Research policies in the triple helix: the case of Switzerland

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Introduction

Our paper analyses the Swiss research policy during the last thirty years and in particular how it reacted to the changing relationships between science and innovation and to the changing models of the role of state policies in economic innovation[1]. While the triple helix thesis suggests that these three spheres are becoming much more closely interconnected than in the past and, thus, that the role of public policies is shifting towards the creation of interfaces between them (Etzkowitz and Leyesdorff 2000), it has also been remarked that the forms of the institutionalisation are very much dependent on the specific situation of each country and on the historical paths of development of science policies (Benner and Sandström 2000).

In this respect, Switzerland appears to be an interesting case, since the Swiss research and innovation system has been characterised for a very long time by a clear separation between public research (mostly in universities) and R&D activities in private companies. The strength of private R&D activities (especially in the pharmaceutical sector, where companies are strongly engaged also in basic research; see Da Pozzo and Von Ins 1999), a traditionally liberal economic policy and the sceptical attitude of the academic milieus towards applied research have long retained the state from intervention to support private R&D and transfer activities; as a consequence, technology and innovation policy has then almost no tradition in Switzerland (Freiburghaus 1991).

While this situation is widely known and has also been criticised by the OECD in the two reviews of the Swiss science policy (OECD 1971 and 1989), it appears that significant changes have occurred during the last two decades. Lack of collaboration between academia and industry and difficulties in the transfer of knowledge have been identified by the Swiss Science Council as one of the major weaknesses in the Swiss R&D system (Conseil Suisse de la Science 1997), while the reinforcement of these relationships has been declared by the government to be a priority for the Swiss science policy (Conseil fédéral 1994 and 1998). Also, the support for applied R&D activities has been strengthened through the launch of the priority programs of research at the beginning of the '90 and through the reinforcement of the commission for technology and innovation, the agency charged of funding applied R&D.

The paper is organised as follows. In the first section we shortly present some general arguments on the evolution of research policies and on the impact of changes in the knowledge production system. In section 2 we define our case study and the methods used to analyse it. In section 3 we shortly present the organisation of the Swiss research system, which largely explains the orientation of the science and innovation policy. In section 4 we analyse the evolution of the Swiss technology and innovation policy during the last thirty years and we present the main changes in the institutions and support instruments. Finally, section 5 draws some conclusion both for the Swiss case and for the general field of studies.

1. Research policies and the triple helix

The triple helix model deals with the changing role of the university in the system of knowledge production and with the changing relationships between university, industry and policy (Etzkowitz and Leysdesdorff 2000). While after the "first academic revolution" at the end of the

[1] The authors wish to thank Patrick Vock of the Centre for Studies of Science and Technology in Bern for useful comments on the content of this work.

19th century the university system has emerged as a distinct "organizational field" in society, regulated mostly through quality review and academic recognition (Benner and Sandström 2000), the triple helix model suggests that the boundaries of the university system are increasingly eroding, both at the organisational and normative level. Thus, criteria of social and economic relevance are integrated into the academic normative system, while universities are moving towards an "entrepreneurial model", playing an increasingly important role in economic development through a systematic exploitation of the knowledge they produce (Etzkowitz et al. 2000). This organisation form overcomes the linear model of economic innovation, based on the distinction between the production of knowledge and their application (both institutionally and temporally), towards a more complex economy of knowledge, where university and industry are active in all phases of the process of knowledge production and application and cooperate through a series of institutional arrangements, including cooperation agreements, joint ventures, spin-off, technological parks, etc. Thus the three spheres of industry, academy and policy are increasingly overlapping, "with each taking the role of the other and with hybrid organisations emerging at the interfaces" (Etzkowitz and Leydesdorff 2000).

Research policies are a very important element in this process. After the II world war these policies helped to consolidate the autonomy of academic system through the institution of research councils, which incorporated into the research funding system the academic norms of quality recognition through peer review. The widespread delegation of decision on research funding to agencies governed by the scientists themselves was then a central feature of science policy after the II world war (Guston 1996).

Since the '70 research policies shifted towards a broader approach, encompassing also social and economic concerns, as well as a more active role of policy in setting priorities and criteria for funding. Economic concerns, but also new theoretical insights on the structure of the innovation process (see for example Mowery and Rosenberg 1979) have pushed towards a more active role of the state to support technological development and economic innovation; in the model of the national systems of innovation (Lundvall 1992, OECD 1999), research policy has been integrated into the much broader realm of the policies towards economic innovation. The shift in terminology, both in OECD publications and scientific literature on the subject, from science policy to "science and innovation policy" reflects this change in orientation.

This picture is broadly coherent with the triple helix model, in that it shows that research policies are now trying to reinforce interaction and cooperation between industry and academy through funding structures (e.g., technological programmes), but also through new regulatory arrangements (e.g. in the area of intellectual property rights) and through the creation of interface structures (cf. Etzkowitz and Leydesdorff 2000).

However, the simple account of a paradigm shift in research policy (Ruivo 1994) from a "policy for science model" (Gibbons et al. 1994) to a model oriented to the social relevance and later to technological innovation (Elzinga and Jamison 1995) appears to be too simplified. In reality, political and economical concerns were well present in the research policy after the II world war and, in the US case, most of the state financing to research was directed through mission-oriented agencies and to large technological programs, like military research; space programmes and nuclear energy programmes (Guston and Keniston 1994; Martin and Etzkowitz 2001). Also, the homogeneity of today's research policies in most countries seems to be largely limited to the general objectives, while at the level of institutions and funding regimes different models coexist, backed by the interests of different actors and in competition for their share of state funding (Benner and Sandström 2000a). Moreover, while it is undisputed that some general tendencies in the evolution of knowledge production system are truly global, it is also clear that "there are distinct national styles of science and technology policy, which reflect more general differences in policymaking and governmental regulation" (Jamison and Elzinga 1995).

