University-industry knowledge transfer: Switzerland

April 2008
Final draft

Professor Dominique Foray
Chair Economics and Management of Innovation
Ecole Polytechnique Fédérale de Lausanne (CH)

1) Introduction[1]

There are a large number of economic opportunities to exploit potential transfers from academic research to industry, generating a range of complementary externalities between the two systems (David, 1998). One such source of externalities is the intellectual support that fundamental scientific knowledge provides to applied researchers, whether in the public or in the private sectors. A second and no less important source is the link between the profitability of corporate R&D and the quality of human capital, and, as it turns out, universities have been the best place to train young scientists and engineers. Finally, the effective transfer of knowledge and technology from university research laboratories to corporate labs attributable to the circulation of academic researchers is an externality that feeds into the viability of the overall symbiotic system of the academic research and industry. The main effects of these complementarities are to raise the expected rates of return, and to reduce the risk of investing in applied R&D. A central policy concern is, therefore, to ensure that these complementarities are properly managed and that they serve to maintain the profitability of applied R&D investments for firms as they have shown to be for the past half century.

This policy concern is even more nuanced as countries progressively shift towards knowledge-based economies[2]. It is of critical importance that the supply of new basic knowledge and highly skilled people would enable the country to respond positively to the increasing demand for those resources, which is a consequence of the expansion of the knowledge sector. Efficient knowledge transfer mechanisms are therefore crucial to properly feed and sustain the growth of these knowledge and innovation-based activities.

It has been largely accepted that direct transfers of knowledge between universities' science communities and the proprietary R&D organisations of the private business sector are problematic to institutionalize. The co-existence of two reward systems within any single organisation makes the behaviours of the participants difficult to anticipate, and tends to undermine the formation of coherent cultural norms which promote co-operation among team members (David et al. 1999). The difficulties of technology transfer are not raised in the first instance by a wrong or ill-adapted institutional framework, legal systems or cultural norms; rather

---

[1] In this paper, I draw heavily on some of the research projects the Chair of Economics and Management of Innovation (EPFL) is developing on university-industry knowledge transfer in Switzerland. Contributions by Stephane Lhuillery and Christian Zellner are gratefully acknowledged. I am also grateful to Intan Hamdan for editorial assistance

[2] Knowledge economy is defined as the sector of production and service based on knowledge-intensive activities, activities that are essentially oriented toward innovation and the continuous supply of "new to the world" goods and services

the difficulties are inherently associated to the process itself, which is a problem shared by all countries. In no country it is a simple task because the problem has the structure of a trade-off between two good things: applicability of academic knowledge useful to the economy and maintenance of the fundamental missions of conducting long term research and training.

Numerous issues are involved in the process of transferability and operation of new knowledge as produced in academic institutions, therefore in this paper I will restrict this discussion to a few points, that I think are relevant for national policies, using references to relevant experiences of Switzerland whenever possible[3].

2)Three levels of policy objectives

Three distinct levels of policy objective related to the relationships between university and industry research exist.

.

The first one *seeks for optimization complementarities* between university and industry in a broad perspective through identification of the proper framework conditions as well as generation and development of favourable structural characteristics of the national system of innovations. Here the neutrality concept forms the basic premise of such objectives such that the usual problems such as picking winners, government failures, competitiveness distortions, early lock in are mitigated. The minimization of discrimination in the public funding allocation process among technologies or sectors thus ensures that resources allocated respond to market signals rather than bureaucratic decisions. However, there are at least two dimensions along which technology policy could opt for non neutral allocation policies: according to fields, and according to type (or rather size) of firms. These two dimensions correspond to the two other levels of the policy objectives: *targeting SMEs* to help them to cooperate with universities; and *using university-industry relations to lever the whole system up to new specializations* of high productivity potential for the future

21 - Optimizing complementarities : framework conditions, structural characteristics

- Developing engineering and transfer sciences

An important issue deals with the institutionalization and development of the so-called **“transfer science” or engineering**. A pivotal element in the “chain of events” occurring between the two spheres (abstract research and concrete applications) is a powerful engineering discipline in the field considered (computer -, chemical -, aeronautical-, electrical -). Engineering sciences support the gradual transformation of knowledge from ideas to operational concepts, and its passage from one codified form (perfectly adapted at some level of abstraction) to another codified form (that is adapted to application). The tensions described above are, therefore, expected to be weaker than in the context of pure fundamental research activities.According to Nelson and Rosenberg (1994) the fact that engineering sciences were recognized early-on by US universities and also highly valued as academic fields are important factors in explaining the American successful performance in regards to knowledge transfer between academia and industry. And as Rosenberg (2004) showed, these factors lay the foundation for the profitability of scientific research by creating an impetus toward transforming basic knowledge and creating learning programs to be

[3] As I suspect that my colleagues R.Barré, J.J.Duby and P.Mustar will give a detailed analysis of the French case, I will focus my case study on the country where I am now located : Switzerland

systematically used by engineers to improve products and processes; and by establishing a new engineering discipline[4].

Engineering schools should, therefore, logically be more "permeable" than basic science and other schools to the industry (Lécuyer, 1998), while specially designed institutions that have research missions distinctive from that of either traditional academic science or profit oriented R&D laboratories may be more effective for facilitating technological transfers.

The issue of allocating resources to different kinds of specialized institutions that conduct specific scientific research activities is a recurring policy problem. The answer is not obvious. While the rationale for public support of research – as a general principle – is still valid, it is less obvious to view public science policy as a tool to influence the allocation of resources among research fields. It is crucial to recognize that incentives play a significant role in decision-making process in university campuses, just as they do in every other part of life. It is probably a good idea to leave universities with the autonomy and freedom of building their research portfolio according to their own perceptions of the kind of opportunities offered by their local (or more global) environment. University-level managers seem best positioned to generate virtuous dynamics of resource allocation among academic field than State authorities. This is, however, just a general principle that should not preclude any State-pushed program in the cases where the discipline does not exist at all. Considerable evidence have demonstrated that the areas of greatest returns from scientific investigation lie at the interstices of established fields. And given that the problem of creating, developing and institutionalizing a new field at the interstices of strong existing disciplines is characterized by severe research market failures (mainly due in this case to increasing returns phenomena), some government intervention may be necessary; particularly in countries where engineering sciences are weak.

