

ERAWATCH Country Report 2009

Analysis of policy mixes to foster R&D investment
and to contribute to the ERA

Switzerland

Benedetto Lepori



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ERAWATCH COUNTRY REPORT 2009: Switzerland

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investment and to contribute to the ERA**

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Benedetto Lepori

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Executive Summary

Knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Hence, a central task of ERAWATCH is the production of analytical country reports to support the mutual learning process and the monitoring of the efforts in increasing R&D investments and improving the performance of national research systems.

The main objective of the report is to characterise and assess the evolution of the national policy mixes in the perspective of the national goals for R&D investments, and for the contribution to the realisation of the European Research Area, as associate country. This report is building on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

The analysis presented in this report has to be seen in the light of the specificities of the Swiss situation, and especially of its economy and research system. Thus, Switzerland is a medium-size European country with a level of economic development among the highest in Europe. Its economy is among the most open worldwide and displays a strong specialisation in a restricted number of technologically-intensive sectors, including pharmaceutical industry, chemical, food industry, machine industry and precision instruments. In these sectors, Switzerland is the seat of some of the largest multinational companies worldwide, including Novartis, Roche, Nestlé and ABB.

The Swiss research system is also of very good quality both concerning scientific and technological outputs, as shown by international indicators concerning scientific production (publications and impact factors) and technological production (patents). It shows a distinct organisation, based on a clear-cut separation between the public sector, centred on very research-intensive universities, and the private sector, centred on the large research units of multinational companies. The cooperation between the two sectors is based on bilateral informal contacts at the level of research units; moreover, universities train large numbers of PhD students, which then to a large extent continue their career in private companies, thus providing them with a large reservoir of skilled researchers.

This context implies that some of the policies recipes proposed by the European Commission either do not fully apply to the Swiss case – since also Switzerland is not member of the EU – or are not really relevant given the strength and openness of the Swiss research system.

Concerning R&D investments, the overall Swiss situation looks as follows.

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Rather low level of spending in the public sector	Strong increase of research budget and focus on competitive research are good responses and will strengthen the Swiss public research landscape. Structural programmes allow addressing relevant research areas at the national level with a good mix of bottom up approach and of national coordination.
High dependency on the corporate strategies of Swiss multinationals.	This is definitively a strength of the Swiss system leading to high level of private investment and of technological production. However, the influence of the State on these strategies is minimal and thus there are high risks in case of relocalisation decisions.

As discussed in chapter 3, with R&D expenditures of 2.9% of GDP Switzerland is already very near to the 3% target. This high level of expenditures is largely due to the private economy, which already exceeds the 2% target for GERD financed from private sources, while with 0.66% of GDP (2004) GERD financed by the State is just above the EU-27 average and well below the 1% target.

High private R&D expenditures are an outcome of the specific structure of the Swiss economy and, particularly, of the high level of research expenditures of Swiss multinational companies in pharmaceuticals and machine industry (2/3 of BERD being concentrated in these two sectors). Given the size of these companies and their global strategies, this implies that the Swiss State has practically no influence on private research, except in securing good localisation conditions to the research activities of these multinational companies. In terms of research policy, this drives to a strategy focused on maintaining the quality of the public research sectors, as well as its ability to train skilled researchers. Of course, there are some risks related to relocalisation decisions and changes in the global economy, but these can hardly be avoided by a country of the size of Switzerland.

The rather low level of public R&D expenditures has to be judged more favourably than at first glance, exactly because these expenditures are focused on basic and long-term research in universities, which on the whole enjoy of a very good funding level in an European comparison. However, after a lasting stagnation of public investment in the '90, voices were raised that the Swiss research system was in danger of losing its quality and competitiveness. A more favourable budgetary situation of the State after 2000 and a stronger priority towards research have led to a rather rapid increase of public investment in the last five years, which has been confirmed in the strategic plan for research, education and innovation for the years 2008-2011. As usual in the incremental budgeting system of the Swiss State, this has not taken place in form of bold new investment plans, but of a rather gradual increase of financial means. Stability and predictability of public investment are a strong asset which favours long-term planning of research activities.

When looking to the relevance of the ERA for Swiss research policy, one needs to consider that Switzerland is not a member of the EU and thus, unsurprisingly, very few references to ERA policies can be found in Swiss official documents. However, by large Swiss research policy complies with ERA objectives and, to some extent, already fulfils them better than many EU countries, as summarized in the following table.

	Short assessment of its importance in the ERA policy mix	Key characteristics of policies
Labour market for researchers	<ul style="list-style-type: none"> • rather important, but in the background of an already very open market for researchers internationally. 	<ul style="list-style-type: none"> • removing the barriers to mobility for EU citizens (immigration policy, social security). • Opening up of some grant schemes also for foreigners.
Governance of research infrastructures	<ul style="list-style-type: none"> • rather limited importance in the Swiss context (few national research infrastructures). 	<ul style="list-style-type: none"> • à la carte participation to joint European infrastructure projects. • national advanced computing plan.
Autonomy of research institutions	<ul style="list-style-type: none"> • clearly the most important issue for Swiss research policy. • highly complex because of division of competences between Cantons and Confederation. 	<ul style="list-style-type: none"> • granting more autonomy to individual higher education institutions. • improving the system-level governance of the system. • promoting specialisation through change in the funding system (higher share of competitive projects).
Opening up of national research programmes	<ul style="list-style-type: none"> • a rather unimportant issue which is left to the funding agencies themselves. 	<ul style="list-style-type: none"> • strong preference towards bilateral agreements between agencies (CH-D-A). • no basis for large-scale joint programming.

This is the case for researcher's mobility, where the Swiss researchers market is one of the most open internationally (about half of the PhD students and of the university professors are of foreign nationality). The impact of the EU in this context has to be sought rather in the liberalisation of the labour market and of people mobility in general, against a traditionally restrictive Swiss policy in these domains.

In the domains of research infrastructures and opening of research programmes, Switzerland is following the decentralised and bottom-up approach which characterizes by large its research policy; thus, participation to European infrastructural initiatives and to international programmes, as well as opening of national programmes, are decided case by case when the research community shows an interest for them. This highly effective approach entails however some risks in case the EU launches large-scale joint schemes, where participation has to be decided at the political level (as the non participation of Switzerland to Joint Technology Initiatives might show).

However, the most important challenge for Swiss research policy is undoubtedly to strengthen its universities and to allow them to position themselves in the European and international context; while this is already the case for some of them – especially for the two Federal Institutes of Technology – cantonal universities need a stronger effort in this direction. At the political level, initiatives have been undertaken to grant to universities wider autonomy and strategic capability but conflicts emerged in this respect between some universities and cantonal authorities. Moreover, today's governance of Swiss higher education is too fragmented between different jurisdictions and regulations are widely different between types of HEI (cantonal universities vs. Federal Institutes of Technology vs. Universities of Applied Sciences). Work on a new higher education act, which should provide a common regulatory framework for the whole system and establish a joint governance body between Confederation and Cantons, started already around 2004-2005 and it is hoped that the new act can entry into force around 2012.

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1 Introduction

Knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Hence, a central task of ERAWATCH is the production of analytical country reports to support the mutual learning process and the monitoring of the efforts in increasing R&D investments and improving the performance of national research systems.

The main objective of the report is to characterise and assess the evolution of the national policy mixes in the perspective of the national goals for R&D investments, and for the contribution to the realisation of the European Research Area, as associate country. This report is building on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

In this report we characterise and assess the performance of the national research system and national research policies. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system have been distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The analysis within each domain is guided by a set of generic "challenges", common to all research systems, which unravel possible bottlenecks, system failures and market failures a research system has to cope with. The main elements of and results from this analysis are presented in Chapter 2, while in the Annex, the reader can find a more detailed account of this exercise.

The need for an effective research policy, appropriately co-ordinated with education, innovation, and other types of policies, is also widely recognised. Therefore, we focus on the following two analytical issues:

- the assessment of the national policy mixes for the achievement of national R&D investment goals set. Particular attention is paid to policies fostering private R&D and addressing barriers (Chapter 3);
- the assessment of national policies contributing to the realisation of the European Research Area, as associated country (Chapter 4).

Finally, chapter 5 provides a final appraisal of the Swiss R&D policy mix and of the relevance of ERA-related policies in the Swiss context.

2 Characteristics of the national research system and assessment of recent policy changes

2.1 Structure of the national research system and its governance

The main features of the Swiss research system and of its governance are the following:

1. the fact that political responsibilities concerning higher education are divided between the central state (the Confederation) and the regional authorities (Cantons) with lasting consequences also in research policy;

2. the division of responsibilities for the research and higher education in the national government between the Federal Department of Internal Affairs, which is responsible for the Universities and the support to basic research (through the Swiss National Science Foundation; SNF) and the Federal Department of Economic Affairs, which is responsible for Universities of Applied Sciences and the support to applied research through the Swiss Innovation Promotion Agency (KTI);
3. a clear organisational separation between the policy level (federal and cantonal administrations), the agencies funding research projects (Swiss National Science Foundation and Commission for Technology and Innovation) and the public research organisations;
4. the dominant role of universities in the public research sector and the weakness of public research laboratories;
5. the size and the structure of private research, being strongly concentrated on the chemical and pharmaceutical sectors and in the (electro)mechanical industry (including precision instruments).

The following figure shows a map of the most important Organisations involved in research policy and research activities, which we briefly detail below. For a more complete overview of the Swiss system refer to (Braun & Leresche, 2007), ([Arvanitis S., 2009](#); Lepori, 2007b).

Political responsibilities for research and higher education are divided between the central state (Confederation) and the regional authorities (the Cantons), as a result of a long-standing historical development (with some Cantons having their own university well before the creation of the Swiss federal State in 1848. Thus, the Confederation is responsible for direct funding of research and for the coordination of research activities, while higher education is shared between Confederation and Cantons as follows:

1. the Confederation is responsible for the two Federal Institutes of Technology (FIT) in Zurich (ETHZ) and in Lausanne (EPFL) whose activities are regulated by a specific act (Federal Act on Federal Institutes of Technology);
2. the Cantons are responsible for their universities (ten of 26 Cantons possess their own university); each Canton has its own university act, while a national act is regulating federal support to these institutions (Federal Act on Cantonal universities);
3. the Universities of Applied Sciences are ruled by the cantons, but under the framework of national law (Federal Act on Universities of Applied Sciences).

At the federal level, since the late '90 responsibilities on research and higher education are divided between the Federal Department of Internal Affairs and the Federal Department of Economic Affairs; there is no research ministry because of the specific organisation of the Swiss government (having 7 Departments only). Other Departments play a very limited role, mainly through funding contract research falling within their own policy sector responsibilities or by managing small intra-ministerial research units (the largest one being in the field of agriculture).

Inside the Federal Department of Internal Affairs, the most important organisational unit is the State Secretariat for Education and Research, whose head has functions very similar to a research minister; it is in charge of the coordination of the whole domain, including the preparation of the four-year strategic plans (Conseil Fédéral,

2007), of support to cantonal universities, of funding of basic research through the Swiss National Science Foundation and of international activities of Switzerland (participation to EU Framework Programmes, to international organisations and bilateral relations). In the same Department, the Board of Federal Institutes of Technology is in charge of the overall steering and funding of the FIT domain, which includes the two FIT and four annex institutes. The relationships between Confederation and FIT domain are regulated by a specific performance agreement (including provision for the allocation of the block grant to the FIT domain).

Inside the Federal Department of Economic Affairs, the Federal Office for Professional Education and Technology (OPET) is responsible for the coordination of the Universities of Applied Sciences (UAS), as well as for the whole domain of professional education; moreover, it manages policy measures supporting applied research and technology transfer through the Swiss Innovation Promotion Agency.

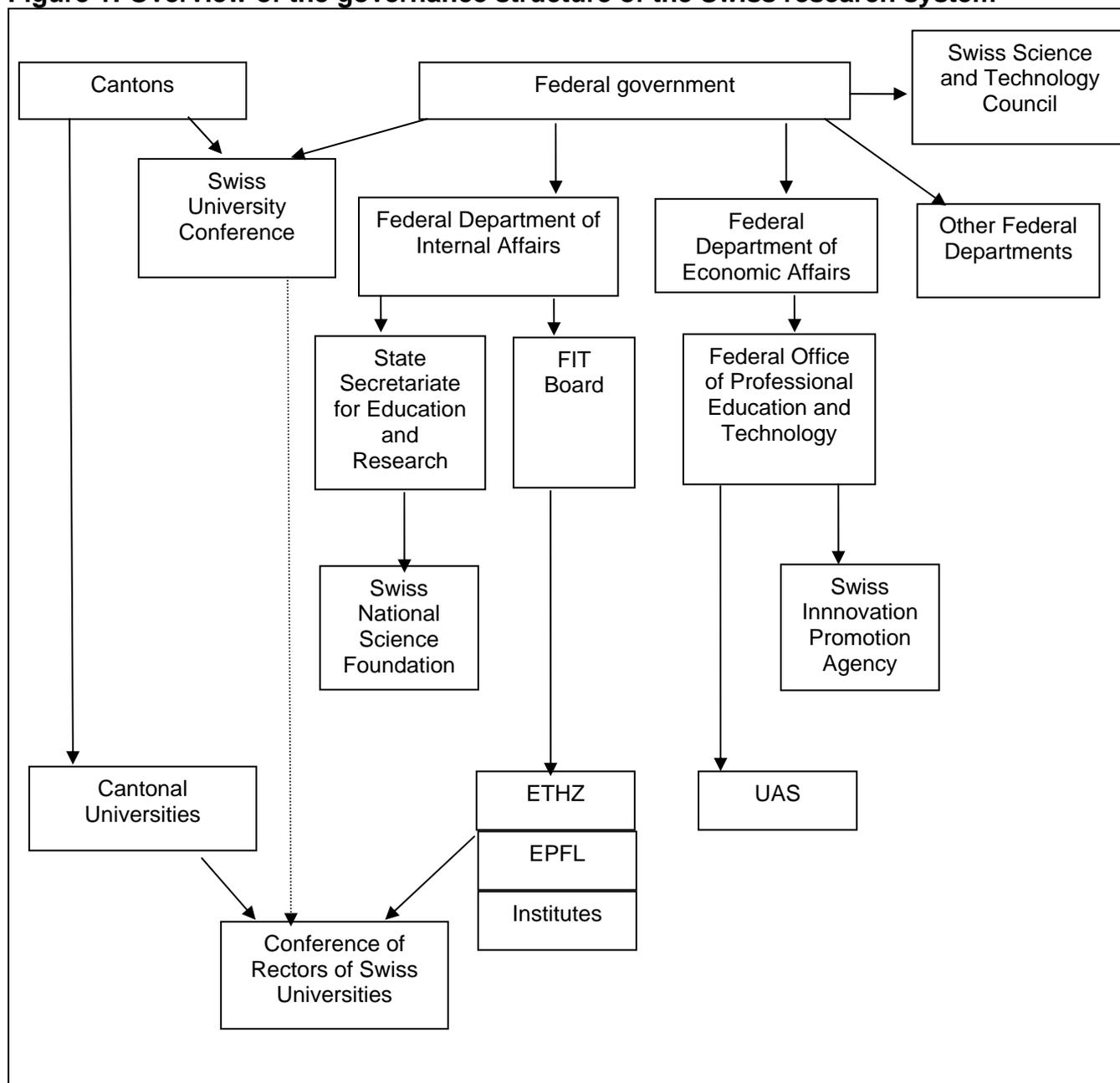
The Swiss University Conference (SUC) is a common body of Cantons and Confederation in charge of the coordination of the university domain (FIT and cantonal universities). The Conference of Rectors of Swiss Universities is a private association composed by the rectors of the cantonal universities and by the presidents of the two FIT; by law it is in charge of the preparation of the university planning on behalf of the SUC and manages a number of coordination programmes and activities between Swiss universities. A parallel body exists for UAS (Swiss Conference of Rectors of Universities of Applied Sciences; KFH).

At the intermediary level, the main actors are the two project funding agencies:

1. the Swiss National Science Foundation (SNF) is a private foundation recognised by the Swiss research act and almost entirely funded by the Confederation. It is responsible for the support to basic research in the Universities and in the FIT: moreover, it manages the national research programmes, as well as a programme aiming to create networks of excellence at the national level. It is a very large agency, which enjoys of substantial autonomy from the State;
2. the Swiss Innovation Promotion Agency (CTI) is a commission of the Federal Department of Economic Affairs which supports joint projects between universities and private companies, as well research activities in the UAS and different technology transfer initiatives.

Finally, the Swiss Science and Technology Council (SSTC) is the advisory body of the national government for science and technology policy.

Figure 1: Overview of the governance structure of the Swiss research system



Source: Author

The institutional role of the regions in research governance

Due to the federal organisation of the country, Cantons are very important actors in Swiss research and higher education policy. By the Swiss Constitution, general education belongs to cantonal competences and the Confederation has very few responsibilities on the school system below the tertiary level. The situation is different at the tertiary level, where responsibilities are shared: Cantons have full sovereignty on their own universities (each ruled by a specific cantonal law), while the Confederation has the right of managing the two Federal Institutes of technology, as well as to support cantonal universities (but without any legal power on them). This drives to what has been called the “impossible coordination” of Swiss higher education policy (Perellon & Leresche, 1999) and to a high diversity of organisational forms and rules between universities; the only national coordination body, i.e. the

Swiss University Conference, has mainly the function of a consultation body where Cantons and Confederation try to reach a minimum consensus (Fumasoli, 2007; Lepori, 2007a).

The situation is even more complex for professional tertiary education, where the Confederation has a general regulatory power, while Cantons run the Universities of Applied Science (Lepori, 2008). The general principle that higher education is a shared competence field of Cantons and Confederation and that the policies in the domain should be developed jointly has been introduced in the Swiss Federal Constitution in the year 2007 only.

Cantons are also relevant actors in all policy debates on research and higher policy, given their veto power on decisions at the national level and strongly intervene in the negotiations on research plans and funding to defend the interests of their own universities. Finally, Cantons are in charge of economic promotion and thus of supporting Small and Medium Enterprises, even if most general cantons do not pursue an explicit innovation-oriented policy including active support for innovative firms and industry ([INNO-Policy Trend Chart, 2009](#)).

Main research performer groups

At performers' level, the Swiss research system is divided between a public sector dominated by the universities and a private sector dominated by a small number of multinational companies.

The higher education sector accounts for about 80% of the public R&D expenditures. It is composed by ten cantonal universities and the two Federal Institutes of Technology (FIT in Zurich and in Lausanne); both are universities in the traditional sense and have the right to award doctorates. The nine Universities of Applied Sciences (7 public and 2 private) have been created in the late '90 through merger and upgrading of existing professional tertiary education institutions; UAS are oriented towards professional education and have a mandate for applied research and technology transfer, without the right of awarding doctorates (Lepori, 2008).

Outside the universities, the main public research institutes are the four institutes belonging of the FIT domain; the most important is the Paul Scherrer Institute, active mostly in the domain of energy and environment. Since these institutes are included Organisationally in the FIT domain, they are normally accounted in the higher education sector in R&D statistics. There is also a small number of public research institutes outside higher education in fields like cancer, tropical studies, biomedicine, as well as some research activities inside the public administration (for example education, health research and agriculture), as well as in non-university hospitals.

The private sector is dominated by two branches, the chemicals (including pharmaceuticals sectors) and the machine industry. Both are characterised by the presence of large multinational companies with headquarters in Switzerland: Novartis, Roche in pharmaceutical and Chemical industry, Nestlé in food industry, ABB and Sulzer in mechanical, engineering and precision instruments. Research of these companies is largely international and, actually, these companies perform most of their R&D abroad (especially in the USA and also increasingly in Asia).

