TECHNOLOGICAL CHANGE AND INTERNATIONAL COMPETITIVENESS: THE CASE OF SWITZERLAND

Stefano Breschi, Rodolfo Helg

Introduction

In this paper we present the preliminary results of a research project on the relationship between trade and technological performance with a special focus on Switzerland. The paper is divided into three major parts. In the first part, after a brief description of the datasets used in the paper, we present an overview of the scientific and technological activity of Switzerland in comparison with the major industrialized countries. In the second part, we characterize some aspects of the relationship between international performance and technological specialization of countries. First, a broad analysis of the sectoral profile of Switzerland's technological and trade specialization will be carried out. Then, a preliminary empirical analysis of the relationship between the two variables will be presented. In both cases, the analysis will deal with the whole aggregate of manufacturing sectors and with a subsample of high-tech sectors. In the third part of the paper, we will deal with the sectoral and the spatial organization of innovative activities for the case of Switzerland. A final section will provide concluding remarks.

The data

In this paper, patent data have been used to measure the innovative capabilities and performance of Switzerland compared with that of other major OECD countries. The data refer to patent applications at the European Patent Office (EPO) of all OECD countries for the period 1980-93. The limitations of patent data are well known. Not all innovations are patented by firms. Different technologies are differently patentable and firms may have different propensities to patent their innovations. The economic value of single patents is highly different and it cannot be assessed unless specific analyses of patent renewals or patent citations are done. However, patents represent a very homogeneous measure of technological novelty across countries and are available for long time series. They also provide detailed data at the firm and technological class levels. For our purposes, they provide therefore a reasonably good measure of innovative activities at the country level.

Patent data have been aggregated according to four classification levels:

a) The whole set of patents has been aggregated into 48 main technological classes and one residual class: whole sample (WS49). These classes have been built at Cespri-Bocconi from the 12-digit disaggregation of the International Patent Classification (IPC), grouping them according to the specific application of patents[1].

b) Two subsamples of patents related to high-technology fields have also been considered. Following a recently elaborated concordance table, patents have been grouped, respectively, into 49 classes (HT49) and 12 high-technology fields (HT12)[2].

c) All patents applied at EPO have been finally classified into 627 technological groups defined by the 4-digit IPC subclasses (WS627). The 627 technological groups have further been divided into four quartiles, according to the rate of change in the total number of patents between the periods 1980-84 and 1989-93. This allowed us to evaluate the contribution of major OECD countries to the areas of greatest technological dynamism.

For the case of Switzerland, patent data have been elaborated also at the firm level, excluding individual inventors. For each patenting firm, the exact name and address has been collected and the total number of patents by year and technological class has been recorded. This allowed us to analyze the sectoral as well as the geographical organization of innovative activities in the Swiss economy and to compare it with other countries for which data at the firm level are already available[3].

Export flows are utilized to build a measure of international economic performance of Switzerland. Data were drawn from the OECD Impex database: it reports export flows in current value (US dollars) for all OECD countries for the period 1980-92. In order to compare technological and market performance of the countries included in our analysis, we built a concordance table between our WS49 technological classes and SITC Revision 2 codes. A perfect matching between the two classifications is not feasible, since the two are based on a different taxonomic approach (Grilliches, 1990). The concordance adopted has reduced the classes from 49 to 37. As far as high-technology fields are concerned, we used the concordance table between high-technology IPC classes and SITC Revision 3 codes elaborated by Cespri, Enea and Politecnico-Milano. Since export data in SITC Revision 3 are only available starting from 1988, our analysis of high-technology classes has been consequently restricted to the period from 1988 to 1992.

Technological competitiveness of Switzerland: an overview

In this section, a broad overview of the technological position of Switzerland is provided by reviewing some aggregate indicators commonly used in these analyses. From table 1 it emerges that among major industrialized countries Switzerland devotes a relatively large amount of resources to research and development (R&D). In relative terms (as a proportion of GDP), Switzerland's expenditures on R&D are second only to Japan in 1993. Moreover, the largest part of these resources are privately funded by business firms (again, in this respect, Switzerland is second only to Japan) and a negligible share of total R&D expenditures is devoted to the military sector.

Table 2 compares over time the share of patents held by each country at different Patent Offices. We have considered patent applications at EPO, on one side, and patent granted by USPO (United States Patent Office), on the other. The figures for Germany, in the former case, and for United States, in the latter, should be interpreted with caution because of the “domestic market” effect. The advantage of using USPO patents together with EPO patents is that the former allow an international comparison over a longer period of time since EPO was created in 1978. Over the longer period, the share of Swiss patents at USPO is slightly decreased (-11%). However, over the shorter period, the decrease in the share of patent applications at EPO has been quite stronger (-25).

TABLE 1 - RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT IN MAJOR OECD COUNTRIES

	R&D exp. as % of GDP		Business funded R&D as % of total R&D exp.		Civil R&D exp. as % of GDP	Share in OECD R&D exp. (%)	
	1981	1993	1981	1992	1992	1981	1992
Switzerland	2.3	2.7[a]	75.1	67.4[b]	2.6	1.2	1.1
Usa	2.4	2.7	48.8	59.1	2.2	46.9	43.7
Japan	2.1	2.9	67.7	76.0	2.9	14.4	18.3
FR Germany	2.4	2.5	57.9	60.8	n.a.	10.2	9.8
France	2.0	2.4	40.9	45.7	2.0	7.1	6.9
Italy	0.9	1.3	50.1	51.5	1.3	2.9	3.6
United Kingdom	2.4	2.2	42.0	51.4	1.8	7.4	5.6
Oecd	2.0	2.2	51.2	59.6	2.0	100.0	100.0

Sources: OECD, Main Science and Technology Indicators, various years; OECD, Industry and Technology. Scoreboard of Indicators, 1995.[a] 1992. [b] Change in survey methods or coverage.

TABLE 2 - PATENTING ACTIVITY OF MAJOR OECD COUNTRIES AT EPO AND USPO [a]

	Share of patents		Share of patents	
	1981-83	1991-93	1963-77	1985-90
	EPO		USPO	
Switzerland	4.8	3.6	1.7	1.5
Usa	27.5	28.4	71.0	52.5
Japan	12.8	22.5	5.7	20.9
Germany	22.5	18.8	7.1	9.0
France	10.0	8.7	2.8	3.3
Italy	2.6	3.7	0.9	1.4
United Kingdom	8.0	5.1	4.2	3.2
Oecd	100.0	100.0	100.0	100.0

Sources: Epo-Cespri database.[a] Patent applications at EPO and granted at USPO.

However, if we combine this fact with others that will be presented in this paper, a slowdown in the technological dynamism of the country may be present[4].

Using again patent applications at EPO and patents granted by USPO, table 3 reports the Revealed Technological Advantage (RTA) index for the major OECD countries in high-technology sectors. The RTA index is defined here as the ratio between the share of patents held by a given country in high-tech sectors in relation to its share of patents in all technological sectors. A value above (below) one indicates therefore a relative strength (weakness) of the country in high-tech sectors. The available data show that Switzerland presents a persistent weakness in high-technology sectors. This is true both for USPO and EPO patent data. However, while the values of RTA at USPO are relatively stable over time, the same cannot be said for RTA at EPO which decreases during the last decade.

Table 4 presents countries' export market shares for industrial sectors aggregated according to their level of technological intensity. As one can note, among major OECD countries, Switzerland shows the largest decrease in its high-tech export market share (-19%) between 1980 and 1992 (compare Germany -9%, Usa -2%). Also this result can be interpreted in different ways. On the one hand, as noted above, far from being new, the relative technological weakness of Switzerland in high-tech sectors appears to be a stable feature over time. On the other hand, as Patel and Pavitt (1995) point out, since the distinction between high and medium technology products is based on R&D intensity, this means that the technological importance of production-instensive (mainly mechanical) and information-intensive (mainly software) products are often underestimated.

TABLE 3 - REVEALED TECHNOLOGICAL ADVANTAGES OF MAJOR OECD COUNTRIES IN HIGH-TECHNOLOGY SECTORS AT EPO AND USPO

	EPO		USPO		
Country	1980-84	1989-93	1963-77	1978-84	1985-90
Switzerland	0.75	0.65	0.72	0.75	0.76
Germany	0.90	0.74	0.86	0.92	0.91
France	0.89	0.81	1.08	1.39	1.02
Uk	0.82	0.94	1.08	1.23	1.31
Italy	0.57	0.60	0.78	0.78	0.67
Japan	1.37	1.24	1.19	0.99	1.11
United States	1.20	1.22	1.01	1.01	0.98

Source: Epo-Cespri database for EPO data; Enea (1994) for USPO data.

TABLE 4 - EXPORT MARKET SHARES OF MAJOR OECD COUNTRIES IN HIGH-, MEDIUM- AND LOW-TECHNOLOGY INDUSTRIES[a]

	High Technology		Medium Technology		Low Technology	
	1980	1992	1980	1992	1980	1992
Switzerland	4.3	3.5	3.1	3.0	1.4	1.6
Usa	24.1	23.5	16.6	14.0	10.6	11.6
Japan	16.5	20.0	12.4	15.9	8.9	6.4
FR Germany	15.8	14.3	19.7	20.7	13.5	14.7
France	7.8	8.3	9.3	8.6	10.2	10.0
Italy	4.5	4.1	6.3	6.1	9.0	9.5
United Kingdom	10.7	8.9	9.6	6.9	7.0	6.2
Oecd	100.0	100.0	100.0	100.0	100.0	100.0

Source: OECD, Industry and Technology. Scoreboard of Indicators, 1995.[a] Industries are grouped on the basis of their R&D intensity in the OECD area as a whole, defined as the ratio of business-enterprise R&D to production.

On the whole, the aggregate picture emerging in this paragraph does not allow us to draw any clear conclusions about the competitive position of Switzerland. Although Switzerland is one of the OECD countries which devote most resources to research and innovative activities, it also shows technological and comparative disadvantages in the most dynamic sectors. In the following sections, we will attempt to shed some light on this puzzling question.

Sectoral strengths and weaknesses of Switzerland

In the following three subsections, we intend to provide a description and an assessment of the technological and trade specialization of Switzerland in specific fields of technology. In this regard, the position of Switzerland will be evaluated on the basis of the four disaggregation of patents mentioned above. In the first place, sectoral patterns of Switzerland's technological and trade specialization will be analyzed considering the whole sample of patents (WS49). A more detailed analysis will be then carried out using two subsamples of high-technology sectors (HT12 and HT49). Finally, the technological performance of Switzerland will be assessed considering a subsample of fast-growing technological subclasses (WS627).

The whole sample (WS49)

In order to evaluate the profile of Switzerland's trade and technological specialization we have used, throughout this section, two different measures. The former is the Revealed Comparative Advantage index (RCA), defined as the share of a country's exports in a given sector in relation to the share of exports of the same country in all sectors:

$$RCA_{ij} = \frac{E_{ij} \big/ \sum_i E_{ij}}{\sum_j E_{ij} \big/ \sum_i \sum_j E_{ij}}$$

where E_{ij} is the value of exports of country i in sector j. The index range is between 0 and $+\infty$. It is equal to 1 (respectively, greater than 1) if the country i's share of exports in sector j is exactly the same (respectively, greater than) as its share of exports in all sectors. A value of the index above (respectively, below) 1 therefore indicates a relative strength (weakness) of the country in a given sector and it should not be

The latter is the Revealed Technological Advantage (RTA), defined in a similar way as:

$$RTA_{ij} = \frac{P_{ij} \big/ \sum_i P_{ij}}{\sum_j P_{ij} \big/ \sum_i \sum_j P_{ij}}$$

where P_{ij} is the number of patents of country i in sector j. A value of RTA greater than 1 therefore indicates a relative technological specialisation of country i in sector j.

The totals used to calculate both indexes- exports for RCA and patents for RTA- refer in this and the following sections to the group of 26 OECD countries[5].

The values of Switzerland's RTA and RCA are reported in table 5, respectively, for the 1991-93 period and the 1990-92 period. The table also shows the percentage change in both indicators over the previous decade[6]. From the technological perspective, Switzerland presents relevant advantages in textiles (18), food (1), chemical processes for food (20) and materials handling apparatus (29). In all these classes, the value of

RTA is consistently higher than one and growing over time. However, other relative advantages can be also found in several classes related to mechanical engineering (like industrial machinery equipment (24), machine tools (22), industrial automation (23) and measurement instruments (36)) and to chemical industry (like, organic chemicals (8), adhesives (11), bio-chemicals (12), chemical treatment of fibres (18) and agricultural chemicals (19)). In most of these classes too, the values of RTA are increasing over time. A special mention deserves the case of biotechnology (12). Although relevant weaknesses were present at the beginning of the 80s, Switzerland has recovered lost ground in this emerging technology which has become an area of relative specialisation for the country. On the contrary, areas of remarkable and persistent weakness are represented by electronics and allied technologies (from 39 to 45).

In brief, the profile of Swiss technological specialisation is quite mixed ranging from science-based (like biotechnology) to scale intensive technologies (such as adhesives and organic chemicals), and from traditional and supplier dominated (like textiles) to specialized supplier sectors (like machinery). Moreover, sectoral patterns of technological specialisation appear also remarkably stable over time. This is confirmed by the figure 1, which reports the scatterplot of RTAs in the two subperiods. With few exceptions, points are located in the north-east and in the south-west quadrants along the bisecting line. In addition, Pearson and Spearman rank correlation coefficients are, respectively, 0.86 and 0.88.