<u>- Attracting Anchor tenants</u>

The **Anchor Tenant hypothesis** assumes that R&D capacities above a certain size are powerful in generating externalities in the form of thickening markets for innovation and technologies on both supply and demand sides so that local university research is more likely to be absorbed by and stimulate local industrial R&D (Agrawal and Cockburn, 2002). An Anchor Tenant (AT) exhibit two important features: (i) strong in R&D in general, and (ii) strong in the fields of expertise of the local universities. Thus a global company can be an Anchor Tenant in any given region for any given field and will not be an AT in another region for the same field. Agrawal and Cockburn gave many reasons for thinking that the presence of an AT will enhance the regional innovation system and will help the relations between local universities and the industry (including SMEs):

- anchor tenants may be directly involved in the commercialization of university inventions;
- anchor tenants may also indirectly stimulate innovative activity by enhancing both the supply and demand sides of the market for new technologies. Anchor tenants thicken markets such as scientific labor, the market for innovation services (IP legal counsel, technology marketing, human resources services) and enhance social networks with suppliers, buyers, partners. They can also play a dynamic role on the demand side by absorbing industrial R&D output from local smaller firms.

[4] The notion of **use-inspired basic research**, attributable to D.Stoke and popularized among economists by Nelson and Romer (1996), provides another conceptual category to describe the same idea that dedicated fields, projects or disciplines are needed to support knowledge transfer.

As a result Agrawal and Cockburn have shown empirically that anchor tenant firms are an important aspect of the institutional structure of local innovation systems, improving the whole set of linkages between the local universities and the other local firms.

The issue here deals with creating and increasing locational advantages to attract a large number orf anchor tenants; a typical issue that determines policy options of wider relevance than the objective of improving university-industry relations. The whole menu of policy orientations involves the enhancement of knowledge infrastructure to create an adequate supply of human capital, ideas and academic collaborations. R&D managers, when undertaking location decision, must be able to anticipate a positive supply response of the domestic knowledge infrastructure to their demand for scientists, ideas, academic collaborations. Furthermore, this menu of policy involves also the improvement of innovation capacities, including the problem of selecting (and moving toward) the "right" S&T specializations. The quality, dimension and specialization of the knowledge base are key factors driving location decisions[5].

<u>- Increasing human mobility</u>

The mobility of people across institutional boundaries is clearly a factor mitigating many of the tensions that arise in settings where the conventions, the culture and the norms of one world (private industry) come up against the convention of another (Hall, 2004). And among the whole range of mobile human resources that can help in this matter, some are more crucial than others. This is the case of the new PhDs entering into their first job. Their placement with industry provides a means by which knowledge is transferred from the university and by which networks are built and reinforced, thus providing a major mechanism by which universities and firms interface (Sumel et al., 2005). Sumel et al. argued that having graduates work for neighbouring firms strengthens the interface between the university and firms at the local and regional level. It is, therefore, obvious that the mobility of the highly educated affects the extent to which knowledge created in universities is absorbed by the local economy. The policy implication of how to influence the location decision of new PhDs working in industry, so that "they stay" is clear. From this perspective, the same kind of issues dealing with the development of locational advantages should be addressed. The famous Midwest syndrome is an illustrative case of policy failure on this issue: states in the Midwest are net exporters, hiring a third fewer PhDs than they train (ibid.).

<u>- Helping cluster formation</u>

Spatial cluster of activities are at least partially explained by the advantage of proximity and the necessity of collocation in the process of knowledge creation and transfer. The fact that geography matters in explaining the importance of spillovers is undisputable. There is, therefore, a case for policy aiming at the creation of proper conditions for the development of spatial cluster, involving both industry and universities. However, proximity in itself may be not enough. It is the way in which professional communities use it to combine their tangible and intangible assets that counts. Depending on the dynamics created, proximity remains a purely geographical phenomenon or becomes an effective organizational structure for knowledge creation and transfer. Thus, Sillicon Valley is not ony a territory, it is above all a set of collaborative practices that blur the boundaries between various types of institutions (Saxenian, 2001).

[5] There is also an issue of ensuring the coherence of the knowledge base: the fact that the science and public research specialization are in harmony with the competitive strengths of the industry.

- Disseminating an IP and knowledge management culture in universities

Knowledge management involves a set of tools and organizational practices that have not yet really been used in universities in order to support and promote knowledge transfer. Knowledge management policy in this case should involve the creation of incentives for the disclosure problem, the development of interfaces and specific institutions to support transfer and the development of indicators to evaluate intellectual capital. Knowledge management is broader than IP management. However, an effective IP policy is part of the agenda. Post-invention processes may require co-development, *i.e.* the active involvement of the two sides in the modification and further development. This can make the problem of negotiating the attribution of rights especially difficult to solve. Universities need to impose a clear definition of the scope of knowledge, which is transferred, as well as of what is "generic" and what has been created prior to the involvement of the licensee. These are key issues to maintain the freedom of operation for future research. However co-development makes this attribution of rights very complex and uncertain.

Is there any policy rationale to deal with these issues? Instead of financial incentives, information provision should be the main policy goal here. As it is well known for a while, "*awareness is of course the start..After all if people are unaware of [knowledge management] and its benefits, they can't be expected to exploit them. The Department's first aim therefore is to encourage the sort of evangelism which not only sells the improvements in productivity and efficiency which [knowledge management] trails behind it, but also shows firms how to go about achieving them*"[6]

22 - Targeting SMEs to overcome absorptive capacities' problems

One possible departure from the neutrality principle is the varying support to firms of different sizes. The rationale for making such distinction deals with the fact that large companies are usually considered, in the literature, as "an efficient solution" to most of the problems raised by the allocation of resources in R&D[7], including those related to building relations with university research. While SMEs, given their size, have logically had more difficulties to optimize the complementarities with university research.

They have difficulties to articulate their research and collaboration needs and they usually cannot afford diverting human resources to organize and manage the collaboration. Divergences and tensions are difficult to minimize because of the lack of "translators" (such as large companies employees who have academic research background or post doc who are specifically hired to facilitate such relations). Moreover, SMEs are less "visible" from the great academic laboratories and the latter have no strong incentives to invest in building relations with the former. As a consequence, there is a prevalence of the disconnection between the SMEs and the academic research system in many countries.

