPA)	n.d.	7 470	n.d.	n.d.	n.d.	9 923
DRDS per capita ($ current PPA)	n.d.	1 002	n.d.	n.d.	n.d.	1 287
DRDS (as % of GDP	n.d.	2,90%	n.d.	n.d.	n.d.	3,01%
Including government (as % of GDP)	n.d.	0,66%	n.d.	n.d.	n.d.	0,69%
Including industry (as % of GDP)	n.d.	2,02%	n.d.	n.d.	n.d.	2,05%
Number of FTE researchers	n.d.	25 400	n.d.	n.d.	n.d.	25 142
Researchers for 1,000 working people	n.d.	5,83	n.d.	n.d.	n.d.	5,4
Estimate of the number of families of triad patents	849	888	875	882	885	873

Source OECD

Chart 1: Growth Of The Drds: International Comparisons



Source OECD

Ranking of the main industrial R&D investment sectors in 2008:
- Pharmaceutical industry
- Machine industry
- ICT - manufacturing
- High Technology Instruments
- Metallurgy industry

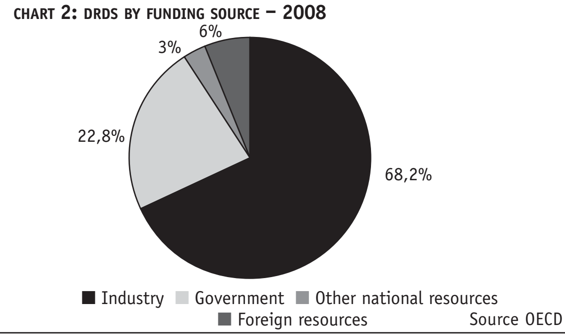
Ranking of the key private sector research players in 2008 by total investment:
- Roche (5,883 million euros)
- Novartis (5,194 million euros)
- Nestlé (1,581 million euros)
- ABB (832 million euros)
- Syngenta (697 million euros)

Source: IRI - Top R&D companies - Switzerlandw

Switzerland is one of the countries that spends the most on research and development as a percentage of GDP (while still behind Japan and Finland). The country's expenditures reached a peak between 2003 and 2005, which allowed it to pull ahead of the United States.

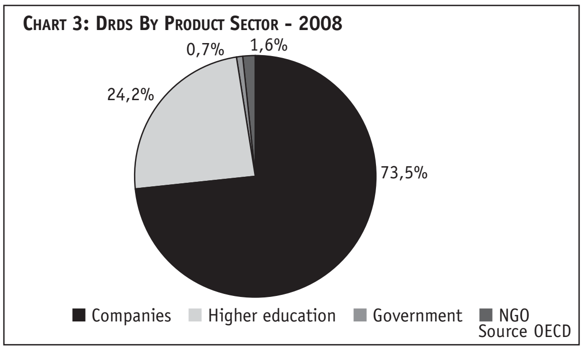
RESEARCH AND DEVELOPMENT, FUNDING SOURCES AND PRODUCT SECTORS

Chart 2: DRDS by funding source – 2008



Source OECD

Chart 3: Drds By Product Sector - 2008



Source OECD

In Switzerland, **the private sector finances more than two thirds of R&D**. After Finland (approximately 70% of private sector financing), this rate is the highest of the European countries in the study (while still remaining below Japan, where the private sector financing amounts to 78%). It is therefore natural that nearly 3/4 of the R&D takes place within companies themselves.
In Switzerland, **multinationals are very involved in the R&D expenditures**. Roche and Novartis, the two Swiss pharmaceutical industry companies, are notably in the Top 10 of the 1,000 worldwide companies that spend the most on Research & Development.

For its part, **the government finances more than 20% of the R&D**, i.e. 0.69% of GDP in 2008. In terms of public sector investment, Switzerland is therefore below the average of the countries in the study.

[42] *DRDS: Domestic research and development spending.*

GOVERNANCE OF PUBLIC SECTOR RESEARCH AND RESEARCH ORGANISATION

The federal law of 7 October 1983 on research introduced the obligation for the Confederation to encourage scientific research. To carry out this mission, the federal government has several organisations at its disposal, the largest of which are the **FNS (Swiss national scientific research fund)** and the **CTI (Innovation promotion agency)**.

- The **FNS** is the main institution for encouraging scientific research in Switzerland. Each year, it supports nearly 7000 scientists and encourages fundamental research. The FNS was created in 1952 in the form of a private law foundation (in order to guarantee the independence needed to encourage research). It ensures that Swiss research has the best conditions to develop on the international level, and it also promotes dialogue with society, the political world and the economy.