We then believe that detailed case studies are needed in order to assess how research policies changed since the II world war, not only at the level of general objectives, but also of the institutions and of the instruments (notably, of the funding practices). Based on this background

our study aims to examine in the Swiss case (1) if and how the research policy is fostering the integration between academy and industry described in the triple helix model (2) how and through which mechanisms the development of a knowledge-based economic impacted on it and (3) how national specific factors (at the level of the structure of the research system and of the political structures) interacted with the general trends identified by models like triple helix to explain the observed change patterns.

2. Description of the case study

Our case study deals with the development of the Swiss research policy and, in particular, on those measures and instruments which were oriented towards the needs of private companies and to the transfer of research results towards economic innovation.

We have recourse to a pragmatic and operational definition, saying that *research policy is the set of objectives, institutions and mechanisms to support research activities (both in the public and private sector) and their use for general social, economic and political objectives* (modified from Calvert and Martin 2000). This definition underscores the fact that the scope of research policy goes beyond the support of public science and includes also economic considerations and instruments oriented to private companies, but is narrower than the approach based on national systems of innovation, which includes almost all policy measures related to economic innovation, like fiscal instruments or regulations of labour market (see Larédo et al. 2001 for recent comparative work based on this model).

A related limitation is that we consider almost exclusively the action of the Swiss central state, leaving outside the role of regional authorities and especially of the Cantons; this is coherent with our focus on research policy, since the Cantons don't have explicit competences in this domain[2]; however, it is important to notice that in Switzerland the Cantons are important actors for regional innovation policies, in particular through incentives and fiscal measures supporting young and innovative enterprises.

Our analysis develops in two main steps. In a first step we will shortly present the *structure of the Swiss research system*, focusing on the role of private research activities, since it has important consequences on research policy (section 3). The second step deals with the *specific measures towards research of economic interest* and with their evolution in the period since the II world war (section 4).

The time period considered spans from the II world war until the end of the XX century, since we believe that only careful historical analysis for a sufficiently long time period (spanning in principle until the II world war) is essential to avoid conclusions based on short term developments or on too simple reconstructions of past policies.

For this reconstruction, we use different kind of information and data: firstly, available data on public financing of research for the period 1969-1998, which were reconstructed by one of us in previous work (Lepori 2002), as well as data on output published by the Centre for Science and Technology Studies in Bern (Da Pozzo et al. 2001); secondly, a series of reports on the Swiss research policy, including the two OECD reviews (OECD 1971 and 1989), official documents on the Swiss technology policy (e.g., Office federal des questions conjoncturelles 1992 and Conseil federal 1997), as well as past published work on the subject (Latzel 1979; Freiburghaus 1991; Hof 2002). This work is also largely based on the experience of the two authors in the Swiss research policy[3] and on informal discussions and exchanges with many actors, which of course we cannot name here.

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[2] However, the Cantons do indirectly influence the public research system and the research policy through their responsibility for the cantonal universities (see section 3)

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3. The structure of the Swiss R&D system

As it will be clear later in this paper, two structural elements of the research system had (and still have) a profound impact on the Swiss research policy. These are (1) the importance and organisation of private research activities and (2) the dominance of universities in the public research system (see figure 1).

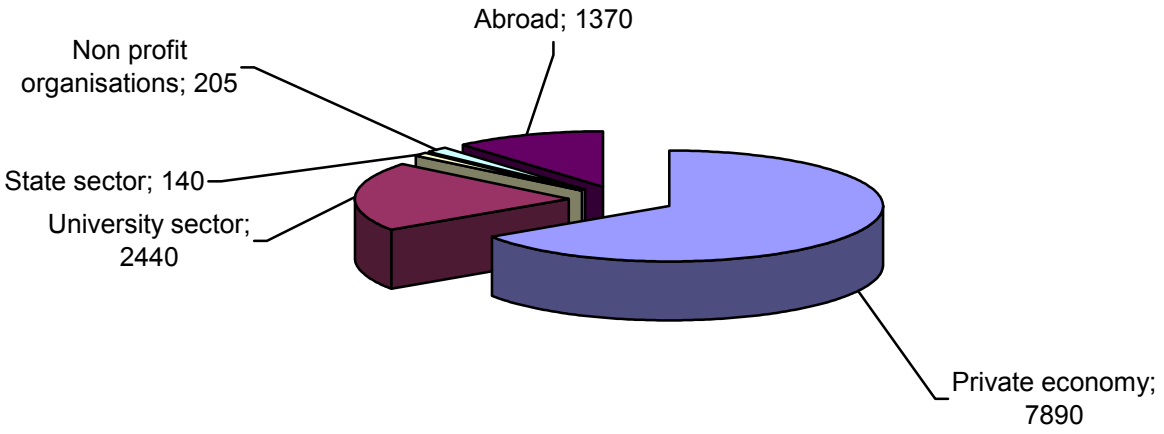

Figure 1. R&D execution in Switzerland 2000 (mio. Sfr.). Source: Federal Office of Statistics

In an international comparison, business enterprises R&D expenditure in terms of GDP with 1,93% (year 2000; source: federal office for statistics) is one of the highest in OECD countries, almost at the same level as the USA (2,04%; 1998) and the Japan (2,18%; 1998) and significantly higher than all other European countries except Sweden (2,77%; 1997). A more detailed analysis shows that expenditures are highly concentrated in two sectors, that is in the pharmaceutical and chemical industry and in the machine industry (including electrotecnics), which account together for 70% of all industrial R&D expenditures (Office fédéral de la statistique 2002). These are of course the two main specialisation sectors of Swiss industry, where large companies are present (Novartis and Hoffman La Roche for chemistry and pharmaceutics; ABB and Sulzer for the machine industry and electrotecnics). OCDE data show also that the Swiss export is strongly specialised towards chemical industry and, to a less extent, machine and electrotecnics (OECD 1999).