---

[6] UK Department of Industry (undated) quoted by David and Stoneman (1985). I have just replaced the word "office automation" with "knowledge management"

[7] - These problems include the inability to diversify risk where capital markets are incomplete or imperfect, the inability to minimize transaction costs when complete contracts cannot be written, the inability to capture spillovers or other externalities, etc.. There is a strong presumption that vertical integration is the first, best solution to most of these economic problems.

The policy goal should be to support and promote, with specific instruments, the relationships between universities and SMEs.

23 - Using university industry relations as leverage for strategic capacities

Departing from neutrality in regards to technological fields has always been tricky, since it entails the risk of market and competition distortions. Thus, policymakers should avoid it except in cases where there are glaring market failures that need to be remedied. A case in point deals with the difficulty – due to coordination failures – to move a whole system to new areas of great productivity potential for the future. In this case, the move towards a new target and shifting resources away from areas of lower productivity into areas of greater productivity only can take place when the country exhibit effective strategic capacities, that is the capacity of governments to create satisfactory incentives and motivations to move the whole system as such. Such a strategy capacity is based on a huge commitment of the Government resources towards a new field through investments in building the knowledge infrastructure, government-sponsored research and public procurement. The success of this policy is strongly conditional to the positive responses of the private sectors to these incentives.

Recent history of technology policy in OECD countries have shown that such strategic capacity (involving non neutral public interventions) has been a key factor notably in the building of the US leadership in the high technology economy[8]. For example, collaborations between researchers and product developers has had salutary effects on computing research, helping to ensure the relevance of academic research and helping industry to take advantage of new academic research. Such collaborations allowed government program managers to better leverage their resources by attracting industry contributions (CSTB, 1999, Movery and Simcoe, 2002).

The success of such policies have been strongly contingent upon careful policy design (including attention to competition policy issues) in order to avoid or reduce the potential problems identified above (picking winners, etc..) (see Mowery and Simcoe, 2002).

Involving and using university-industry relationships as leverage for strategic capacities can thus be considered as an important policy objective. However, doing so would involve the need to carefully identify priorities (fields, topics), and the commitment to promote intensive university industry research collaborations and investment in the building of hybrid research communities in these fields.[9]

---

[8] The ingredients of the US strategic capacity are known. It involves a diversity of public agencies; all working on specific but overlapping agendas; a key role for the Department of Defense (DoD) showed both in the history of Internet revolution and, recently, in information security R&D programs launched after September 11. In both cases the impact of government-sponsored research was great in building the knowledge infrastructure in particular areas, generating spillovers to the benefit of the industry (including SMEs), creating incentives for business R&D to respond positively to this policy and initiating market development through public procurements.

[9] However, the issue is more complicated than simply selecting the most “exciting” fields and allocating resources there. This is not a trivial problem: technology foresight and forecasting approaches tend to produce the same “priority” ranking regardless of the context of the clients for whom they are prepared. In some countries, public policy has perhaps overemphasized new science-based leading edge industry in an unimaginative way, resulting in greater uniformity of their national knowledge bases and deterioration of their distinctiveness and originality. A possible consequence of this is that large companies suffer in global competition or act increasingly as a global knowledge network, and allocate their innovative activities outside the home country. Policy makers must pay attention to this “particularization” process to find the key areas for focus.

3) National case: Switzerland

31 – Evidence

The most recent survey undertaken by KOF on university-industry research relations provide interesting figures about how Swiss firms evaluate the importance of 5 generic transfer mechanisms (figure 1). Informal channels and a wide spectrum of education-related activities appear as the most important forms, as evaluated by private companies. Surprising is the relatively low score of research cooperation, research contract and research consortium as a knowledge transfer channel.

This is consistent with some results of the OFS survey on private R&D expenditures (figure 2). In 2004, the business sector spent for contract-R&D performed everywhere and in all sectors approximately CHF 4046 million. Of this amount CHF 2428 million have been spent for contract R&D performed abroad, CHF 1053 million for contract R&D performed by other Swiss private companies and only CHF 259 million for contract R&D performed in the domestic academic research (6.4% of the total of extra muros expenditures).

This last figure is worrying. Although international comparisons are difficult, there are serious presumptions that the 6.4% express a low level.[10]

Also put in an historical perspectives we see (figure 3) that R&D contracting out increased at an extraordinary rate; the amount destined to foreign partners increased at a higher rate than that received by domestic partners; the amount destined to Swiss universities also increased (by a factor 5) but remains lower than the amount received by the business sector.

32 – Surprise?

This fact is surprising given that there are many structural characteristics of the system which strongly favour complementarities between university and industry research.

- Swiss knowledge infrastructure (scientific research, S&T human resources) is considered as excellent, ranking very close to the top in many fields. For example in terms of scientific publication intensity and the relative prominence of cited scientific literature Switzerland is ranked top two worldwide (OECD, 2005). Switzerland also has a very strong basic research capacity, which is partly funded by the private sector.

- The development of engineering and applied science is a case in point. The two Institutes of Technology (EPF Zürich and Lausanne) are rightly considered as the "jewels of the crown"; having developed historically a strong academic research tradition in engineering sciences and applied sciences. They are very generously funded at the federal level and strongly committed in relations with industries. They exhibit most of the characteristics of the "permeable engineering school" described by Lécuyer (1998) à propos du MIT.

[10] Mowery argued during the World Bank conference that the amount of contract-R&D expenditures of US private companies destined to the US universities is much higher than the Swiss figure.

These factors hint at the positive response of the knowledge infrastructure to the growing demand of the business sector in terms of knowledge, high skilled people and collaborations with academic partners.

- On the demand side, the situation is again very good. An important characteristic is related to the size structure of the Swiss industry and services: for a country of its size, Switzerland has an unusual number of large multinational companies. The list includes big banks, big insurance companies but also a good number of global firms in high tech sectors, such as Novartis, Roche, Nestlé, Rollex, Swatch, ABB, Sulzer, Serono, etc. which are able to develop global links working at the advantage of the originating location. These companies are likely to play the role of Anchor Tenants making the whole local system more innovative and more oriented toward co-operations with local universities.