On the trade side, sectoral patterns of Switzerland's comparative advantage are broadly coherent with its technological specialisation. In fact, Switzerland shows comparative advantages in certain chemical technologies (like organic chemicals (8), adhesives (11), misc. chemical compounds (13) and agricultural chemicals (19)) in several mechanical sectors (such as, machine tools (22), industrial machinery (24), mechanical engineering (32) and measurement instruments (36)) and in a few traditional sectors (like, clothing (2) and sports (46)). Areas of relevant and increasing weakness are instead found in all electronic sectors (from 39 to 44, except 41), in optics (38) and transport technologies- especially, vehicles (26), agricultural machinery (25), aircraft (27), railways (28). In the case of optics (38), it should be noted that Switzerland had a comparative advantage in this sector at the beginning of the 80s.

Similarly to technological, also the sectoral patterns of comparative advantage are remarkably stable over time. Evidence in this regard is provided by figure 2 which reports the scatterplot of RCA for the two subperiods. With small deviations, points are located in the north-east and the south-west quadrants along the bisecting line, as confirmed by Pearson and Spearman rank correlation coefficients which are both equal to 0.98[7].

TABLE 5 - REVEALED TECHNOLOGICAL AND COMPARATIVE ADVANTAGES

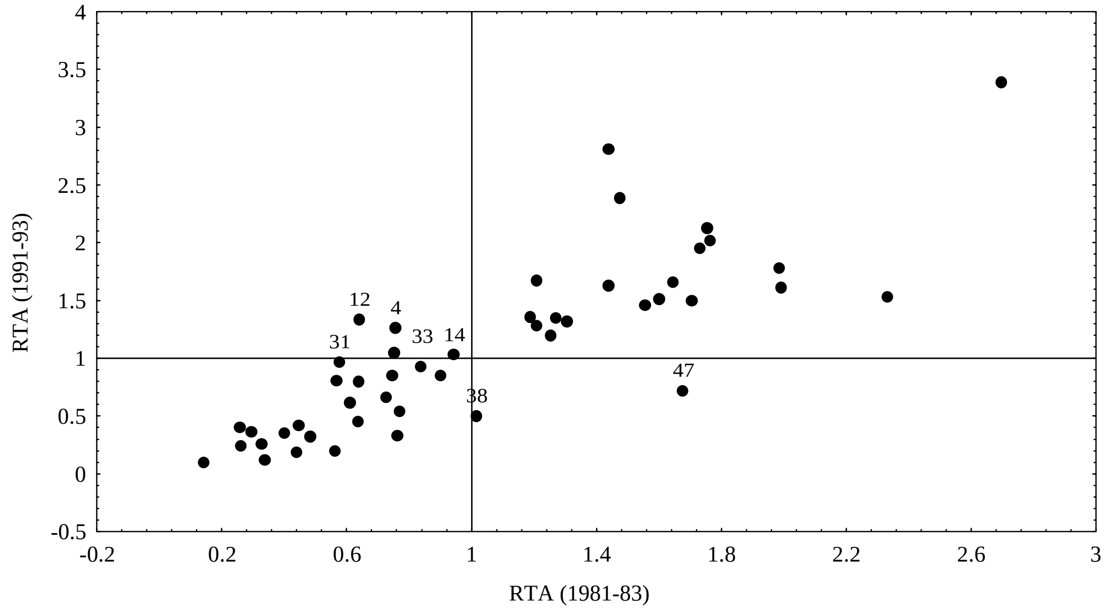
SWITZERLAND , 49 TECHNOLOGICAL CLASSES (WS49), CUMULATIVE VALUES AND PERCENTAGE CHANGE

Technological Classes	RTA 1991-93	Δ (%) 91-93/81-83	RCA 1990-92	Δ (%) 90-92/80-82
1. Food and Tobacco	2.16	25.15	0.32	6.67
2. Clothing and Shoes	1.83	-5.16	1.19	-22.22
3. Furnitures	1.47	-12.59	0.84	37.70
4. Agriculture	1.17	55.48	-	-
5. Mining	0.45	-24.50	-	-
6. Gas, Hydrocarbons, Oil	0.36	25.12	0.04	100.00
7. Inorganic Chemicals	0.86	16.76	0.36	-2.70
8. Organic Chemicals	1.62	-1.74	2.23	-7.47
9. Macromolecular Compounds	0.81	43.02	0.59	1.72
10. New Materials	0.61	-0.90	2.32	8.41
11. Adhesives, Coatings, Resins	1.54	-33.68	3.52	-25.58
12. Biochemicals, Bio and Genetic Engineering	1.28	103.32	-	-
13. Miscellaneous Chemical Compounds	0.56	-19.82	1.29	15.18
14. Chemical, Physical Processes	1.01	7.49	-	-
15. Drugs	0.83	-5.17	4.79	-4.58
16. Medical Preparations	1.36	5.72	1.21	1.68
17. Natural or Artificial Fibres, Paper	3.35	22.86	0.86	-12.24
18. Chemical Treatment of Natural or Artificial Fibres	1.96	12.81	-	-
19. Agricultural Chemicals	1.58	-19.16	1.48	13.85
20. Chemical Processes for Food and Tobacco	2.77	91.63	-	-
21. Metallurgy	0.56	-28.39	0.67	15.52
22. Machine Tools	1.29	5.36	2.60	1.17
23. Industrial Automation	1.32	2.26	-	-
24. Industrial Machinery and Equipment	1.70	40.38	2.72	-21.16
25. Agricultural Machinery	0.27	-19.35	0.19	0.00
26. Vehicles, Motorcycles	0.42	-6.64	0.09	28.57
27. Aircraft	0.26	7.44	0.20	5.26
28. Railways, Ships	1.21	-2.79	0.18	5.88
29. Materials Handling Apparatus	2.39	61.21	0.73	-15.12
30. Civil Engineering	1.48	-4.84	0.19	58.33
31. Engines, Turbines, Pumps	0.94	63.24	0.77	-29.36
32. Mechanical Engineering	0.94	12.33	1.40	-5.41
33. Mechanical and Electric Technologies	1.05	37.26	1.16	11.54
34. Household Electric Appliances	1.64	13.73	0.58	-1.69
35. Lighting Systems	0.32	-33.41	-	-
36. Measurement and Control Instruments	1.34	12.63	5.62	-6.80
37. Laser Technology	0.33	-55.73	-	-
38. Optics and Photography	0.50	-50.89	0.81	-35.20
39. Computers, Data Processing Systems	0.10	-27.11	0.21	-12.50
40. Other Office Equipment	0.19	-57.66	0.38	-33.33
41. Electrical Devices and Systems	0.80	24.55	1.44	-22.99
42. Electronic Components	0.35	-12.19	0.22	-33.33
43. Consumer Electronics	0.20	-66.08	0.15	-28.57
44. Telecommunications	0.31	-20.24	0.40	-47.37
45. Multimedial Systems	0.11	-74.42	-	-
46. Decorative and Figurative Arts, Sports, Toys	1.53	-6.17	1.51	0.67
47. Ammunitions and Weapons	0.76	-54.30	0.41	51.85
48. Nuclear Technology	0.42	64.83	-	-
49. Others	2.02	15.32	-	-

Source: Epo-Cespri database. *Note*: the symbol (-) indicates classes for which it was not possible to establish a concordance between technological and productive sectors.

Figure 1 - Revealed Technological Advantages, Switzerland

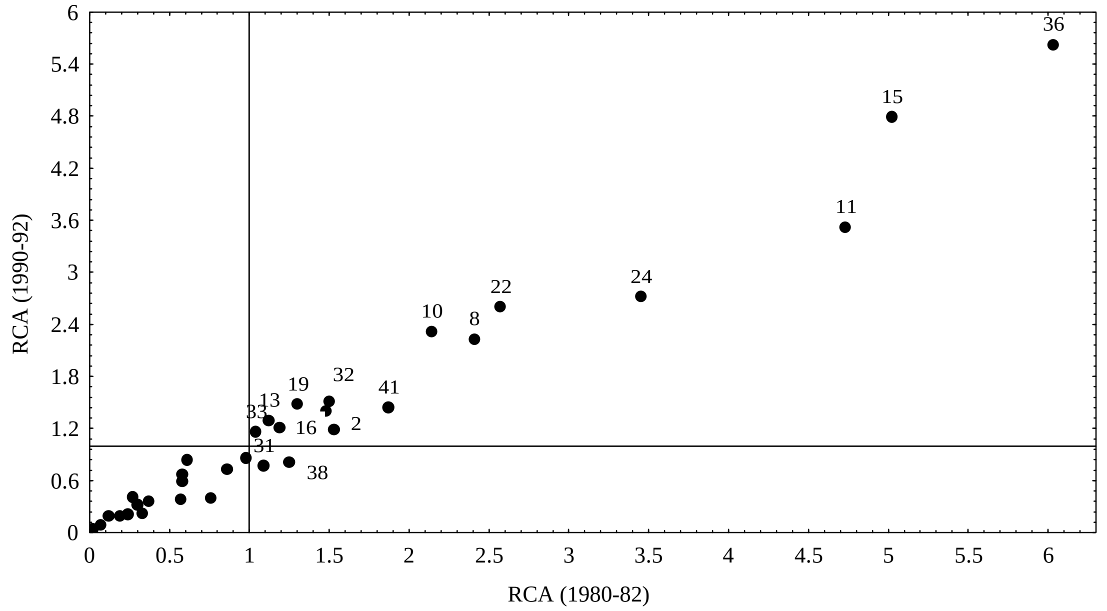
1981-83 and 1991-93, Cumulative



Note: the Pearson correlation coefficient is 0.86; the Spearman rank correlation coefficient is 0.88. Both are significant at 1% level.

Figure 2 - Revealed Comparative Advantages, Switzerland

1980-82 and 1990-92, Cumulative



Note: the Pearson correlation coefficient is 0.98; the Spearman rank correlation coefficient is 0.98. Both are significant at 1% level.

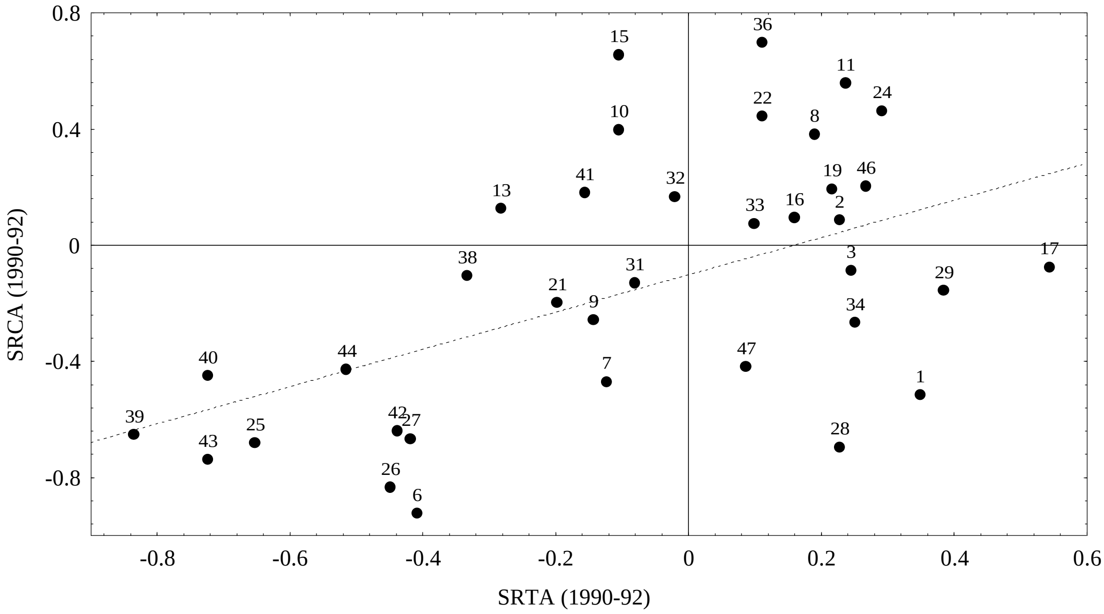
Although at first glance there seems to be evidence in support of a correlation between the technological and trade specialisation of Switzerland, several exceptions should be however noted. While a deeper analysis of the relationship between RCA and RTA will be carried out in a later section, we have here plotted the values of RTA against RCA for our 37 technological classes. For graphical purposes, we have transformed RCA as:

$$\mathrm{SRCA} = \frac{\mathrm{RCA} - 1}{\mathrm{RCA} + 1}$$

The standardized RCA has the following properties. It ranges between -1 and +1. A value above (below) zero indicates a relative comparative advantage (disadvantage). A value of the indicator equal to zero indicates the absence of any specialisation. The same transformation has been applied to RTA.

The scatterplot of the standardized values of RCA and RTA for the period 1990-92 is reported in figure 3.

Figure 3 - Revealed Technological vs. Revealed Comparative Advantages
Switzerland, 1990-92, Cumulative



Note: the Pearson correlation coefficient is 0.50; the Spearman rank correlation coefficient is 0.44. Both are significant at 1% level.

By and large, the evidence seems to support the existence of a certain correlation between the two variables. In most sectors, a relative comparative advantage (disadvantage) is generally matched by a relative technological specialisation (weakness). This is confirmed also by Pearson and Spearman rank correlation coefficients which are, respectively, equal to 0.50 and 0.44. However, there are also several sectors which deviate from such pattern. On the one hand, there is a group of sectors in which a good technological performance does not apparently translate into relative trade advantages- like weapons (47), food (1), household appliances (34) and railways (28). On the other hand, there is a group of sectors for which, conversely, a poor technological performance is matched by relative comparative advantages, like miscellaneous chemical compounds (13), electrical systems (41), new materials (10) and, especially, drugs (15).