2.2 Summary of strengths and weaknesses of the research system

The analysis in this section is based on the methodological approach of the ERAWATCH Analytical Country Reports 2008 which characterised and assessed the performance of the national research systems. Four policy-relevant domains of the research system have been distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The analysis within each domain has been guided by a set of generic "challenges", common to all research systems, which reflect possible bottlenecks, system failures and market failures a research system has to cope with. The complete analysis of the research system can be found in the Annex.

To summarize, the Swiss research system is among the best ones in Europe and it is undoubtedly a strong asset for the whole country, contributing to its high level of economic development and social welfare, as well as to the very low rate of unemployment. With 2.9% of GDP, GERD is among the highest in Europe and private financing of research already reaches the 2% Lisbon target. Private R&D is strongly concentrated in few sectors – chemicals, pharmaceutical, machine industry – which corresponds very well to the technological specialisation of Swiss export industry, as well as in a few Swiss multinational companies in these sectors. This strength drives however also to a very limited influence of the State on private R&D and makes it dependent from the fate and corporate strategies of these large companies, whose research expenditures exceeds in some cases the whole national research budget.

Public-sector expenditures are slightly above EU-27 average of European countries and much below the 1% Lisbon target: however, expenditures are strongly concentrated on supporting university research, which receives excellent international marks for the quality of its scientific production. Universities are also very effective in training large number of PhD students, which then continue their career in private companies or in the public administration, thus effectively providing transfer of high-skilled researchers. Fears of the Swiss system losing ground because of the stagnation of financial resources have emerged in the '90; since then, the State substantially increased its investments and this is planned to continue in the next years. National research policy emphasises bottom-up activities, where decision on research direction is left to researchers and private companies and there are few policy instruments focusing on thematic priorities. While this model has proven to be very effective, it drives to a fragmentation of research policy and to a largely incremental practice in setting priorities and allocating financial means; this lack of strategic intelligence and of priority-setting could become a relevant weakness in case of rapid changes in the scientific, technological and economic environment requiring rapid and concerted action.

Traditionally, cooperation between public and private R&D-performers and transfer of research results have been left to the bilateral contacts between university institutes and companies with little intervention from the State. While these mechanisms have proven to be very effective where private companies have good research capacities, concerns have emerged since the '80 on the technological and innovation capacities in sectors like machine industry, watches and precision industry, especially concerning SME's. The policy response to these concerns has been the reinforcement of the Swiss Innovation Promotion Agency (funding joint cooperation

projects between public and private) and the creation of the Universities of Applied Science, which assumed the role of regional knowledge providers and cooperation partners of SMEs.

Table 1: Summary assessment of strengths and weaknesses of the national research system

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	High political priority of research and innovation policy, but in the context of a budgeting policy which is by large incremental.
	Securing long term investment in research	Public expenditures rather low, but strongly focused on support to basic research in universities. Increase in resources from the year 2000 onwards should continue in the next years.
	Dealing with barriers to private R&D investment	Very high level of private R&D expenditures, but strong dependency on strategies of Swiss multinational companies. Very few intervention possibilities of the State in this area.
	Providing qualified human resources	Very good educational level of workforce and good professional training. Excellent performance of universities in training PhDs, then working in the public and private sector.
Knowledge demand	Identifying the drivers of knowledge demand	Strong integration of stakeholders in the design of policies, but lack of systematic instruments for strategic intelligence and priority-setting.
	Co-ordination and channelling knowledge demands	Focus on generic support of research and few instruments to drive scientific and technological policies; researchers and private companies can express their demands directly through bottom-up funding schemes.
	Monitoring of demand fulfilment	Good practice of internal quality evaluation in universities, but lack of a national assessment exercise. Widespread use of studies and evaluations at national level (of programmes, funding agencies, etc.).
Knowledge production	Ensuring quality and excellence of knowledge production	Excellent quality of research output especially in sciences; Swiss universities among the best ones in Europe.
	Ensuring exploitability of knowledge	Excellent innovation indicators in the Innovation scoreboard; some well-developed mechanisms for public-private partnerships especially for SMEs and in the regional context. Lack of venture capital is a source of concern.
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Established tradition of direct cooperation between companies and research institutes, but fears that transfer is not enough established. Technology transfer centres have been created in most Swiss universities and are being supported through a national programme.
	Profiting from international knowledge	The Swiss system is very open internationally concerning academic research, hiring of researchers and professors; excellent participation to European and international programmes. Private R&D is strongly internationalised.
	Enhancing absorptive capacity of knowledge users	Traditionally Swiss industry required little support given its strong research activities. Capacity building in SMEs is mostly promoted through joint project with public research institutes funded by the Swiss Innovation Promotion Agency and collaborations with Universities of Applied Sciences (including postgraduate education and training of technical personnel).

2.3 Analysis of recent policy changes since 2008

The contribution of research and research policies to national goals (as well as to other societal objectives) goes beyond the fostering of R&D investment. It is therefore important to also analyse how other remaining shortcomings or weaknesses of the research system are addressed by the research policy mix. The focus of the section is on the analysis of main recent policy changes which may have a relevant impact on the four policy-related domains.

In Switzerland, the focus in research policy lies in the implementation of the strategic plan for research, higher education and innovation, which has been approved by the Swiss Parliament at the end of the year 2007.

2.3.1 Resource mobilisation

In its last strategic plan on research, higher education and innovation, the Confederation decided an increase of federal research and higher education expenditures of about 6% per year from 2008 to 2011; given the rather favourable financial situation in 2007 and 2008, these investments goals have been maintained. Moreover, to address the financial crisis, the Swiss government is launching a series of conjunctural support measures: the second economic stabilisation package, which has been proposed by the government in February 2009, includes additional means also for research and innovation: €12m for the Swiss Innovation Promotion Agency to launch new projects in the field of sustainable development and energy savings, €3m for the Swiss National Science Foundation to improve valorisation of research results, €0.5m for technology transfer (see below) and €5m for preliminary measures in the field of advanced computing. In May 2009, the federal government transmitted to the Parliament the new action plan for advanced computing, including new buildings and machines for the Swiss Centre for Scientific Computing (CSCS) with a total investment of around €100m.

Table 2: Main policy changes in the resource mobilisation domain

Challenges	Main Policy Changes
Justifying resource provision for research activities	<ul style="list-style-type: none"> • strong emphasis on research and innovation to address the financial and economic crisis.
Securing long term investments in research	<ul style="list-style-type: none"> • increase of public research expenditures foreseen by strategic plan confirmed and implemented. • additional resources in the economic stabilisation plan. • national plan for advanced computing.
Dealing with uncertain returns and other barriers	<ul style="list-style-type: none"> • additional targeted funding for the Swiss Innovation Promotion Agency in the stabilisation plan for cooperation with companies and technology transfer.
Providing qualified human resources	<ul style="list-style-type: none"> • implementation of the measures foreseen in the strategic plan (new SNF grant schemes).

2.3.2 Knowledge demand

As explained in the Annex, the Swiss research policy has an orientation towards generic support and a strong bottom-up component and thus activities to identify knowledge demands and to define (thematic) priorities play a rather limited role. Moreover, most of these activities take place in the preparation phase of the strategic plans, while current activities are strongly focused on its implementation.

Nevertheless, a number of relevant initiatives started in 2008-2009. Firstly, a new series of National Research Programmes on topics like urbanism, materials, water

has been launched; the calls for proposals have been launched between autumn 2008 and spring 2009, while most projects will start in 2010.

Additionally, the State Secretariat for Education and Research launched a call for ideas of new National Research Programmes to be launched in 2010/2011 to collect from social and political stakeholders their most urgent needs for policy oriented-research: 57 propositions of themes have been received, the Swiss government will decide on 5-6 new programmes towards the end of 2009.

Moreover, the call for proposals for a new series of National Competence Centres in Research will allow the SNF and the State Secretariate to identify a number of priority domains where to build national competence networks, taking into account both the development of scientific domains and the relevance for policy and economic development; as a response to the call launched in 2008, 54 proposals were received, while 5-7 new networks should be launched from 2011.

In the monitoring and evaluation domain, the most relevant initiative has been the start of the national programme on “Evaluating research performance” coordinated by the Conference of Rectors of Swiss Universities (CRUS); a complete bibliometrics analysis of the scientific production of the Swiss universities in the Web of Science has been prepared through a framework contract with CWTS Leiden; a summary report will be published by the CRUS, while detailed data will be available to individual universities for their strategic decision-making. Moreover, three specific projects have been launched to develop new methodologies for the evaluation of the quality of research in social sciences and humanities and to develop new methods adapted to the characteristics of these domains.

Table 3: Main policy changes in the knowledge demand domain

Challenges	Main Policy Changes
Identifying the drivers of knowledge demand	<ul style="list-style-type: none"> • call for new themes for the next series of national research programmes.
Co-ordinating and channelling knowledge demands	<ul style="list-style-type: none"> • launch of new series of national research programmes (NRP) on social and political relevant topics.
Monitoring demand fulfilment	<ul style="list-style-type: none"> • start of the national research evaluation programme managed by the rector’s conference; • new bibliometric analysis of Swiss research.

2.3.3 Knowledge production

The main stimulus to improve the (already excellent) quality of knowledge production in the Swiss systems comes undoubtedly from the increase in project funding from the Swiss National Science Foundation decided in the strategic plan 2008-2011. Additionally, from 2009 an overhead contribution will be introduced to the SNF projects, which will be paid directly to the universities to cover part of their general costs; starting with less 10% of funding volume, it should progressively reach a level around 20%.

In this framework, two highly relevant initiatives to structure the Swiss research landscape have to be mentioned:

- the launch of a new series of National Competence Centres in Research (NCCRs) by the Swiss National Science Foundation; the call for proposals was closed in December 2008, while the new NCCRs are due to start in 2010);
- the launch of a set of large-scale cooperation programmes financed by the Swiss University Conference, the largest one being the SystemX.ch programme in the

field of system biology and the nano-tera programme on micro/nano-systems engineering for distributed embedded systems design.

These measures implement the goal of the strategic plan to increase the role of competitive allocation of project funding in public research funding.

At the structural level, two major reforms are being launched in 2008 and 2009. The first one is the reform of the Swiss Innovation Promotion Agency (KTI); its legal status as a consulting commission of the federal administration and its legal basis on the economic promotion law do not correspond any more to the KTI profile and functions. Therefore, after extensive consultation of stakeholders, the federal government proposed in December 2008 a revision of the Swiss Research Act, which would integrate KTI in the Swiss research policy as the innovation-oriented pendant of the SNF, define more clearly its functions and make it more autonomous from the federal administration. The relationship between Confederation and KTI will be managed through a performance contract, as already the case for the SNF. It is foreseen that this new regulation will be approved by the parliament this year and will provide the KTI with a sound basis for its future action.

The second main reform concerns the new higher education act, which should provide some stronger governance of the whole system and at least a minimum set of common rules for the three types of HEI (Cantonal universities, Federal Institutes of Technology, Universities of Applied Sciences; see section 4.3). The process has however been more difficult than foreseen: the draft new act released for stockholder's consultation in autumn 2007 received much criticism from different sides. Based on the results of this consultation, the Federal Government approved in May 2009 a revised version which has been transmitted to the Parliament for discussion. The most contested issues concern the distinction between types of HEI (universities vs. universities of applied sciences), the competence of the new University Conference and the respective power of the Confederation and of the Cantons. The new university act and the related reforms of the federal structures in charge of higher education, where it is foreseen that all competences in the domain should be concentrated in the State secretariate, as well as the revision of the funding criteria for HEI would represent the most important reform of Swiss higher education governance in the last decades.

Table 4: Main policy changes in the knowledge production domain

Challenges	Main Policy Changes
Improving quality and excellence of knowledge production	<ul style="list-style-type: none"> • strong stimulus to basic research through additional SNF funding, including a new series of National Competence Centres in Research; • new large-scale national programmes on strategic areas (system biology, nanosystems); • reform of the higher education governance; • promote technical and natural sciences to attract more students
Ensuring exploitability of knowledge production	<ul style="list-style-type: none"> • reform of the Swiss Innovation Promotion Agency.

2.3.4 Knowledge circulation

To promote knowledge circulation and absorption by SMEs, additional measures have been included in the economic support package decided by the Swiss government in spring 2009; three specific measures are foreseen:

- additional financial means (€12m) for the Swiss Innovation Promotion Agency, with a focus on clean technologies and smart materials, as well as funding criteria which are more favourable for companies; thus, the Confederation will in some cases contribute also to materials and infrastructure required for the project and the (mandatory) cash contribution of private companies to R&D expenditures at the university partner will be reduced;
- innovation vouchers for companies to buy services of technology transfer offices at universities (€0.5m);
- information activities on the new funding possibilities for R&D of economic interest, especially at the Swiss Innovation Promotion Agency;

Innovation is considered as a priority domain to overcome the economic crisis; it is expected that additional measures will be decided in 2009.

In the domain of internationalisation of public research, a set of relevant initiatives has been launched between 2008 and 2009. The most important are the bilateral cooperation programmes in research with emerging countries – the programmes with India, China, Russia and South Africa started in 2008, as well as the cooperation programmes with developing countries and with Eastern European countries, launched by SNF in 2008 and 2009. Moreover, a highly relevant initiative is the set-up of procedures which allow the financing of joint research projects between the Swiss National Science Foundation and the research councils of Germany (DFG) and Austria (FWF); given the strong scientific ties between these countries, it is likely that this measure will have a strong impact on international scientific cooperation.

Table 5: Main policy changes in the knowledge circulation domain

Challenges	Main Policy Changes
Facilitating knowledge circulation between university, PRO and business sectors	<ul style="list-style-type: none"> • additional means to reinforce technology transfer; • innovation vouchers for SMEs to use technology transfer offices services.
Profiting from access to international knowledge	<ul style="list-style-type: none"> • launch of a bilateral cooperation programmes in research with emerging countries; • SNF agreement with Germany and Austria for joint funding of transnational research projects.
Absorptive capacity of knowledge users	<ul style="list-style-type: none"> • additional financial means for public-private cooperation projects through the Swiss Innovation Promotion Agency.

2.4 Policy opportunities and risks related to knowledge demand and knowledge production: an assessment

Following the analysis in the previous section, this section assesses whether the recent policy changes respond to identified system weaknesses and take into account identified strengths.

Swiss research policy is characterized by continuity and stability of its main orientation, as well as of budgetary planning. The policy orientations decided in the strategic plan 2008-2011 approved by the parliament in winter 2007 (Conseil Fédéral, 2007) have been implemented without major alterations in 2008 and 2009. These measures allow addressing following main issues in Swiss research policy:

- increasing the mobilisation of public resources through a rather strong increase of the budget for research and higher education and setting the priority to research rather than university education;
- improving the quality of knowledge production through the increase of competitive funding schemes (mostly through SNF) and the launch of cooperation programmes to structure the Swiss university landscape.

Policy measures in the strategic plan are much less concerned with the identification of knowledge demands and especially of providing research policy with strategic intelligence for long-term definition of priorities, even if some of the newly launched cooperation programmes – like System.X.ch in system biology and nano-tera in nanosystems – address new priority domains of science and technology. Also, rather limited measures have been envisaged to improve knowledge circulation, to meet business knowledge demands and to increase resources mobilisation in the private sector.

Thus, the Swiss research and innovation policy is almost exclusively focused on small and medium enterprises and their cooperation with higher education institutions. While this policy has been highly successful, it has hardly an impact on the bulk of Swiss private research and innovation activities which are performed by multinational companies; in this area there is a noteworthy lack of coordination between research policy (focusing on the quality of academic research and provision of skilled researchers) and economic promotion policy (focusing on market and localisation conditions), because of fragmentation of responsibilities both at the federal level and between Confederation and Cantons.

An impetus of changes in national research policy has been the current economic and financial crisis, which has strong impact on Switzerland also through its very large banks; while most of the economic stabilisation programmes address directly financial problems of the banking system, there is a wide political consensus that research and innovation will be decisive in overcoming the crisis. Hence, the second economic stabilisation programme released by the government in spring 2009 includes measures to strengthen the field of research and innovation, even if funding is rather limited; it is expected that this context will drive additional new investments like the funding of the national programme in advanced computing during 2009. However, one cannot preclude cuts in the R&D budgets due to budgetary deficits which, given the traditionally restrictive budgetary policy of the Confederation, would directly impact on public research funding (the resources provided by the strategic plan have to be confirmed year by year in the State budget and cuts cannot be excluded).

Table 6: Summary of main policy related opportunities and risks

Domain	Main policy related opportunities	Main policy-related risks
Resource mobilisation	<ul style="list-style-type: none"> • increase of public spending for research foreseen in the strategic plan. • new emphasis on research and innovation to overcome financial crisis. 	<ul style="list-style-type: none"> • dependency on strategies of multinational companies and limited influence of the State on private spending; • risk of budgetary cuts if the financial situation of the Confederation will become more difficult because of the economic crisis.
Knowledge demand	<ul style="list-style-type: none"> • efficient mechanisms to identify bottom-up demands of the research system and private companies and to launch new programmes. 	<ul style="list-style-type: none"> • lack of strategic intelligence and planning with the risk of not anticipating new demands which are radically different from today
Knowledge production	<ul style="list-style-type: none"> • focus on competitive research funding through Swiss National Science Foundation. • development of sound research evaluation practices at the university level. • new strategic initiatives in the field of system biology, nanoscience and advanced computing. 	<ul style="list-style-type: none"> • fragmentation of the governance of the higher education system and slow pace of reforms in this area.
Knowledge circulation	<ul style="list-style-type: none"> • reform of the Swiss Innovation Promotion Agency will strengthen its role to promote public-private cooperation. • good success in establishing SMEs as regional knowledge provider and future reinforcement of their research activities. 	<ul style="list-style-type: none"> • little coordination between research policy and economic promotion policy risks to jeopardize efforts to address challenges in the private sector. • focus on SMEs and regional development, which don't constitute the bulk of private research and innovation.

3 National policy mixes towards R&D investment goals

The aim of this chapter is to deepen the analysis of national policy mixes with a focus on public and in particular **private R&D investment**. R&D investment is seen as important yardstick for the capacity of an economy to turn the results of science and research into the commercially viable production of goods and services and hence knowledge into growth. Corresponding investment policies are mainly pursued at national level and determined with a national focus.

The chapter is structured around five questions:

1. What are the specific barriers in the country that prevent reaching the Lisbon goal? What barriers exist in the country to prevent reaching the specific targets, particularly related to the private sector R&D investments?
2. Given the above, what are the policy objectives and goals of the government that aim to tackle these barriers?
3. What Policy Mix routes are chosen to address the barriers and which specific instruments and programmes are in operation to implement these policies?
4. What have been the achievements in reaching the above mentioned R&D investment objectives and goals?

5. What are the reasons for not reaching the objectives, adaptation of the goals?

The chapter aims to capture the main dimensions of the national policies with an emphasis on private R&D investment. The chosen perspective of looking at investments in R&D is the concept of Policy Mixes. The analysis and assessment follows a stepwise approach following the five questions mentioned above.

3.1 Barriers in the research system for the achievement of R&D investment objectives

With R&D expenditures of 2.9% of GDP (2004), Switzerland is not very far from the Lisbon target. Further, the 2% target for GERD financed from private sources is already reached; however, with 0.66% of GDP (2004) GERD financed by the State is just above the EU-27 average and well below the 1% target. At least from 1985 until 2004 (latest available data) no significant progress has been made in this respect.