Output data show however that the situation of these two sectors is quite different. Data on scientific publications show that the chemical and pharmaceutical industry is actively involved in basic research: in the 25 Swiss institutions which produce the largest number of scientific publication we find four companies and two privately-financed research institutes in this sector (Novartis; Hoffman-la-Roche; Glaxco; Nesté; Basler Institut für Immunologie; Friedrich Miescher Institut); except the IBM research centre in Rüschlikon there are no other private companies in this list (CEST 2001). The share of scientific publications from industry reaches 50% in pharmacology and exceeds 25% in immunology and food sciences (Conseil Suisse de la Science 1999). OECD data on patents show the same specialisation pattern in the sectors agro-food, health and chemistry (OECD 1999).

Then, the picture of the Swiss industry being strong in R&D activities and thus refusing any state help or intervention (see section 4) holds in general terms, but the situation must be differentiated according to the sectors: the chemical and pharmaceutical industry has a strong

research base and is well integrated with the academic world (as shown by the publication data), while the machine industry seems to be in a weaker position; also small and medium enterprises, which correspond to 75% of the total employment, don't have the same resources for R&D as large companies. As we will see in section 4, since the beginning of the '70 the representatives of these sectors hold different position towards state support for private R&D.
The counterpart is a strong university sector, composed by ten cantonal universities and the two federal institutes of technology (FIT) in Zurich and in Lausanne. The decision-making process – with the Cantons ruling their universities and the Confederation the FITs – brings a strong decentralisation of the system, lacking common rules for things like university organisation, academic careers, financial rules; this means also that there has little room for centrally defined priorities and for the establishment of centres of gravity in research[4]. Publication data show also that Swiss universities are generally very strong in research (Da Pozzo et al. 2001) and that research activity is widespread; there is then no clear distinction between research-strong universities and other universities, as it is present in other countries (Geuna 1999).

Rank	Publications 1994-99	Org. Type	
1	University of Zurich	HES	11919
2	Eidgenössische Technische Hochschule Zürich (ETHZ)	HES	11080
3	Université de Genève	HES	9737
4	Universität Bern	HES	8099
5	Université de Lausanne	HES	6927
6	Universität Basel	HES	6795
7	European Organization for Nuclear Research (CERN)	INT	4602
8	Ecole Polytechnique Fédérale de Lausanne (EPFL)	HES	4259
9	NOVARTIS AG	IND	3338
10	Paul Scherrer Institut (PSI), Villigen	INST	2113
11	F-HOFFMANN-LA-ROCHE & Co Ltd	IND	1883
12	Université de Fribourg	HES	1262
13	Université de Neuchâtel	HES	1160
14	World Health Organization (WHO/OMS)	INT	1145
15	EAWAG, Dübendorf	INST	766
16	Basler Institut für Immunologie (ROCHE)	IND	638
17	F. Miescher Institut (NOVARTIS)	IND	609
18	Spitäler in Basel (mehrere Institutionen; exkl. Univ.-Spital)	INST	594
19	Kantonsspital St. Gallen	HES	542
20	IBM Corp.	IND	518
21	NESTLE Ltd.	IND	467
22	GLAXO WELLCOME (Glaxo-Smith-Kline)	IND	428
23	Inst. Suisse de Rech. Exp. sur le Cancer (ISREC), Lausanne	INST	403
24	Inselspital Bern (exkl. Univ.-Spital)	INST	378
25	BA für Landwirtschaft (BLW) (inkl. Forschungsanstalten)	INST	337
	Autres institutions (env. 700)		9177
Total		**89176**	**89176**

Figure 2. Publications of Swiss research institutions.
Source: Centre for Studies in Science and Technology.
HES: Higher education; IND: Industry; INT: international organisations; INST: public research institutes.

[4] The recent programme for the creation of national centres of excellence in research sponsored by the Swiss National Science Foundation has in reality led to the creation of networks of academic institutions coordinated by a leading house, rather to geographically concentrated centres.

The weakness of the public non-university research sector is a major difference between Switzerland and other European countries like Germany and France. The most important institutes outside universities are the so-called “Annexanstalten”, four institutes which are part of the domain of the Federal Institutes of Technology; three of them have principally a service function in the domain of water protection (EAWAG), materials and testing (EMPA) and forestry and landscape (WSL) along with a small part of R&D activities; the fourth one, the Paul Scherrer Institute (PSI), develops and exploits large research facilities in sectors like physics, chemistry, materials, energy and environmental research. With 250. mio sfr. per year the R&D budget of the PSI is comparable to the largest Swiss universities[5].
Thus, the Swiss research system appears at a first sight to be characterised by the a clear separation of tasks between the public sector – mostly concerned with the development of new knowledge and training of skilled people for needs of industry – and the private sector, charged with the development of new technologies and its commercialisation. Fluxes of money between the two sectors are very small and, in particular, state finance for private R&D activities is together with Japan the lowest in all OECD countries (see figure 3).