The factors causing such deviation from the expected pattern are probably different for the two groups of sectors. Although a fuller analysis of these factors is beyond the scope of this paper, two points should be noted. In the first place, several R&D establishments of foreign multinational firms (e.g. IBM, Siemens-Albis) are located in Switzerland. While this may result in good technological performance as expressed by patents, the production of goods incorporating innovations often takes place in the home country thus resulting in a mismatch between technological and trade specialisation (Schmoch, Grupp and Laube, 1996). The converse may be also true. In the case of Ciba-Geigy, for instance, a number of relevant patents in biotechnology are registered by its US branch Ciba Corning Diagnostics.

In the second place, a fundamental methodological problem must be pointed out. In the previous analysis it has been implicitly assumed a one-to-one concordance between the technological and productive sectors. Thus, for instance, the pharmaceutical sector is defined by matching the A61K IPC subclass with the 54 SITC Rev. 2 sector. However, it should be stressed that in affecting the comparative strength of a country in a certain sector (e.g. pharmaceutical), several related and allied technologies (e.g. biotechnology, vitamins, etc.) can play a fundamental role. It becomes therefore essential, in order to evaluate correctly the relationship between technological and comparative advantages, to assess the contribution of apparently distant technologies, which may provide fundamental knowledge spillovers to receiving sectors. Of course, in order to carry out this type of analysis, one needs to map the flows of knowledge spillovers among technological sectors. Efforts in this direction are currently done at Cespri-Bocconi.

However, a second methodological problem, closely related to the previous one, should be also pointed out. European Patent Office assigns patents according to two forms of classification: main and supplementary codes. The main code is a single technological class which provides the “invention information”, i.e. technical information as defined by the claims. In assigning patents to main codes, EPO uses “function-oriented” criteria, i.e. inventions are assigned to one IPC class according to the specific technical function performed. In addition to that, patents are also assigned by EPO to (multiple) supplementary classes according to “application-oriented” criteria, i.e. inventions are assigned to IPC classes according to the specific field of technical applications. In building our concordance between technological and productive sectors, we have exclusively used patents classified according to main codes, thus missing a piece of relevant information provided by supplementary codes. A concrete example of the problems created by this methodology, which is commonly used in all studies on patenting, is represented by the case of pharmaceutical sector in Switzerland. As it has been noted above, in this sector, there is apparently a mismatch for Switzerland between a relative technological weakness and a relative comparative specialisation. This situation reflects the fact that the share of patents registered by Switzerland under the main code A61K- which defines in our classification the pharmaceutical sector- is lower than its share of total patents[8]. However, if we consider also those patents containing as a supplementary code the class A61K, Switzerland shows a relative technological specialisation in pharmaceutical (as it was expected). Interestingly enough, the majority of patents reporting as a supplementary code the class A61K are classified in the main code C07C, C07D, C07G, and C07M, which correspond to vitamins, provitamins and antibiotics and which do not therefore belong, from a purely technical point of view, to the pharmaceutical sector. The risk of considering only patents classified under the main code is therefore that of drawing wrong or biased inferences on the relationship between relative technological and trade specialisation. In this respect, the next step of our research is to evaluate the differences in such relationship when patents are classified according to supplementary classes.

The high-tech sample (HT12 and HT49)

The analysis carried out in the previous section can be replicated for the subsample of high-technology sectors, therefore allowing a better evaluation of the technological and competitive position of Switzerland in sectors at the technological frontier. To this end, we have calculated the values of RCA and RTA both for the subsample of 12 high-tech fields (HT12) and for the more disaggregated subsample of 49 high-tech classes (HT49). Note that RTA and RCA have been calculated as the share of a country in a given high-tech class relative to the share of that country in all classes (not only high-tech).

Switzerland's RTA in the 12 high-tech fields for the 1980-84 and the 1989-93 periods are reported in table 6. To permit an international comparison, we have also reported the same indicators for the major OECD countries. The evidence shows that among high-tech sectors Switzerland concentrates its areas of relative strength in pharmaceutical (1), specialty chemicals (3) and industrial automation (5). Quite surprisingly, it shows relative weaknesses in both precision instruments (11) and optical instruments (12), which at the aggregate level are a sector of strength (see above). Relevant and persistent disadvantages are instead found in electronics- computers (6), consumer electronics (7), electronic components (9)- and in aerospace (10).

TABLE 6 - REVEALED TECHNOLOGICAL ADVANTAGES, MAJOR OECD COUNTRIES

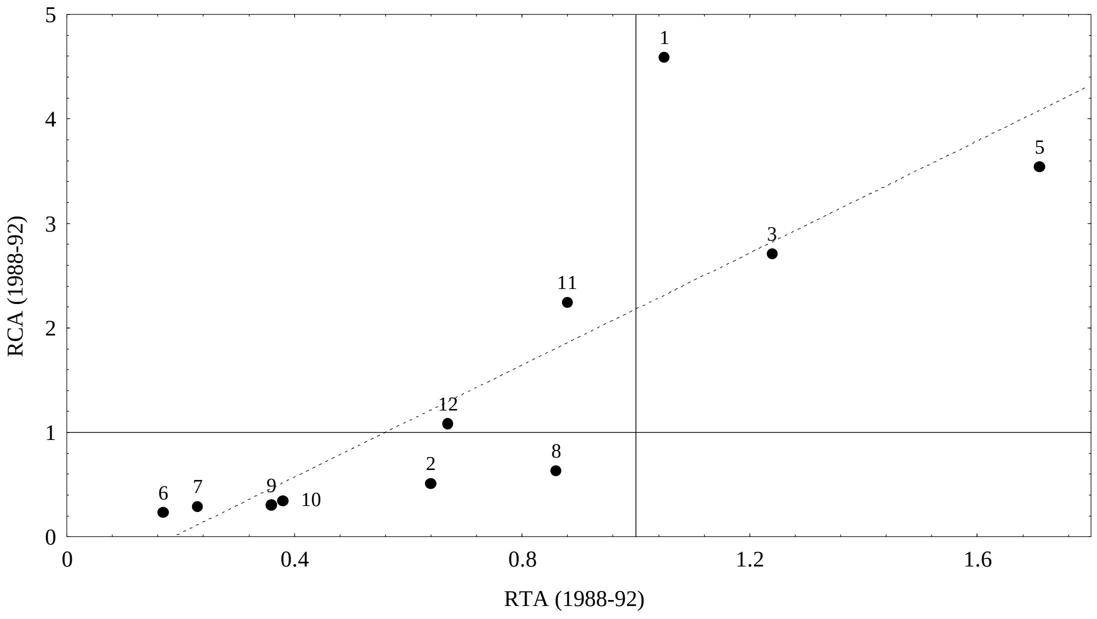
12 HIGH-TECHNOLOGY FIELDS (HT12), 1980-84 AND 1989-93, CUMULATIVE VALUES

	Switzer.		Germany		France		UK		Italy		Japan		USA	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1 Pharmaceutical	0.97	1.10	0.56	0.52	0.72	0.68	1.18	1.35	0.59	0.95	1.49	0.82	1.32	1.46
2 Plastics. Elastomers	0.42	0.62	1.25	1.09	0.46	0.46	0.58	0.65	0.61	0.85	1.16	1.22	1.41	1.19
3 Specialty Chemicals	1.98	1.10	1.26	0.85	0.42	0.79	0.85	1.23	0.56	0.43	1.08	1.13	1.05	1.17
4 New Materials	0.60	0.77	1.12	0.98	1.36	1.08	1.12	0.82	0.43	0.65	1.19	1.37	0.71	0.89
5 Industrial Automation	1.57	1.53	1.04	1.39	1.14	1.05	0.77	0.92	0.99	1.32	1.40	1.05	0.76	0.61
6 Computers	0.23	0.16	0.51	0.30	0.64	0.62	0.58	0.70	0.39	0.31	1.75	1.48	1.77	1.70
7 Consum. Electr., Telecom.	0.38	0.24	0.95	0.68	1.35	0.94	0.79	0.93	0.66	0.43	1.38	1.51	0.93	0.98
8 Electromedical App.	0.81	0.89	0.88	0.84	0.55	0.72	0.41	0.59	0.89	0.60	1.10	0.51	1.40	1.74
9 Electronic Components	0.31	0.34	0.70	0.57	0.94	0.70	0.60	0.54	0.23	0.54	2.05	1.78	1.24	1.10
10 Aerospace	0.16	0.36	0.71	0.91	2.59	2.88	1.89	2.51	0.51	0.48	0.10	0.19	1.26	1.21
11 Precision Instruments	0.78	0.92	0.88	0.96	1.02	1.09	1.09	1.20	0.63	0.62	1.15	0.92	1.12	1.11
12 Optical Instruments	0.86	0.65	0.96	0.76	1.16	0.84	0.75	1.00	0.55	0.42	1.16	1.32	1.11	1.23

Source: Epo-Cespri database. *Note*: 1=1980-84, 2=1989-93.

The relationship between the sectoral profile of technological and trade specialisation in the 12 high-tech fields is illustrated for the case of Switzerland in figure 4, which reports the scatterplot of RCA and RTA in the period 1988-92.

Figure 4 - Revealed Technological and Revealed Comparative Advantages
Switzerland, 12 High-Technology Fields, 1988-92, Cumulative



The evidence seems to support the existence of a correlation among the two variables. In the case of specialty chemicals (3) industrial automation (5) and pharmaceutical (1), a good technological performance is matched by a relative comparative trade advantage. Conversely, in electronics (6,7,9), plastics (2), aerospace (10) and electromedical apparatus (8) poor technological performances are matched by relative trade weaknesses. A deviation from this pattern is represented by two sectors, precision instruments (11) and optical instruments (12), in which Switzerland shows good trade performances in spite of relative technological weaknesses.

A more detailed analysis of Switzerland’s specialization in high-technology sectors has been carried out considering the disaggregation of our 12 high-tech fields into 49 high-tech classes. For each of these classes, we have calculated RTA and RCA indexes for the period 1988-92 (see table 7). From this disaggregation, it emerges a clearer picture of Switzerland’s areas of technological and comparative strength and weakness. The data show that Switzerland concentrates its areas of technological and comparative strength in classes related to pharmaceutical industry (like, vitamins, hormones, genetic engineering) and mechanical industry (like, industrial robots, numerically controlled machines and measurement instruments). On the other hand, areas of both technological and comparative disadvantage are found in fields related to electronics, optics and photography and aerospace. The interesting point, however, concerns the group of sectors located in the north-west quadrant of table 7. For these sectors, in fact, a relative comparative strength (RCA>1) is not matched by a corresponding technological specialisation (RTA<1). A closer look at the data, however, suggests a possible interpretation of this apparent mismatching between the two variables. Among the sectors located in such quadrant, in fact, one can find a relevant number of pharmaceutical (like, reagents, vaccines, other medical specialties) and instruments classes (like, instruments for calculus, automatic control, etc.). As mentioned above, within these fields, Switzerland presents both technological and comparative advantages in a number of other sectors. It may well be possible that these latter sectors contribute in a fundamental way to explain the comparative strength of the former sectors. Thus, for instance, the good technological performance of Switzerland in vitamins and hormones could contribute to explain not only the relative trade specialisation of Switzerland in this specific class of products, but it could also contribute to determine its comparative advantages in vaccines and reagents. In other terms, our claim is that it is not possible to correctly evaluate the relationship between technological and trade specialisation by matching one-to-one technological and productive classes, unless an explicit analysis of the flows of knowledge spillovers among technological classes is done.

TABLE 7 - REVEALED TECHNOLOGICAL AND REVEALED COMPARATIVE ADVANTAGES

SWITZERLAND, 49 HIGH-TECHNOLOGY CLASSES (HT49), 1988-92, CUMULATIVE VALUES

RCA>1 **RTA<1** 5 Other Medical Specialties (0.99 , 5.20) 40 Instrum. for Calculus, Drawing etc. (0.95 , 2.83) 41 Instrum. for Phys. & Chem. Analysis (0.90 , 2.51) 3 Vaccines, Serums (0.76 , 2.64) 17 Adhesives (0.75 , 1.84) 42 Other Control Instruments (0.64 , 2.80) 43 Instrum. for Automatic Control (0.63 , 2.08) 4 Reagents (0.65 , 1.64) 39 Instrum. for Geophysics, Meteo, etc. (0.58 , 1.53) 46 Optical Fibres (0.51 , 2.10) 7 Tecnopolymers (0.43 , 1.62) 14 Cosmetics (0.42 , 1.64) 48 Optical Precision Instruments (0.37 , 1.36)	**RCA>1** **RTA>1** 13 Dyeing (5.97 , 8.36) 19 Numerically Controlled Machine Tools (1.78 , 3.55) 16 Phitopharmaceuticals (1.60 , 3.55) 1 Vitamins, Provitamins, Antibiotics (1.45 , 5.35) 45 Measur. Instrum. for Liquids, Gas (1.37 , 2.48) 2 Hormones (1.06 , 4.10) 44 Measur. Instrum. for Radiations/Electr. (1.04 , 1.13) 20 Industrial Robots (1.03 , -) 6 Genetic Engineering (1.02 , -)
RCA<1 **RTA<1** 49 Photography (0.95 , 0.95) 33 Electrodiagnostic Apparatus (0.93 , 0.61) 47 Lenses, Prisms, etc. (0.82 , 0.53) 18 Chem. Products for Electronics (0.73 , -) 12 Catalysts (0.72 , 0.14) 35 Vacuum Tubes (0.62 , 0.63) 34 X-Ray Apparatus (0.62 , 0.63) 31 Radars, Radio Receivers (0.60 , 0.99) 23 Photocopiers (0.59 , 0.05) 8 Thermoplastics (0.50 , 0.23) 32 Telecommunications (0.40 , 0.46) 36 Printed Circuits (0.40 , 0.13) 38 Aerospace (0.38 , 0.29) 29 Phones (0.35 , 0.98) 26 Microphones (0.33 , 0.30) 10 Nat. & Synthetic Rubber (0.33 , 0.08) 15 Tapes, Films (0.32 , 0.67) 37 Active Electronic Components (0.29 , 0.25) 28 Cameras (0.24 , 0.07) 30 Switching Apparatus (0.21 , 0.17) 27 Radio, Tv Sets (0.14 , 0.23) 21 Computers (0.13 , 0.24) 22 Memories (0.10 , 0.22) 25 Video, Audio Recorders (0.06 , 0.25)	**RCA<1** **RTA>1** 24 Other Office Machines (2.79 , 0.85) 11 Mineral Oils Additives (1.04 , 0.41) 9 Resins, Polyacetyles (1.01 , 0.67)

Source: Epo-Cespri database; OECD, Impex database. *Note*: the first number refers to the value of RTA, while the second number refers to value of RCA. The symbol (-) indicates that it was not possible to establish a concordance between technological and productive classes.