These facts must be interpreted in light of the context of the Swiss research policy, namely the central role of Swiss multinational companies in the private sector and the policy choice not to fund private research activities through public money. Thus, firstly, the level of private R&D is highly dependent on the localisation strategies of few large companies and the State has little influence on it (except from offering good framework conditions for their research departments). Secondly, public money is almost exclusively directed to research in universities, with a strong orientation towards basic research, and this results to a comparatively good funding level of university research (and, correspondingly, good scientific performance results).

Regarding private R&D investments, barriers are essentially related to the structural organisation of the Swiss economy and the dominance of large multinational companies in the high tech sectors; in the context of an extremely open economy with traditionally low levels of State intervention in private economy, public research policy has limited leeway to trigger changes.

In the public sector, barriers for increasing investments in research are related to different factors: firstly, a budgetary policy traditionally conservative, aiming at keeping State expenditures to a low level and avoiding budgetary deficits. Secondly, a strongly incremental practice in political decision-making and allocation of financial resources: in practice, political priorities translate in differences in increases of spending across sectors rather than in the redistribution of resources; thirdly, fiscal federalism – with Cantons having their own budgets and collecting their own taxes – substantially reduces the size of the federal budget. Cantons invest significant amounts of money in their own higher education institutions, but these resources are jointly attributed for research and education and largely drive to a priority towards educational spending. The stagnation of public research spending from the mid-'80 to the year 2000 can thus be largely explained by a political priority towards financing of education, as a response to the strong increase of the number of students.

However, the situation has significantly evolved since the year 2000. At current prices, Global Budgetary Allocations for Research and Development (which include also public funding to international organisations) decreased from CHF2,850m in 1992 to CHF2,700m in the year 2000, but then increased rather rapidly to CHF3,510m in 2006; from 2000 to 2006 the share of research and higher education in federal spending rapidly increased from 7% of total expenditures to 9% and it is expected to reach 10% in 2012.

3.2 Policy objectives addressing R&D investment and barriers

Since Switzerland is not a member of the European Union, there is little explicit reference in the policy documents to the Lisbon target, but some of the objectives stated in the Swiss policy documents can be related to it.

The most recent strategic plan, covering the period 2008-2011, states that research and innovation are key elements in the economic welfare of the country and that there is a need to increase investment in order to maintain the excellent international position of the country (both concerning scientific outputs and innovation; (Conseil Fédéral, 2007). To this aim, the strategic plan explicitly focuses on two objectives, namely the scientific excellence of the research basis and the training of highly-skilled workers and researchers. Thus, as we will discuss more in detail below in the analysis of policy mix routes, public intervention in Switzerland largely focuses on the increase of R&D expenditures in the public sector.

To achieve these objectives, the strategic plan devises a strategy based on following pillars:

- firstly, an increase in overall spending for research and higher education; with about 6% annual increase, this domain received one of the highest priorities in the federal budget (compared with an annual increase of total expenditures of 3.7% according to the Confederation financial plan);
- secondly, a shift of priority setting between research and higher education; while in the latter domain the goal is to stabilize expenditures and to increase efficiency of spending, the former receives most of the increase in resources, especially through a substantial increase of resources for the two project funding agencies (Swiss National Science Foundation and Swiss Innovation Promotion Agency);
- thirdly, the increase of efficiency in public funding of research through different structural measures: the reform of higher education system and of its governance (see section 4.3); targeted funding to inter-university cooperation projects in specific sectors (see section 4.3); selective increase of competitive project funding (SNF and KTI; see section 3.3).

What is more relevant, public support to research and innovation is considered as a key factor to overcome the current financial crisis and thus this level of spending should be maintained even if public finances run into deficit. In fact, the stabilisation programme approved by the government in spring 2009 includes additional measures for strengthening the field of research and innovation.

3.3 Characteristics of the policy mix to foster R&D investment

This section is about the characterisation and governance of the national policy and instrument mix chosen to foster public and private R&D investment. While policy goals are often stated at a general level, the policy mix has a focus on how these policy goals are implemented in practice. The question is what tools and instruments have been set up and are in operation to achieve the policy goals? The following sections will each try to tackle a number of these dimensions.

3.3.1 Overall funding mechanisms

Switzerland shares with most Continental European countries a mixed funding system based on the combination of core funding to public research institutions and

project funding to individual research groups (Lepori et al., 2007). However, the mix of different instruments displays a number of specificities directly related to the context of the country and the main orientations of its research policy.

A mixed model between core and project funding

The mixed model of public research funding has been created progressively since the Second World War with the creation of specialised funding agencies for innovation (Swiss Innovation Promotion Agency; 1944) and basic science (Swiss National Science Foundation; 1952; (Benninghoff & Leresche, 2003);(Lepori, 2007b).

Core funding to higher education institutions (Federal Institutes of Technology; Cantonal Universities; Universities of Applied Sciences) is attributed jointly for education and research. Universities are free to decide how to allocate internally funding among domain and activities. Some performance incentives have been introduced through the use of performance contracts (Federal Institutes of Technology) and, especially, through the use of third-party funding to calculate the research component of federal subsidies to cantonal universities. However, core allocation can be considered as weakly competitive and provides to all universities a basis for developing research across all their domain of activity. Also, internal allocation is largely based on negotiation and historical criteria, even if most universities are trying to develop some measures of performance of their units at least to inform this process.

Direct funding to public research institutes outside universities is more limited. The largest of them are the four institutes attached to the FIT domain, whose resources are provided through the performance contract of the whole FIT domain. The Confederation has a specific funding instrument for research institutes outside the university sector, but its share of total funding is very low.

In the '80 and '90, core allocation covered about $\frac{3}{4}$ of total public funding of research, but since the year 2000 the Confederation consequently shifted its priorities towards project funding. Thus, the strategic plan for the years 2008-2011 foresees an increase of resources for the Swiss National Science Foundation of 48% and for the Swiss Innovation Promotion Agency of 32%, while only of 11% for federal subsidies to Cantonal universities and of 9% for the core allocation to the FIT domain. It is not likely that this shift in federal policies will lead to a dominance of project funding, but the change in the composition of resources is strongly impacting both on the strategies of the research groups and of those of the universities themselves, which pay more attention to the acquisition of third-party funding and the success of individual research groups in this respect.

A further relevant change has been the introduction from 2009 of an overhead to the SNF grants to cover general costs of the universities. Despite the limited amount - it corresponds to 10% of the grant, but should be increased in the future to reach 20% (Conseil Fédéral, 2007) -, this measure has a highly political relevance, since it is a first step towards the direct financing of general costs of research, separated from the universities core budget.

Project funding targeted to basic research in universities

Project funding in Switzerland has specific features compared with other European countries:

- a concentration of project funding in few specialised agencies, namely the Swiss National Science Foundation, the Swiss Innovation Promotion Agency and the European Framework Programmes; the role of other Federal Departments is limited and continuously decreased in the last ten years; direct research contracts from Federal Departments amounted to only €50m in 2006, i.e. 1/5 of the budget of the Swiss National Science Foundation;
- the dominance of the Swiss Science National Foundation, which accounted in 2006 for more than 60% of national project funding, its strong academic orientation, where investigator driven grants account for about 80% of the total budget, and its large autonomy from the State (being a private foundation essentially managed by university professors). For comparison, SNF budget is about five times the budget of the Swiss Innovation Promotion Agency;
- the fact that 80% of public project funding benefits to universities and thus it is a choice instrument to support academic research. This sharply contrasts with the situation in other countries where public project funding is considered also as an instrument to support research in private companies (Lepori et al., 2007).

Thus, the emphasis on project funding in Switzerland is a conscious choice to promote investigator-driven university research, where grant recipients are selected through peer review processes and academic merit. Moreover, since 90% of personnel engaged in SNF-funded project are PhD students working on a dissertation related to the project, project funding is also an instrument to promote training of skilled researchers.

Very limited role of thematic funding instruments

This organisation of funding entails a very low level of intervention by the State in setting research priorities and to a policy mix orientation towards generic support rather than development of specific research topics. Following OECD's criticism (OECD 1989), a major effort was undertaken in the '90 to launch a set of priority programmes in key technological areas, like informatics, biotechnology, material sciences; since the year 2000, thematic priorities have almost disappeared from Swiss research policy, with the exception of some focused initiatives of the Swiss Innovation Promotion Agency and of National Research Programmes launched to directly address social and political relevant topics (see the Annex).

The function of promoting research in specific technological domains has been largely delegated to European framework programmes, whose importance has strongly increased in the Swiss context – after SNF, Framework programmes are the second most important project funding instrument in Switzerland after SNF, as well as to other European agencies, like the European Space Agency and Euratom (SBF Staatssekretariat für Bildung und Forschung, 2008).

No direct funding of private R&D, but focus on collaboration instruments

The lack of instruments to support directly private R&D is a further relevant characteristic of Swiss research funding; with 1% of BERD funded by the State Switzerland has by far the lowest share among OECD countries and there are no specific instruments directed to this aim.

Support to private companies has been explicitly targeted only towards SME's without sufficient research capacity in order to address their needs for technological innovation through joint cooperation projects between academia (mostly FIT and

UAS) financed by the Swiss Innovation Promotion Agency (KTI). These projects are driven by innovation needs of companies which request public research institutes to perform research needs to overcome some technological bottlenecks. KTI funds the public research partner, while the company provides at least half of the project effort mostly in own work, but then has the ownership of the project results. This mechanism has proven to be very effective in answering to the private companies needs and evaluation studies have shown that KTI funded firms showing a significantly better innovation performance than comparable firms without KTI support (Arvanitis, Donzé, & Sydow N., 2005). The KTI budget has been strongly increased since the end of '90 in parallel with the creation of the Universities of Applied Sciences (UAS).

In December 2008, the Swiss government released a project of reform of the Swiss research act which will provide a sounder legal status to the KTI, by transforming it from a consultative commission into a largely independent agency from the federal administration, with its own secretariat and decision-making power on the allocation of projects. This reform consolidates the today's role of KTI as the Swiss Innovation Promotion Agency with a stronger independence from the federal administration. It should be approved by the parliament during 2009.

3.3.2 Policy Mix Routes

The "Policy Mix Project" identified the following six 'routes' to stimulate R&D investment:

1. promoting the establishment of new indigenous R&D performing firms;
2. stimulating greater R&D investment in R&D performing firms;
3. stimulating firms that do not perform R&D yet;
4. attracting R&D-performing firms from abroad;
5. increasing extramural R&D carried out in cooperation with the public sector or other firms;
6. increasing R&D in the public sector.

The routes cover the major ways of increasing public and private R&D expenditures in a country. Each route is associated with a different target group, though there are overlaps across routes. The routes are not mutually exclusive as, for example, competitiveness poles of cluster strategies aim to act on several routes at a time. Within one 'route', the policy portfolio varies from country to country and region to region depending to policy traditions, specific needs of the system etc.

The Swiss context is very specific in this respect given the tradition of no direct intervention of the State in private R&D activities. Thus, routes 2 (stimulating greater R&D investment in R&D performing firms) and 3 (stimulating firms that do not perform R&D yet) are not relevant in the Swiss context, while route 4 (attracting R&D-performing firms from abroad) has a limited importance at the federal level; however, some Cantons have been active in this respect in their economic promotion policies, for example setting incentives for the establishment of innovative companies. A further area of activity left to Cantons is to propose favourable localisation conditions to new companies, as well as to keep the R&D laboratories of multinational companies; this might include for example simplification of administrative procedures concerning personnel and building, tax relieves (being of Cantonal competence) and investment in infrastructure. In their economic promotion

policy, most Cantons provide for this type of measures and there is a clear trend to favour innovative companies against more traditional activities.

However, at the national level, routes 1 (promoting the establishment of new indigenous R&D performing firms), 5 (increasing extramural R&D carried out in cooperation with the public sector) and 6 (increasing R&D in the public sector) are clearly the main action lines.

Route 1: Promoting the establishment of new indigenous R&D performing firms

Promoting the establishment of new R&D performing firms, especially of university start-ups, has been a clear focus in the most recent years. Most initiatives have been promoted by regional actors together with the universities themselves: among the most active have been the EPFL, which host on its site a science park, as well as the universities of applied sciences; science and technology parks have been created in about 20 Swiss cities, mostly in cooperation with higher education institutions (<http://www.swissparks.ch>). They offer favourable locations, coaching and support to start-ups.

At national level, the Swiss Innovation Promotion Agency supports the creation of innovative start-ups through its KTI start-up programme, while training in entrepreneurship is provided through the national Venturelab programme.

These initiatives have some relevance to promote the creation of innovative start-ups, but in the aggregate the impact on private R&D activities is likely to be very limited ([INNO-Policy Trend Chart, 2009](#)).

Route 5: Increasing extramural R&D carried out in cooperation with the public sector

Promotion of cooperative research between higher education institutions and private companies is the main route of direct support from the State to technological innovation, especially in companies without their own research capacity. Most of the budget of the Swiss Innovation Promotion Agency (about €50m) is devoted to these projects. This approach has been confirmed also in the economic support programme approved by the government in spring 2009, where additional €12m have been provided for the KTI, with a focus on renewable energies and smart materials. These measures target essentially SMEs.

Route 6: Increasing R&D in the public sector

As discussed in sections 3.2 and 3.3 increasing the volume and the efficiency of R&D activities in the public sector is a priority of Swiss research policy; as usual in the Swiss context, this does not take the form of new investment plans, but of a gradual increase of resources and shifts in priorities.

This route is meant also to have an indirect impact on private R&D activities: namely, given the sector composition of these activities, it is assumed that multinational companies tend to locate their laboratories near to very good research centres and are very sensible to the availability of well-trained researchers (having done their PhD in universities).

The importance of education and innovation policies

In a country where practically all public research is performed in higher education institutions, it is more than obvious that higher education policies are highly relevant also for public research. Thus the on-going reforms of the higher education system (see section 4.3) are considered also a relevant contribution to the strengthening of the Swiss research system.

At the national political level, coordination between higher education policy and research policy has been much improved since the '90, thanks to the practice of including in the four-year strategic plans all relevant measures concerning higher education and research. This allows for example a common planning of general university support and of direct research funding through SNF and KTI. Moreover, because of the strong research tradition of Swiss universities, the Swiss University Conference and, especially, the Conference of Rectors of Swiss Universities have a strong focus on research and consider it as a priority in dealing with university and higher education overall.

Coordination is weaker concerning technological policy and, especially, innovation policy. Technology and innovation support through the KTI is included in the strategic plans, but at the federal level is managed through the Federal Office for Professional Education and Technology and thus its integration in the overall research and higher education planning is weaker. The reform of the research act, which will provide the KTI with the status of a research support agency, ought to improve to some extent the situation.

At the contrary, research policy and general innovation policy, including economic support measures and measures to improve the framework conditions for companies (regulatory measures, monopolistic regulations, opening of the markets, fiscal rules, etc.), are two distinct policy domains, with little coordination taking place. At the federal level, these measures are the resort of the State Secretariat for Economy, while direct economic promotion – for example to attract foreign companies – are the responsibility of the Cantons. This fragmentation of responsibilities is even more worrying since, in the Swiss context with its tradition of non direct intervention of the State in public R&D, these indirect measures would be extremely important to stimulate private R&D activities.

Assessment of the importance of policy mix routes and their balance

The table below summarizes the importance of the different policy mix routes for the Swiss case.

Table 7: Importance of routes in the national policy and recent changes

Route	Short assessment of the importance of the route in the national policy	Main policy changes since 2008
1	This route is especially relevant concerning the establishment of start-ups, especially as spin-offs from university research.	Few changes except the introduction of innovation vouchers for SMEs to use TTOs services (however at a very small scale).
2	Not relevant.	
3	Not relevant.	
4	Not relevant at federal level. Some Cantons introduced in their economic promotion criteria related to technology and innovation.	No major changes.

Route	Short assessment of the importance of the route in the national policy	Main policy changes since 2008
5	A strong focus of Swiss research policy through cooperation project of the Swiss Innovation Promotion Agency, however strongly focused on SMEs.	Resources for the Swiss Innovation Promotion Agency have been increased in the economic stabilisation programme; moreover, the reform of the research act will provide KTI with a clearer legal basis, grant more autonomy and integrate better in research and technology policy.
6	The main focus of Swiss research policy: strengthening universities and basic research is seen as the main contribution to innovation and economic development, since this is also an incentive for multinational companies to keep their research laboratories in Switzerland (thanks also to the excellent availability of trained researchers).	Increase of spending in the public sector decided in the strategic plan 2008-2011 has been implemented, as well as the launch of new research programmes in strategic areas (system biology, nano-science).

3.4 Progress towards national R&D investment targets

In the recent years, Switzerland has made good progress in achieving national R&D investment targets in the public sector; not only public R&D expenditures have increased since the year 2000, but the strategic plan 2008-2011 provides for a further growth, as well as attributing a high priority to competitive funding of research. These plans have been consequently implemented in 2008 and 2009, while additional spending is foreseen through the economic stabilisation programmes. In the medium term, the economic crisis is however likely to have a negative impact on the financial situation of the Confederation and this could result in budgetary cuts also in the research sector.

The Swiss policy rationale is that these investments will also improve the attractiveness of Switzerland as a location for private R&D, with a focus on keeping and strengthening the research laboratories of Swiss multinational companies; target programmes in new technological domains like system biology and nanoscience should provide a contribution in this direction. However, because of its fragmentation and of the limited influence of the State on private investments decisions, today's Swiss research and innovation policy is hardly able to provide a coherent framework to address challenges of globalisation of private R&D and to influence corporate strategies.

Table 8: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Rather low level of spending in the public sector	Strong increase of research budget and focus on competitive research are good responses and will strengthen the Swiss public research landscape. Structural programmes allow addressing relevant research areas at the national level with a good mix of bottom up approach and of national coordination.
High dependency on the corporate strategies of Swiss multinationals.	This is definitively a strength of the Swiss system leading to high level of private investment and of technological production. However, the influence of the State on these strategies is minimal and thus there are high risks in case of localisation decisions.

4 Contributions of national policies to the European Research Area

This Chapter provides a thorough discussion of the national contributions to the realisation of the European Research Area (ERA). An important background policy document for the definition of ERA policies is the Green paper on ERA¹ which comprises six policy dimensions, the so-called six pillars of ERA. Based on the Green Paper and complementing other ongoing studies and activities, this chapter investigates the main national policy activities contributing to the following four dimensions/pillars of ERA:

- developing a European labour market of researchers facilitating mobility and promoting researcher careers;
- building world-class infrastructures accessible to research teams from across Europe and the world;
- modernising research organisations, in particular universities, with the aim to promote scientific excellence and effective knowledge sharing;
- opening up and co-ordination of national research programmes.

In the ERA dimension, the *wider context of internationalization of R&D policies* is also an issue related to all ERA policy pillars and is normally present in the dynamics of national ERA-relevant policies in many countries.

4.1 Towards a European labour market for researchers

The overall situation of the Swiss labour market for researchers has to be assessed as comparatively good both concerning supply of trained researchers and offer of positions. This has to be seen in the context of a favourable employment situation in general, where unemployment rates are well below the European average – 3.3% of working population in January 2009 – and also young people find a job rather easily. In fact, during phases of economic growth, there has been repeatedly a shortage of qualified workers both for public and private positions (in January 2009, the unemployment rate of workers with tertiary education was only 1.9%). The average salary of employees with a university degree is about the double of the Swiss average salary.