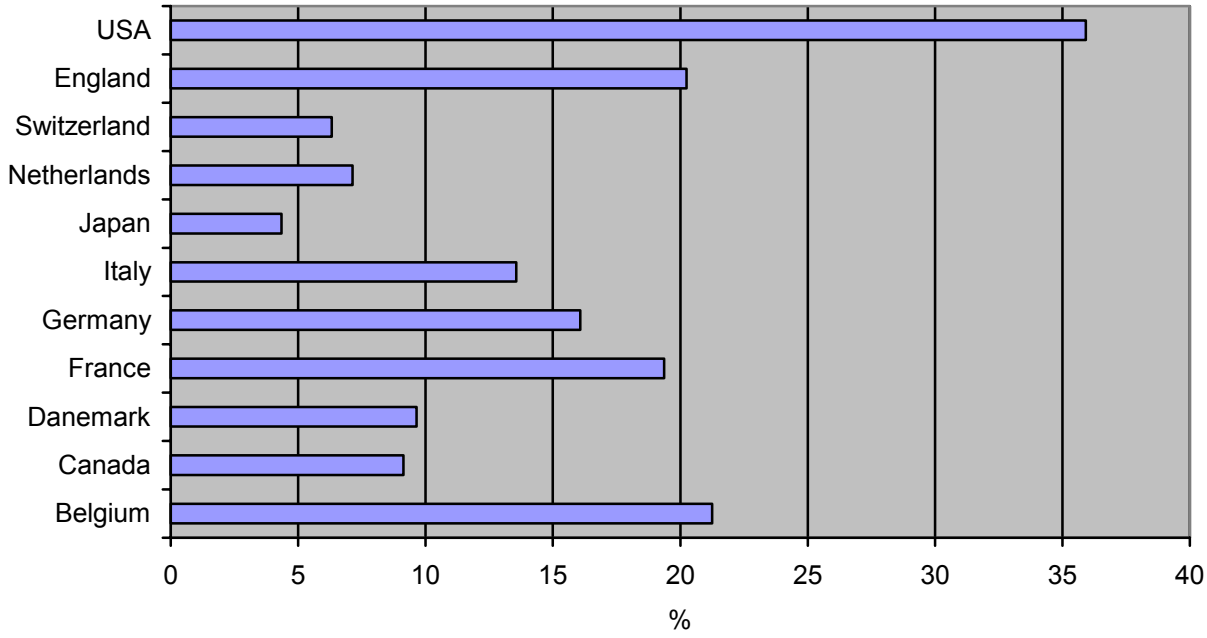

Figure 3. Percentage of state R&D financing going to private economy, 1996 (source: OECD).

While the real picture of the relationships between state and industry in R&D activities is much more complex, it remains true that the evolution towards a research policy more actively engaged towards innovation has been very strongly influenced by these structures and has then led to solutions which are specific to the Swiss system.

[5] Other research institutes outside the universities include six institutes of research on agriculture, which are part of the federal administration, a group of about 20 small structures funded by the Confederation through the research act and some cantonal structures (i.e., the cantonal hospitals). Switzerland hosts also some large international research organisations, in particular the CERN and the headquarters of the World Health Organisation in Geneva.

4. The evolution of the Swiss research policy 1945-2000

We divide our account of the development of the Swiss research policy in five main phases:

- The post-war period between 1945 and the mid of the '60;
- The period of institutional restructuring between 1965 and 1973;
- The economic crisis period between 1973 and 1989;
- The period of technology programs between 1989 and 1995;
- Finally, the creation of new institutional setting since 1995.

While this periodisation doesn't match exactly that used in the international literature on research policy (see for example Ruivo 1994 and Jamison and Elzinga 1995), it is in our view more coherent with the specific developments in Switzerland.

4.1 1945-1965: policy for science and technological development

As in many other European countries (Braun 1997), direct state support to research activities (not as a part of the general university financing) began in Switzerland in the period across the II world war. Not surprisingly given the economic problems during the 30ies and the war, economic concerns were at the forefront. The federal government received then in 1934 the formal competence to support industrial research activities, as an instrument to create workplaces and against unemployment. However, industry refused state support, fearing that the state would try to control their research activities (Hug 1998).

This refusal led to a funding structure, where the state finances the public part of research projects realised in cooperation between academia and industry and serving direct industrial needs; the private companies finance their share of the projects, but keep the exploitation rights of the results. This model was implemented in 1944 with the creation of the commission for the encouragement of scientific research (CTI); in 1945, the CTI was given a first credit of 4 mio. sfr., an amount which was comparable to the total annual budget of the ETHZ in the same year (Heiniger 1990). This is today (but not at the epoch, as we will shortly see) the dominant model for state support to research oriented to economic needs.

However, the CTI lost very quickly its importance in the period after the war. Firstly, the attempts to create a research council supporting academic research succeeded in 1952 with the foundation of the Swiss National Science Foundation (SNF; Fleury and Joye 2002). Secondly, the favourable economic climate – Switzerland did not suffer from the war destructions and thus recovered much more quickly than other European countries – made state intervention against unemployment superfluous and thus reinforced industry's scepticisms against CTI. In the subsequent years, the SNF budget grew very quickly, reaching 67 mio. Sfr. in 1970, while the CTI budget stagnated between 1 and 2 mio. Sfr. in nominal terms.