- Finally the innovativeness and absorptive capacities of Swiss SMEs are outstanding. They are on average more innovative than in any other OECD countries (in terms of patents, R&D intensity, involvement in international cooperation). It is clear that the whole industry structure exhibits good characteristics.

- There is, therefore, a virtuous combination of Anchor Tenants, innovative SMEs, excellent academic research, a high level of financial development and a large proportion of foreigners in the positions of PhDs, postdocs and S&T human resources population. This combination creates strong impetus toward the formation and development of high tech clusters, involving the creation and entry of new high tech firms (Arc Lemanique, Zürich region, North West Switzerland (Basle), Jura region, Bern region), with relatively little government interventions. It is clear that the existence of these clusters integrating scientific research, industries and services and the banking system play a key factor in the development of university-industry relations[11].

Any expert exposed to such an enthusiastic description would expect successful and flourishing research collaborations between university and industry. However this is not really the case, and there are both good and not so good reasons for this.

33 – R&D internationalisation and the size of the domestic knowledge base as “good excuses”

One good reason is the level of internationalisation of Swiss companies. Swiss companies have been increasing their FDI-R&D outward investments significantly (see figure 4) – the share of foreign R&D expenditures of Swiss-based firms reached 54% in 1996 and remained more or less unchanged until 2004, creating an impetus for the development of academic collaborations with foreign universities[12]. Moreover, the growth of research collaborations with foreign partners seems to be a parallel development. Even Swiss SMEs are strongly involved in such research collaborations : 17.3% of patent applications by Swiss SMEs are co-patent applications involving foreign inventors, a percentage unbeaten elsewhere when surveying SMEs in the OECD countries. Since foreign R&D is a means to tap into the worldwide pool of knowledge in order to

[11] Zellner (2005) presents a case study of the creation of high tech start ups at EPFL and analyses the various factors which are likely to explain the relatively low growth performances of most of these companies.

[12] For example, Novartis moved R&D capacities to Cambridge (US) some years ago and established over 100 research collaborations with academic teams based in this region.

complement the domestic knowledge base, it is quite logical that R&D contract expenditures and R&D collaborations destined to foreign institutions are increasing at a high rate.

The size and specializations of the Swiss domestic knowledge base are another element of explanation. Switzerland is a small country and its academic research institutions are just unable to cover the whole range of fields and research topics that are likely to be of interest for the industry. There is therefore a size effect that explain part of the problem of the relatively low importance of research cooperation, research contract and research consortium as a knowledge transfer channel.There is not so much to do from a policy point of view, and the response of the industry in terms of tapping into the global knowledge pool is certainly the right one.

34 – Systemic failures

But there are also some failures in the system, that can explain (partly) the relative lack of successful and flourishing university-industry research collaborations, and this requires some policy responses.

<u>Low participation in tertiary education</u>

A major drawback deals with the production of highly skilled human capital. The quite low participation in tertiary education results in a limited domestic supply of scientists and engineers.

This is compensated to some extent by large inflows of foreign students, scientists and engineers. However, this deprives the domestic economy of a key element in the knowledge transfer chain, which is the young scientist or engineer taking his first job. When the young scientist is coming from abroad to be recruited in a Swiss-based company, the link between the firm and the local university is not established. Moreover, the very high proportion of foreign PhDs and post docs makes it likely that a significant fraction of this population will leave the country after having completed their studies[13], and this again is a major impediment to university-industry relations.

As a policy response, significant efforts have already been made by upgrading vocational education at the secondary school level and creating universities of applied sciences which makes it possible to conclude vocational education at university level. The authorities are currently preparing a reform of the whole system, which will improve the quality and efficiency of university education, by reducing for example the time required to complete studies.

<u>Problems at the interfaces</u>

Let's return for a moment to the KOF survey. Firms were asked to evaluate the importance of different obstacles to knowledge transfer activities and it clearly appears that firm deficiencies appear as a problem (lack of interest in scientific projects; firms R&D question not interesting for universities) (figure 5). Then, deficiencies of scientific institutions are also perceived as an important obstacle as well as the costs, risks and uncertainties of knowledge transfer activities.

In sum, most important obstacles can be localized at the interface. Many firms think that their R&D questions are not interested for universities and many firms think that R&D orientations of

[13] The fact that foreigners cannot stay in the country for more than one month after having defended their thesis (work permit issue) makes the problem worse. Switzerland is probably the only country which does not make its best to incite foreign PhDs to stay!

universities are not interested for firms. Clearly, firms with a focus on research activities do not seem to be seriously hampered by this category of impediments. However, some obstacles and impediments have clearly not been removed yet. It is, therefore, interesting to see how the government responds to this specific issue through policy choices.

Problem with the Universities of Applied Sciences

University of Applied Sciences (UAS) were created in 1997 by re-organizing and merging more than 60 tertiary-level professional institutions. The rationale was to upgrade these institutions and to extend their mandate from education to applied research and technology transfer (especially towards SMEs) (see Lepori and Attar, 2006, for an excellent analysis of the UAS). UAS were, thus, created to increase the participation of students to tertiary education – the low participation is an historical feature that may create problem at the time of the knowledge economy. UAS offer tertiary type B education and are clearly oriented toward applied research and relations with local industry. However, it does not work that well. The EPFs, for instance, are more inclined to technology transfer activities than universities and universities of applied science (see figure 6). Because these Universities are not delivering masters and have no doctoral schools, they are lacking R&D personals (PhDs, postdocs, researchers, professors) and are thus not equipped to respond positively to the needs and demands of their local environment, although this is part of their missions. There is now a hot political debate to address the issue of revisiting the missions of UAS and re-articulating their role vis à vis technological transfer and SMEs.

4 – The policy response

Swiss innovation policy strongly focuses on promoting co-operation and network building among the industry and the university. Switzerland has no tradition of direct policy interventions (like direct funding). Firms are subsidised only indirectly. This is partly related to the financial development of the country (ranked first) which means that firms have usually no problem to fund their projects (even the most risky and uncertain) (figure 7); and partly related to the predominant laissez faire ideology in most political parties. In a certain sense, this "no provision of direct financial support for business R&D" seems appropriate given the already very high level of business R&D and hence the risk of large deadweight losses.