Available data show that the transition from higher education to the labour market functions smoothly three months after graduation 2/3 of the graduates already have found work and their salaries are quite good. Shortages are related to the structure of the labour market, to the heritage of an immigration policy which favoured immigration of low-skilled workers; the situation is likely to be improved thanks to the creation of UAS and the launch of the first UAS master studies. However, the stagnation of the numbers of students in sciences and engineering and the inability to promote women participation in these fields is a source of concern.

Regarding trained researchers, the Swiss situation is certainly excellent, with 2.33 doctoral graduates per 1000 inhabitants Switzerland ranks at the top among

¹ Commission of the European Communities: Green paper: The European Research Area: New perspectives. Brussels 4.4.2007, COM(2007) 161final
(see http://ec.europa.eu/research/era/pdf/era_gp_final_en.pdf).

European countries. This is the result of a consistent policy of training of PhD students in universities (thanks also to SNF funding) instead of creating permanent researchers positions, as well as of the opening of the PhD market to students from abroad; the policy in the field of higher education thus followed a rather different path than general labour market policy and regulation. Doing a PhD is attractive also for a future career in public administration and in private companies, since a doctorate is considered as an asset also in professional life; moreover, the strength of private research provides a good offer of positions in the private sector, especially for doctoral students from sciences and biological sciences. This translated to some extent also in difficulties for universities in recruiting post-docs and researchers in these domains, given also the higher salaries in the private sector.

The situation of PhD students is more difficult in human and social sciences, where graduate education is less structured, but also career opportunities outside academia are more difficult; complaints on the situation of researchers in these domains have repeatedly emerged in the last years (BBW Bundesamt für Bildung und Wissenschaft, 2002).

In the university sector, the career structure has been reorganised in the recent years, even if it is difficult to provide general information since differences between universities are very large. After the doctorate, the career structure is based on different types of temporary post-doc positions; permanent researcher positions are very rare. The access to upper academic ladder is increasingly provided through assistant professors positions (usually 6 years). The salary structure is strongly skewed, with rather low salary levels (when compared with salaries in private companies) for non-professoral positions, where practically all contracts are temporary, much better conditions for professors, which are employed on a permanent basis. Funding and working conditions for PhDs are however very favourable, since most of them have a grant and can work on research projects sufficiently near to their thesis.

4.1.1 Policies for opening up the national labour market for researchers

The Swiss doctorate is very attractive and open internationally (50% of doctoral students in Swiss universities have a foreign nationality). Especially in sciences, Swiss universities offer favourable conditions in terms of research quality, supervision and available grants (including funding for travelling and other expenses); moreover, in practically all domains except social sciences and humanities, most of the doctoral education and activities are in English and students without knowledge of national languages can readily be accepted. English is becoming the teaching language also for master studies in these domains, as well as in economics.

The situation of graduate education in social sciences and humanities has been improved with the launch in 2004 of a programme of graduate schools managed jointly by the Swiss National Science Foundation and the Conference of Rectors of Swiss Universities: the Pro*Doc programme funds training of PhD students in networks of Swiss universities and provides grants to the students themselves to prepare their dissertation.

There is also a strong tradition of mobility of Swiss PhD students, thanks especially to a specific grant scheme of the Swiss National Science Foundation for research stays abroad of young researchers. Increasingly, an experience abroad is considered

as a requirement for an academic career in Switzerland and, for example, is becoming mandatory to apply to most assistant professors positions.

Overall, rules concerning academic personnel in Swiss universities make little distinction between Swiss and foreign applicants; the same applies to personnel to be engaged in SNF-funded projects. Barriers in engaging foreign researchers came mostly from labour market and immigration regulations (see next section).

Social security schemes and immigration policies

Switzerland traditionally followed a very restrictive policy concerning immigration, which was justified by the already high share of foreigners in the overall population. Immigration policy gave the priority to the recruitment of temporary workers in sectors like construction and tourism, while it was very restrictive in the recruitment of permanent personnel (with a limited number of yearly recruitments at national level). Moreover, priority of Swiss citizens was mandatory and foreigners could be recruited only if suitable qualifications could not be found in the domestic labour market.

However, de facto immigration policy in the academic domain has been more liberal than official regulations. Thus, the widespread practice has been to recruit PhD students with students' permits, considering their grants as side work. Also, for university professors suitable solutions could be found in most cases.

The entry into force of the bilateral agreements with the European Union from 2007 onwards largely deregulated the system: immigration of EU citizens is no longer limited and there is no priority to Swiss citizens on the labour market. Restrictions still apply to non-EU countries. These changes considerably improved the situation concerning the labour market for researchers and simplified also the situation concerning the mobility of researchers. As a matter of fact, a major argument for accepting the bilateral agreements have been the needs of private companies and universities for skilled personnel.

The situation concerning social security and health insurance is still of some concern for the mobility of researchers especially at the upper academic level. The main barriers do not concern the basic insurances, but the well-developed system of mandatory professional security which has the objective of guaranteeing a life standard after retirement corresponding to the past salary. Professional security is based on contributions of the workers and of their employees; for researchers moving to Switzerland in a later stage of career the amount of missing contributions can be rather high and thus limit mobility opportunities. Concerning basic social security, the bilateral agreements with the European Union introduce to wide extent reciprocity and should avoid researchers losing their social contributions, but it is for the moment being too early to evaluate their impact on mobility.

For Swiss citizens moving for a few years abroad to hold a research experience suitable transitory solutions can usually be found, like freezing social security contribution and professional security.

Overall, the Swiss system seems to be well suited for mobility in the early stages of career (both inward and outward), as well for hiring professors from abroad on a stable basis. Mobility in the middle-stage of career and joint appointments in two countries seems to be more difficult from the point of view of taxes and social security.

4.1.2 Policies enhancing the attractiveness of research careers in Europe

Uptake of the European charter for researchers

Participation of Switzerland to the ERA-MORE initiative and to the EURAXESS network is managed through the Conference of Rectors of Swiss Universities, which is coordinating a national network of contact points in each Swiss university. CRUS signed also the European charter for researchers and coordinates the process of implementation in all universities and, especially, of the integration of the Charter's principles in the internal quality assurance systems of each university. CRUS is also coordinating the collection of information on employment conditions, social security, visa, etc., which should be made available from 2009 on the [Swiss EURAXESS website](#).

Overall, Swiss universities seem already to comply to a large extent with the principles and practices of the charter.

Remuneration policies

In Switzerland, given the Cantonal competence on universities, there have never been national salary scales for academic personnel, but most universities were bound to the salary scales of their own Cantons. In the last two decades the salary policy has been to a large extent deregulated and nowadays most universities have their own salary scales, as well as some freedom to negotiate salary classes when employing new people. However, competition between universities takes hardly place concerning remuneration, but much more concerning reputation of the university and of the specific research groups.

For PhD students, there are minimum wages set by the Swiss National Science Foundation for those employed in SNF project, which de fact are accepted also by universities; especially in sciences and engineering, where competition from private companies is strong, universities set higher salaries (especially the two federal institutes of technology).

Overall, Swiss wages and working conditions have to be considered as very competitive internationally, taking also into account the excellent international reputation of Swiss universities.

Promotion of Women

The situation concerning scientific careers of women has been a source of major concern also in Swiss research policy. In an European comparison, Switzerland ranks below the European average for most indicators concerning participation of women to science (European Commission, 2006).

Since the year 2000, the Confederation has launched a national programme to promote gender in universities, which is coordinated by the Conference of Rectors (€10m for the years 2008-2011). The programme includes the creation of gender services in Swiss universities, mentoring, financial incentives to recruit professors and the creation of additional places in child gardens. Partially as a result, the share of women among Swiss university professors increased from 7% in 1998 to 14% in 2004), with the goal of reaching 25% in 2011 (see <http://www.crus.ch/information-programme/chancengleichheit.html?L=3>).

Promotion of women has been also a major concern in research funding: quantitative targets have been set for the share of women in most grant schemes. Moreover, SNF has introduced a specific grant scheme for women wishing to come back to academic career have a break for family reasons (so-called Marie Heim Vögtlin grants). An extensive study has recently been published on the funding policy of SNF, which concludes that there is no specific discrimination of women in SNF support, but that a number of actions have to be taken to promote women participation (Leemann & Stutz, 2008).

4.2 Governing research infrastructures

There are good reasons why, with the exception of advanced computing, the issue of research infrastructure is not very prominent in the Swiss context: the decentralised organisation of research activities with limited steering from the State; the lack of focus on strategic thematic domains requiring large infrastructure and, finally, the small size of the country which drives to the delegation of many infrastructure issues to international Organisations.

Thus, Switzerland is founding member and full partner of most international research organisations and Swiss researchers are among the most successful users of these facilities; additionally, the Swiss National Science Foundation provides specific funding for experiments at CERN (FORCE programme).

A further reason is the overall very good level of equipment of laboratories in Swiss universities and Federal Institutes of Technology; investments both in building and equipments are financed by the Confederation and the Cantons. The Swiss National Science Foundation runs also a small programme to purchase scientific equipment required for research projects (R'Equip programme).

At national level, the only large-scale facility in natural science is the Paul Scherrer Institute (PSI), which is part of the Federal Institutes of Technology domain; besides developing its own research, PSI runs for the whole Swiss research community a high-intensity proton accelerator complex and the Swiss synchrotron light source; complementary to the European XFEL project, the PSI is currently planning a new X-ray Free Electron Laser for experiments in physics, chemistry, biology and medicine. The foreseen investment of about €150m should be included in the strategic plan 2012-2015.

Some other smaller infrastructural programmes deal with social sciences and humanities, like the creation of a Swiss archive of data collected in social sciences projects (SIDOS), as well as Swiss-level data collection like the Swiss household panel, which is financed through the Swiss National Science Foundation.

Finally, the national high-speed communication network of Swiss universities is managed by the Switch foundation (www.switch.ch): Switch manages the high-speed connections between Swiss academic institutions through its own glass fibre connections, offers support services and connectivity to Internet and the academic community worldwide (e.g. through the Geant network). Switch is funded through contributions of Swiss universities, as well as specific federal support for large projects and network upgrading.

Switzerland is also an associated partner to ESFRI; an extensive consultation of scientific milieus has been launched to evaluate the interest of the infrastructure projects promoted by ESFRI and possibility of a Swiss participation.

A strong focus on advanced computing

The main focus of Swiss policy in the area of research infrastructures concerns the domain of advanced computing. Switzerland had a pioneering role in this domain with the creation at the mid-'80 of the Swiss Scientific Computing Centre (CSCS; www.cscs.ch), a unit of the Federal Institute of Technology located in the south of the country and running high-power computing machines at service of the whole Swiss scientific community. Advanced computing is essential in many fields relying on modelling, like in physics, in chemistry, material sciences, climate, etc. and Swiss science is internationally leading in many of these areas.

To prepare the Swiss research system to the new generation of computing machines (petaflow machines) an ambitious action plan is under preparation; it includes a scientific cooperation project between CSCS and Swiss universities to develop petaflow applications in different domain sciences, the construction of a new building for the CSCS and the purchase of a next generation petaflow machine which should be operational around 2012, for a total investment exceeding €100m. The Swiss government transmitted to the parliament the advanced computing action plan and the request of funding in May 2009.

4.3 Research organisations

As introduced in section 2.1, the Swiss public research sector is dominated by higher education institutions, whereas the role of public research laboratories is quite limited. Therefore, in this section we shortly present the organisation of higher education, as well the main on-going reforms and their impact on research.

A very strong university system

The quality of research in the university system (the ten cantonal universities and the two federal institutes of technology) is certainly very high and above the European average. This is reflected also in international rankings: in the bibliometrics-based Leiden ranking of European universities three of the top-ten universities are Swiss, while in the Shangai ranking ETHZ comes at position 24 as the fourth European university after Oxford, Cambridge and UCL, while 5 out of 12 Swiss universities are in the first 150 ranks. Thus, not only some Swiss institutions (especially the two FITs) rank among the best European universities, but also the average research intensity and quality in the whole system are well above average. Even if there are some differences in quality and research intensity, all ten Cantonal universities and the two Federal Institutes of Technologies strive to achieve international visibility in research and to profile some of their research areas as excellent worldwide; this is true also for the small institutions like Neuchâtel (with a specific strengths in microtechnics) or Lugano (with a focus on informatics and computational sciences). This reflects by large a strongly academic-oriented conception of the university, where research and international visibility are considered as a must and criteria related to research are central in hiring staff at all levels of careers.

The increase of the number of students has not changed radically this picture: firstly, even if rapidly growing, enrolment rates in Swiss universities are still lower than in most European countries (thanks also to the creation of Universities of Applied Sciences); secondly, the increase has essentially concerned social sciences and humanities (accounting now about 2/3 of total students numbers), while the research-intensive fields in natural sciences and technology have been much less affected; finally, the overall funding situation of Swiss universities has to be considered very

favourable and since the '60 universities succeeded in mobilizing other sources of income (federal subsidies at the end of the '60; funding for students from other cantons in the '80; project funding since the mid-'90).

Traditionally, the Swiss university system has been considered as a combination of bureaucratic control from the Cantons concerning general strategy and administration and of large autonomy of the professors concerning research and teaching, as well as in hiring academic personnel. Cantonal competence protected this autonomy by refraining the central State to issue common directives (Perellon & Leresche, 1999). Correspondingly, university central boards and the ability of universities of defining their own strategy were limited by Cantonal politics and by the autonomy of the academic understructure (Lepori, 2007a).

Towards more autonomous and strategic universities

Reforms aimed to increase the autonomy of universities and the power of governing board started in the '80, under the pressure of restrictions in funding and of the increase in the number of students, but also thanks to the diffusion of new policy models (new public management) both at the Cantonal and at the federal level. The direction has been similar in all Cantons, strengthening the role of the rector or the president, broadening the competences of the higher governing board (the university council), shifting from line-item budget to global budget allowing internal redistribution and the creation of reserves and, finally, deregulating contracts and salaries (with the exceptions of the professors level). Moreover, universities were requested to produce regularly strategic plans, which are consolidated in a national planning by the Conference of Rectors.

However, the impact of these reforms has been very different from case to case (Fumasoli, 2007): in some Cantons, universities received more managerial autonomy, but strategic decisions (for example on main research fields) are still firmly in the hands of the cantonal government, while in other cases the university council has become a strategic organ with real power and the rector/president enjoys of a considerable autonomy. Given their position at arm's length from the Confederation, Federal Institutes of Technology are much more advanced in this process than most cantonal universities.

Swiss universities are increasingly under pressure to define a more focused profile of their activities, as a consequence of stronger selectivity of research funding, of the need of positioning in the European and international university landscape and of the limitations of funding for education. However, situations are very different: the two FIT's are firmly positioned as leading international universities and some large universities like Zurich and Bern can keep their position and a broad profile; at the contrary medium and small universities need to better focus on some strong areas concerning research and to make difficult strategic choices, like to abandon most of natural sciences (Lausanne) or the cost-intensive but prestigious microtechnics department (Neuchâtel). While federal policy by large promotes autonomy and competition between universities, some Cantons try to keep control of their own universities and to follow a more regional logic, leading in some cases to conflicts with university governance bodies.

Restructuring the landscape through cooperation projects

The strong decentralisation of the system, while being strength in terms of diversity and academic autonomy, nevertheless has been criticised as being a source of

inefficiency and duplications and lacking critical mass in some research areas. Attempts to better coordinate university research and to concentrate some research areas in few universities failed during the '90 because of the opposition of universities themselves and of their Cantons, as well as because of lack of federal competences on Cantonal universities.

The new strategy launched at the end of the '90 under the slogan "cooperation and competition" tried to address this issue providing federal funding to so-called structuring projects in cooperation between different universities; with the revision of the University act in 1999, the Swiss University Conference received the competence to launch these projects, as well as substantial financial resources; with €260m for university cooperation projects, plus €70m for FIT national projects for the period 2008-2011 structuring projects are a strong priority of the Swiss research policy.

The projects launched in period 2000-2007 included some significant restructuring processes, like the reorganisation of the portfolio of activities between University of Lausanne and EPFL, with the concentration of most natural sciences to EPFL and the creation of a strong pole of life sciences at the University, and the merger of the two faculties of veterinary in Bern and Zurich (VETSWISS). Other relevant projects are the Swiss research and education networks in public administration and in public health and the national programme Swiss Virtual Campus to promote the introduction of elearning in Swiss universities.

For the period 2008-2011, two new large cooperation programmes have been launched, the SystemX.ch programme in the systems biology (about €300m from different sources) and the nano-tera programme in micro/nano-systems engineering for distributed embedded systems design; both are based on a core of universities, but are open through calls for proposals for the participation of research groups in all Swiss universities. While rather decentralised in their nature, these projects increasingly involve the directions of universities, which are asked to provide additional resources and to take care of the coherency between national projects and university strategy.

The emergence of the second university sector and blurring borders

The most important reform in the Swiss higher education system in last three decades has undoubtedly been the creation of a second university sector, through upgrading and merging of existing professional education institutions (Lepori & Attar, 2006). The seven public Universities of Applied Sciences started in 1997 with an educational offer focused on a few domains (technology, economics, social work, design), but gradually expanded to integrate practically all domains of professional education, including arts, health professions, teacher training. Nowadays, UAS cover nearly half of new enrolments at the tertiary level.

This reform is highly relevant for research policy in two aspects: firstly, it was explicitly meant to improve the quality of professional training and UAS built their whole educational offer and career system with a focus on the needs of private industry (for example UAS professors are required to have experience in private companies). Secondly, UAS received from the beginning an explicit mandate of applied research and technology transfer to SMEs in the regional context; starting with a low level of research, these institutions have grown to a relevant actor at least in domains like manufacturing, engineering and informatics, even if the overall research volume and intensity are much lower than in universities. A recent study on private-public collaborations showed that UAS are rated as one of the main partners

of private companies, just after the two federal institutes of technology and before cantonal universities (Arvanitis, Kubli, Sydow ., & Wörter M., 2005).

A new governance of Swiss higher education

Despite the good results of decentralised coordination through cooperation projects, there is clearly a need to overcome the current fragmentation of governance and regulatory framework of higher education. Thus, at federal level, three separated acts rule the Federal Institutes of Technology (under full federal competence), the support to cantonal universities (with no regulatory competence of the Confederation) and the Universities of Applied Sciences (with a federal competence to edict general rules). Moreover, there are wide differences in cantonal university laws and funding mechanisms are different according to the type of institution. The only common body in Swiss higher education, the Swiss University Conference, has no mandatory competences and its intervention is limited by the need to gain the consensus of all Cantons on joint decisions.

The process for a new higher education act, which should provide a common regulatory framework for the whole system and establish a joint governance body between Confederation and Cantons, started already around 2004-2005, while a draft of the act has been submitted in consultation in autumn 2007; the draft new act has been submitted to the parliament in May 2009 and should entry into force at best in 2012 (see also section 2.3.3).

4.4 Opening up national research programmes

As a general rule, nationality is not a criterion to participate to Swiss research programmes. What is required instead, is to have a stable long-term appointment in a Swiss institution (this applies also to professors living in border regions and working in Swiss universities). Most funding from SNF and Swiss Innovation Promotion Agency has to be spent in Switzerland (with some exceptions for justified reasons).

However, in the recent years, a number of SNF schemes have been opened to international collaboration:

- the Sinergia programme, launched in 2008, supports cooperation networks of 3-4 research teams in basic research; the programme is open to the participation of a partner abroad (with SNF funding), if its competences are critical for the success of the project;
- with Germany (DFG) and Austria (FWF) an agreement has been signed for joint financing of bilateral or trilateral projects, where submission and evaluation takes place in one of the three countries, while funding is on national basis (lead agency procedures) or from the country where most of the research is performed (money follows cooperation line procedure);
- the cooperation programmes with Eastern European Countries (SCOPES) and with developing countries allow to fund directly research and capacity building in these countries.