- For more than 60 years, the **CTI** has supported the transfer of knowledge and technology between companies and higher learning institutes. Its role is as the intermediary between applied research and industrial exploitation (by putting dynamic companies in contact with researchers in the higher education institutes) The CTI has a budget of approximately 100 million francs (74.5 million euros).

Switzerland has no Federal Ministry for Education and the Swiss Confederation's responsibilities for education are exercised by several offices, the most important of which is the Federal Department of the Interior. The OFFT (Federal Office for Professional Training and Technology), which is dependent on the Federal Department for the Economy, also participates.

The Swiss system's organisation is therefore complex; The Confederation, the Federal Council, the Federal Department of the Interior and the Cantons themselves all have bodies that coordinate the national policies regarding education and research.

Higher education in Switzerland involves 10 universities, 2 federal polytechnical institutes, and several specialised higher education institutes. The universities and polytechnical institutes focus their research efforts on fundamental research (in Switzerland, fundamental research is primarily carried out within a university setting). For their part, the higher education institutes specialise in applied research. For the higher education establishments, research is funded in a mixed manner (including research funds - the Swiss National Scientific Research Fund for example -, as well as the budgets of universities and competing funds that result from calls for projects).

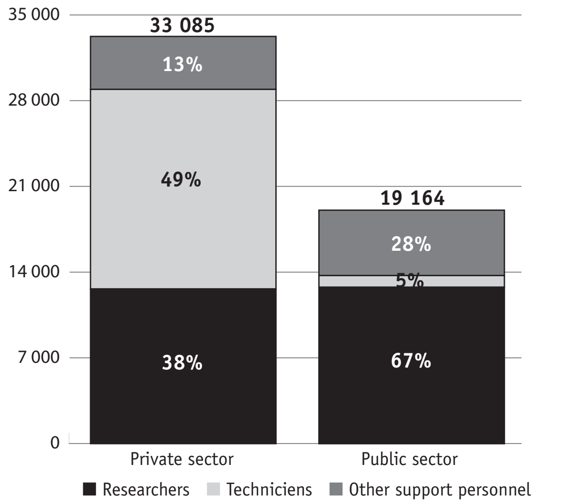
RECENT DEVELOPMENTS

To encourage research professionalization, Switzerland has developed the **PNR (National research poles)**. Financed by the Confederation, this system involves setting up competence centres that participate in coordinating the research networks made up of university and non-university partners. These excellence centres therefore promote partnerships between the university world and industry. They serve to group the research strengths and to distribute the work between research institutes. These programmes also serve as "retention" tools for researchers, since they make it possible to recruit post-doctoral students who will remain in the Swiss research system thereafter. Set up in 2000, the PNR currently consists of 27 National research poles.

2- RESEARCH PERSONNEL

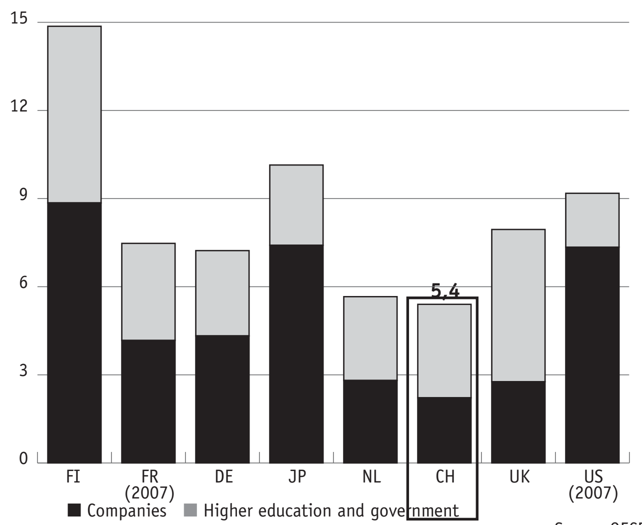
2.1. DEMOGRAPHICS AND DISTRIBUTION

Chart 4: Total FTE R&D Personnel In The Public And Private Sectors, By Job Type - 2004