However, in the same period the Swiss state engaged in the biggest technological support programme of his history, namely in the field of nuclear energy. Officially, the objective was to develop a Swiss nuclear industry; however, military interests for a Swiss atomic bomb played probably an important role, even if they were never stated officially. The financial engagement was substantial; the newly created commission for atomic energy was granted in 1945 a budget of 18 mio. Sfr for the period 1947-1951; according to Peter Hug the total costs of the development of the atomic technology in Switzerland from 1944 to 1966 amounted to 615 mio. Sfr, of which 87% where financed by the state (Hug 1998). The private industry was actively involved in the programme; the two major companies in the Swiss machine industry, Brown Boweri (BBC) and Sulzer, participated in 1955 in the creation of the Reaktor AG, a company which should have developed a Swiss nuclear reactor. This attempt failed due to technical difficulties, but also to the concurrence between the two companies. In 1959 BBC decided to develop nuclear technology in Germany cooperating with Krupp; in 1960, the Reaktor AG came back to the state as the Institute for Research on Reactors, which became in 1989 part of the Paul Scherrer Institut. In 1964, the Swiss electricity companies decided to build nuclear plants on American licence, thus bringing the attempts to develop a national industry to the end.

The conclusion is that research policy in this period matched both the interests of academia and of the dominant industry sectors. Academia benefited from the increasing support from the SNF. The chemical and pharmaceutical industry having sufficient financial means for his R&D activity, as well as good connections to the universities and especially the ETHZ, was mostly interested in the output of trained personnel from the universities. At the same time, the Confederation took almost all costs of the development of a whole technological sector in the machine industry through the nuclear programme. This was of course possible in a period of favourable economic conjuncture and of positive state accounts; the percentage of the federal budget dedicated to research (excluding higher education financing) grew from 0,6% in 1950 to 2,6% in 1970 (Lepori 2002).

4.2 1965-1973: institutional restructuring and new issues

During the second half of the '60 the Swiss research policy went through its most important period of institutional innovation, laying down the structures which are still present today. The major events were the creation of the Swiss Science Council (SSC) in 1965, the beginning of federal support to cantonal universities in 1966, the creation of the Swiss University Conference and of the Division of Science and Research (later Federal Office for Education and Science; FOES) in 1969. Thus, for the first time, the state administration had bodies with competences to develop concepts and instruments for the science policy, gaining autonomy from the interests of academia and industry. In 1969 too, the federal parliament created the commission for science and research, while the association of private industry (the "Vorort") created its commission for science and research.

Early in this period the discussion on support to research oriented to economic needs surfaced again; in 1966 the CTI submitted a report to the federal government, stressing that the federal support to applied research should be put in a broader context than the fight against unemployment, while in 1967 the deputy to the parliament Eric Choisy proposed the creation of a Swiss national foundation for applied research. The OECD survey of 1969 states the existence of a debate on this issue, as well as the existence of different positions in the industrial milieus (OECD 1971). In 1968 the federal council charged the CTI to prepare a new conception for the support to economic oriented research; following this report in 1971 (Commission pour l'encouragement des recherches scientifiques 1971), in 1972 the Swiss Science Council published his recommendations. The SSC report distinguishes between three objectives of state support for research, i.e. a) the encouragement of research linked to higher education teaching and to the development of human knowledge b) the support to research oriented to social and political problems and c) the support to research serving the economic innovation. While the state was clearly legitimate to support the first two kinds of research, much care had to been taken in the third domain to order to respect the private initiative and the freedom of industry and commerce (Conseil Suisse de la Science 1972).

The search for an institutional solution proved also very difficult. Two alternatives were in the foreground: the creation of a new institution (along the Choisy proposal) and the assignment of the support to economic-oriented research to SNF. The SSC preferred the second solution, which however would have requested a major revision of the SNF structure that was hardly compatible with its academic orientation.

The impression is that the discussion was somewhat an abstract one; the concerns about the competitiveness of the Swiss industry and the pressure of the OECD not being, in a period of (still) favourable conjuncture, strong enough to push existing actors to modify their attitudes; moreover, the issue of financing of the universities, faced with a strong increase of the number of students, and of the development of the socially-relevant research were clearly in the foreground.

4.3 1973-1989: stability and economic crisis

In 1973 the Swiss citizens refused with a very small difference a new article of the federal constitution which would have given to the confederation larger competences in the education

sector and, in particular, for universities. Along with the financial crisis of public powers (the federal budget showing large deficits since 1971), the confrontation between the Confederation and the Cantons on the division of competences in the university sector blocked the institutional development of research policy until the mid of the ’80.
At the same time the economic crises of 1975-1978 and 1981-1983 (in 1975 the GIP of Switzerland dropped by about 7%) led to a more interventionist attitude of the state into economic affairs[6]. A series of programmes directed to revitalize the Swiss economy were launched in 1978 (Impulse programme I), 1982 (Impulse programme II) and 1983 (Measures to strengthen the Swiss economy), while at the same time public support was granted to structurally weak regions (especially for the swatch manufacturing in the Jura region) and to mountain regions. A substantial part of these programmes were dedicated to research and innovation activities, in fields like machine industry, energy savings in buildings, management informatics. The total amount of the research and innovation measures in the three programmes was about 140 mio. Sfr (OECD 1989).
The management of the research support measures was attributed to the CTI, which received substantial financial means; its annual budget grew from 1,5 mio. Sfr. in 1969 to 15,3 mio. Sfr. in 1985. In fact, the increased support to the CTI was the only measure in the impulse programme that the Vorort accepted without reservation. Thus, the combined effect of the failure of reform attempts at the beginning of the ’70 and of the economic crisis was that the CTI could slowly gain of importance and establish itself in the Swiss research policy. In 1985, the parliament approved for the first time a four-year credit for the CTI, which enabled the commission to better plan its activities (previous credits were granted on an year to year basis); with 150 mio. Sfr. the amount was substantially higher than in the previous years. In 1987, the Commission was also charged to manage the Swiss participation to the European framework programmes and to EUREKA.
A second train of measures started at the beginning of the ’80 to support research and technology transfer in the domain of microelectronics, which was considered as a key technological area both at the international level and for the Swiss industry (the message of the federal council of 1987 cites the programmes of other countries, like the UK programme ALVEY and the European programmes ESPRIT and RACE; Conseil federal 1987). The Confederation and the Cantons participated, together with private industry, in the creation of the Fondation Suisse de Recherche en Michrotechnique (FSRM; 1978) and of the Centre Suisse d’Electronique et de Michrotechnique (CSEM; 1983), both located in Neuchâtel at the hearth of the main swatch-producing region. The mission of the CSEM, being a private company whose financing comes in equal parts from the state and from private companies, is to develop high-level competences in microelectronics and to offer services for the technological needs of industry. In the same domain, the Confederation financed university research through a national research programme in microelectronics, started in 1984 and endowed with 21 mio. Sfr. The first elements of the large technological programmes which would characterize the first part of the ’90 where thus laid down.