Thus, the main policy mechanism deals with the promotion of technology transfer and research cooperation between universities and industry. CTI (Commission for Technology and Innovation) finances R&D for the business sector **at Swiss public research institutions** according to a public-private partnership model for innovation in products and services: the project partners (academic and business) defining the projects by themselves, with the business side covering at least half of the project costs. Econometric studies have investigated the impact of CTI policy on the performance of private firms and they have shown that this policy improved the innovation performance of firms both in terms of R&D intensity and sales of innovative products. There has also been a positive impact on labour productivity (KOF, 2005). The CTI's bottom up approach to strengthen technology transfers between academic and firms, its coaching services for start-ups as its nation-wide education programme for would-be entrepreneurs, are the main ingredients of this impact.

The following sections explore the relevant policy responses beyond the general mechanism just described.

- Supporting the knowledge transfer mission of the Universities of Applied Sciences

To deal with this problem, the CTI acts as a "coach" to the Universities of Applied Sciences in order to foster cooperation between them and the business world. This measure promotes joint projects by funding the salaries of University researchers. The CTI helps also the Universities of Applied Sciences to identify and develop areas of focus and major topics of interest in selected fields. Based on the results of evaluations by experts, the Federal Department of Economic Affairs awards a national competence "trademark", which signals the particular research competences of the University. As a result, research capacities have been expanded and there is a clear increase of collaborations and contracts with the private sector (Lepori and Attar, op.cit.). The question remains however whether these minor policy adjustments are enough to significantly increase the collaborative capacities of the Universities of Applied Sciences or, at some points in the future, the radical transformation of them into research universities will be considered as inevitable. However the question is whether the evolution of UAS toward the model of the more traditional universities involving a strong academic culture will not put at risk the mission of being close to and serving the local economy. Another set of questions is whether the country can afford this change. This is a systemic problem since there is no tradition of tuition fees in Switzerland, so that any change toward upgrading and deepening tertiary education in UAS could only be done at the expenses of federal and cantonal public budgets.

- New models for IP management

The management of IP as part of technology transfer activities is fast becoming a policy issue. A new model is currently being discussed for cooperative research and co-development and will be tested in few cases. If the model succeeds, it would become a standard model to help IP management in other relevant cases. This model involves the full transfer of IP to the industry, with a clear definition of the field of use, the granting of a license outside of the field of use to the university; the university charging very high overhead costs (about 40%). The rationale of this are that i) the complexity of IP negotiations is considered by the industry as a major impediment to research cooperation; ii) very few cooperative research leads at the end to IP of very high market value; and iii) the higher overhead cost is not considered as an obstacle for companies to engage in cooperative research (although this issue is rather uncertain in the case of SMEs).

- Targeting SMEs

A new policy impulse has been given recently to the involvement of SMEs into university-industry relations. Given the usual drawbacks as documented in the last innovation survey (above), the goal is to help SMEs to better articulate their research needs and to find research partners. The CTI provides funding to support the creation of *knowledge and technology transfers consortia* involving all TTOs of a given region (*Alliance* for instance involves the TTOs of the Universities of Geneva, Lausanne, Neuchâtel and of the Italian speaking Switzerland, of the EPF and of the University Hospitals of the cantons of Geneva and Lausanne). Each of these consortiums creates a platform to reinforce the interface between SMEs and academic research. This involves for example the recruitment of technology officers who know well a particular industry and will help SMEs to articulate their research needs, to identify an academic partner and to manage the collaboration.

The value of creating a consortium here is to share the costs of hiring several TOs (specialized in different fields) and also to increase the probability of finding a good partner for SMEs since one TO is not stuck into a single TTO but have a broader view and knowledge.

5) Conclusion

Framework conditions and structural characteristics are more important than innovation policies in Switzerland as driving factor of the performance of the Swiss national innovation system : excellence of science, S&T skills and competences, Anchor Tenants, innovative performance of SMEs, financial development and clusters are important characteristics explaining the high innovative performance of the country. Indeed, the assertion of a largely insufficient knowledge and technology transfer between corporations and science institutions in Switzerland is not supported by empirical evidence (KOF, 2005).

However, innovation policy matters and it is particularly clear when we look at the recent history of the Swiss innovation system.
- It matters during **recession period**. Switzerland experienced severe macroeconomic recessions during the nineties (actually a double shock) and as a result R&D intensity declined dramatically in relative term (while public R&D declined in absolute term). Degradation of innovative performance logically followed this period; and there was no R&D policy to play a contra-cyclical role and help financially-constrained firms to maintain R&D capacities during the recession period.

- It matters during **revolution period**. The ICT revolution provided extraordinary economic opportunities and some countries with vigorous public policy exploited them quite successfully. Recent history of the high tech revolution shows the centrality of public policy to create strategic orientations and rapidly redirect resources toward new objectives and fields promising highest returns. Public policy can be very useful to overcome co-ordination failures that may impede a whole system to move toward new fields and topics. This was not the case of Switzerland. The sort of "mission-oriented" policy in these subject matters are new to policy makers and industry managers in this country. Therefore, the strategic capacity in this regard is weak and there is no real policy willingness to generate top down programs in order to help the system as a whole to move and transform its knowledge base[14]. It may be a good thing since many governments have experimented failures in trying to select fields and push the industry to invest in. However, an interesting question for the future is whether the economy will respond positively to the outstanding basic research capacities in nanotechnology. No policy initiative is expected to support some initial market dynamics and to create incentives for the private sector to invest in these fields. Will market incentives only work sufficiently well for pushing the Swiss economy toward these new important areas?