Concerning SNF grant schemes a distinction has to be made between early stage career and later grant schemes; early stage career grants for a research stay abroad are reserved to PhD students of Swiss universities; the Ambizione programme for post-docs is open to applicants from abroad, while the SNF assistant professor

programme requires a Swiss university diploma or at least two years of activity in a Swiss university (but a stay abroad is a mandatory requirement).

For researchers moving abroad, there are also possibilities to transfer SNF funding to finalise the project; a specific agreement has been signed with Austria and Germany (D-CH-A cooperation).

Joint programming

Switzerland has a rather good tradition of joint programming at the European level. The most relevant examples are

- the participation to the European Science Foundations joint schemes (European Cooperative Research Projects and Eurocores programmes) through funding of the Swiss National Science Foundation;
- participation to European technology initiative EUREKA, where Swiss participations are funded through the Swiss Innovation Promotion Agency;
- participation to the Cooperation in Science and Technology in Europe (COST), where Switzerland provides through the State Secretariat for Education and Research additional funding for research in COST actions with Swiss participation.

In the 6th FP Switzerland has participated to 19 ERA-NET projects, while there are 4 over 10 ERA-NET initiatives in the 7th Framework programme with Swiss participation (SNF and Federal Departments). Decision on Swiss funding of joint calls is decided case by case by the participating body. At the contrary, there is no Swiss participation to joint activities in JTI since there is no Swiss funding available; Swiss private companies and research organisations can participate on an individual basis to selected JTIs, but have to bear themselves their own costs.

As a general evaluation, Swiss participation to joint programmes and opening of national programmes reflects the decentralised nature of Swiss research policy and the lack of planning of research topics. Thus, research funding organisations are generally willing to participate and their funding situation allows finding resources for these activities; the funding situation of Swiss partners in ESF initiatives, COST and Eureka is generally more favourable than in the other European countries.

At the same time, the decentralised nature of the process means that there is no overall planning of such initiatives and of the domains where joint programming should be promoted, the main rationale being the interest expressed by the research community itself. There are also structural limits since both SNF and KTI are based on a bottom-up approach in project selection and thus will never devote a large share of their resources to joint programmes, whereas Federal Departments dispose of very limited resources. This is for example an obstacle to the participation to large structural initiatives like JTI.

4.5 National ERA-related policies - a summary

The overall assessment of ERA-related policies in Switzerland has to take into account the specificities of the national research system (see also the Annex), but also the specific situation of Switzerland in the European context, being not a member of the European Union.

Thus, Swiss research policy rarely makes reference to ERA policy objectives, but includes them as a part of a general strategy of opening the Swiss system and positioning it in the international research landscape; even if the importance of the European context is clear, in many respects other countries like USA are a major reference for some policy actions (for example concerning mobility of researchers). Moreover, the Swiss public and private research system are already one of the most open worldwide and thus some policy recipes required in EU countries might not be very relevant in the Swiss context.

In this context, the main focus of Swiss research policy is certainly on strengthening the higher education system through reforms providing higher education institutions with more autonomy and pushing them to define clearer specialisation profiles and distinct strategies; progress has been made in this direction through reforms of Cantonal and federal laws and the increase of competitive projects in the overall share of funding; however, a lot of tensions still exists between Cantons and institutions, as well as between Cantons and Confederation. The outcome of the policy debate on the new higher education act taking place in 2009-2010 will be very important in this respect.

Concerning careers, research infrastructures and opening of research programmes, Swiss research policy is following a pragmatic and bottom-up approach to improve stepwise existing instruments (on the basis of an already very good degree of opening). A la carte participation to European initiatives through ad hoc funding is thus the main approach; while this is certainly a successful approach concerning research performers and individual researchers, it remains to be seen to which extent this allows a wide integration in the European Research Area also at the policy and funding agencies level.

Table 9: Importance of the ERA pillars in the ERA policy mix and key characteristics

	Short assessment of its importance in the ERA policy mix	Key characteristics of policies
Labour market for researchers	<ul style="list-style-type: none"> • rather important, but in the background of an already very open market for researchers internationally. 	<ul style="list-style-type: none"> • removing the barriers to mobility for EU citizens (immigration policy, social security). • Opening up of some grant schemes also for foreigners.
Governance of research infrastructures	<ul style="list-style-type: none"> • rather limited importance in the Swiss context (few national research infrastructures). 	<ul style="list-style-type: none"> • à la carte participation to joint European infrastructure projects. • national advanced computing plan.
Autonomy of research institutions	<ul style="list-style-type: none"> • clearly the most important issue for Swiss research policy. • highly complex because of division of competences between Cantons and Confederation. 	<ul style="list-style-type: none"> • granting more autonomy to individual higher education institutions. • improving the system-level governance of the system. • promoting specialisation through change in the funding system (higher share of competitive projects).
Opening up of national research programmes	<ul style="list-style-type: none"> • a rather unimportant issue which is left to the funding agencies themselves. 	<ul style="list-style-type: none"> • strong preference towards bilateral agreements between agencies (CH-D-A). • no basis for large-scale joint programming.

5 Conclusions and open questions

The analysis presented in this report has to be seen in the light of the specificities of the Swiss situation, and especially of its economy and research system. Thus, Switzerland is a medium-size European country with a level of economic development among the highest in Europe. Its economy is among the most open worldwide and displays a strong specialisation in a restricted number of technologically-intensive sectors, including pharmaceutical industry, chemical, food industry, machine industry and precision instruments. In these sectors, Switzerland is the seat of some of the largest multinational companies worldwide, including Novartis, Roche, Nestlé and ABB.

The Swiss research system is also of very good quality both concerning scientific and technological outputs, as shown by international indicators concerning scientific production (publications and impact factors) and technological production (patents). It shows a distinct organisation, based on a clear-cut separation between the public sector, centred on very research-intensive universities, and the private sector, centred on the large research units of multinational companies. The cooperation between the two sectors is based on bilateral informal contacts at the level of research units; moreover, universities train large numbers of PhD students, which then to a large extent continue their career in private companies, thus providing them with a large reservoir of skilled researchers.

This context implies that some of the policies recipes proposed by the European Commission either do not fully apply to the Swiss case – since also Switzerland is not member of the EU – or are not very relevant given the strength and openness of the Swiss research system.

5.1 Policy mix towards national R&D investment goals

As discussed in chapter 3, with R&D expenditures of 2.9% of GDP Switzerland is already very near to the 3% target. This high level of expenditures is largely due to the private economy, which already exceeds the 2% target for GERD financed from private sources, while with 0.66% of GDP (2004) GERD financed by the State is just above the EU-27 average and well below the 1% target.

High private R&D expenditures are an outcome of the specific structure of the Swiss economy and, particularly, of the high level of research expenditures of Swiss multinational companies in pharmaceuticals and machine industry (2/3 of BERD being concentrated in these two sectors). Given the size of these companies and their global strategies, this implies that the Swiss State has practically no influence on private research, except in securing good localisation conditions to the research activities of these multinational companies. In terms of research policy, this drives to a strategy focused on maintaining the quality of the public research sectors, as well as its ability to train skilled researchers. Of course, there are some risks related to relocalisation decisions and changes in the global economy, but these can hardly be avoided by a country of the size of Switzerland.

The rather low level of public R&D expenditures has to be judged more favourably than at first glance, exactly because these expenditures are focused on basic and long-term research in universities, which on the whole enjoy of a very good funding level in an European comparison. However, after a lasting stagnation of public investment in the '90, voices were raised that the Swiss research system was in

danger of losing its quality and competitiveness. A more favourable budgetary situation of the State after 2000 and a stronger priority towards research have led to a rather rapid increase of public investment in the last five years, which has been confirmed in the strategic plan for research, education and innovation for the years 2008-2011. As usual in the incremental budgeting system of the Swiss State, this has not taken place in form of bold new investment plans, but of a rather gradual increase of financial means. Stability and predictability of public investment are strong assets which favour long-term planning of research activities.

5.2 ERA-related policies

When looking to the relevance of the ERA for Swiss research policy, one needs to consider that Switzerland is not a member of the EU and thus, unsurprisingly, very few references to ERA policies can be found in Swiss official documents. However, by large Swiss research policy complies with ERA objectives and, to some extent, already fulfils them better than many EU countries.

This is the case for example for researcher's mobility, where the Swiss researchers market is one the most open internationally (about half of the PhD students and of the university professors are of foreign nationality). The impact of the EU in this context has to be sought rather in the liberalisation of the labour market and of people mobility in general, against a traditionally restrictive Swiss policy in these domains.

In the domains of research infrastructures and opening of research programmes, Switzerland is following the decentralised and bottom-up approach which characterized by large its research policy; thus, participation to European infrastructural initiatives and to international programmes, as well as opening of national programmes, are decided case by case when the research community shows an interest for them. This highly effective approach entails however some risks in case the EU launches large-scale joint schemes, where participation has to be decided at the political level (as the non participation of Switzerland to Joint Technology Initiatives might show).

However, the most important challenge for Swiss research policy is undoubtedly to strengthen its universities and to allow them to position themselves in the European and international context; while this is already the case for some of them – especially for the two Federal Institutes of Technology – cantonal universities need a stronger effort in this direction. At the political level, initiatives have been undertaken to grant to universities wider autonomy and strategic capability but conflicts emerged in this respect between some universities and cantonal authorities. Moreover, today's governance of Swiss higher education is too fragmented between different jurisdictions and regulations are widely different between types of HEI (cantonal universities vs. Federal Institutes of Technology vs. Universities of Applied Sciences). Work on a new higher education act, which should provide a common regulatory framework for the whole system and establish a joint governance body between Confederation and Cantons, started already around 2004-2005 and it is hoped that the new act can entry into force around 2012.

References

- Arvanitis S. (2009): ERAWATCH research inventory report for Switzerland <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&countryCode=CH&topicID=4>
- Arvanitis, S., Donzé, L., & Sydow N. (2005): Wirksamkeit der projektförderung der kommission für technologie und innovation – analyse auf der basis verschiedener matched-pairs methoden. Zürich: KOF-Arbeitspapier 103.
- Arvanitis, S., Kubli, U., Sydow., & Wörter M. (2005): Knowledge and technology transfer (KTT) activities between universities and firms in Switzerland: The main facts.
- BBW Bundesamt für Bildung und Wissenschaft. (2002): Förderung der geistes- und sozialwissenschaften. Bern: Bundesamt für Bildung und Wissenschaft.
- Benninghoff, M., & Leresche, J. (2003): La recherche affaire d'etat. enjeux et luttes d'une politique fédérale des sciences. Lausanne: PPUR.
- Braun, D., & Leresche, J. (2007): Research and technology policy in Switzerland. In U. Klöti, P. Knoepfel, H. Kriesi, W. Linder, Y. Papadopoulos & P. Sciarini (Eds.), Handbook of swiss politics (2nd edition ed., pp. 735-762). Zürich: NZZ Libro.
- Conseil Fédéral. (2007): Message relatif à l'encouragement de la formation, de la recherche et de l'innovation pendant les années 2008 à 2011
- European Commission. (2006): She figures 2006. women and science statistics and indicators.
- Fumasoli, T. (2007): Governance in swiss universities. A comparative analysis through cantonal and federal laws. Draft Paper. Università della Svizzera italiana, Lugano:
- INNO-Policy Trend Chart. (2009): INNO-policy TrendChart – policy trends and appraisal report. Switzerland 2008 http://www.proinno-europe.eu/extranet/upload/countryreports/Country_Report_Switzerland_2008.pdf
- Leemann, R. J., & Stutz, H. (2008): Geschlecht und forschungsförderung. synthesebericht.
- Lepori, B. (2007a): Patterns of diversity in the swiss higher education system. In A. Bonaccorsi, & C. Daraio (Eds.), Universities and strategic knowledge creation. specialization and performance in europe (pp. 209-240). Cheltenham: Edwar Elgar.
- Lepori, B. (2007b): La politique de la recherche en suisse. institutions, acteurs et dynamique historique. Bern: Haupt.
- Lepori, B. (2008): Research in non-university higher education institutions. the case of the swiss universities of applied sciences. Higher Education, forthcoming
- Lepori, B., & Attar, L. (2006): Research strategies and framework conditions for research in swiss universities of applied sciences
- Lepori, B., Dinges, M., Reale, E., Slipersaeter, S., Theves, J., & Van den Besselaar, P. (2007): Comparing the evolution of national research policies: What patterns of change? Science and Public Policy, 34(6), 372-388.

Perellon, J. F., & Leresche, J. (1999): Co-ordinating the impossible? current changes of governance patterns in swiss university policy. In D. Braun, & F. Merrien (Eds.), Towards a new model of governance for universities? A comparative view (pp. 119-140)

SBF Staatssekretariat für Bildung und Forschung. (2008): Participation de la suisse au 6ème programme-cadre européen de recherche

List of Abbreviations

BERD	Business Expenditures in Research and Development
CRUS	Conference of Rectors of Swiss Universities
CSCS	Swiss Centre for Scientific Computing
EPFL	Federal Institute of Technology in Lausanne
EPFL	Federal Institute of Technology in Lausanne
ERA	European Research Area
ETHZ	Federal Institute of Technology in Zurich
ETHZ	Federal Institute of Technology in Zurich
EU	European Union
FIT	Federal Institutes of Technology
GDP	Gross Domestic Product
GERD	Gross Expenditures on Research and Development
HEI	Higher Education Institutions
HEI	Higher Education Institutions
KFH	Conference of Rectors of Swiss Universities of Applied Sciences
KTI	Swiss Innovation Promotion Agency
NCCR	National Centres of Competence in Research
NRP	National Research Programmes
OECD	Organisation for Economic Cooperation and Development
OPET	Federal Office for Professional Education and Technology
PRO	Public Research Organisation
R&D	Research and Development
SER	State Secretariate for Education and Research
SME	Small and medium Enterprises
SNF	Swiss National Science Foundation
SSH	Social Sciences and Humanities
SSTC	Swiss Science and Technology Council
SUC	Swiss University Conference
UAS	Universities of Applied Sciences

RESEARCH SYSTEM ANALYSIS REPORT

**Elements on Research System Analysis relevant for
the policy Mix Reports 2009 for non EU Member
States**

Country: Switzerland

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1 - Introduction and overview of analytical framework

1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. The strategy reflects this in guideline No. 7 of the Integrated Guidelines for Growth and Jobs. This aims to increase and improve investment in research and development (R&D), with a particular focus on the private sector. One task within ERAWATCH is to produce analytical country reports to support the mutual learning process and the monitoring of Member States' efforts.

The main objective is to analyse the performance of national research systems and related policies in a comparable manner. The desired result is an evidence-based and horizontally comparable assessment of strength and weaknesses and policy-related opportunities and risks. A particular consideration in the analysis is given to elements of Europeanisation in the governance of national research systems in the framework of the European Research Area, relaunched with the ERA Green Paper of the Commission in April 2007.

To ensure comparability across countries, a dual level analytical framework has been developed. On the *first level*, the analysis focuses on key processes relevant to system performance in four policy-relevant domains of the research system:

1. Resource mobilisation: the actors and institutions of the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system.
2. Knowledge demand: needs for knowledge have to be identified and governance mechanisms have to determine how these requirements can be met, setting priorities for the use of resources.
3. Knowledge production: the creation and development of scientific and technological knowledge is clearly the fundamental role of a research system.
4. Knowledge circulation: ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production.

These four domains differ in terms of the scope they offer for governance and policy intervention. Governance issues are therefore treated not as a separate domain but as an integral part of each domain analysis.

Table 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
<ul style="list-style-type: none"> • Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources 	<ul style="list-style-type: none"> • Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment 	<ul style="list-style-type: none"> • Quality and excellence of knowledge production • Exploitability of knowledge production 	<ul style="list-style-type: none"> • Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

On the *second* level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see figure 1). The way in which a specific research system responds to these generic challenges is an important guide for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter the analysis in terms of how they contribute to system performance in the four domains.

Based on this framework, analysis in each domain proceeds in the following two steps. The first step is to analyse the current situation of the research system with regard to the challenges. The second step in the analysis aims at an evidence-based assessment of the strengths and weaknesses with regard to the challenges.

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory¹ and other important publicly available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Quantitative information and indicators are used, where appropriate, to support the analysis.

After an introductory overview of the structure of the national research system and its governance, chapter 2 analyses resource mobilisation for R&D. Chapter 3 looks at knowledge demand. Chapter 4 focuses on knowledge production and chapter 5 deals with knowledge circulation. Each of these chapters contains four main subsections in correspondence with the four steps of the analysis. The report concludes in chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and risks across all four domains in the light of the Lisbon Strategy's goals.

1.2 Structure of the national research system and its governance

The main features of the Swiss research system and of its governance are the following:

¹ ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS. The ERAWATCH Research Inventory is accessible at <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home>. Other sources are explicitly referenced.

- 1 the fact that political responsibilities concerning higher education are divided between the central state (the Confederation) and the regional authorities (Cantons) with lasting consequences also in research policy.
- 2 the division of responsibilities for the research and higher education in the national government between the Ministry of Internal Affairs, which is responsible for the Universities and the support to basic research (through the Swiss National Science Foundation; SNF) and the Ministry of economy, which is responsible for Universities of Applied Sciences and the support to applied research through the Swiss Innovation Promotion Agency (KTI).
- 3 a clear organisational separation between the policy level (federal and cantonal administrations), the agencies funding research projects (Swiss National Science Foundation and the Swiss Innovation Promotion Agency) and the public research organisations.
- 4 the dominant role of universities in the public research sector and the weakness of public research laboratories;
- 5 the size and the structure of private research, being strongly concentrated on the chemical and pharmaceutical sectors and in the (electro)mechanical industry (including precision instruments).

The following figure shows a map of the most important organizations involved in research policy and research activities, which we briefly detail below. For a more complete overview of the Swiss system refer to ([Arvanitis S., 2009](#); Braun & Leresche, 2007; Lepori, 2007b).

Political responsibilities for research and higher education are divided between the central state (Confederation) and the regional authorities (the Cantons), as a result of a long-standing historical development (with some Cantons having their own university well before the creation of the Swiss federal State in 1848. Thus, the Confederation is responsible for direct funding of research and for the coordination of research activities, while higher education is shared between Confederation and Cantons as follows:

- 1 the Confederation is responsible for the two Federal Institutes of Technology (FIT) in Zurich (ETHZ) and in Lausanne (EPFL) whose activities are regulated by a specific act (Federal Act on Federal Institutes of Technology).
- 2 the Cantons are responsible for their universities (ten of 26 Cantons possess their own university); each Canton has its own university act, while a national act regulating federal support to these institutions (Federal Act on Cantonal Universities).
- 3 the Universities of Applied Sciences are ruled by the cantons, but under the framework of national law (Federal Act on Universities of Applied Sciences).

At the federal level, since the late '90 responsibilities on research and higher education are divided between the Federal Department of Internal Affairs and the Federal Department of Economy; there is no research Federal Department because of the specific organisation of the Swiss government (having 7 Federal Departments only). Other Departments play a very limited role, mainly through funding contract research falling within their own policy sector responsibilities or by managing small intra-departmental research units (the largest one being in the field of agriculture).

Inside the Department of Internal Affairs, the most important organisational unit is the State Secretariat for Education and Research, whose head has functions very similar to a research ministry; it is in charge of the coordination of the whole domain, including the preparation of the four-year strategic plans (Conseil Fédéral, 2007), of support to cantonal universities, of funding of basic research through the Swiss National Science Foundation and of international activities of Switzerland (participation to EU Framework Programmes, to international organisations and bilateral relations). In the same department, the Board of Federal Institutes of Technology is in charge of the overall steering and funding of the FIT domain, which includes the two FIT and four annex institutes. The relationships between Confederation and FIT domain are regulated by a specific performance agreement (including provision for the allocation of the block grant to the FIT domain).