[6] This competence is given to the Confederation in article 100 of the federal constitution, which states that the Confederation shall ensure a balanced economic development and, in particular, prevent and fight unemployment and inflation; to this aim, the Confederation may in some domains depart from the principle of economic freedom.

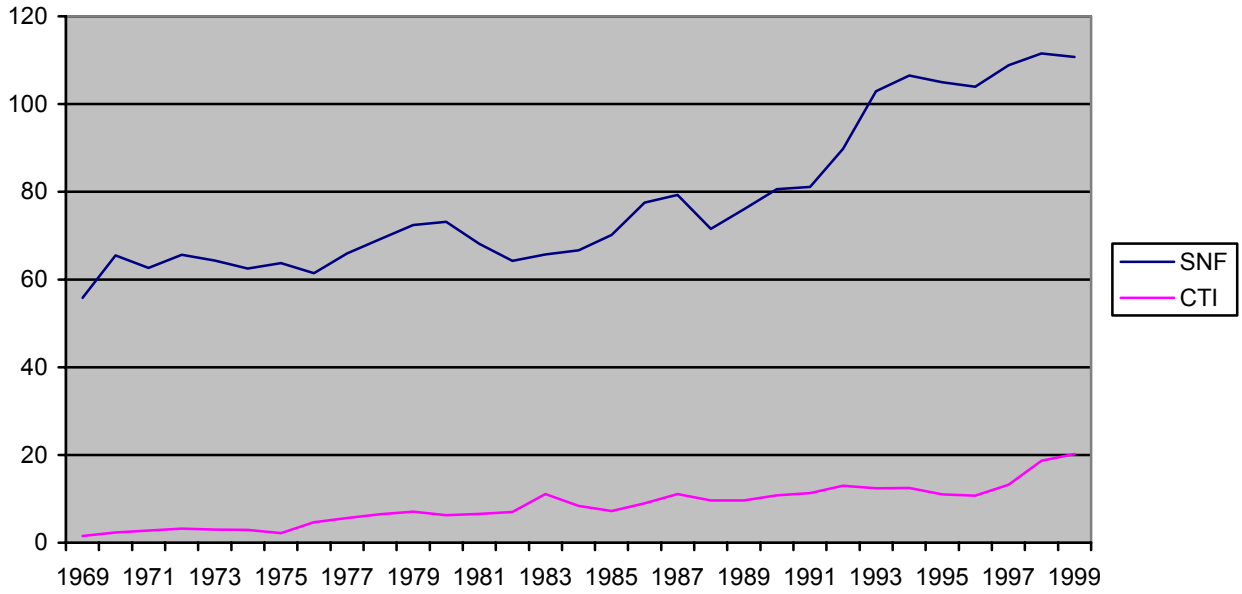

Figure 4. Budget of SNF and CTI 1969-1999 in real terms (1969 mio. sfr.).
Source: Lepori 2002.

4.4 1989-1995. The age of the technology programmes

In the years 1988-1989 the OECD realised a second review of the Swiss science and technology policy (OECD 1989). In the chapter dedicated to technology and innovation, the experts noticed that the Swiss industry in general was still in a good position, but that its technological portfolio was too conservative and that Switzerland was lagging behind in some new key technologies like information technologies and materials. They also noticed that there was a need for more active state intervention in three domains, i.e. support to small and medium enterprises, state support programs in new key technological fields and promotion of the interface between academia and industry. This point was fiercely contested by the Swiss delegation at the review meeting; the representatives of the industry found the picture of the Swiss situation too negative and stressed the traditional position that the state should not intervene in the private R&D (with the notable exception of the representative of machine industry). This discussion showed of course that the issue was being felt as an important one, but also that possible solutions where very controversial, especially on the evaluation of the Swiss situation and on the need to support specific technological fields.

The actuality of the issue is demonstrated also by a number of the studies, which were financed by the federal office for conjuncture (the office supervising the CTI; see Bundesamt für Konjunkturfragen 1995) and by the Swiss Science Council through its committee for technological policy (Mooser 1992; Knöpfel 1992; Balthasar and Knöpfel 1993). These studies showed that the technological level of the Swiss industry was still good and comparable to other European countries, but also weaknesses in the new technological domains and specific problems with the SMEs (an analysis which largely matches the contents of the criticized OECD report). The SSC developed later in the ’90 this approach in direction of an evaluation of the innovation potential of the Swiss economy combining data on scientific production and on innovation activities (Conseil Suisse de la Science 1998 and 1999a).