The fast-growing technological subclasses (WS627)

The results discussed in the two previous sections can be further qualified by looking at countries' sectoral strengths and weaknesses from a slightly different perspective. As many authors have pointed out, the contribution of individual technological classes to the overall technological and market performance of countries is highly skewed: while some have a substantial impact being associated to expanding product markets and to increasing competition among countries, others play a marginal and often negligible role (Archibugi and Pianta, 1992). From such perspective, an indicator of the relative technological importance of various classes is the rate of growth in the total number of patents. As case studies and empirical investigations have shown, fast-growing technological classes often correspond in fact to new or enlarging markets and in any case they identify the technological frontier (Patel and Soete, 1988; Trajitenberg, 1990; Walsh, 1984).

In order to evaluate the position of Switzerland in fast growing technological fields, in this section we consider the 627 technological subclasses as defined by the 4-digit level of the International Patent Classification Such subclasses have been further divided into four quartiles according to the rate of growth in the total number of patents applied at EPO between the 1980-84 period and the 1989-93 period. For 7 of the 627 technological subclasses, the rate of growth was not calculable since there were no patents in both periods. For this reason, our sample is reduced to 620 technological subclasses. The first quartile- declining subclasses- includes 153 4-digit subclasses with low or negative rates of growth (< 15%). The second quartile- stable subclasses- includes 156 subclasses with a rate of growth between 16% and 60 %. The third quartile- medium-growing subclasses- comprises 155 subclasses with a rate of growth between 61% and 115%. Finally, the fourth quartile- fast-growing subclasses- includes 156 subclasses with rates of growth above 116%[9].

A first indicator of countries' technological specialisation in groups growing at different rates is shown in Table 8, which reports the revealed technological advantage index for the major OECD countries in the 1980-84 and the 1989-93 periods. The data show that only Japan and Usa exhibit a clear pattern of specialisation in the most dynamic groups. On the other hand, all European countries, besides presenting persistent weaknesses in fast-growing patent groups, show an increasing specialisation in medium and especially stable and declining patent groups. This is particularly true for Switzerland whose index of specialisation in declining classes remarkably increases between the two periods thus resulting the highest among major OECD countries[10].

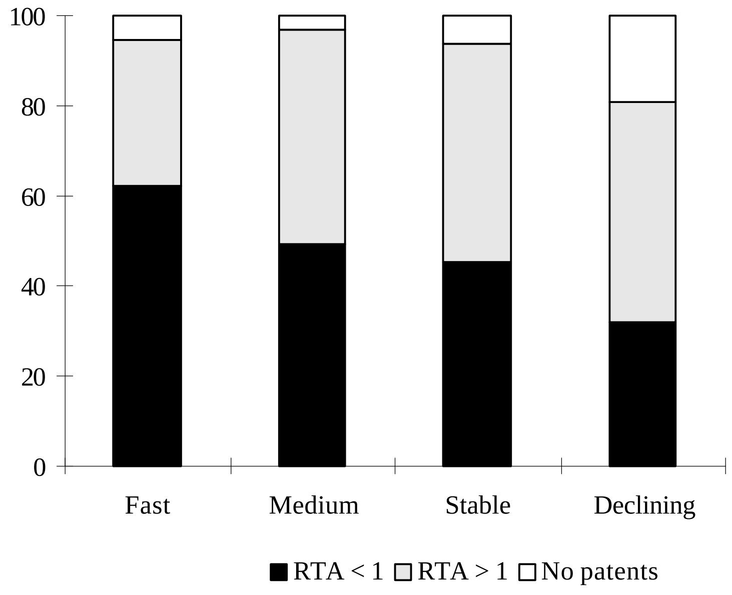
TABLE 8 - REVEALED TECHNOLOGICAL ADVANTAGES
IN FAST-GROWING TECHNOLOGICAL SUBCLASSES (WS627)
MAJOR OECD COUNTRIES

	Fast Growing		Medium Growing		Stable		Declining	
	1980-84	1990-93	1980-84	1990-93	1980-84	1990-93	1980-84	1990-93
Switzerland	0.68	0.72	0.99	1.10	1.23	1.25	1.28	1.62
FR Germany	0.82	0.76	1.01	1.14	1.12	1.17	1.15	1.30
France	0.94	0.85	0.95	1.00	1.09	1.29	1.11	1.17
UK	0.88	0.91	1.03	1.02	1.07	1.12	1.02	1.18
Italy	0.76	0.69	1.10	1.17	1.04	1.22	1.18	1.40
Japan	1.38	1.26	0.92	0.88	0.87	0.78	0.63	0.61
Usa	1.20	1.16	1.03	0.94	0.87	0.85	0.72	0.68

Source: Epo-Cespri database.

Further evidence on the position of Switzerland in fast-growing technological groups is provided in Graph 1, which reports the percentage distribution of RTA values in the period 1989-93 within each of the four categories identified by the growth rate in world patenting. In fast-growing technological groups, Switzerland presents a specialisation (RTA>1) only in 44 out of 156 subclasses, or 28% of all fast-growing subclasses. Such share is the lowest among major OECD countries: Germany is specialized in 69 fast-growing subclasses, France in 61, United Kingdom in 67, Italy in 58, Japan in 52 and Usa in 71. On the contrary, the share of subclasses in which Switzerland appears to be specialized increases moving towards medium, stable and declining groups: the share of specialized subclasses (RTA>1) is 47% in medium-growing and 45% in stable group.

It is also interesting to look in more detail at the sectoral specialization of Switzerland in fast-growing fields. To this end, we have reported the absolute number of subclasses in which major OECD countries are specialized (RTA>1 in period 1989-93), aggregating such subclasses in 1-digit sections of the International Patent Classification (see Table 9). Among parentheses, we have also indicated for each cell the share of specialized subclasses on the total number of subclasses included.



Graph 1 - Distribution of Revealed Technological Advantages within Fast-Growing, Medium-Growing, Stable and Declining Subclasses, Switzerland, 4-digit IPC Groups, RTA 1989-93.

With respect to Switzerland, one can note how the distribution of specialized sectors in fast-growing technological fields is highly skewed towards machinery (B), textiles (D), as well as primary goods (A) sections. These three sections account for 31 out of 44 fast-growing subclasses in which Switzerland is specialized. In addition, the share of specialized sub-classes within each of these sections appears very high. For example, in section D (textiles and paper), Switzerland is specialized in 7 out 14 (50%) of all fast-growing classes included in this section.

For a better evaluation of the sectoral specialisation of Switzerland in fast-growing technological subclasses, we have also produced the list of the 43 specialized subclasses (see Table 10). Looking at the data, a positive note for Switzerland emerges in the case of chemical subclasses. Among the fast-growing subclasses included in this section, in fact, Switzerland is specialized in biotechnology (C12N) and related subclasses (C12P, C12Q and C12S). This result appears even more important considering that in the first period (1980-84) Switzerland was relatively weak in such technology and it witnesses an increasing commitment, especially on part of largest firms, in this fundamental area of research. The position of Switzerland, on the contrary, appears extremely and persistently weak over time in most subclasses included in electricity (H), physics (G) and to a less extent in mechanical engineering (F) sections (see Table 10). In electricity section (H), which includes a large number of dynamic subclasses, there is only 1 sector out of 20 (5%) in which Switzerland shows specialisation, which represent the lowest absolute figure among major OECD countries.

TABLE 9 - TOTAL NUMBER AND SHARE OF SPECIALIZED SUBCLASSES (RTA>1) CLASSIFIED ACCORDING TO IPC SECTIONS (ONE-DIGIT) (WS627), RTA 1989-93, CUMULATIVE.

		A Primary Goods		B Machinery Transports		C Chemistry Metallurgy		D Textiles Paper		E Building Infrastruct.		F Mechanical Engineering		G Physics		H Electricity	
		N°	Share	N°	Share	N°	Share	N°	Share	N°	Share	N°	Share	N°	Share	N°	Share
CH	F	5	0.45	19	0.40	5	0.29	7	0.50	0	0	2	0.11	5	0.20	1	0.05
	M	17	0.74	22	0.59	7	0.30	6	0.55	3	0.30	10	0.53	6	0.33	3	0.21
	S	13	0.45	19	0.58	3	0.19	4	0.57	9	1.00	12	0.43	7	0.33	3	0.23
	D	5	0.29	15	0.33	12	0.36	4	0.67	2	0.29	16	0.48	3	0.27	0	0
FRG	F	2	0.18	32	0.68	4	0.24	8	0.57	2	0.67	14	0.78	3	0.12	4	0.20
	M	11	0.48	32	0.86	13	0.57	4	0.36	9	0.90	16	0.84	6	0.33	11	0.79
	S	17	0.59	26	0.79	8	0.50	5	0.71	8	0.89	19	0.68	8	0.38	4	0.31
	D	6	0.35	27	0.60	17	0.52	4	0.67	4	0.57	27	0.82	6	0.55	1	1.00
FRA	F	2	0.18	20	0.43	4	0.24	3	0.21	3	1.00	14	0.78	7	0.28	9	0.45
	M	13	0.57	15	0.41	12	0.52	4	0.36	8	0.80	11	0.58	11	0.61	5	0.36
	S	21	0.72	18	0.55	9	0.56	2	0.29	8	0.89	19	0.68	12	0.57	8	0.62
	D	12	0.71	19	0.42	11	0.33	2	0.33	5	0.71	16	0.48	5	0.45	1	1.00
UK	F	7	0.64	18	0.38	7	0.41	4	0.29	3	1.00	9	0.50	10	0.40	9	0.45
	M	16	0.70	12	0.32	6	0.26	3	0.27	7	0.70	13	0.68	12	0.67	2	0.14
	S	16	0.55	11	0.33	7	0.44	4	0.57	9	1.00	14	0.50	12	0.57	4	0.31
	D	9	0.53	17	0.38	8	0.24	1	0.17	6	0.86	21	0.64	5	0.45	0	0
ITA	F	3	0.27	26	0.55	4	0.24	4	0.29	2	0.67	13	0.72	3	0.12	4	0.20
	M	16	0.70	25	0.68	6	0.26	6	0.55	8	0.80	11	0.58	5	0.28	5	0.36
	S	22	0.76	27	0.82	4	0.25	5	0.71	7	0.78	13	0.46	6	0.29	4	0.31
	D	8	0.47	20	0.44	14	0.42	4	0.67	5	0.71	16	0.48	2	0.18	0	0
JAP	F	1	0.09	7	0.15	7	0.41	3	0.21	1	0.33	4	0.22	16	0.64	14	0.70
	M	1	0.04	8	0.22	10	0.43	3	0.27	0	0	4	0.21	6	0.33	7	0.50
	S	2	0.07	5	0.15	3	0.19	1	0.14	1	0.11	7	0.25	10	0.48	10	0.77
	D	3	0.18	5	0.11	5	0.15	1	0.17	1	0.14	1	0.03	4	0.36	0	0
USA	F	6	0.55	16	0.34	13	0.76	6	0.43	0	0	6	0.33	14	0.56	10	0.50
	M	7	0.30	3	0.08	12	0.52	6	0.55	1	0.10	3	0.16	10	0.56	2	0.14
	S	4	0.14	5	0.15	7	0.44	1	0.14	0	0	6	0.21	8	0.38	4	0.31
	D	4	0.24	3	0.07	11	0.33	0	0	1	0.14	6	0.18	3	0.27	0	0

Source: EPO-Cespri database.

Legend: F=Fast Growing; M=Medium Growing; S=Stable; D=Declining. N°=absolute number of subclasses in which the country is specialized (RTA>1). Share=share of specialized subclasses on the total number of subclasses included in each cell.