Inside the Department of Economy, the Federal Office for Professional Education and Technology (OPET) is responsible for the coordination of the Universities of Applied Sciences (UAS), as well as for the whole domain of professional education; moreover, it manages policy measures supporting applied research and technology transfer through the Swiss Innovation Promotion Agency.

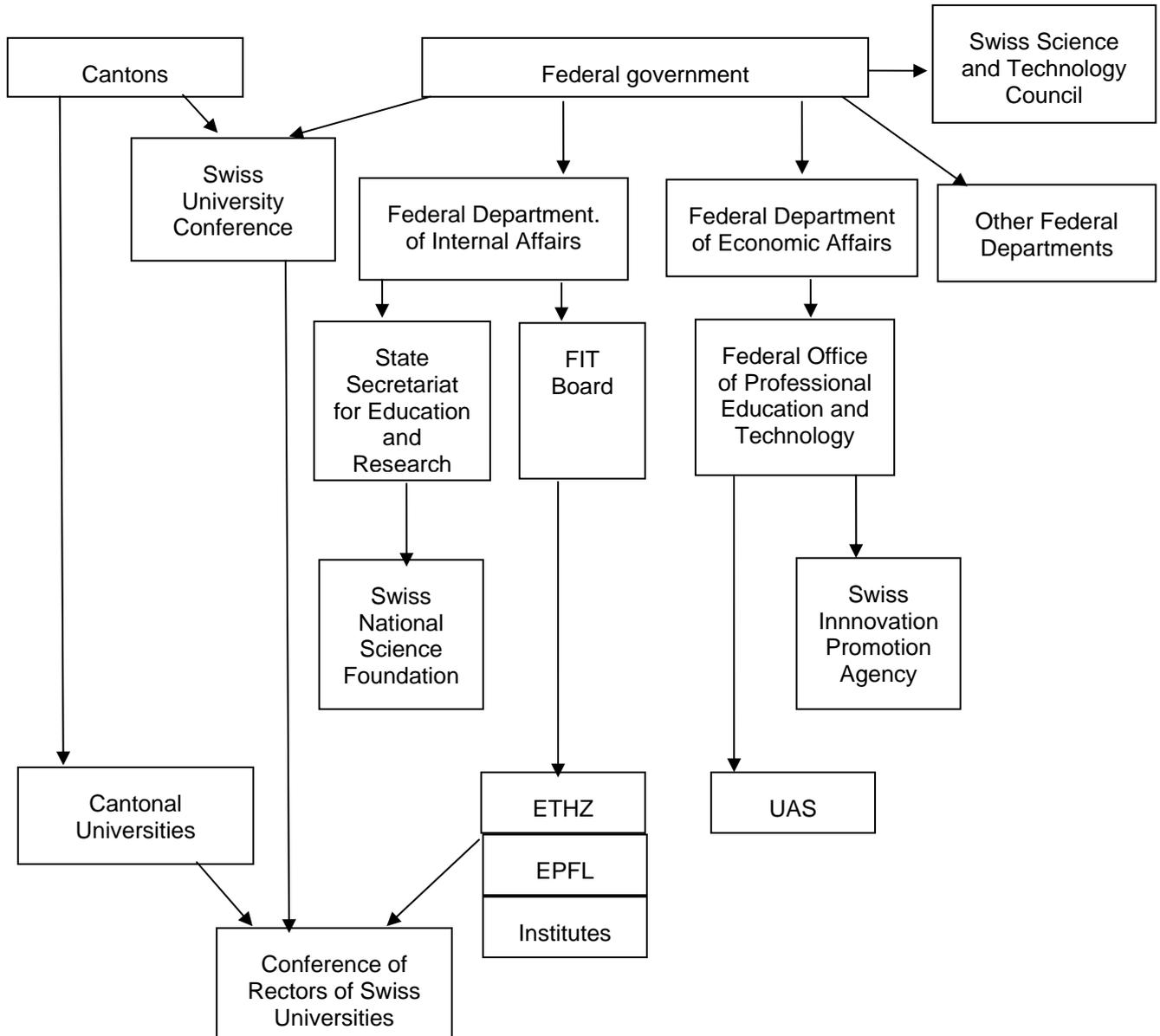
The Swiss University Conference (SUC) is a common body of Cantons and Confederation in charge of the coordination of the university domain (FIT and cantonal universities). The Conference of Rectors of Swiss Universities is a private association composed by the rectors of the cantonal universities and by the presidents of the two FIT; by law it is in charge of the preparation of the university planning on behalf of the SUC and manages a number of coordination programmes and activities between Swiss universities. A parallel body exists for UAS (Swiss Conference of Rectors of Universities of Applied Sciences; KFH).

At the intermediary level, the main actors are the two project funding agencies:

- 1 the Swiss National Science Foundation (SNF) is private foundation recognised by the Swiss research act and almost entirely funded by the Confederation. It is responsible for the support to basic research in the Universities and in the FIT: moreover, it manages the national research programmes, as well as a programme aiming to create networks of excellence at the national level. It is a very large agency, which enjoys of substantial autonomy from the State.
- 2 the Swiss Innovation Promotion Agency (KTI) is a commission of Department of economy which supports joint projects between universities and private companies, as well research activities in the UAS and different technology transfer initiatives.

Finally, the Swiss Science and Technology Council (SSTC) is the advisory body of the national government for science and technology policy.

Figure 1: Overview of the governance structure of the Swiss research system



Source: Author

The institutional role of the regions in research governance

Due to the federal organisation of the country, Cantons are very important actors in Swiss research and higher education policy. By the Swiss Constitution, general education belongs to cantonal competences and the Confederation has very few responsibilities on the school system below the tertiary level. The situation is different at the tertiary level, where responsibilities are shared: Cantons have full sovereignty on their own universities (each ruled by a specific cantonal law), while the Confederation has the right of managing the two Federal Institutes of technology, as well as to support cantonal universities (but without any legal power on them). This drives to what has been called the “impossible coordination” of Swiss higher education policy (Perellon & Leresche, 1999) and to a high diversity of organisational

forms and rules between universities; the only national coordination body, i.e. the Swiss University Conference, has mainly the function of a consultation body where Cantons and Confederation try to reach a minimum consensus (Fumasoli, 2007; Lepori, 2007a).

The situation is even more complex for professional tertiary education, where Confederation has a general regulatory power, while Cantons run the Universities of Applied Science (Lepori, 2008). The general principle that higher education is shared competence field of Cantons and Confederation and that the policies in the domain should be developed jointly has been introduced in the federal Constitution in the year 2007 only.

Cantons are also relevant actors in all policy debates on research and higher policy, given their strong veto power on decisions at the national level and strongly intervene in the negotiations on research plans and funding to defend the interests of their own universities. Finally, Cantons are in charge of economic promotion and thus to support to Small and Medium Enterprises, even if most general cantons do not pursue an explicit innovation-oriented policy including active support for innovative firms and industry ([INNO-Policy Trend Chart, 2009](#)).

Main research performer groups

At performers' level, the Swiss research system is divided between a public sector dominated by the universities and a private sector dominated by a small number of multinational companies.

The higher education sector accounts for about 80% of the public R&D expenditures. It is composed by ten cantonal universities and the two federal institutes of technology (in Zurich and in Lausanne); both are universities in the traditional sense and have the right to award doctorates. The nine Universities of Applied Sciences (7 public and 2 private) have been created in the late '90 through merger and upgrading of existing professional tertiary education institutions; UAS are oriented towards professional education and have a mandate for applied research and technology transfer, without the right of awarding doctorates (Lepori, 2008).

Outside the universities, the main public research institutes are the four institutes belonging of the FIT domain; the most important is the Paul Scherrer Institute, active mostly in the domain of energy and environment. Since these institutes are included organizationally in the FIT domain, they are normally accounted in the higher education sector in R&D statistics. There is also a small number of public research institutes outside higher education in fields like cancer, tropical studies, biomedicine, as well as some research activities inside the public administration (for example education, health research and agriculture), as well as in non-university hospitals.

The private sector is dominated by two branches, the chemicals (including pharmaceuticals sectors) and the machine industry. Both are characterised by the presence of large multinational companies with headquarters in Switzerland: Novartis, Roche in pharmaceutical and chemical industry, Nestlé in food industry, ABB and Sulzer in mechanical, engineering and precision instruments. Research of these companies is largely international and, actually, these companies perform most of their R&D abroad (especially in the USA and also increasingly in Asia).

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research system. Its actors have to ensure and justify that adequate financial and human resources are most appropriately mobilised for the operation of the system. A central issue in this domain is the long time horizon required until the effects of the mobilisation become visible. Increasing system performance in this domain is a focal point of the Lisbon Strategy, with the Barcelona EU overall objective of a R&D investment of 3% of GDP and an appropriate public/private split as orientation, but also highlighting the need for a sufficient supply of qualified researchers.

Four different challenges in the domain of resource mobilisation for research which need to be addressed appropriately by the research system can be distinguished:

- Justifying resource provision for research activities;
- Securing long term investment in research;
- Dealing with uncertain returns and other barriers to private R&D investment; and
- Providing qualified human resources.

2.1 Analysis of system characteristics

Switzerland can be characterized as middle-size research system with a high R&D intensity especially in the private sector, as well as with a very level of scientific and technological outputs. GERD amounted to €8.5b in 2004, corresponding to 2.9% of the GDP, thus almost reaching the 3% target and well above the European average (2.09% in 2006). 23% of total spending came in 2004 from the State (16% from the Confederation and 9% from the Cantons), while the business sector contributed for 70% and 5% from abroad. These shares have been fairly stable since 1992, while in real terms GERD has increased rather continuously growing from 2.74% of GDP in 1989 to 2.94 in 2004.

With 0.67% of GDP public funding of research is just above the EU-27 average and thus relatively low if compared to other countries with a similar level of scientific and technological development; as we shall see, it is strongly focused on the promotion of basic university research, which thus enjoys of a comparatively good funding situation.

2.1.1 Justifying resource provision for research activities

In Switzerland, the debate on public support to research activities takes place essentially during the preparation of the four year strategic plans for education, research and innovation, the current one covering the period from 2008 to 2011 (Conseil Fédéral, 2007). The strategic plan indicates key objectives and measures for the next planning period, but also defines the financial means available for the whole period. Even if these have to be confirmed in the yearly budget by the Parliament, changes are rather limited and thus this mechanism provides for a suitable medium-term planning of resources.

Despite the difficult situation of public finances, many voices have been raised to ask for a substantial increase in public support to research and higher education, which slowed down significantly during the difficult economic period in the '90. For example,

the Swiss Science and Technology Council in its recommendations remarks that the share of expenditures for research and education in the total federal budget has not increased in the last 20 years and advocates for a strong growth (Conseil Suisse de la Science et de la Technologie, 2006).

All political documents state the increasing importance of research and innovation for the economic development of Switzerland and the risk that Switzerland could lose its very good position because of lack of funding, but also because of bottlenecks in the transfer of results from basic research towards innovation (BBT Bundesamt für Berufsbildung und Technologie, 2002; OECD, 2006).

As a matter of fact, total public budgetary allocations for research and development have stagnated in real terms from 1992 to 2002, but rapidly increased in the most recent years from 6.9% of total federal budget in 2000 to 7.7% in 2006 and 9.1% in 2008. Since the last strategic plan provides for an annual increase of expenditures in the domain of 6% yearly, which is substantially higher than the growth of overall expenditures of the Confederation, the share should approach 10% in 2012. This gradual evolution reflects the incremental character of Swiss budgetary planning, which does not allow for rapid shifts in policy.

This positive development has been the outcome of setting a higher degree of priority to research and higher education in the federal policy, but also of a shift in the allocation of financial resources from core budget of universities (largely used for education) in favour of direct project funding to research attributed through the Swiss National Science Foundation and other research programmes. In parallel, some major reforms have been undertaken to improve the efficiency of the public research system, the most important one being the attempt to introduce a common higher education act covering all Swiss higher education institutions and improving coordination between Cantons and Confederation.

Finally, one should mention that new conjectural support plan announced by the federal government in spring 2009 includes some measures to support research and innovation, mostly by anticipating future infrastructure spending, which are considered as a key to overcome the current economic crisis.

2.1.2 Securing long term investment in research

In Switzerland, public funding of research is divided in two main streams, namely core funding to higher education institutions and project funding to individual research groups (Lepori, 2006). As we shall detail later, direct public funding of research activities in private companies is very limited.

a) Most of funding of research in higher education institutions (HEI) is attributed through their core budget, as a joint allocation both for research and teaching activities. It is basically left to universities themselves to decide how to use these resources.

The structure of core funding is rather complex because of the shared competences between Cantons and Confederation and because different rules apply to different types of HEI (each of them being ruled by a specific law):

- the two Federal Institutes of Technology are directly funded by the Confederation through a four-year performance contract. This is a lump-sum allocation with some indicators to assess the performance of FIT, but the institutions have a wide freedom on how to use these means;

- the ten cantonal universities are directly funded as a lump sum budget from their host Canton. Additionally, they receive federal subsidies calculated on the basis of the number of students (70% of the allocation) and of third-party funding (30% of the allocation), as well as contributions from other Cantons for their students calculated on the basis of a fixed tariff per head;
- universities of Applied Sciences have a similar mechanism like universities, but public funding is by large directed towards education (with a small component of research funding; (Lepori, 2009) and based on tariffs by students (with different rates for each domain).

Core allocation, which in the average comprises 3/4 of the total budget and covers about 70% of research expenditures, can be considered as weakly competitive and provides to HEI a suitable basis to develop their research, complementing competitive allocation through projects.

Direct funding to public research institutes outside universities is more limited, the main case being the four institutes attached to the FIT domain, whose resources are provided through the performance contract of the whole FIT domain. The Confederation has a specific funding instrument for research institutes outside the university sector, but its share of total funding is very low.

b) Project funding, i.e. funding attributed to individual researchers or research groups to develop projects with limited time and duration. It is mostly channelled through two funding agencies:

- the Swiss National Science Foundation (SNF) is a private foundation managed by scientists and funded by the Confederation under the research act; it is strongly oriented towards academic research and the promotion of young researchers. About 80% of its resources are attributed to basic investigator-driven projects; SNF manages also a rather large number of grant schemes for individual researchers and some policy-oriented programmes (see below). Compared to other research councils in Europe, SNF is a very large and independent agency, whose budget has been substantially increased in the recent years;
- the Swiss Innovation Promotion Agency (KTI) is an independent commission inside the Department of Economy, which supports joint cooperation projects between HEI (mostly FIT and UAS) and private companies, as well as a number of specific programmes for example in training for entrepreneurship and technology transfer (see below). Its role has been substantially reinforced since the late '90 (OECD, 2006), but its budget is only 20% of SNF and much lower than the Swiss contribution to European Framework Programmes.

Public contracts from other federal and cantonal departments are relevant in some specific sectors, but strongly decreased in the last decades; as a matter of fact, Swiss research policy tends to delegate to SNF and KTI the execution of most of public project funding schemes (also in policy-oriented domains), in order to keep the quality of proposal evaluation.

It is highly relevant to remark that, at the difference of other European countries, more than 2/3 of national project funding benefits to HEI, while the share of private companies is very low (Lepori et al., 2007). The main change since the year 2000 has been a strong increase of the share of project funding through SNF, KTI and European Framework programmes in respect to institutional funding.

Finally, Switzerland has a long tradition of participation to international research programmes and organisations and hosts on its territory the European Organisation for Nuclear Research (CERN). Policy and funding of resources-intensive domains like nuclear and space have been largely delegated to Euratom (of which Switzerland is full partner) and the European Space Agency. Participation to the European Framework Programmes started in the '90 on a project by project basis funded by the Swiss Confederation, while full association to FP was achieved at the beginning of 6 FP.

If compared to the size of the research system, Switzerland is among the European countries with more participations to FP: for FP6, it ranked 11th for the number of participations (2.6%) and 9th for the project contributions (2.9%; (SBF Staatssekretariat für Bildung und Forschung, 2008). Participations are strongly concentrated in the ICT sector and in life sciences (the two domains accounting for about half of the Swiss participations) and in higher education institutions (65% of Swiss participation), while with 25% of the participations the share of industry is rather low (reflecting the limited interest of Swiss companies to publicly funded research programmes).

At the contrary, Switzerland cannot participate for the moment being to the Community Innovation Programme, even if negotiations are underway.

2.1.3 Dealing with uncertain returns and other barriers to business R&D investment

The following table provides an overview of R&D expenditures of the private economy in Switzerland for 2004, the most recent year for which complete data are available (Source: Swiss Federal Statistical Office). With 2.17% of the GDP in 2004, BERD in Switzerland is one of the highest among OECD countries after Sweden, Finland and Japan and almost the double of the average of EU-25 (1.15% of GDP). As it is shown by the table, expenditures are highly concentrated in a few industrial domains where large multinational companies have their seat in Switzerland, including Novartis and Roche (chemicals and pharmaceuticals), Nestlé (food) and ABB (machine industry). Statistical data show that 87% of these expenditures are in companies with more than 100 employees, but it is likely that most of BERD is covered by a few large companies.

A further noteworthy feature is the amount of R&D expenditures by affiliates abroad; this is especially a distinctive phenomenon for pharmaceutical companies, where 2/3 of R&D expenditures are abroad. The global character of the research strategies of these companies has a profound influence on the relationships between public and private sector in research policy (S. Arvanitis & Hollenstein, 2002); (Hollenstein, 2006).

In 2004 89% of BERD was financed by the companies themselves, 7% of abroad (which might include some funding from European programmes and organisations like European Space Agency) and 1% for the Swiss state; this is one of the lowest shares among OECD countries.

Table 2: R&D Expenditures of Swiss private companies in Switzerland and abroad

Sector	Switzerland	Abroad
Food	502	842
Chemicals	686	787
Pharmaceutical	3565	6574
Metals industry	65	2
Machine industry	1575	293
High-tech instruments	545	32
ICT production	831	100
ICT services	374	118
Research activities	1372	618
Insurance	143	237
Total	9659	9603

Source: Swiss Federal Statistical Office; 2004, mio CHF

According to the European Innovation Scoreboard, the investment in early-stage venture capital, measured as the early stage venture capital in percentage of GDP, is comparatively low in Switzerland. Since the experiences with innovations are quite good in Switzerland and the capital markets are functioning well, this points to an above-average risk consciousness with respect to innovation activities ([INNO-Policy Trend Chart, 2009](#)). One should however be careful with this indicator whose methodological foundations are rather weak (Schibany, A., Streicher, G., 2008).

The structure of business R&D strongly influences public policies in the field. Pharmaceutical and chemical industry have historically been against direct intervention of the State to support private R&D for fear of losing their independence. Other explaining factors are the size of expenditures in these sectors, which exceeds for some multinational companies the total public R&D funding, and the fact that private R&D in these sectors is also oriented towards long-term basic research. Companies have been more interested in getting localisation advantages, in the protection of the home market, in close collaboration with university research in the same field and in provision of skilled researchers. Thus, the Swiss economic association Economiesuisse is against public support of private R&D and in favour of a research policy oriented towards basic investigator-driven research in universities (Economiesuisse, 2008).