In the objectives for the Swiss research policy for the years 1992-1994 prepared by the Swiss Science Council and approved by the federal council in 1990 (Conseil Suisse de la Science 1990), one of the priorities is the promotion of the technological development and the support to key technologies. The new secretary of state for science and research Heinrich Ursprung, formerly president of the Federal Institutes of Technology, was one the major advocates of this

more dirigistic attitude and of the definition of clear thematic orientations, which of course draws strongly on the example of other countries and on OECD work. To the other side, the department of economy and the federal office for conjuncture promoted a broader approach more oriented towards a diffusion-oriented policy. The 1992 report on technology policy of the Confederation (Office Fédéral des Questions Conjoncturelles 1992) considered technology policy as a part of economic policy, giving thus the priority to measures oriented to reinforce the competitiveness of the Swiss economy and to the incentives to private innovation. In the higher education and research policy, the reform of the education of engineers and of the technical school was indicated to be the first priority.

However, in this phase, the support to key technologies was clearly at the forefront. In 1992, the Swiss parliament approved the launch of six priority programs aiming to support research in key technological areas like information sciences, material sciences, biotechnology and environmental technologies (Conseil federal 1991). With 357 mio. Sfr. for the years 1992-1995 the budget for these programs was about the double of the CTI budget for the same period. Respecting the industry's veto for direct financing of private R&D these programs financed only research projects in the universities and federal institutes of technology, but a clear objective was to establish strong links with private economy. Moreover, 100 mio. Sfr. were approved for the MICROSWISS program in the domain of microelectronics; together with the federal support to the FSRM and CSEM and with two of the priority programmes (power electronics and optics) this constituted a strong priority in microelectronics. Another programme was launched in 1992 to support the introduction of Computer Integrated Manufacturing in industry, through the creation of regional research and support centres.

A closer look reveals how a coalition of different interests brought to the creation of these programs. Research in key technology areas was clearly fashionable in this period and thus was seen by academic circles (including the SNF and the board of the FIT, which managed the priority programs) as an opportunity to get more money from the parliament; at the same time, the Vorort backed this proposition because the new programs were of interest for private industry (the alternative being discussed were big investments for new facilities at the Paul Scherrer Institute), but not too interventionist. With the exception of the biotechnology programmes, these programmes were also concentrated in the industrial sectors (informatics and machine industry) which were most favourable to state intervention.

The second major initiative of this period was the participation to the European framework programmes. Not being member of the EU, Switzerland signed in 1986 an agreement permitting the participation to EU projects through Swiss financing. Since 1988 the CTI financed Swiss partners according to his normal rules, i.e. excluding financing for private companies. However, in 1992 the Swiss voters refused the European Area Agreement, which provided for full Swiss participation in EU research programmes. To ensure the Swiss participation the procedures to get financing were simplified and Switzerland accepted the EU financing rules, meaning that also Swiss industries would receive state support. Also, responsibility for the management was transferred from the CTI to the Federal office for education and science, with the motivation that EU programmes were more "science-oriented" that Eureka. It is probable that the growth of these programmes was not foreseen at the epoch and that Eureka was considered to be more important. In reality, FOES financing increased from less than 10 mio. sfr. in 1992 to more than 100 mio. in the year 2000, an amount which exceeds the actual CTI budget. Given the high priority of the European policy, the parliament has voted without difficulty the credits required for this participation.

A look to the participation data shows the scepticism of parts of the industry towards European programmes; about ¾ of the financial means for Swiss participation benefit to universities and public research institutes, while the industrial participation is dominated by the informatics sector (ASCOM, IBM research laboratories and Swisscom; Balthasar et al. 1997 and 2001). Thanks to the argument of the importance of the participation to the European programmes, the Vorort could then accept the support to Swiss industry (welcome by some of its members, like the machine industry) without endangering the general principle of no State support to private R&D.

4.5 1995-2002. A new institutional setting

A major problem of the Swiss technology policy in the ’80 and the ’90 was its institutional fragmentation, some initiatives being of resort of the department of the internal affairs, while other activities being in the department of economy.

At the mid of the ’90 began a process of reorganisation of the whole domain of technology policy and professional training which has led to a concentration of these competences in the department of economy. There are a few reasons which may explain this evolution. Firstly, at an international level, the age of large technological programs came to an end during the ’90 and most European countries delegated this function to the European programmes (Larédo et al 2001); the diffusion-oriented approach promoted by the federal office for conjuncture was then the (internationally) dominant one. Secondly, in 1998 a new state secretary for science and research was nominated; the main concern of Mr. Kleiber was to reform the structures of the Swiss universities (Kleiber 1999) rather than to direct research towards specific technologies. The priority programs have then been replaced since 2000 by the instrument of the national centres of excellence in research, which aim to create scientific centres of excellence in the Swiss universities; the focus has then clearly shifted towards the reinforcement of the Swiss scientific place and towards basic research, a reorientation which matched the interests of the SNF and of the academic milieus.

At the same time, in 1995, the new federal law on universities of applies sciences started a process of reform in the sector of the tertiary professional training (Hof 2002; Conseil federal 1994a): the existing technical schools were grouped in seven universities of applied sciences (Fachhoschulen), which received also an explicit mandate to perform applied research and transfer of knowledge especially to local companies. Thus, the Swiss higher education sector was reorganised in two distinct filières, one more oriented to basic research and to general university training composed by the cantonal universities and the two FIT, the other to applied research and professional training composed by the Fachhoschulen.

Finally, in the framework of the reform of the federal administration, the whole field of higher education, research and technology was reorganised by concentrating all the competences in the department of internal affairs and the department of economy. The former received all the tasks concerning basic scientific research and universities, while the second took in charge the domain of applied research and technology transfer, the Fachochschulen and the professional training. To this aim, two existing federal offices were merged in 1998 into the new Federal Office for Professional Education and Technology (FOPET), which is in some respects the counterpart in the economy department of the Federal Office for Education and Science in the internal affairs department. The two existing institutions for research funding were attached to this structure: the SNF receives his funding from the FOES, while the CTI is attached to the FOPET which host his secretariat. The CTI received thus an official mandate as the federal agency for the support to research oriented to economic applications (Conseil federal 1998), as well as supplementary financial means to strengthen research activities in the Fachoschulen.