- It matters any time to correct the strongest market failures, and this is a usual case for resource allocation in R&D when SMEs and start ups are concerned. Here the Swiss policy has been active through indirect and neutral mechanisms, and is seeking to expand its scope of intervention. Some policy objectives are currently discussed to improve the interface between universities and small firms, such as a deeper enrolment of Universities of Applied Sciences into technology transfer activities and a better integration of SMEs into the knowledge and technology flows. This should be achieved through boosting the funding of R&D at public research institutions by substantially increasing the resources of the CTI. However the Swiss economy is engaged in a process of restoring a better control of public spending (to keep the deficit down to $1^{1/4}$ per cent

[14] To a minor extent the CTI follows a top-down approach to promote cooperation in specific research areas: innovation for successful ageing, nanoscale technologies, life science and medical technologies. However, the proportion of public funding allocated to this approach is small

of GDP, (OECD, 2005)), making it politically difficult to aim at a large increase of public funding of R&D.

As a general conclusion, the Swiss (and the other national) case(s) make it clear that many institutional models can be used to support technology transfer between the university and industry. National laws and legal environment play an important role in enabling and facilitating the process. However the most important factors deal with the type of "private arrangements" developed:

- at firm level in order to increase absorptive capacities and,
- at university level in order to achieve a good balance between making technology transfer more effective and maintaining the basic missions (pure and long term basic research and education).

The fact that the university level -- *i.e.* the capabilities of university to create rules and organisational structures in a decentralised way as well as the managerial competence and autonomy of the central university administration -- is more important than the national laws dictates is clearly demonstrated by the Bayh-Dole Act experience (David, 2005). Several well-known studies on some leading US research universities have found that biomedical patents issued to US universities between 1969 and 1979 increased by 123% (the BDA was passed in 1980). The first TTO did not open its doors in 1981 and had in fact been in existence for 56 years at the University of Wisconsin and so on. Thus, the Bayh-Dole Act just provided a legal framework for behaviours and strategies that had already existed for a long time in some successful universities.

References

A.Agrawal and I.Cockburn, *University research, industrial R&D and the Anchor Tenant hypothesis*, June 2002

S.Arvanitis, U.Kubli, N.Sydow and M.Wörter, *Knowledge and technology transfer between Universities and private enterprises in Switzerland*, Study on behalf of the ETH-Board, KOF, ETH Zürich, 2006

Computer Science and Telecommunications Board (CSTB), *Funding a Revolution*, Washington DC: National Academies, 1999

P.A.David, *Knowledge spillovers, technology transfers and the economic rationale for public support of exploratory research in Science*, draft, 1998

P.A.David, *Innovation and Universities'role in commercializing research results: second thoughts about the Bayh-Dole experiment*, May 2005

P.A.David and P.Stoneman, *Adoption subsidies vs information provision as instruments of technology policy*, CEPR publication 49, Stanford University, 1985

P.A.David, D.Foray and W.E.Steinmueller, “The research network and the economics of science: from metaphors to organizational behaviours”, in Gambardella and Malerba, *The organization of Economic Innovation in Europe*, Cambridge University Press, 1999

European Commission, *Annual Innovation Policy Trends and Appraisal report: Switzerland*, Enterprise Directorate General, Innovation/SMEs program, 2004-2005

D.Foray and S.Lhuillery, *La Suisse dans une économie globalisée de la connaissance*, CEMI Report, EPFL, December 2005

B.Hall, *University-Industry research partnerships in the United States*, Kansai Conference paper, 2004

F.Jaumotte, *Maintaining Switzerlands' top innovation capacity*, Economic department WP 487, Paris: OECD, 2006

KOF, *Innovative Activities in Switzerland – Strengths and Weaknesses*, Background report, ETH Zürich, 2006

C.Lécuyer, “Academic science and technology in the service of industry: MIT creates a ‘permeable’ engineering school”, *American Economic Review*, vol.88, 2, 1998

B.Lepori and L.Attar, *Research strategies and framework: conditions for research in Swiss Universities of Applied Science*, CTI/KTI report, Lugano

D.C.Mowery and T.Simcoe, “Is the Internet a US revolution? – an economic and technological history of computer networking”, Research Policy, 31(8-9), 2002

R.R. Nelson and P.Romer, “Science, economic growth and public policy”, in Smith and Barfield (eds.), *Technology, R&D and the economy*, The Brookings Institution, Washington DC, 1996

R.R.Nelson and N.Rosenberg, *American universities and technical advances in industry, CEPR publication*, 342, Stanford University, 1994

OECD, *Economic survey of Switzerland*, 2005, Paris

OECD, *Science, technology and Industry scoreboard*, 2005, Paris

N.Rosenberg, *Science and technology: which way does the causation run?*, 2005

A.Saxenian, “Transnational technical communities and regional growth in the periphery”, Saint Gobain Centre for Economic Research, Paris, 2001

A.Sumell, P.Stephan and J.Adams, *Capturing knowledge: the location decision of new PhDs working in industry*, June 2005

C.Zellner, *The origins of high-technology start up companies at EPFL, workshop University-industry linkages*, World bank, Cambridge, UK, December 2005

Knowledge and technology transfer activities	**% of KTT active firms reporting 4 or5 on a 5 point Likert scale**
Informal (% of firms reporting 4 or 5 at least in one single form of the category)	***56.6***
Contacts	30.4
Conference	30.4
Publications	33.1
Technical infrastructure	***11.9***
Common lab	3.9
Use of university technical infrastructure.	10.7
Education	***52.3***
Employing graduates in R&D (+ contacts)	28.5
Students'participation in firm R&D	10.9
Join diploma theses or join PhDs	22.7
University researcher participation in firm	10.1
Attending university training course	22.1
Research	***17.8***
Joint R&D projects	16.3
Long term research contracts	5.0
Research consortium	4.1
Consulting	***15.3***

Figure 1 : The main transfer mechanisms as evaluated by the industry
N = 669
Source : KOF survey 2005