Source OECD

Chart 5: Number Of Researchers / 1000 Working People - 2008



Source OECD

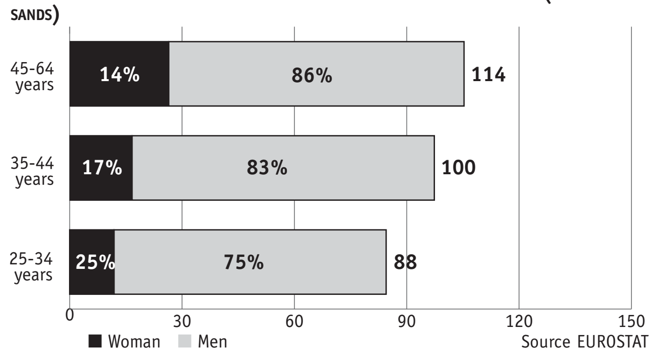
In all, Research & Development employed more than 52,000 people (full-time equivalents) in Switzerland in 2004 (chart 4), of which almost 2/3 in the private sector and a strong proportion of technicians and other research support personnel.

The number of researchers per 1000 working people is the lowest of all the studied countries.

The majority of Swiss researchers fall into the 45-65 years of age bracket, while parity, unbalanced amongst the oldest, is once again leaning towards balance in the youngest (25-45 years of age).

Note: in chart 4, the data for 2008 are not available, with the most recent data being from 2004.

CHART 6: AGE DISTRIBUTION OF SCIENTISTS AND ENGINEERS IN FRANCE - 2008 (IN THOUSANDS)



2.2. GROWTH OF THE POPULATION OF DOCTORS

CHART 7: GROWTH OF THE PERCENTAGE OF DOCTORS IN THE TOTAL POPULATION OF NEW GRADUATES BETWEEN 2000 AND 2007

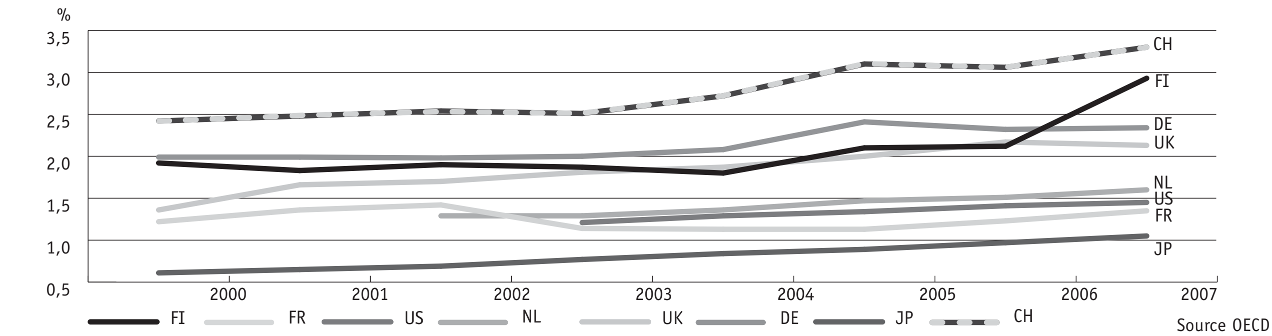
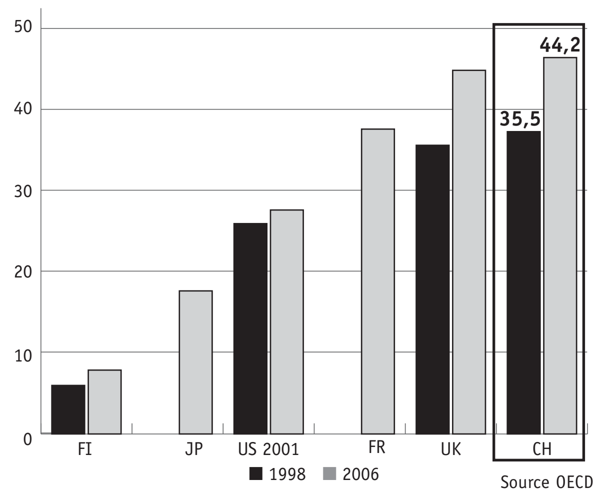


CHART 8: GROWTH OF THE PERCENTAGE OF FOREIGN DOCTORAL STUDENTS



Not only is **the proportion of doctors amongst graduates the highest of all the studied countries**, the number has been climbing consistently (chart 7).

Another characteristic of Swiss higher education **is the rate of international openness of its institutions** (chart 8), as indicated by the strong presence of foreign doctoral students involved in doctoral studies (more than 44%). Switzerland is at the head of the studied countries, well ahead of Finland, for example.

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