Surprisingly enough, this organisation seems to match more the needs and the concepts of the ’70 when the idea of a national foundation for applied research was born than the new concepts about the relationships between science and innovation, which would call for a much closer integration between the two. We could say that the conceptual integration of research policy in a wider innovation framework (see for example Office federal de la formation professionnelle et de la technologie 2002) has not come along with a parallel integration in the institutions of research policy and of funding mechanisms.

5. Continuity and change in the Swiss research policy

While a complete reconstruction of the functioning of the Swiss research policy would go well beyond the scope of this paper, we find useful to present three concluding remarks which emerge from our case study.

1) The *first remark* is that the triple helix framework proves to be fruitful to analyse the Swiss research policy. In fact we can describe it as an institutional space where academia, industry and state interact to define research funding practices and to distribute the available financial means

What is more surprising is that, according to the materials presented in section 4, this description holds true not only for the most recent years, but for the whole period since the II world war. For example trilateral coalitions between actors in industry, academia and state have always played a crucial role for the set-up of research funding programs. Examples include the Swiss nuclear programme with the alliance between Brown Boweri and Sulzer, the military department and a group of university professors in nuclear physics, in particular Paul Scherrer (Hug 1998), as well as for the reinforcement of the CTI at mid '90, with a coalition between the federal office for conjuncture, the machine industry and the new Fachochschulen, interested to receive support for their research.

Thus, the picture of research policies evolving from a bilateral (state-academia) to a trilateral structure does hardly correspond to the (Swiss) reality. Our analysis shows however a progressive process of consolidation of the Swiss research policy, with the creation of institutions specially devoted to the elaboration of strategies and funding programmes. In other words, while it is still true that the research policy is a locus of negotiation between academia, industry and state, this interaction is now structured through dedicated institutions and established procedures (for example for the decisions on the research budget).

2) The *second remark* is that there are strong elements of continuity along the whole period considered. For instance, the Confederation financed large technology development programs during the '40 and '50 (in the nuclear energy field) and during the '90 (mostly in informatics and microelectronics); both cases were based on an institutional setting where the public sector performed research to develop technologies of direct interest to specific industries, but too risky for the (conservative) Swiss private sector. We should then speak of the recurrence of specific institutional models to support research of economic interest, based basically on the same arguments (the need to keep with new technological developments which seemed to be very important for the future of the Swiss economy). Also, the model of a funding agency for economic-oriented research emerged repeatedly in this period (with the creation of the CTI in the '40; at end of the '60; finally in the 2nd half of the '90). The criteria applied by the CTI for funding project are today almost the same as fifty years ago.

This continuity can partially be explained by the natural resistance of existing institutions to change. However, over a fifty years period, this argument appears to be too weak. In our opinion, this shows that the underlying forces shaping the Swiss research policy have not changed so dramatically as some analysis may have suggested. In fact, the Swiss research system has today a structure which is, in general terms, quite similar to that of fifty years ago, with the public sector dominated by the universities and the private sector dominated by chemical and pharmaceutical industry and mechanical industry. Also, in its institutional organisation the Swiss State has evolved little during the same period and has kept some basic features of the policy-making process, in particular federalism, direct democracy and search for the consensus.

This remark may of course be specific for Switzerland, with his history devoid of upheavals and being not involved in the two world wars; but, more in general, we think that an history of research policies should not only focus on change, but also on continuity elements, which may in some cases be more important.

3) The *third remark* is that one should not take change in the objectives and general strategies, as presented in official documents, as a sign of a real change of the same magnitude in institutions and funding practices.

In fact, looking at the Swiss case, we can readily find an evolution from a conception where the role of the state was limited to the support to academic research, leaving to private companies

the task of transferring the results to economic application, towards the idea of a more active role in the development of key technologies and, more recently, in the promotion of university-industry linkages and the transfer of results to practice. The key concepts present in the Swiss official documents are then hardly different from those in OECD works, but with a significant time lag of some years. However, as we already noticed, institutional structures and patterns of funding don't follow the same path.

For example, the recent restructuring of economic-oriented research led to a clear separation between basic research and university training at one side, applied research, professional training and technology transfer to the other side, a model which is much more coherent with the old linear model than with the most recent concepts about innovation. This institutional structure seems to depend much more on the need to share competences between two departments which were historically involved in research policy than on conceptual reflections.

The position of private economy towards state intervention shows also how general principles motivated with ideological arguments can in practice cover vested interests. While the industry has always refused state financing of private R&D with the argument that this intervention would distort concurrence, the state has repeatedly taken over the costs of the development of technologies which were of direct interest of *specific* industrial branches (the most evident cases being that of nuclear technology and micro-electronics).

This shows that research policies are complex objects composed by at least two different levels, that of the general models and strategies and that of the institutions and funding practices; it seems then in our case that these levels are only loosely coupled and are subject to quite different forces, so that their evolution can follow different (but, of course not unrelated), paths. A corollary of this remark is that the thesis of a convergence between national research policies must handled with some care; while it is unquestionable that the models of state intervention in this field are very much similar, it is clear that they can conceal practices which are quite different between countries.

While it is of course impossible to generalize these remarks because some of the observed patterns may depend on national specificities, we however think that these can contribute to a fruitful discussion on the development of research policies in advanced countries.

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