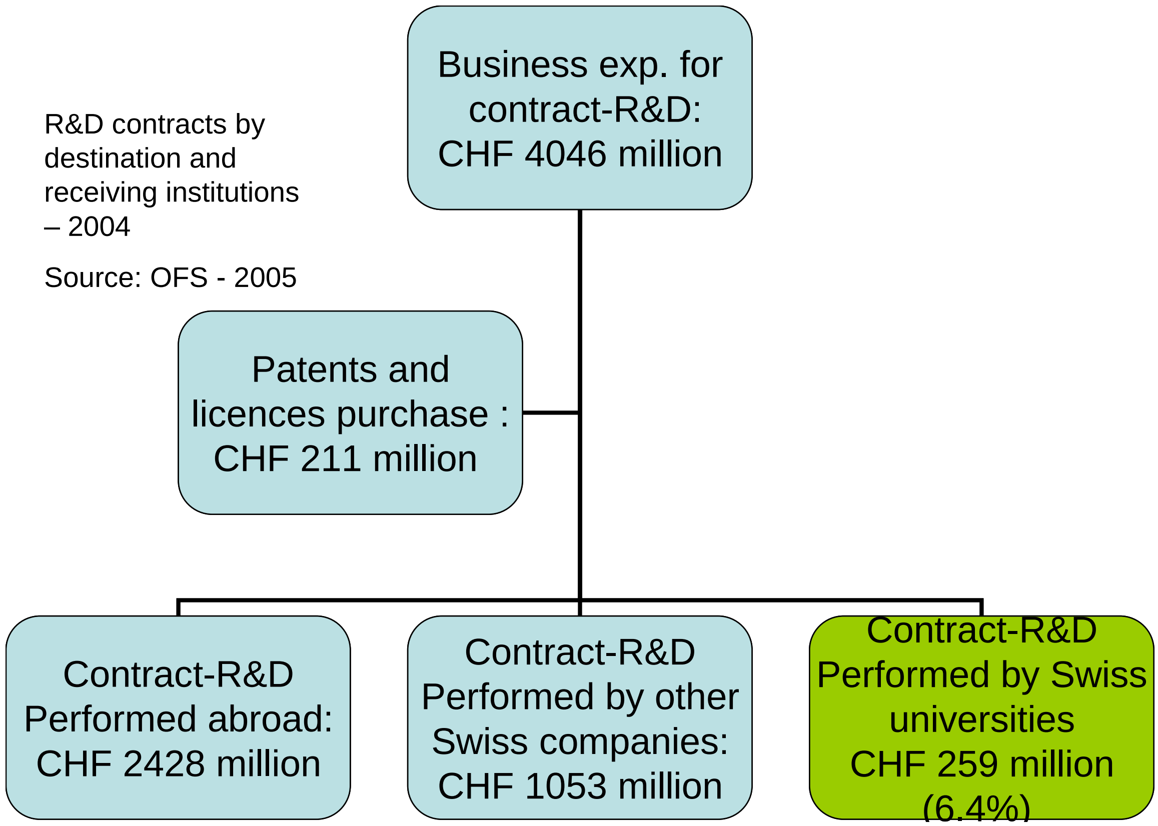


Figure 2 : R&D contracts by destination and receiving institutions (2004)
Source: OFS – 2005

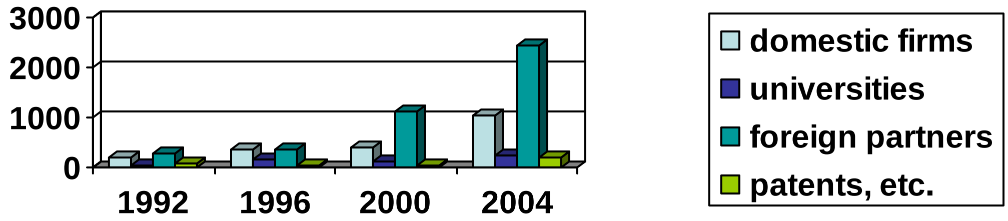


Figure 3 – The historical evolution of extra mural R&D expenditures (Mio SFR)
Source : KOF, 2005

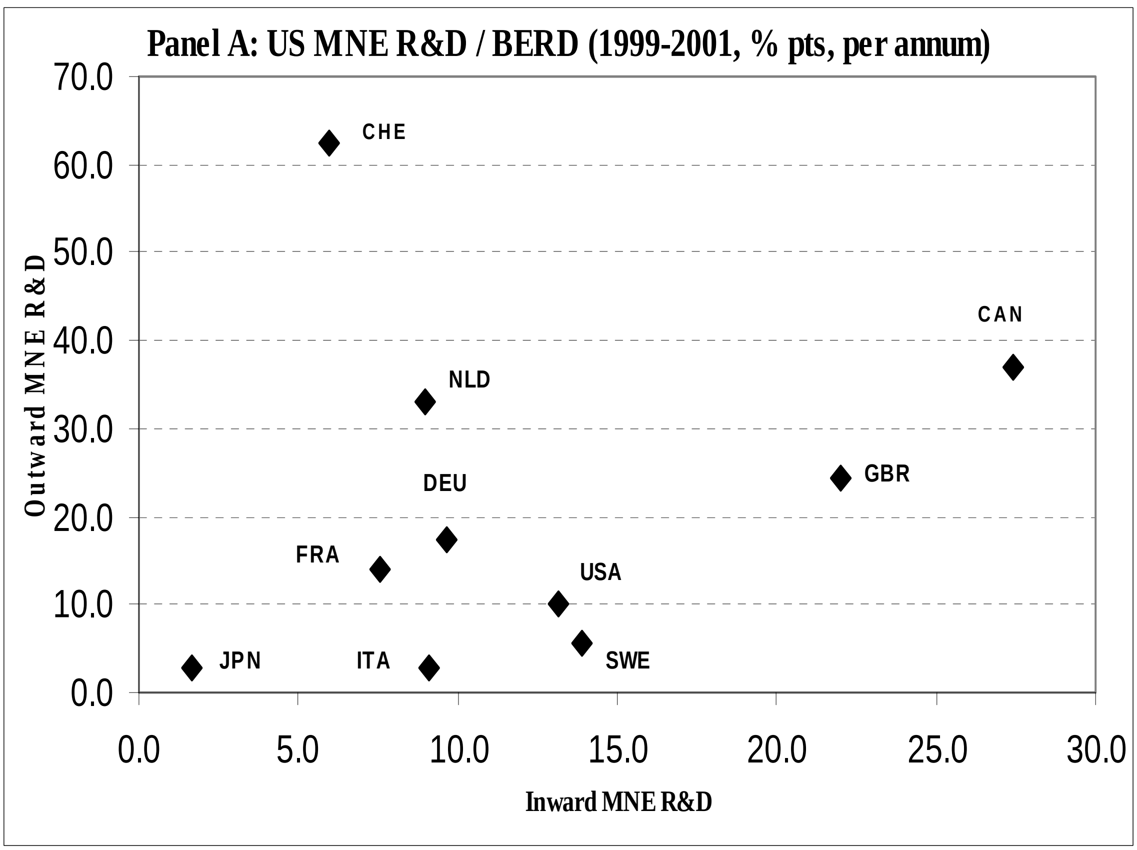


Figure 4 – MNE R&D inward (to USA) and outward (from USA)
Source: Jaumotte and Pain, 2005