TABLE 10 - REVEALED TECHNOLOGICAL ADVANTAGES IN FAST-GROWING TECHNOLOGICAL SUBCLASSES (WS627), SWITZERLAND, 1980-84 AND 1989-93

Fast-Growing Subclasses	1980-84	1989-93
D01G Preliminary treatment of fibres	6.63	15.16
G04D Apparatus or tools for making clocks or watches	20.63	11.09
D02H Warping, beaming, leasing	2.95	10.79
D03J Weavers' tools	13.13	9.13
B66B Elevators, escalators	4.81	8.78
D01H Spinning or twisting	5.80	7.83
B42B Permanently attaching sheets, quires, signatures	1.29	7.44
A23P Shaping or working of foodstuffs	6.88	6.55
B31D Making other paper articles	2.58	6.53
B61G Couplings, draught or buffing appliances	-	6.16
B23H Working of metals using electrodes	2.79	5.57
D02J Finishing of filaments	3.64	5.20
B42C Bookbinding	0.63	4.58
F23R Generating combustion products	1.59	3.78
C12S Processes using enzymes	-	3.08
A61F Orthopaedic appliances	1.99	2.78
B26D Cutting	1.38	2.61
B61D Body details of railways vehicles	2.39	2.16
G07B Ticket-issuing apparatus	0.75	2.14
F41A Cannons	-	2.01
A41G Wigs, feathers	-	1.98
B05B Spraying apparatus	0.95	1.85
D04C Braiding machines	-	1.85
G09C Ciphering apparatus	-	1.85
C08K Use of inorganic substances as compounding ingredients	2.30	1.75
D01B Mechanical treatment of artificial fibres	.	1.73
B01L Chemical or physical lab. apparatus	1.17	1.68
B26F Perforating, punching	1.81	1.68
B42D Printed matter of special format	2.55	1.53
B25F Components of power-driven tools	1.29	1.50
B41C Processes for reproduction of printing surfaces	-	1.43
G03H Holographic processes	0.69	1.42
H02N Electric machines	1.47	1.42
B60M Power supply lines	1.59	1.39
C12Q Testing processes involving enzymes	0.33	1.22
C12P Fermentation	0.61	1.18
G01R Measuring electric, magnetic variables	0.68	1.17
A61L Disinfection, sterilisation	1.07	1.15
B43M Bureau accessories	-	1.09
B61F Rail vehicles suspensions	-	1.09
B06B Apparatus for transmitting vibrations of sonic, ultrasonic frequencies	1.68	1.08
C12N Enzymes, Mutation, Genetic Engineering	0.58	1.06
A61B Diagnosis, Surgery	0.79	1.00

Source: EPO-Cespri database. *Note*: one residual class not included; - =no patents in the period.

Moreover, its position does not improve if one looks at medium-growing and stable subclasses included in this section. Similar results emerge for the case of physics (G), which includes Testing and Measurement classes. In this section, the number of specialized fast-growing subclasses for Switzerland is 5 out of 25 (20%), a figure too low for a country in which measurement and control instruments are a sector of vital importance for international competitiveness. These arguments are also partly true for the mechanical engineering section (F). In this field of technology, there are only 2 subclasses out of 18 (11%) in which Switzerland results specialized. This is again the lowest figure among the major OECD countries. The position of Switzerland slightly improves if one looks at medium-growing and stable subclasses, but it remains rather weak, particularly compared with other European countries.

A preliminary analysis of the relationship between RCA and RTA

In this section we focus on the relationship between technological and international performance. Even if the main aim of the analysis is descriptive, it is clear that we do not approach the data "tabula rasa". By now, there is an extensive theoretical literature on trade and technology, mainly phrased in terms of the neoclassical approach (see for example Grossman and Helpman (1995), Krugman (1995)) or of the structuralist-evolutionary one (see Dosi, Pavitt and Soete,1990). Also on the empirical side there is a very large literature. However, when we concentrate on the subset of studies on the relationship between technological and international performance there are two main problems: first, it is very difficult to find a robust link between the empirical specification and the theoretical proposition. The major consequence, is that the results of these analysis are observationally equivalent from the point of view of the different theories; in other terms, we have a problem of identification of our reduced form analysis. Secondly, a common interpretation of the empirical literature is that there is a strong link between the two variables[11].

Our reading of the empirical literature is less conclusive on the general validity of this link[12].

In this section, we focus on the second issue. More precisely, we perform an exploratory analysis on the relationship between the revealed comparative advantage index (RCA), as a measure of international performance, and the revealed technological advantage index (RTA), as a measure of technological performance. Our database has three dimensions: country, sector and time. As a starting point we try to exploit the information contained in all the dimensions simultaneously, for the sample containing all sectors (WS49). Most of the existing empirical analysis have focused separately either on the cross-industry dimension or on the cross-country one.

The first step adopted is the two-way analysis of covariance. The two ways are: sector and country[13]. We present the results in a linear regression format. The model of reference is:

$$Rca_{ijt} = a_{ij} + b \bullet Rta_{ijt} + e_{ijt}$$

Table 11 reports the results both for the OLS and the within estimates. The latter estimator control for effects that are fixed along the time dimension but vary in the other two. A typical candidate in this context is the technological opportunity which is an unobserved variable that can be considered as constant over time and correlated with RTA (Helg , 1987).

The results in table 11 show that the RTA is significatively and positively associated with RCA when we control for country and sector fixed effects. Moreover, both fixed factors result separately significant. in any case the results are not very different from those of the OLS estimator. The portion of variance of RCA accounted by the two categorical variables and by RTA is 0,18.

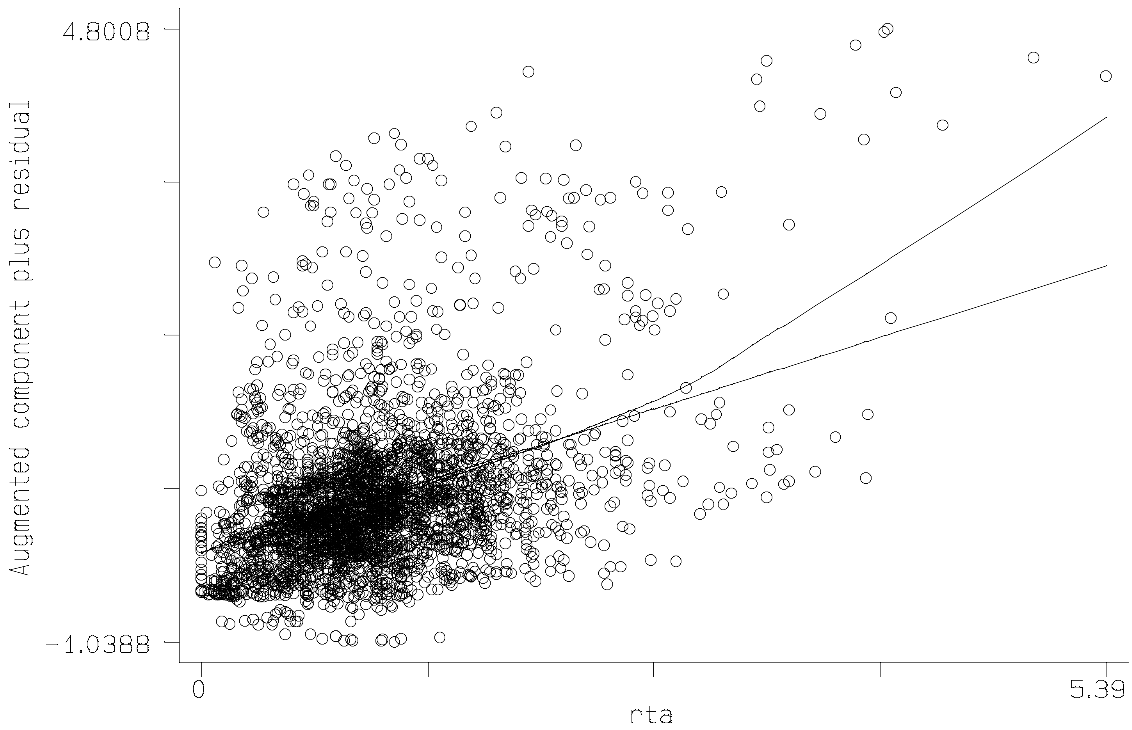
TABLE 11 - RESULTS FOR OLS AND WITHIN ESTIMATES (WS49), (OBS. N=3367)

I) Sample WS49	β	R^2	F^1	F^2
OLS	0.47 (14.1)	0.13		
WITHIN ESTIMATOR	0.50 (15.7)	0.18	4.82	8,26
II) Sample WS49 less clothing				
OLS	0.39 (14.2)	0.09		
WITHIN ESTIMATOR	0.42 (14.7)	0.15	4.93	11.01

Notes: In brackets heteroskedasticity-robust t values. F^1: F-test of sector-fixed effect. F^2: F-test of country-fixed effect.

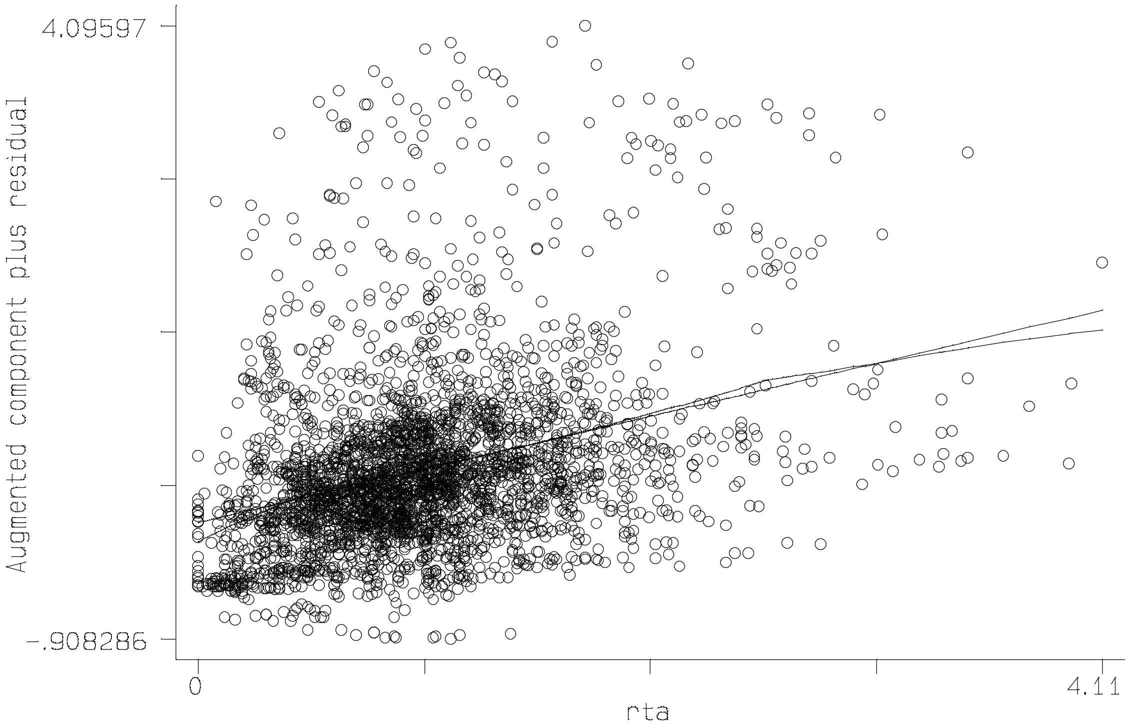
This analysis imposes a linear relationship among the variables. To check the validity of this specification, we plot in Graph 2 a modified scatter diagram: the augmented component-plus-residual plot (Mallows, 1986) is reported. It contains both the within estimator fitted values (the straight line) and the lowess smoother[14]. The evidence appears to be against the linear specification since above a certain level of RTA the lowess curve diverges from the straight line. However, before rejecting that specification, note that all the observations in north-east corner of the picture belong to the clothing sector.

Hence, we repeat the same exercise after having dropped these observations. As can be seen from Graph 3, the linear approximation is now acceptable. The result of regression analysis for this sample (i.e. dropping the observation relative to the clothing sector) are reported in the bottom half of table 11. They are very similar to those obtained with the full sample. What is interesting to notice is the role of the clothing sector in driving the positive relationship; dropping it we have a reduction in the R^2 .



Graph 2: Modified scatter diagram:

straight line (from within estimates) and lowess smoother



Graph 3: Modified scatter diagram without textile sector:

straight line (from within estimates) and lowess smoother

We then allow the coefficient of RTA to be different across countries. This allows us to focus the analysis on Switzerland and to compare our results with those of previous studies. The within estimator results (now controlling only for the industry fixed effect) show a weak[15], but significant positive relationship between international and technological performance for Switzerland, Germany, Italy and the United States (table 12).

On the contrary, no relationship arises for France, the United Kingdom and Japan. For the case of France a plausible explanation is the mainly government driven orientation behind technological progress (the “mission oriented” approach). United Kingdom, on the contrary, is very strong in scientific research, but is very weak in transferring these advances into innovations (Archibugi-Pianta, 1992). For the case of Japan we do not have, at the moment, a coherent story to explain the poor result obtained, but for the fact that our evidence is consistent with that of other studies (for example, van Hulst-Mulder-Soete, 1991).

The next step is to analyze the sample including only high-tech sectors (HT46). The approach is the adopted is the same as the one for the full sample. Table 13 reports results for the sample in which all the three dimensions (country-sector-time) are pooled together. The relationship between RCA and RTA is stronger than in the previous case. The two fixed factor are still separately significant.

TABLE 12 - COUNTRY RESULTS FOR OLS AND WITHIN ESTIMATES (WS49) (OBS. N=481)

Countries	OLS		Within Estimator		
	β	R^2	β	R^2	F
Switzerland	0.46 (6.2)	0.07	0.05 (2.2)	0.98	694
Germany	0.44 (9.8)	0.17	0.10 (5.2)	0.99	193
France	-0.11 (-3.4)	0.02	0.04 (0.2)	0.99	155
United Kingdom	0.02 (0.4)	0.0004	0.02 (0.4)	0.95	45.5
Italy	0.71 (18.8)	0.43	0.08 (3.5)	0.98	175.2
Japan	0.84 (15.2)	0.33	-0.03 (-0.8)	0.98	185
United States	0.33 (4.15)	0.03	0.17 (3.1)	0.99	200

Notes: In brackets heteroskedasticity-robust t values. F: F-test of sector-fixed effect.