However, since the economic crisis in the '70, the debate on public support to private R&D has been renewed and in the '80 harsh criticism was moved from the OECD on the lack of specific policies to support private research and technological development (OECD, 1989). The main area of concern has been small and medium enterprises especially in domains like machine industry and watch industry. Public intervention has taken the form of joint projects between HEI and companies funded by the KTI, where the Confederation finances research done in public sector, whereas companies invest their own resources and exploit the result of the project. This setting has proven to be quite successful to promote innovation in SMEs and especially in sectors with limited internal research capacity (Mayer, Geyer, Sturn, & Zellweger, 2006).

2.1.4 Providing qualified human resources

Switzerland belongs to the European countries with a very good level of education of the general population. Thus, in 2007 31.7% of the active population had tertiary education, which is one of highest shares among EU countries, while, with 6% of GDP total educational expenditures situate Switzerland among the countries investing more in education after the Nordic countries.

Tertiary education entry rates have been historically lower than in other European countries, but this is largely the outcome of the divide between general and practical education already from the secondary level, with a strong focus on apprenticeship. This is considered as a strength of the Swiss system improving the quality of university students, reducing drop-outs and better serving the needs of industry for professional education (OECD Organisation for Economic Co-operation and Development, 2003).

Much effort has been invested since the '90 to improve the professional education system with the introduction of a federal professional maturity and with the progressive transformation of most of the former tertiary education institutions in Universities of Applied Sciences; at their creation, these institutions received also a mandate of applied research and technology transfer towards SMEs and regional economy. Consequently, the entry rate to higher education has increased from 25% in 1997 to 35% in 2007, while tertiary education expenditures have grown from 1% in 1981 to 1.5% of GDP in 2005. However, the number of students and graduates in science and engineering is stagnating since almost two decades and this is a source of concern for the future provision of skilled workers in these domains.

A specific strength of the Swiss system is the ability of the Swiss universities to train a large number of doctoral students which continue their career in private economy or in the public administration, thus providing highly qualified workforce and trained research personnel.

Of the 18'000 doctoral students enrolled in Swiss Universities in 2007, 10'000 were in Science and Engineering while 50% came from abroad, showing the openness and competitiveness of Swiss Universities.

However, in Switzerland there is too little secondary growth in the mathematical, scientific and technical areas of study (especially female students). In contrast, subject areas such as publishing, teaching and psychology are increasingly popular among students. The future need for scientists and engineers can in part be covered by the influx of foreign personnel. It is therefore essential to increase the recruitment of students completing their studies in scientific and technical areas in order to augment the reservoir of available qualified people.

With 2.33 doctoral graduates for 1000 inhabitants Switzerland ranks at the top of European countries with almost the double of the European average. This is the result of a coherent policy of Swiss universities to engage doctoral students for most of their activities in teaching assistance and research, while limiting to a strict minimum the number of permanent researchers at the post-graduate level; as a comparison the total personnel of Swiss universities was just 31'000 FTEs.

PhD education is also strongly promoted by the SNF: about 90% of the personnel paid through SNF grants is at the doctoral level and doctoral dissertation and training of researchers are considered as one of the main outcomes of these projects (alongside scientific publications). Moreover, SNF invests about 1/5 of its yearly

budget in a whole range of instruments to support PhD students and researchers in the early career stages and these schemes have been progressively extended to cover all stages of scientific careers below the professor position. These include:

- grants for PhD students and post-docs for research stays abroad;
- a range of doctoral programmes (PRO*DOC programme) supporting joint education of PhD students, but also providing grants to the students themselves (with a focus on social sciences and humanities);
- a specific programme funding assistant professors positions in Swiss universities for a four-year period; these grants are meant to allow brilliant post-docs to prepare themselves for a professor position. More recently, a new programme has been launched to support brilliant post-doc researchers to develop their own research in Switzerland (Ambizione programme);

SNF grants are thus explicitly focused to select the most promising Swiss PhD students and post-docs and to offer them the best possible research conditions, including international experience and funding of their own PhD students (at the assistant professor level).

2.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swiss research system in terms of resource mobilisation for R&D can be summarised as follows:

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • High level of private research funding. • Strong orientation of public funding towards basic and generic research. • very good provision of trained researchers with PhD. • highly efficient project funding system especially for basic research (through Swiss National Science Foundation). 	<ul style="list-style-type: none"> • high dependency of private-sector research from the strategies of few Swiss large multinational companies. • relatively low level of public-sector expenditures. • low number of (female) students in technical and natural sciences

The Swiss system has an excellent research basis in terms of both financial and human resources mobilisation. Thanks to the high level of R&D investment in the private sector the Lisbon target of 2% of GERD financed by private sector is achieved; public financing is just around the European average, but it is strongly concentrated towards support to basic research in universities, where research enjoys of favourable financing conditions. The university sector is also very effective in providing trained researchers for the private industry and public administration thanks to very high number of PhD students.

However, the concentration of BERD in (Swiss) multinational companies drives to a strong dependency of private-sector research from their global strategies and to an extremely limited steering possibility of the State, with corresponding risks if these companies would decide to change their regional focus. Also, public-sector research suffered from a stagnation of financial means in the '90, even if the situation has improved after the year 2000.

3 - Knowledge demand

The purpose of this chapter is to analyse and assess how research related knowledge demand contributes to the performance of the national research system. It is concerned with the mechanisms to determine the most appropriate use of and targets for resource inputs.

The setting and implementation of priorities can lead to co-ordination problems. Monitoring processes identifying the extent to which demand requirements are met are necessary but difficult to effectively implement due to the characteristics of knowledge outputs. Main challenges in this domain are therefore:

- Identifying the drivers of knowledge demand;
- Co-ordinating and channelling knowledge demands; and
- Monitoring demand fulfilment

Responses to these challenges are of key importance for the more effective and efficient public expenditure on R&D targeted in IG7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

The Swiss economy is a small open economy where exports and imports account for a large GDP share and international investment flows are very large (European Trend Chart on Innovation, 2007). Exports are strongly concentrated in a few economic sectors, which are technology and research intensive: thus, in 2001 70% of the value of Swiss exports was generated in three domains, chemical products and pharmaceuticals (30%), machine industry and electronics (26%) and precision instruments and watches (16%). This export specialisation by large correspond to the BERD specialisation (see section 2.1.3). As a result, Switzerland ranks in the sixth position among OECD countries for the share of high-tech exports with 22.9%.

This peculiar sectoral structure influences knowledge demands to the research system. In pharmaceutical industry, business research has a long-term and basic focus, requiring also long-term and risky investments by the companies themselves. This drives to a request to the public sector for training of highly-skilled researchers and for cooperation in basic research in fields like biomedicine, and biotechnology. At the contrary, the machine industry, electronic services and watches have a larger presence of small and medium-sizes enterprises (alongside some large companies like ABB and Sulzer); not only business research in these domains is more applied and directed towards development, but also SMEs lack in many cases of own research capacities. As we shall see later, this has been the main focus of public intervention in the last two decades.

In general terms, the small dimensions of the country, the lack of natural resources and the high level of development drive to consider research and innovation as one of the main assets for the economic development of the country and thus to establish research policy at the top of political priorities.

National research policy is also to some extent driven by other social and political challenges which are partly similar to other European countries – like immigration, healthcare, social security -, but also specific to Switzerland, like issues related to culture, multilingualism, etc.

3.1.1 Identifying the drivers of knowledge demand

Coherently with its focus on generic support to research and to the non-intervention in private R&D, there are relatively few instruments to identify systematically knowledge demands and to translate them directly in policy actions. It is implicitly assumed that knowledge demands will express themselves through application to investigator-driven schemes both for basic research (SNF) and for applied research (KTI).

At the institutional level, the Swiss Science and Technology Council has the official task of developing propositions for a national science and technology policy, but, as a matter of fact, performed relatively few activities in the recent years.

In the public sector, some instruments are also used to identify societal and political demands. Thus, the selection process of National Research Programmes (see 3.1.2) is based on a call for subject proposals, where political parties and social stakeholders can express their needs for specific research. Also, sectoral ministries provide some assessment of policy needs when designing their research plans (the most important ones being those in the fields of energy and health). Swiss Scientific Academies have a relevant role in expressing academic knowledge demands through different, while private economy expresses their position mostly through Economiesuisse, which has a specific committee for research and higher education.

The main mechanisms for transferring knowledge demands in research policy is however the practice of stakeholders' consultation concerning changes in the legal framework of research policy and on the four-year strategic plans. Thus, in the year immediately preceding the preparation of the strategic plans, most stakeholders and actors of research policy – including Economiesuisse, the funding agencies, the Rector's conference, Cantons, Swiss Scientific Academies – publish their views and requests for future policy priorities and actions.

3.1.2 Co-ordinating and channelling knowledge demands

Switzerland science and technology policy has a general orientation towards support to generic knowledge production, leaving autonomy to the research performers in the choice of the scientific and technological areas of specialisation; correspondingly proactive public actions to develop specific knowledge areas has little tradition in this country.

The main experience in this respect was the launch of a number of technological priority programmes at the beginning of the '90, in domains like informatics, biotechnology, material sciences; after 2000, the definition of priorities in terms of fields (both scientific and economic) is not any more a very relevant issue in Swiss research policy, which is mostly oriented towards structural issues like strengthening the university system and its research basis, training of highly-qualified researchers, promoting the cooperation between public and private and the positioning of the Swiss research institutions at the international level, both in Europe and worldwide.

Also, the Swiss Innovation Promotion Agency follows a bottom-up approach where projects are proposed by the companies themselves depending on their technological needs; the priority areas of KTI match by large the relevant domains of Swiss industry, including ICT, machine production and nanotechnology. The KTI has also launched a small number of focused initiatives in domains like medical technologies or aging, but these account for a small share of total funding volume.

There are two specific mechanisms which allow to some extent integrating in research policy specific knowledge demands from economy and society:

- the National Competence Centres in Research initiatives supports large networks of research groups (mostly in universities) in specific domains with a medium term-focus (8-10 years). When launched in 2000, the initiative was oriented towards priority technological areas, but it has now transformed in a generic instrument to build national networks in all scientific areas (including social sciences and humanities). The programme is managed by the Swiss National Science foundation, but final decisions on which centres to finance are taken by the State Secretariat for Education and Research;
- the National Research Programmes are a series of research programmes geared towards the solution of urgent social and political problems; they aim to provide new scientific insights and advice to political decision in domains like environment, urban planning, culture, language policy etc. The topics of the programmes are decided by the government (as an issue of a call for proposals).

3.1.3 Monitoring demand fulfilment

In Switzerland, the main instrument for monitoring the achievement of policy goals and of demand fulfilment is the four-year strategic plan for research, higher education and innovation which is submitted by the government to parliament together with the budgetary request for the next four-year period (Conseil Fédéral, 2007). The first part of this documents provides a synthetic overview of the state of Swiss research system, of its strengths and weaknesses and of the main challenges for the future; this analysis is based on internal expertise at the State Secretariat of Education and Research, studies and analyses on specific topics, as well as on an extensive consultation of the involved stakeholders and on statistical information provided by the Swiss National Statistical Office.

At the national level, the Swiss Science and Technology Council by its mandate regularly produces analyses and statements on the situation of Swiss research policy. However, if compared to the late '90 when SSTC undertook a number of extensive evaluations of scientific fields in Switzerland (physics; social sciences), its role is much less relevant. The SSTC was recently in charge of the evaluation of the Swiss National Science Foundation and of the Swiss Innovation Promotion Agency.

Studies and evaluations are also regularly commissioned to external research institutes on specific topics like higher education funding (Benninghoff, Perellon, & Leresche, 2004), research in Universities of Applied Sciences (Lepori & Attar, 2006), Swiss participation to European programmes (SBF Staatssekretariat für Bildung und Forschung, 2008). The OECD undertook also in the last year two large evaluations of the Swiss tertiary education (OECD Organisation for Economic Co-operation and Development, 2003) and of the Swiss innovation system (OECD, 2006).

Evaluation *stricto sensu* of research activities is delegated to the universities themselves, while there is no national research assessment. Most universities have a regular practice of evaluation of research institutes, most of them based on self-assessment reports and site visits by external experts. To support these evaluations, the Conference of the Rectors of the Swiss Universities has launched in 2008 a large programme on methodologies to measure research outputs; this programme finances the development of competences in each university, as well as a set of projects dealing with performance measurement in social sciences and humanities.

In the small-scale Swiss environment these practices are very effective in keeping the quality of academic research. A central role in this respect is assumed by the Swiss National science Foundation: thanks to the large financial means and the strict peer review procedures, SNF provides a benchmark for most Swiss university professors also concerning the quality of their research activities.

Finally, monitoring the fulfilment of demand for knowledge from the private economy has been a specific area, where both the Federal Office of Professional Education and Technology and the State Secretariate for Economy are launching regularly evaluations, like those on the impact of KTI project on the economy (Mayer et al., 2006).

3.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swiss research system in terms of knowledge demand can be summarised as follows:

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • strong bottom-up approach where the demand can be expressed directly at the level of performers or funding agencies; • extensive consultation practice of social and economic stakeholders in the design of research policy; • good internal evaluation practices to the academic community. 	<ul style="list-style-type: none"> • lack of a systematic mechanisms to identify knowledge demands and to translate them in policy actions; • limited level of strategic intelligence at the political level and of long-term term foresight activities.

The Swiss system is characterized by a strong bottom-up approach, where the choices concerning research domains are left to the performers themselves (including private companies), as a well as through a strong involvement of social and economic stakeholders in the design and decision-making processes of research policy. Thus, in a way, knowledge demands can be expressed and embedded in policy action without a strong intervention of the State.

However, the system is lacking of a systematic mechanism to identify knowledge demands and, especially, to anticipate future challenges which would require new policy action. Stakeholders' consultation is largely reactive and related to the next planning phase (four-year cycles); what is missing is a place where these demands can be articulated and compared with analysis of the environment and future challenges, in order to develop a long-term strategy. Moreover, despite the rather large number of studies and evaluations commissioned by different federal bodies, there is a lack of systematic foresight of new trends in research and technology.

4 - Knowledge production

The purpose of this chapter is to analyse and assess how the research system fulfils its fundamental role to create and develop excellent and useful scientific and technological knowledge. A response to knowledge demand has to balance two main generic challenges:

- On the one hand, ensuring knowledge quality and excellence is the basis for scientific and technological advance. It requires considerable prior knowledge

accumulation and specialisation as well as openness to new scientific opportunities which often emerge at the frontiers of scientific disciplines. Quality assurance processes are here mainly the task of scientific actors due to the expertise required, but subject to corresponding institutional rigidities.

- On the other hand there is a high interest in producing new knowledge which is useful for economic and other problem solving purposes. Spillovers which are non-appropriable for economic knowledge producers as well as the lack of possibilities and incentives for scientific actors to link to societal demands lead to a corresponding exploitability challenge.

Both challenges are addressed in the research-related Integrated Guideline and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1 Improving quality and excellence of knowledge production

Switzerland public research system is considered as one of the best worldwide in terms of the quality and impact of its scientific production. A recent bibliometric study of Swiss research commissioned by the State Secretariat confirms the excellent international level of Swiss science. Namely, with 1.5% of WoS publications and 2.5 publications per 1000 habitants Switzerland is the most productive OECD country (SBF Staatssekretariat für Bildung und Forschung, 2007); the impact factor of Swiss publications is the highest worldwide. For their impact, Swiss publications rank at the first place worldwide in life sciences, environmental sciences and natural sciences, thus displaying clearly the strong orientation of Swiss research towards these areas.

This excellent output is due to the strength of the Swiss university system, which produces about 80% of total WoS publications. This is also reflected in international rankings: in the bibliometrics-based Leiden ranking of European universities three of the top-ten universities are Swiss, while in the Shanghai ranking ETHZ comes at position 24 as the fourth European university after Oxford, Cambridge and UCL, while 5 out of 12 Swiss universities are in the first 150 ranks.

There are a number of factors which contribute to this very good position. A first factor is certainly the large autonomy that Swiss universities enjoy in academic matters, including the identification of research areas and hiring professors and research personnel (subject to internal practices of peer review). This approach has been criticised as leading to fragmentation of research effort and making difficult to create critical mass; instead of trying to coordinate centrally these decisions, the policy answer has been to charge the Swiss National Science Foundation to launch a programme of National Centres of Competence in Research, providing joint funding and networking of the best centres in the country in different scientific areas. A second factor is the organisation of public funding based on the complementarity between core funding, which leaves large autonomy to the universities themselves on its use, and project funding, which is mostly oriented towards investigator driven research. The strength and autonomy of the Swiss National Science Foundation, where political influence is minimal and academic peer review is the basis of funding allocation, plays a central role in this respect. A third factor is a strongly academic-oriented conception of the university, where research and international visibility are considered as a must and criteria related to research are central in hiring staff at all levels of careers. Even if there are some differences in quality and research intensity,

all ten Cantonal universities and the two Federal Institutes of Technologies strive to achieve an international visibility in research and to profile some of their research areas as excellent worldwide; this is true even for the smallest institutions like Neuchâtel (with a specific strengths in microtechnics) or Lugano (with a focus on informatics and computational sciences). A fourth factor is the organisational of internal careers of universities, with a very large basis of PhD students and then a strong selection leading to relatively few professors positions; all positions below professors are limited in time and increasingly strict time limits are being introduced (5-6 years for Phd students, 6 years for post-docs). There are practically no permanent researchers' positions.

This generally very positive panorama hides some specific issues; the most relevant of them is probably the difficult situation in many fields of human and social sciences (SSH), where students numbers are very high and research is less well organised than other field of sciences, for example concerning scientific careers and PhD education (BBW Bundesamt für Bildung und Wissenschaft, 2002). In a way, the success of Swiss universities in sciences has been built through a strong concentration of funding in these areas, while nowadays 2/3 of the university students are in SSH.

Outside the university sector, public research institutes contribute also to the scientific output in a number of specific areas: this is the case of CERN (nuclear energy), World Health Organisation (Health), physics and engineering (Paul Scherrer Institute), as well as a number of cantonal hospitals in clinical medicine. Moreover, Swiss multinational companies like Novartis, Roche and Nestlé count among the top-publisher in the private sector worldwide; with 10% of WoS publications with at least one author in the private sector, the share of this sector in Switzerland is well above the international average (SBF Staatssekretariat für Bildung und Forschung, 2007).

4.1.2 Improving exploitability of knowledge production

Switzerland is the best European country in most indicators on the exploitation of knowledge production of the Innovation Scoreboard: thus, EPO patents are 400 per mio. habitants, four times the EU average; the same applies for trademarks and designs, the two other indicators used in the European Innovation Scoreboard. With 5.5% of GDP, Technology Balance of Payment flows are also the highest in the EU (EU average being 1.07 in 2006). Sectoral specialisation of patents match by large the specialisation of business R&D, with chemicals accounting for about 15% of EPO patents (average 1999-2003) and pharmaceutical for another 13%, machinery 12%, electronic equipment 11% and precision instruments 10% ([ERAWATCH, 2007](#)).

However, this very positive picture hides some difficulties. Firstly, these data have to be interpreted with care since they are by large the outcome of the technological activities of large multinational companies with seat in Switzerland; to which extent, these patents are really exploited in the country remains difficult to establish. This drives also to a strong dependency on the strategies of these large companies, even if some studies showed that, for most Swiss multinational companies, internationalisation of R&D is more a complement than a substitute for research performed in Switzerland (Hollenstein, 2006).

Secondly, there have been some worries already in the '90 on Swiss technological portfolio being too strongly concentrated in traditional, low-growth fields, as well as difficulties of transforming scientific results in technological products, the example of

informatics being cited in many cases. Given the high quality of science, the implication would then be that the mechanisms for exploitation and transfer of knowledge are not as efficient as they should be (European Trend Chart on Innovation, 2007); a wide debate took place in the last two decades on Swiss innovation policy (BBT Bundesamt für Berufsbildung und Technologie, 2002).