Obstacles	% of KT active firms reporting a single obstacle as important
LACK OF INFORMATION	24.1
Difficulties to find contact persons	17.9
FIRM DEFICIENCIES	49.2
Lack of interest in scientific projects	25.0
Firm’s questions not interested for univ.	35.9
DEFICIENCIES OF UNIV.	42.0
R&D orientations of univ. not interesting	25.6
Possible R&D outcomes cannot be commercialized	25.3
COSTS, RISKS	42.4
Lack of in-house financial resources	27.4
Lack of financial resources of univ. To cooperate on an equal basis	12.3
Costly administrative procedures	15.0
Uncertainty about outcomes of coop.	10.8
INSTITUTIONAL OBSTACLES	24.5
Secrecy not guaranteed	10.3
Problems with IP	6.4
Different understanding of priorities	10.1

Figure 5 - Obstacles to knowledge transfer activities
Source: KOF – 2005

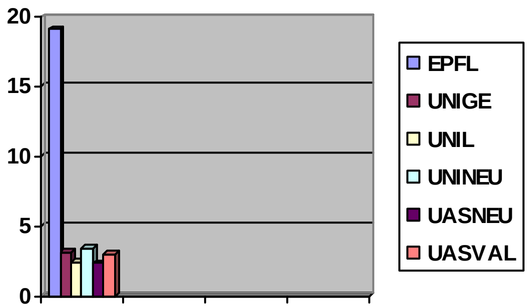
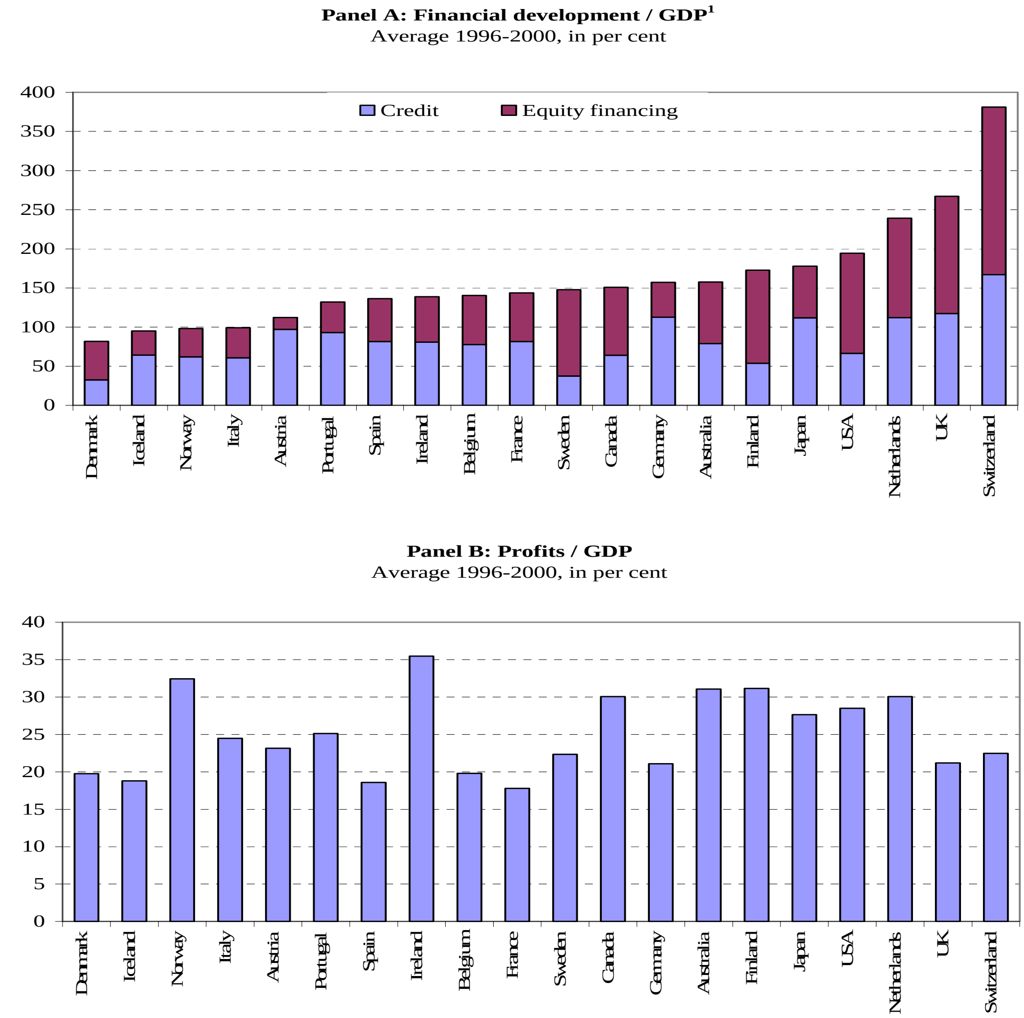


Figure 6 - Percentage of firms with KTT activities by partners in Suisse Romande (2004)
Source: KOF – 2005
EPFL: Ecole Polytechnique Fédérale de Lausanne
UNIGE : University of Geneva
UNIL : University of Lausanne
UNINEU: University of Neuchâtel
UAS : University of Applied Science (School of Engineering canton Neuchâtel)
UAS: University of Applied Science (School of Valais)

Nota: 5 other UAS exist but with percentage lower than 2.3



1. Financial development is defined as the sum of credit and equity financing. Credit refers to private credit by deposit money banks. Equity financing refers to the stock market capitalisation.
Source: World Bank Financial Development and Structure database for data on financial development and OECD Analytical database for data on profits.

Figure 7 – Financial development
Source Jaumotte and Pain, 2005