TABLE 13 - RESULTS FOR OLS AND WITHIN ESTIMATES (HT49)

	β	R^2	F^1	F^2
OLS	0.78 (5.1)	0.28		
WITHIN ESTIMATOR	0.71 (4.5)	0.37	1.28	20.33

Notes: In brackets heteroskedasticity-robust t values. F^1: F-test of sector-fixed effect. F^2: F-test of country-fixed effect.

TABLE 14 - COUNTRY RESULTS FOR OLS AND WITHIN ESTIMATES (HT49)

Countries	OLS		Within Estimator		
	β	R^2	β	R^2	F
Switzerland	0.79 (2.0)	0.30	-0.00 (-0.03)	0.99	231.3
Germany	0.65 (12.5)	0.34	-0.07 (-1.8)	0.94	31.9
France	0.45 (3.4)	0.14	0.02 (0.66)	0.99	177.1
United Kingdom	0.32 (4.1)	0.11	-0.01 (-0.1)	0.91	27.9
Italy	0.18 (1.8)	0.10	0.01 (1.4)	0.95	49.7
Japan	1.48 (9.8)	0.46	0.01 (0.3)	0.99	199.6
United States	0.64 (5.4)	0.14	-0.16 (-1.4)	0.96	63.9

Notes: In brackets heteroskedasticity-robust t values. F: F-test of sector-fixed effect.

As far as the single countries are considered (Table 14) , the results are not very supportive of the relationship. The fixed effect estimates show a significant positive relationship (although weak) only for Switzerland. Note that the pattern of results is substantially different from those obtained with the OLS estimates, where a positive and significant result is obtained for all countries. Our presumption, in this case, is that the fixed effect estimates are not reliable because of the small variability of the observation in the time dimension (in this sample the number of years considered is reduced to 5).

Sectoral organization of innovative activities in Switzerland

Recent developments in the Schumpeterian tradition have emphasized that the ways innovative activities are structured and organized within industries may differ to a great extent (Nelson and Winter, 1982; Malerba and Orsenigo, 1993). In some industries, patterns of innovative activity are characterized by the dominance of few large firms, which account for the largest fraction of innovations and which continuously innovate over time through the accumulation of technological capabilities, and by the presence of relevant barriers to entry of new innovative firms. In other industries, innovative capabilities are more evenly diffused among a large population of small and medium size firms and new innovators continuously appear enlarging the innovative base and eroding the competitive advantages of established firms in the industry (Malerba and Orsenigo, 1994). Using USPO and EPO patent data at the firm level, Malerba and Orsenigo (1994, 1995) have shown that the first pattern of innovative activity- labeled Schumpeter Mark II from Schumpeter (1942)- is typically found in most chemical and electronic industries and that such pattern shows remarkable similarities across a large set of countries[16]. On the other hand, the second pattern of innovative activity- labeled Schumpeter Mark I from Schumpeter (1934)- characterizes most mechanical engineering and electrical sectors in highly similar ways across countries. Drawing upon Nelson and Winter (1982), Dosi (1988), Cohen and Levin (1989), and Levin, Cohen and Mowery (1985), the authors claim that such regularities in sectoral patterns of innovation may be related to the working of technological imperatives, rather invariant across countries, and to the specific properties of each technology and of its technological regime defined in terms of opportunity, appropriability and cumulativeness conditions and the relevant knowledge base. Far from denying the relevance of country specificities, they also argue that country specific effects, such as the national system of innovation, the peculiar history of industrial development, the specific competences and organization of firms, can all affect the organization of innovative activities, thus producing differences among countries within the same industry or technological sector. However, a very important result emerging from their analysis is that those countries that show structural features more in accordance with the specific pattern characterizing a technological class are also specialized in that class. More specifically, in Schumpeter Mark II technological classes, those countries characterized by higher concentration of innovative activities and higher stability in the ranking of innovative firms have also an international specialisation in these classes. On the contrary, in Schumpeter Mark I classes, lower levels of concentration, higher rates of entry of innovative firms and, more broadly, higher turbulence all foster greater technological specialisation of countries.

Inspired by such contributions, the purpose of this section is to provide a description of the ways innovative activities take place and are organized in technological sectors of Swiss national system of innovation. More precisely, the aim is to evaluate the coherence of sectoral patterns of innovation in Swiss technological classes with those found in other industrialized countries. In addition to that, an attempt is also made to assess the extent to which technological and comparative advantages of Swiss economy, analyzed in previous sections, are related to sectors whose structural features are in accordance with the specific Schumpeterian patterns characterizing such classes. Following Malerba and Orsenigo (1994, 1995), for each of the 49 technological classes four indicators of sectoral patterns of innovation have been calculated using patent data at the firm level[17]:

i) Concentration of innovative activities: this is measured by the concentration ratio of the top four firms innovating in the period 1978-91 (C4 Index);

ii) Asymmetry among innovative firms: it is defined as the sum of squared shares of patent applications by firms over the period 1978-91 (Herfindahl Index);

iii) Stability in the hierarchy of innovative firms: it is measured by the Spearman rank correlation coefficient between the hierarchies of firms innovating in the period 1978-85 and firms innovating in the period 1986-91;

iv) Entry of innovative firms: it represents the share of patent applications of firms which apply for the first time in a given technological class in the period 1986-91.

The four indicators of sectoral patterns of innovation are reported for Switzerland in Table 15. At first glance, the data seem to provide further support to the hypothesis that patterns of innovative activities are technology-specific. By and large, concentration and asymmetry are relatively higher in most chemical as well as electronic technological classes, whereas they take relatively lower values in most traditional and mechanical engineering sectors. Conversely, the degree of turbulence and dynamism- as captured by stability and entry indicators- appears to be relatively higher in these latter sectors as compared with chemical and electronic sectors. At the same time, however, a closer look at the data and a comparison with major industrialized countries also reveal the existence of relevant peculiarities in the sectoral organization of innovative activities in Switzerland.

TABLE 15 - SECTORAL PATTERNS OF INNOVATION, SWITZERLAND, 49 TECHNOLOGICAL CLASSES (WS49)
STABILITY, ASYMMETRY, CONCENTRATION AND ENTRY

Technological Classes	CONCENTRATION	ASYMMETRY	STABILITY	ENTRY
1. Food and Tobacco	0.72	0.21	-0.12	0.28
2. Clothing and Shoes	0.48	0.10	-0.25	0.35
3. Furnitures	0.23	0.02	-0.16	0.60
4. Agriculture	0.25	0.03	-0.28	0.70
5. Mining	0.49	0.11	-0.13	0.52
6. Gas, Hydrocarbons, Oil	0.75	0.35	-0.12	0.20
7. Inorganic Chemicals	0.44	0.07	-0.21	0.57
8. Organic Chemicals	0.87	0.39	0.06	0.03
9. Macromolecular Compounds	0.85	0.62	-0.11	0.12
10. New Materials	0.30	0.03	-0.23	0.51
11. Adhesives, Coatings, Resins	0.92	0.73	-0.12	0.08
12. Biochemicals, Bio Engineering	0.64	0.15	0.06	0.19
13. Misc. Chem. Compounds	0.84	0.25	0.34	0.20
14. Chemical, Physical Processes	0.29	0.03	-0.09	0.48
15. Drugs	0.59	0.11	-0.16	0.31
16. Medical Preparations	0.38	0.06	-0.08	0.35
17. Natural or Artificial Fibres, Paper	0.59	0.17	-0.07	0.20
18. Chem. Natural, Artificial Fibres	0.72	0.35	-0.15	0.22
19. Agricultural Chemicals	0.83	0.51	-0.04	0.15
20. Chem. P. for Food and Tobacco	0.65	0.26	-0.21	0.31
21. Metallurgy	0.38	0.06	0.10	0.37
22. Machine Tools	0.55	0.13	0.17	0.21
23. Industrial Automation	0.34	0.04	-0.05	0.42
24. Industrial Mach. and Equip.	0.32	0.06	-0.14	0.37
25. Agricultural Machinery	0.46	0.09	-0.25	0.50
26. Vehicles, Motorcycles	0.38	0.04	-0.33	0.66
27. Aircraft	0.69	0.16	-0.33	0.80
28. Railways, Ships	0.41	0.06	-0.23	0.49
29. Materials Handling Apparatus	0.33	0.03	-0.18	0.38
30. Civil Engineering	0.10	0.01	-0.24	0.61
31. Engines, Turbines, Pumps	0.54	0.11	-0.30	0.39
32. Mechanical Engineering	0.21	0.02	-0.19	0.55
33. Mech. and Electric Techn.	0.39	0.06	-0.28	0.54
34. Household Electric Appliances	0.24	0.03	-0.17	0.57
35. Lighting Systems	0.38	0.07	-0.79	1.00
36. Meas. and Control Instrum.	0.17	0.02	-0.14	0.42
37. Laser Technology	0.60	0.12	0.10	0.48
38. Optics and Photography	0.61	0.20	-0.12	0.22
39. Computers	0.37	0.05	-0.32	0.75
40. Other Office Equipment	0.62	0.15	0.00	0.25
41. Electrical Devices and Systems	0.37	0.06	-0.02	0.37
42. Electronic Components	0.47	0.09	-0.12	0.37
43. Consumer Electronics	0.45	0.07	-0.22	0.57
44. Telecommunications	0.45	0.07	-0.23	0.48
45. Multimedial Systems	1.00	0.56	-1.00	1.00
46. Figurative Arts, Sports, Toys	0.59	0.22	-0.44	0.32
47. Ammunitions and Weapons	0.74	0.29	-0.02	0.37
48. Nuclear Technology	0.61	0.14	-0.16	0.67
49. Others	0.45	0.08	-0.38	0.77

Source: Epo-Cespri database.

I) Switzerland emerges as a highly concentrated and stable country

In order to compare sectoral patterns of innovation in Swiss technological classes with those found in major industrialized countries, we have calculated for the four indicators the deviations from the average values for the group of G6 countries (Japan, Usa, Italy, France, Uk and Germany) (see Table 16)[18]. In addition to that, we have also reported for the same indicators the average values calculated across the 49 technological classes as well as the linear correlation coefficients between pairs of countries (see Tables 17 and 18). From such comparison, Switzerland emerges as a rather concentrated and stable country. In most technological classes, the values of CONCENTRATION, ASYMMETRY and STABILITY appear significantly higher than those registered on average in the group of G6 countries. A relevant exception to this pattern is represented by several electrical-electronic and transport sectors, where the degree of concentration and stability in the ranking of innovative firms appear to be lower than in the group of G6 countries. Also at the aggregate level, the average values of CONCENTRATION and ASYMMETRY are significantly higher in Switzerland, while the average value of STABILITY is quite similar to Japan and Germany and consistently higher than in the other countries (see Table 17). This result is rather interesting considering the relatively small dimension of Switzerland in terms of patents and it witnesses the existence of a strong and stable core of firms which continuously accumulate over time technological capabilities. Among these firms one finds some of the largest multinationals operating in chemical-pharmaceutical as well as mechanical-electrical sectors- such as Ciba-Geigy, Hoffmann-La Roche, Sandoz and Brown-Boveri- which account for the bulk of Swiss patenting in these fields.

In addition to that, Switzerland also shows relatively low rates of entry of innovative firms (ENTRY). This is especially so in most chemical and traditional sectors, whereas the degree of turbulence appears more in accordance with G6 countries in mechanical engineering sectors and significantly higher in electrical-electronic classes. At the aggregate level, the average rate of entry of innovative firms in Switzerland is higher than in Japan and Germany and slightly lower than the rest of countries (Table 17).