Despite the traditionally non-interventionist approach in research and technology policies, a number of specific instruments have been introduced to promote the matching of scientific specialisation with economic specialisation. While formal public private-partnerships in research have little tradition in Switzerland (Meissner, 2007), a major positive experience in public-private partnerships in research has been the creation in the '90 of the Swiss Centre for Microelectronics (CSEM), located in Neuchâtel at the hearth of the watch industry region, jointly financed by industrial contracts and by the State.

However, the most important mechanism for public-private partnerships are joint cooperation projects between academia (mostly FIT and UAS) financed by the Swiss Innovation Promotion Agency (KTI). These projects are driven by the innovation needs of companies which request public research institutes to perform research required to overcome some technological bottlenecks. KTI finances the public research partner, while the company has to provide at least half of the project effort mostly in own work, but in exchange owns the project results and can exploit them for its commercial activities. This mechanism has proven to be very effective in repounding to needs of SMEs; evaluation studies have shown that KTI funded firms show a significantly better innovation performance than comparable firms without KTI support (S. Arvanitis, Donzé, & Sydow N., 2005). The budget of the KTI has been strongly increased since the end of '90 in parallel with the creation of the Universities of Applied Sciences (UAS)

The creation of UAS has certainly been the main reform in this area in the last decades. Like in other European countries, UAS have been created has a “second” higher education sector with an orientation towards professional education (Lepori & Attar, 2006); moreover, they have been attributed from the beginning a research and technology mandate focused towards collaboration with SMEs in the regional context (Lepori, 2008). This policy has been highly successful: not only UAS research volume has rapidly grown in the last decades, but these institutions have become one of the most important partners of private economy alongside the two Federal Institutes of Technology (S. Arvanitis, Kubli, Sydow ., & Wörter M., 2005).

While public-private cooperation is largely established through direct contracts and bottom-up projects which are financed through the Swiss Innovation Promotion Agency (CTI), in some cases this cooperation is evolving towards more stable structures with the creation of joint ventures, for example for the delivery of services like testing. Examples for this are the laboratory for materials testing at the UAS of Southern Switzerland and the partnership between the Hochschule Rapperswil and Microsoft in the Institute of Networked Systems (<http://www.ins.hsr.ch>).

There are also signs of stronger institutionalized cooperation between large multinational companies and universities – for example through financing of chairs -, but especially of the involvement of private companies in large national research programmes, like the SNF-sponsored National Centers of Competence in Research (NCCR). The example of the NCCR on finance, whose activities will be transferred to the new Swiss Finance Institute, funded by the Swiss Banking Association, is revealing of new emerging cooperation forms.

Finally, while traditionally Swiss higher education institutions have not been very active in patenting and managing their IPR – in most cases left to the inventors or cooperating companies -, some steps have been undertaken to ensure a more professional management. For example, the revised FIT act of 2004 sets rules for IPR management in the FIT domain and creates the possibility that FIT research institutes hold a share in companies in order to commercialise IPR (European Trend Chart on Innovation, 2007). Relevance of these measures in this context is however rather limited.

4.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swiss research system in terms of knowledge production can be summarised as follows:

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • excellent international quality of research; • very strong university sector; • good record of cooperation between the public and the private sector; • strong role of Universities of Applied Sciences in regional transfer. 	<ul style="list-style-type: none"> • concerns on the capacity of transferring research results towards innovation; • technological portfolio of companies rather conservative and concentrated in few sectors.

The Swiss research system has to be considered as one of the best worldwide in terms of basic research output and Swiss universities are very well represented in all international rankings. Also, cooperation between public and private sector is well developed thanks to direct connections between university institutes and companies; suitable policy actions (reinforcement of the Swiss Innovation Promotion Agency; creation of the Universities of Applied Sciences) have been taken to strengthen this cooperation in the last years.

However, there have been some concerns that, firstly, the technological portfolio of the Swiss economy is rather conservative and concentrated in a few sectors and, second, that scientific discoveries are not transferred to the economy as efficiently as it would be required. Policy intervention in this area has been mainly indirect and focused to SMEs, through the creation of the Universities of Applied Science and through joint public-private project funding by the Swiss Innovation Promotion Agency. The overall impact of these measures on the Swiss economy is likely to be rather limited ([INNO-Policy Trend Chart, 2009](#)).

5 - Knowledge circulation

The purpose of this chapter is to analyse and assess how the research system ensures appropriate flows and sharing of the knowledge produced. This is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production. Knowledge circulation is expected to happen naturally to some extent, due to the mobility of knowledge holders, e.g. university graduates who continue working in industry, and the comparatively low cost of the reproduction of knowledge once it is codified. However, there remain three challenges related to specific barriers to this circulation which need to be addressed by the research system in this domain:

- Facilitating knowledge circulation between university, PRO and business sectors to overcome institutional barriers;
- Profiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mediate limited firm expertise and learning capabilities.

Effective knowledge sharing is one of the main axes of the ERA green paper and significant elements of IGL 7 relate to knowledge circulation. To be effectively addressed, these require a good knowledge of the system responses to these challenges.

5.1 Analysis of system characteristics

5.1.1 Facilitating knowledge circulation between university, PRO and business sectors

Traditionally, knowledge circulation between public and private sector has been left to the initiative of the companies and university institutes with limited direct intervention from the State. As some studies show, this policy has been highly successful. A recent survey of companies shows that most respondents rate direct contacts and flows of skilled researchers – for example PhD degree holders working in industry and keeping good contacts with their old university professor – as the most effective means of knowledge circulation (S. Arvanitis, Kubli et al., 2005), while the role of technology transfer offices is considered as much less relevant.

However, there have been some steps towards more formal mechanisms of knowledge transfer and providing researchers with professional support in this area. Thus, during the last decade most Swiss higher education institutions have created Technology Transfer Offices; some of them, especially those at the Federal Institutes of Technology, are very active in promoting transfer and provide professional support for example concerning license agreements, creation of spin-offs, IPR management (Vock Patrick, Wirth K., & Scheidegger Franziska, 2005). The most developed policy in this direction has certainly been that of the Federal Institute of Technology of Lausanne: besides a technology transfer office, this initiative includes specific innovation grants for EPFL researchers, direct liaisons and sponsoring from private companies. Moreover, a scientific park on the EPFL site is run by a private foundation with a focus on support to start-ups and hosting of innovative companies. A large number of scientific and technological parks have also been created in Switzerland in the recent years, most of them in close collaboration with higher education institutions or with the institutes of the FIT domain (<http://www.swissparks.ch>). The creation of UAS allowed spreading out these initiatives also outside the main cities in most Swiss regions, like in Winterthur, Chur or in Wallis.

In 2004, the Swiss Innovation Promotion Agency has launched a large technology transfer initiative promoting the establishment of regional consortia between higher education institutions, technology transfer centres and association of private companies, to promote transfer of knowledge (push function), but especially monitoring of knowledge demands of companies and brokering with the relevant research units at HEI possessing the required competences.

5.1.2 Profiting from access to international knowledge

The Swiss research and innovation system is traditionally very open internationally, both in academia and in private companies. Thus Swiss universities have a strong tradition of international contacts and collaborations and the labour market for researchers is very open. In 2007, 45% of professors in Swiss universities, had a foreign nationality, as well as about half of the PhD students enrolled in Swiss universities. Despite the limitations due to national labour market regulations (which have been recently softened for EU citizens), de facto hiring practices of research are very open internationally also for researchers with no previous linkage to Switzerland.

Also, Swiss research policy promoted from the '50 an attitude of international opening and Switzerland belongs to the founding members of most European and international research organizations, including Euratom, ESA, ESF, COST etc. Given the small size of the country, sector policies in domains like nuclear energy and space has been largely delegated to the international organizations and Swiss researchers are among the most active participants to these initiatives.

Participation to EU activities has been made more difficult because of general political difficulties; this in 1992 Swiss voters refused the European Economic Area agreement which included the full association to European Framework programmes. However, participation could be maintained at high level thanks to a project by project participation funded by Switzerland until the 6th FP, when an association agreement was finally signed as part of the bilateral treaties with EU. Swiss institutions are also well integrated in some ERA-NET initiatives. A major limitation in this respect is that Switzerland cannot for the moment being participate to the Community Innovation Programme, even if negotiations are underway.

A number of national initiatives are also relevant to promote opening of research programmes at national level: these include an agreement between Swiss National Science Foundation and the Austrian and German research councils for joint submission and cofinancing of research projects involving research groups in these countries, the SNF-funded cooperation programmes in research with Eastern European countries and developing countries. SNF exchange programmes are also very relevant for the opening of the Swiss research system: the grant system for researchers at the PhD and post-doc level provides only grants for research stays abroad; about 40% of the 500 grant recipients in 2007 went to the United States. Conversely, both SNF and most universities systematically require a research experience abroad to apply for assistant professors positions.

Since 2000, the State Secretariat for Education and Research has also developed its network of scientific liaison offices abroad – with swissnex locations (Swiss scientific houses) in Boston, San Francisco, Singapore and Shanghai – and is funding bilateral research collaboration programmes with China, India, Russia, South Africa, Japan, South Korea, Brazil and Chile. Besides traditional strong relationships with the EU and the United States, Swiss research policy is thus clearly focusing on emerging countries.

International opening of the private sector is largely related to the extreme degree of internationalisation of the Swiss economy and to the central role of (Swiss) multinational companies in technology-intensive sectors. Empirical studies showed that this international orientation of many Swiss firms (including SMEs) strengthens the Swiss economy since international and domestic activities are rather complements than substitutes (Hollenstein, 2006).

5.1.3 Absorptive capacity of knowledge users

Overall, absorptive capacity of private companies has to be evaluated as very good, given the industrial structure and the strong role of multinational companies with a large R&D capacity; the Swiss educational system proved to be very effective in providing highly-qualified labour force and, especially, well-trained researchers with a PhD degree. The creation of UAS has improved the situation concerning technical personnel: UAS students need to have professional experience before starting their higher education study, but then receive good tertiary education at the bachelor level. Moreover, UAS have the widespread practice of keeping their best students to work a few years in applied research projects with companies before going to the private sector, thus providing a further source of well-trained personnel in technical activities (like in manufacturing, machine industry, informatics). UAS also strongly developed their offer of continuing education courses.

Absorptive capacities of SMEs have been more a concern, but have been addressed by public intervention only indirectly through Swiss Innovation Promotion Agency projects and cooperation with Universities of Applied Sciences.

Finally, even if according to international comparisons Switzerland shows a satisfactory level of entrepreneurial behaviour (European Trend Chart on Innovation, 2007), some initiatives have been launched in the recent years to promote the creation of innovative companies and to develop entrepreneurial skills especially among higher education personnel and graduates. These include the Swiss Innovation Promotion Agency Start-up programme, offering coaching to the best innovative companies as well as a label improving their access to the venture capital market and a large training programme for entrepreneurship financed by the sConfederation (venturelab programme; www.venturelab.ch).

5.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swiss research system in terms of knowledge circulation can be summarised as follows:

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • high degree of internationalisation of Swiss research; • strong bilateral collaborations between public and private sector; • UAS as a strong transfer actor towards regional economy and SMEs. 	<ul style="list-style-type: none"> • lack of a systematic policy for knowledge circulation and support to absorptive capacity of knowledge users; • lack of investment in venture capital.

Thus, the Swiss research and innovation system is very open internally both in the public and the private sector and the labour market for researchers is among the most open and internationalised in OECD countries. Also, there is very good tradition of direct collaboration between research institutes in universities and private companies, favoured by informal contacts and transfer of people. Most universities have been in the last years active in developing institutional policies towards transfer, while the situation in the regional context and concerning SMEs has undoubtedly improved thanks to the creation of Universities of Applied Sciences at the end of the '90.

What remains unclear is to which extent this indirect and decentralised policy of knowledge circulation is able to answer to all needs and, especially, to promote the

transfer of radically new advances in knowledge, for which knowledge users are not already well equipped. Moreover, the current lack of investment in venture capital would need to be addressed through more proactive interventions.

References

- Arvanitis S. (2009): ERAWATCH research inventory report for Switzerland. <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&countryCode=CH&topicID=4>
- Arvanitis, S., Donzé, L., & Sydow N. (2005): Wirksamkeit der projektförderung der kommission für technologie und innovation – analyse auf der basis verschiedener matched-pairs methoden. Zürich: KOF-Arbeitspapier 103.
- Arvanitis, S., Kubli, U., Sydow ., & Wörter M. (2005): Knowledge and technology transfer (KTT) activities between universities and firms in Switzerland: The main facts.
- Arvanitis, S., & Hollenstein, H. (2002): Emerging patterns of R&D in the swiss economy. KOF Working Papers, ETHZ, No. 61, July 2002
- BBT Bundesamt für Berufsbildung und Technologie. (2002): Die schweiz im weltweiten innovationswettbewerb. "innovationsbericht" zu handen von herrn bundesrat P. couchepin
- BBW Bundesamt für Bildung und Wissenschaft. (2002): Förderung der geistes- und sozialwissenschaften. Bern: Bundesamt für Bildung und Wissenschaft.
- Benninghoff, M., Perellon, J. F., & Leresche, J. (2004): L'efficacité des mesures de financement dans le domaine de la formation, de la recherche et de la technologie. perspectives européennes comparées et leçons pour la suisse
- Braun, D., & Leresche, J. (2007): Research and technology policy in Switzerland. In U. Klöti, P. Knoepfel, H. Kriesi, W. Linder, Y. Papadopoulos & P. Sciarini (Eds.), Handbook of swiss politics (2nd edition ed., pp. 735-762). Zürich: NZZ Libro.
- Conseil Fédéral. (2007): Message relatif à l'encouragement de la formation, de la recherche et de l'innovation pendant les années 2008 à 2011
- Conseil Suisse de la Science et de la Technologie. (2006): Rocommandations concernant la politique suisse de la formation, de la recherche et de l'innovation pour la période 2008-2011.
- Economiesuisse. (2008): Bildungs-, forschungs- und innovationspolitik 2008 bis 2011 - leitlinien der wirtschaft
- ERAWATCH. (2007): Country specialisation report. Switzerland. <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=home.downloadFile&fileID=913>
- European Trend Chart on Innovation. (2007). Annual innovation policy trends and appraisal report. Switzerland 2006
- Fumasoli, T. (2007): Governance in swiss universities. A comparative analysis through cantonal and federal laws. Draft Paper. Università della Svizzera italiana, Lugano:
- Hollenstein, H. (2006): Strategies pursued by swiss firms in investing in R&D at foreign locations Zurich.
- INNO-Policy Trend Chart. (2009): INNO-policy TrendChart – policy trends and appraisal report. Switzerland 2008 http://www.proinno-europe.eu/extranet/upload/countryreports/Country_Report_Switzerland_2008.pdf

- Lepori, B. (2006): Public research funding and research policy: A long-term analysis for the swiss case. *Science and Public Policy*, 33(3)
- Lepori, B. (2007a): Patterns of diversity in the swiss higher education system. In A. Bonaccorsi, & C. Daraio (Eds.), *Universities and strategic knowledge creation. specialization and performance in europe* (pp. 209-240). Cheltenham: Edward Elgar.
- Lepori, B. (2007b): *La politique de la recherche en suisse. institutions, acteurs et dynamique historique*. Bern: Haupt.
- Lepori, B. (2008): Research in non-university higher education institutions. the case of the swiss universities of applied sciences. *Higher Education*, forthcoming
- Lepori, B. (2009): Funding for which mission? changes and ambiguities in the funding of non-university institutions and of their research activities. In S. Kyvik, & B. Lepori (Eds.), *Research in the non-university sector in europe* (). Dordrecht: Springer.
- Lepori, B., & Attar, L. (2006): Research strategies and framework conditions for research in swiss universities of applied sciences
- Lepori, B., Dinges, M., Reale, E., Slipersaeter, S., Theves, J., & Van den Besselaar, P. (2007): Comparing the evolution of national research policies: What patterns of change? *Science and Public Policy*, 34(6), 372-388.
- Mayer, S., Geyer, A., Sturn, D., & Zellweger, E. (2006): *Evaluierung des kompetenzaufbaus für angewandte FuE an fachhochschulen durch die KTI/CTI 1998-2004. endbericht*
- Meissner, D. (2007): *Forschungskooperationen mittels public private partnership - argumente und beispiele*. Bern: Center for Science and Technology Studies.
- OECD. (1989): *National policies of science and technology. Switzerland*.
- OECD. (2006); *OECD reviews of innovation policy: Switzerland*. Paris: OECD.
- OECD Organisation for Economic Co-operation and Development. (2003). *L'enseignement tertiaire en suisse*. Paris: OECD.
- Perellon, J. F., & Leresche, J. (1999): Co-ordinating the impossible? current changes of governance patterns in swiss university policy. In D. Braun, & F. Merrien (Eds.), *Towards a new model of governance for universities? A comparative view* (pp. 119-140)
- SBF Staatssekretariat für Bildung und Forschung. (2007): *Analyse bibliométrique de la recherche scientifique en suisse*. Berne:
- SBF Staatssekretariat für Bildung und Forschung. (2008): *Participation de la suisse au 6ème programme-cadre européen de recherche*
- Schibany, A., Streicher, G. (2008): The european innovation scoreboard: Drowning by numbers? *Science and Public Policy*, 35(10), 717-732.
- Vock Patrick, Wirth K., & Scheidegger Franziska. (2005): *Technologietransferaktivitäten 2003, umfrage bei hochschulen und öffentlich finanzierten forschungsorganisationen*.

List of Abbreviations

BERD	Business Expenditures in Research and Development
CRUS	Conference of Rectors of Swiss Universities
CSCS	Swiss Centre for Scientific Computing
EPFL	Federal Institute of Technology in Lausanne
EPFL	Federal Institute of Technology in Lausanne
ERA	European Research Area
ETHZ	Federal Institute of Technology in Zurich
ETHZ	Federal Institute of Technology in Zurich
EU	European Union
FIT	Federal Institutes of Technology
GDP	Gross Domestic Product
GERD	Gross Expenditures on Research and Development
HEI	Higher Education Institutions
HEI	Higher Education Institutions
KFH	Conference of Rectors of Swiss Universities of Applied Sciences
KTI	Swiss Innovation Promotion Agency
NCCR	National Centres of Competence in Research
NRP	National Research Programmes
OECD	Organisation for Economic Cooperation and Development
OPET	Federal Office for Professional Education and Technology
R&D	Research and Development
SER	State Secretariate for Education and Research
SME	Small and medium Enterprises
SNF	Swiss National Science Foundation
SSH	Social Sciences and Humanities
SSTC	Swiss Science and Technology Council
SUC	Swiss University Conference
UAS	Universities of Applied Sciences

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Title: ERAWATCH Country Reports 2009: Analysis of policy mixes to foster R&D investment and to contribute to the ERA: Switzerland

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Abstract

The main objective of the ERAWATCH Policy Mix Country reports 2009 is to characterise and assess in a structured manner the evolution of the national policy mixes in the perspective of the Lisbon goals, with a particular focus on the national R&D investments targets and on the realisation and better governance of the European Research Area. The reports were produced for all EU Member State and six Associated States to support the mutual learning process and the monitoring of Member and Associated States' efforts by DG-RTD in the context of the Lisbon Strategy and the European Research Area. The country reports 2009 build and extend on the analysis provided by analytical country reports 2008 and on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

This report encompasses an analysis of the research system and policies in Switzerland.

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