Among major industrialized countries, Germany shows greater similarities with this particular pattern of high concentration, asymmetries among firms and stability in the ranking of innovators coupled with low rates of innovative entry (see Tables 17 and 18)

TABLE 16 - SECTORAL PATTERNS OF INNOVATION, SWITZERLAND, 49 TECHNOLOGICAL CLASSES (WS49)

DEVIATIONS FROM G6 AVERAGE

Technological Classes	CONCENTRATION	ASYMMETRY	STABILITY	ENTRY
1. Food and Tobacco	0.34	0.11	0.18	-0.17
2. Clothing and Shoes	0.08	-0.04	0.25	-0.18
3. Furnitures	0.08	0.00	0.40	-0.18
4. Agriculture	0.07	0.01	0.39	-0.10
5. Mining	0.11	0.05	0.23	-0.07
6. Gas, Hydrocarbons, Oil	0.31	0.28	0.06	-0.11
7. Inorganic Chemicals	0.12	0.02	0.03	0.11
8. Organic Chemicals	0.51	0.33	-0.14	-0.09
9. Macromolecular Compounds	0.38	0.52	-0.11	-0.06
10. New Materials	0.03	0.00	-0.08	0.12
11. Adhesives, Coatings, Resins	0.55	0.66	0.03	-0.30
12. Biochemicals, Bio Engineering	0.32	0.11	0.14	-0.15
13. Misc. Chem. Compounds	0.19	-0.02	0.42	-0.15
14. Chemical, Physical Processes	0.10	0.01	0.16	0.05
15. Drugs	0.32	0.08	-0.19	0.00
16. Medical Preparations	0.15	0.03	0.21	-0.15
17. Natural or Artificial Fibres, Paper	0.31	0.14	0.09	-0.27
18. Chem. Natural, Artificial Fibres	0.43	0.31	0.04	-0.24
19. Agricultural Chemicals	0.40	0.42	0.27	-0.34
20. Chem. P. for Food and Tobacco	0.39	0.22	0.21	-0.31
21. Metallurgy	0.16	0.03	0.21	0.00
22. Machine Tools	0.27	0.09	0.46	-0.34
23. Industrial Automation	0.08	-0.01	0.26	-0.04
24. Industrial Mach. and Equip.	0.21	0.05	0.14	-0.06
25. Agricultural Machinery	-0.03	-0.05	0.17	0.02
26. Vehicles, Motorcycles	0.03	-0.01	-0.15	0.37
27. Aircraft	0.12	0.01	-0.14	0.32
28. Railways, Ships	0.12	0.02	0.19	-0.14
29. Materials Handling Apparatus	0.21	0.02	0.15	-0.15
30. Civil Engineering	-0.02	0.00	0.19	-0.02
31. Engines, Turbines, Pumps	0.19	0.06	-0.10	0.12
32. Mechanical Engineering	-0.02	0.00	0.07	0.14
33. Mech. and Electric Techn.	0.20	0.04	0.08	0.03
34. Household Electric Appliances	-0.03	0.00	0.21	0.02
35. Lighting Systems	-0.04	0.00	-0.29	0.32
36. Meas. and Control Instrum.	-0.02	0.00	0.07	0.04
37. Laser Technology	0.12	0.02	0.09	0.04
38. Optics and Photography	0.20	0.14	-0.03	-0.04
39. Computers	-0.07	-0.05	-0.15	0.44
40. Other Office Equipment	0.08	0.00	0.14	0.01
41. Electrical Devices and Systems	0.12	0.03	0.11	0.02
42. Electronic Components	0.03	-0.01	-0.05	0.13
43. Consumer Electronics	0.04	0.01	0.01	0.30
44. Telecommunications	-0.04	-0.03	-0.18	0.26
45. Multimedial Systems	0.30	0.35	-1.00	0.54
46. Figurative Arts, Sports, Toys	0.42	0.21	0.11	-0.38
47. Ammunitions and Weapons	0.28	0.19	0.24	-0.03
48. Nuclear Technology	-0.10	-0.07	-0.05	0.37
49. Others	0.23	0.05	0.04	0.09

Source: Epo-Cespri database.

TABLE 17 - MEASURES OF SECTORAL PATTERNS OF INNOVATIVE ACTIVITIES,
49 TECHNOLOGICAL CLASSES (WS49), AVERAGES AND STD. DEVIATIONS

	CH	FRG	FRA	UK	ITA	JAP	USA	G6
CONCENTRATION	0.51	0.37	0.33	0.34	0.38	0.35	0.29	0.34
	(0.21)	(0.20)	(0.15)	(0.19)	(0.20)	(0.17)	(0.18)	(0.15)
ASYMMETRY	0.16	0.07	0.05	0.07	0.08	0.07	0.06	0.07
	(0.17)	(0.07)	(0.05)	(0.10)	(0.09)	(0.08)	(0.09)	(0.06)
STABILITY	-0.17	-0.13	-0.29	-0.36	-0.35	-0.06	-0.23	-0.24
	(0.21)	(0.18)	(0.20)	(0.19)	(0.33)	(0.26)	(0.19)	(0.17)
ENTRY	0.43	0.33	0.45	0.45	0.65	0.41	0.35	0.44
	(0.22)	(0.18)	(0.19)	(0.20)	(0.20)	(0.22)	(0.18)	(0.15)

Source: Epo-Cespri database.

TABLE 18- MEASURES OF SECTORAL PATTERNS OF INNOVATIVE ACTIVITIES,
PEARSON CORRELATION COEFFICIENTS[a], SWITZERLAND VS. G6, 49 TECHNOLOGICAL CLASSES (WS49)

	CONCENTRATION	ASYMMETRY	STABILITY	ENTRY
Germany	*0.57*	*0.48*	*0.45*	*0.47*
France	*0.29*	0.25	0.20	0.22
Uk	*0.54*	*0.41*	0.25	*0.34*
Italy	0.26	0.26	0.05	*0.34*
Japan	0.01	-0.01	0.19	0.20
United States	*0.30*	0.10	*0.39*	*0.36*

Source: Epo-Cespri database.

[a]Marked correlations significant at 0.05% level.

II) <u>Switzerland shows relevant exceptions in sectoral patterns of innovation compared with other countries</u>

Although the sectoral patterns of innovation in Switzerland broadly correspond to those found in other large countries, there are some relevant exceptions which emerge if technological classes are grouped according to measures of Schumpeterian patterns of innovation. To this purpose, principal component analysis has been performed for 37 technological classes on the four indicators (concentration, asymmetry, stability and entry)[19]. The analysis identifies one dominant factor which captures a high fraction of the total variance among indicators (72%). This principal component shows a positive correlation with concentration, asymmetry and stability, and a negative correlation with entry. As a consequence, factor scores may be reasonably interpreted as measuring the extent to which a given technological class belongs to either Schumpeterian patterns of innovation.

These results can be compared with those found by Malerba and Orsenigo (1995) which performing the same kind of analysis for the group of G6 countries identify an analogous relationship among indicators. In particular, they find that in all countries analyzed concentration and asymmetry are positively correlated, while entry is negatively related with concentration, asymmetry and stability. Furthermore, by grouping technological classes according to principal component values- summing up the relationship between single indicators- they identify sectors that in all countries have a Schumpeter Mark I or a Schumpeter Mark II pattern. Drawing upon such results, we have grouped the 37 technological classes for Switzerland according to the value of principal component scores, putting in evidence those sectors whose pattern is markedly different from that in G6 countries (see Table 19). It should be noted that negative values of principal component scores identify Schumpeter Mark I patterns, while positive values of such scores correspond to Schumpeter Mark II patterns.

Looking at the data, the most relevant exceptions to G6 patterns can be found in all electronic (computers, consumer electronics, electronic components, telecommunications) and transport (vehicles, engines, agricultural machinery) technological classes. In these sectors, the degree of turbulence (entry and stability) is too high and the level of concentration and asymmetry among innovative firms too low compared with the other countries, thus resulting in a “wrong” pattern of innovation. The lack of a stable core of firms accumulating technological capabilities over time, possibily associated with the small size of firms operating in such fields, can therefore be seen as the fundamental cause of the relative weakness of Switzerland in these sectors.

On the contrary, Schumpeterian patterns of innovation are largely in accordance with those found in all other countries in most mechanical (industrial machinery, mechanical engineering, civil engineering, materials handling app., measurement instruments) and chemical (organic chemicals, macromolecular compounds, adhesives, misc. chemical, agricultural chemicals) technological classes. In the former, innovative capabilities are diffused across a quite large population of (small and medium size) firms, whose base is continuously enlarged by the entry of new innovators. In the latter, innovative activities are concentrated in the hands of few (large) firms, while the low rates entry concern a fringe of marginal firms.

TABLE 19- SCHUMPETERIAN PATTERNS OF INNOVATION IN SWITZERLAND

DIFFERENCES AND SIMILARITIES WITH G6 COUNTRIES

RTA, RCA AND PRINCIPAL COMPONENT SCORES, 37 TECHNOLOGICAL CLASSES

Schumpeter Mark I (High Entry-Low Concentration-Low Asymmetry-Low Stability)	Schumpeter Mark II (Low Entry-High Concentration-High Asymmetry-High Stability)
39 Computers (0.14, 0.18, -1.5) ***	11 Adhesives, Resins (1.87, 3.87, 2.2)
25 Agricultural Machinery (0.24, 0.18, -1.3) ***	8 Organic Chemicals (1.57, 2.18, 1.8)
30 Civil Engineering (1.54, 0.14, -1.1)	9 Macromolecular Compounds (0.64, 0.62, 1.8)
34 Household elec. appl. (1.51, 0.54, -1.1) †	13 Misc. Chem. Compounds (0.61, 1.20, 1.8)
44 Telecommunications (0.37, 0.51, -1.0) ***	19 Agricultural Chemicals (1.65, 1.58, 1.4)
26 Vehicles (0.43, 0.07, -1.0) ***	6 Gas, Oil (0.41, 0.05, 0.9)
3 Furnitures (1.7, 0.77, -0.9)	1 Food and Tobacco (1.60, 0.41, 0.9) †
32 Mechanical Engineering (0.93, 1.31, -0.8)	40 Other Office Machines (0.30, 0.39, 0.8)
28 Railways (1.31, 0.17, -0.7)	22 Machine Tools (1.30, 2.38, 0.7) †
43 Consumer Electronics 80.34, 0.14, -0.7) ***	17 Natural, Art. Fibres (2.99, 1.22, 0.7) *
36 Measurement Instrument (1.19, 4.45, -0.7)	47 Weapons (1.32, 0.40, 0.5)
33 Mech. Electr. Technol. (1.01, 0.98, -0.6)	38 Optics and Photography (0.79, 0.94, 0.5)
42 Electronic Components (0.43, 0.20, -0.5) ***	15 Drugs (0.85, 4.51, 0.4) †
21 Metallurgy (0.67, 0.72, -0.4)	2 Clothing (2.07, 1.29, 0.1) †
7 Inorganic Chemicals (0.73, 0.33, -0.4) †	46 Arts, Sports, Toys (1.68, 1.36, 0.0) *
41 Electrical Systems (0.75, 1.46, -0.4) †	
29 Materials Handling App. (1.85, 0.83, -0.3)	
10 New Materials (0.60, 2.47, -0.3) †	
16 Medical Apparatus (1.32, 1.01, -0.3)	
27 Aircraft (0.29, 0.17, -0.2) ***	
24 Industrial Machinery (1.41, 2.60, -0.2)	
31 Engines, turbines (0.78, 0.76, -0.1) ***	

Source : EPO-Cespri database; Malerba and Orsenigo (1995). Note: the first number among brackets indicates the value of RTA; the second number the value of RCA; the third number is the factor score resulting from principal component analysis.

*** In all G6 countries Schumpeter Mark II.

* In all G6 countries Schumpeter Mark I

† Not classifiable in G6 countries.

A few comments are however required for the case of drugs, which represents a relevant sector of strength for Switzerland. In this respect, it should be noted that the Schumpeter Mark II pattern which characterizes this sector in Switzerland has a similar behavior only in United Kingdom, whereas in all other countries it shows the specific features of a Schumpeter Mark I sector.

III) <u>The technological and comparative advantages of Switzerland are rather coherent with its sectoral patterns of innovation</u>

The previous discussion implicitly suggests the existence of a tight relationship between sectoral patterns of innovation, on the one hand, and international specialisation, on the other hand. More specifically, as mentioned at the beginning of this section, it has been demonstrated that those countries that show structural features more in accordance with the specific pattern characterizing a technological class tend to be also specialized in that class (Malerba and Orsenigo, 1995). In order to test such hypothesis for the case of Switzerland, we have calculated the correlation coefficients (Pearson and Spearman) between revealed technological (RTA) and comparative (RCA) advantages, on the one hand, and the measures of sectoral patterns of innovation, on the other hand (see Table 20). In addition, Figures 5 (8) and 6 (9) report for the 37 technological classes the plot of principal component scores against, respectively, RTA and RCA (see also Table 19).

TABLE 20 - REVEALED TECHNOLOGICAL AND COMPARATIVE ADVANTAGES
AND SECTORAL PATTERNS OF INNOVATION
37 TECHNOLOGICAL CLASSES, PEARSON AND SPEARMAN CORRELATION COEFFICIENTS

	RTA		RCA	
	Spearman	Pearson	Spearman	Pearson
CONCENTRATION	0.013	0.058	0.064	0.103
ASYMMETRY	0.065	0.180	0.109	0.224
STABILITY	0.189	0.262	0.395**	0.303*
ENTRY	-0.440**	-0.430**	-0.585**	-0.484**
PRINCIPAL COMPONENT	0.288*	0.280*	0.404**	0.327**

* significant at 0.10% level.

** significant at 0.05% level.

An interesting result emerging from the data is represented by the negative relationship between entry and RTA-RCA and by the positive and significant relationship between stability and RTA-RCA. This result reflects the relative specialisation of Switzerland in Schumpeter Mark II sectors (chemical and pharmaceutical) and the relative weakness in most electronic and transport classes. Further evidence in this respect emerges from the positive and significant association between principal component scores- summing up the relationship between single indicators of Schumpeterian patterns- and RTA and RCA.

At the level of specific classes, the scatterplots reveal three distinct sets of technological classes (see Figures 5 and 6). On the one hand, Switzerland shows technological as well as trade specialisation in several mechanical classes (industrial machinery, mechanical engineering, measurement instruments), whose structural features, as said before, are largely in accordance with the specific patterns for those classes. On the other hand, Switzerland also presents technological and trade strength in several chemical classes (organic chemicals, adhesives and resins, misc. chemicals, drugs), where once again the sectoral organization of innovative activities closely correspond to the particular pattern for such classes.

Figure 5 - Sectoral Patterns of Innovation and Revealed Technological Advantages
Switzerland, 37 Technological Classes

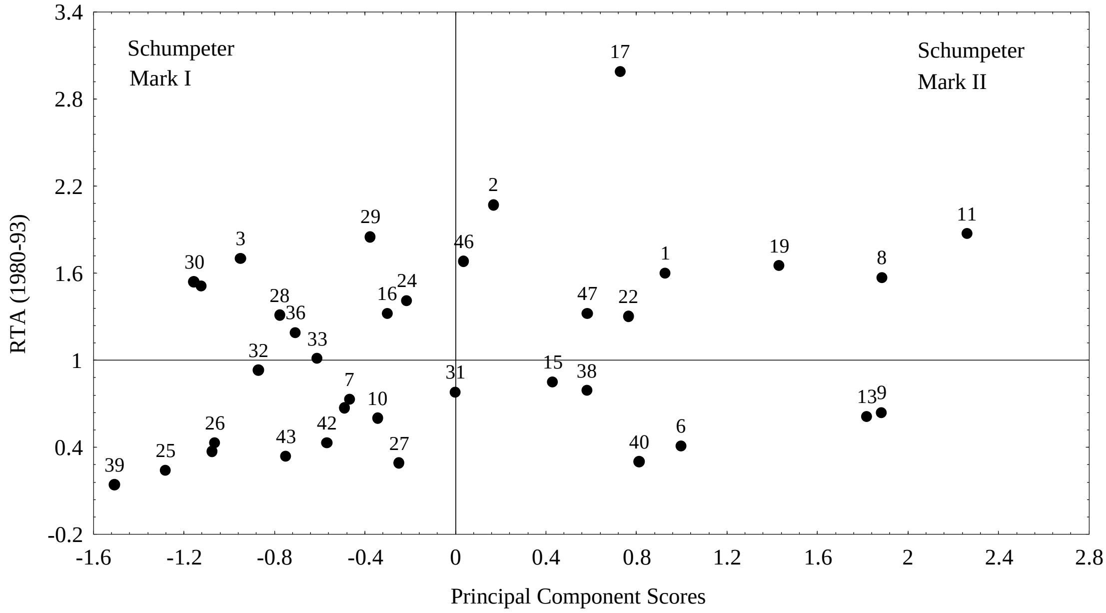
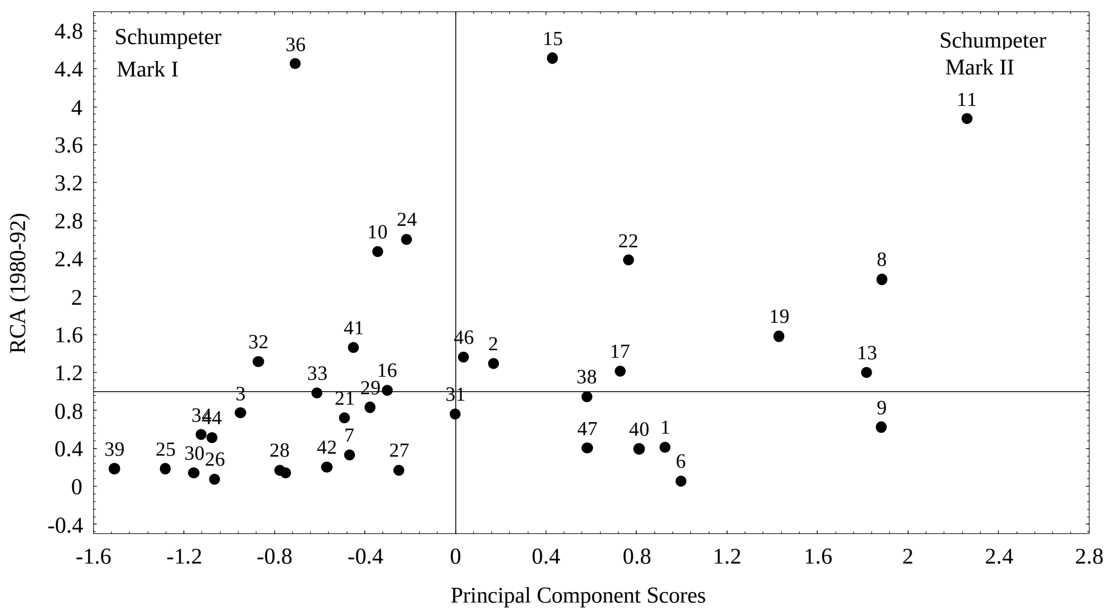


Figure 6 - Sectoral Patterns of Innovation and Revealed Comparative Advantages
Switzerland, 37 Technological Classes



Finally, a third group of sectors, which comprises most electronic and transport classes, is characterized by both technological and trade weaknesses. In this latter case, as already mentioned, the weakness of Switzerland can be largely attributed to the lack of a strong core of innovative firms and to excessive degrees of turbulence which translate into a discontinuous commitment to the development of new technologies.

Spatial distribution of innovative activities in Switzerland

The last few years have witnessed a renewed interest on the part of economists towards the geographical dimension of innovative activities. Jaffe, Trajitenberg and Henderson provided evidence that knowledge spillovers, as measured by patent citations, are most likely to occur within geographically bounded areas rather than flowing freely across regions. Feldman (1993 and 1994) and Audretsch and Feldman (1993) have shown that innovative activities tend to cluster spatially where knowledge inputs are located, due to the "local" nature of knowledge externalities and to the cumulative properties of technical change by which past innovation breeds future location of innovative activities within selected areas. Finally, one of us found evidence that the intensity of geographical concentration and the spatial organization of innovative activities are likely to differ across technological sectors (Breschi, 1994 and 1995).

In the case of Switzerland, recent contributions have shown that spatial proximity and agglomeration economies have offered a significant comparative advantages for Swiss industries (Maggi and Haeni, 1986). Moreover, it has been also shown that, in the case of micro-mechanical and precision instruments industry, spatial proximity among firms and research centres in northern cantons and a long industrial tradition of watch-makers have both played a fundamental role in promoting the international competitiveness of such technologies (Maillat, Nemeti, Pfister and Siviero, 1992).

Building upon such results, the purpose of this section is to provide additional evidence on the spatial location of innovative activities in Switzerland. To this end, we have used patent data at the firm level. In particular, patents have been attributed to the canton in which the applicant firm is located. Two remarks are needed in this respect. First, the choice of crediting a patent to the canton in which the firm is located could introduce a potential bias in favor of central cantons where firms' headquarters are situated. This risk is particularly high in those sectors where multi-plant firms are operating. Second, the choice of cantons as spatial unit of observation is not entirely satisfactory given that knowledge flows and functional linkages among firms are likely to differ across sectors and firms ranging from the world, to the industrial district and the town. While there are not easy solutions to this problem, it should be also observed that recent contributions have shown that the ranking of innovative regions does not change much if patents are substituted with more direct measures, like innovation counts (Feldman, 1994). Keeping these remarks in mind, we therefore assume that patents represent a reasonably good indicator for the spatial distribution of innovative efforts.

The geographical distribution of total patenting activity among Swiss cantons reveals two major facts (see Table 21). First of all, innovative activities are strongly concentrated in two core areas- Zürich and Basel- which together account for almost half of total patent applications. Beside these cantons, however, a substantial fraction of innovative activities is distributed across a rather large number of cantons most of which located in the northern and central part of the country. Finally, a fringe of peripheral cantons in the southern part contributes negligibly to the overall innovative effort. Although this type of geographical pattern is common to virtually all European countries, it must be noted that Switzerland appears as a relatively “diffused” country compared with other European national systems of innovation. In the periods 1980-84 and 1989-93 the Herfindahl equivalent index has been for Switzerland, respectively, 6.96 and 7.81 (see Table 21). Using regions as defined by Nuts level II of Eurostat, the value of such indicator for the period 1978-91 has been 5.31 for Italy, 4.29 for United Kingdom, 1.65 for France and 10.31 for Federal Republic of Germany (Breschi, 1995). The second fact emerging from the data is that the spatial concentration of innovations appears to decrease over time. Also in this case, the trend is common to all European countries, even though the extent of the process differs across national systems.

At a more disaggregated level, we have calculated for the 49 technological classes the Herfindahl index over the period 1989-93 and the percentage change between 1989-93 and 1980-84 (see Table 22). In order to compare spatial concentration of innovative activities in Switzerland with other European countries, we have also reported for the period 1978-91 the deviation from the average value for four European countries (Italy, Uk, France and Federal Republic of Germany).

TABLE 21 - THE SPATIAL DISTRIBUTION OF TOTAL PATENTING ACTIVITY AMONG SWISS CANTONS, 1980-84 AND 1989-93

Canton	Patents	Share	Patents	Share	Patents per 1.000 Workers
	1980-84		1989-93		(1991)
Basel	1846	29.61	2224	23.73	60.71
Zurich	1155	18.52	2071	22.09	15.26
Vaud	308	4.94	651	6.94	14.02
Aargau	478	7.67	613	6.54	7.96
Zoug	310	4.97	546	5.82	44.81
Saint Galles	230	3.69	486	5.18	7.73
Berne	307	4.92	480	5.12	4.76
Luzern	244	3.91	325	3.47	9.65
Geneve	277	4.44	269	2.87	9.77
Soleure	123	1.97	213	2.27	5.59
Fribourg	115	1.84	208	2.22	10.75
Neuchatel	113	1.81	193	2.06	7.60
Schaffhausen	261	4.19	182	1.94	13.64
Ticino	55	0.88	169	1.80	5.18
Thurgau	62	0.99	153	1.63	4.88
Baselland	81	1.30	147	1.57	4.88
Valais	86	1.38	138	1.47	7.07
Graubunden	86	1.38	90	0.96	8.29
Glarus	43	0.69	70	0.75	10.04
Schwyz	16	0.26	65	0.69	5.63
Appenzell AR	20	0.32	23	0.25	4.34
Uri	2	0.03	23	0.25	6.21
Jura	7	0.11	16	0.17	1.49
Nidwalden	10	0.16	14	0.15	4.81
Appenzell IR	0	0.00	4	0.04	3.40
Total	6235	100	9373	100	
Herfindahl E.N.		6.96		7.81	

Source: Epo-Cespri database.

The first result emerging from the data is that the degree of geographical concentration of patenting activity markedly differs across technological classes. This is relatively high in most chemical and pharmaceutical sectors, whereas a wider spatial diffusion of innovative capabilities seems to characterize mechanical and traditional sectors.

TABLE 22 - SPATIAL CONCENTRATION OF INNOVATIONS, SWITZERLAND

HERFINDAHL EQUIVALENT INDEX, 49 TECHNOLOGICAL CLASSES (WS49), 1989-93,

PERCENTAGE CHANGE 1980-84/1989-93 AND DEVIATION FROM EUROPEAN AVERAGE

Technological Classes	1990-93	Δ%	Deviation
1. Food and Tobacco	3.68	-8.2	0.6
2. Clothing and Shoes	5.63	-1.7	2.1
3. Furnitures	8.47	-12.8	4.7
4. Agriculture	9.33	28.5	0.4
5. Mining	6.81	18.2	1.7
6. Gas, Hydrocarbons, Oil	3.37	-23.6	0.7
7. Inorganic Chemicals	5.11	-12.6	2.8
8. Organic Chemicals	1.54	13.2	-0.6
9. Macromolecular Compounds	1.75	15.9	-0.3
10. New Materials	7.24	-12.3	7.4
11. Adhesives, Coatings, Resins	1.32	11.9	-1.0
12. Biochemicals, Bio and Genetic Engineering	2.28	-26.5	-0.3
13. Miscellaneous Chemical Compounds	2.69	-23.1	1.2
14. Chemical, Physical Processes	7.45	11.4	5.2
15. Drugs	2.95	45.3	0.3
16. Medical Preparations	6.98	8.4	3.3
17. Natural or Artificial Fibres, Paper	2.12	14.6	-2.2
18. Chemical Treatment of Natural or Artificial Fibres	2.09	-3.2	-2.0
19. Agricultural Chemicals	1.67	5.0	-1.7
20. Chemical Processes for Food and Tobacco	2.51	-37.1	-1.1
21. Metallurgy	5.43	-3.2	6.1
22. Machine Tools	2.95	-9.8	1.4
23. Industrial Automation	10.05	71.8	4.8
24. Industrial Machinery and Equipment	4.56	-30.2	-0.1
25. Agricultural Machinery	4.50	-15.6	1.6
26. Vehicles, Motorcycles	6.20	33.9	2.4
27. Aircraft	3.57	78.5	3.3
28. Railways, Ships	7.38	86.8	2.4
29. Materials Handling Apparatus	7.06	-6.2	0.7
30. Civil Engineering	10.10	6.9	4.3
31. Engines, Turbines, Pumps	2.71	-9.4	0.4
32. Mechanical Engineering	6.51	-17.0	4.7
33. Mechanical and Electric Technologies	5.43	34.4	1.8
34. Household Electric Appliances	7.31	-18.8	4.2
35. Lighting Systems	3.60	34.8	4.5
36. Measurement and Control Instruments	8.49	20.1	5.3
37. Laser Technology	3.45	23.7	2.3
38. Optics and Photography	4.75	84.1	1.6
39. Computers, Data Processing Systems	6.09	128.1	3.6
40. Other Office Equipment	2.64	-53.4	2.8
41. Electrical Devices and Systems	6.45	28.2	2.8
42. Electronic Components	5.33	35.6	1.9
43. Consumer Electronics	5.39	17.7	1.6
44. Telecommunications	3.18	-36.3	1.8
45. Multimedial Systems	1.00	0.0	-0.7
46. Decorative and Figurative Arts, Sports, Toys	4.68	21.6	-3.3
47. Ammunitions and Weapons	3.11	72.8	-0.2
48. Nuclear Technology	3.27	-7.1	3.0
49. Others	5.19	-18.8	1.1

Source: Epo-Cespri database.

These patterns appear broadly similar, apart from specific classes, to those found on average in other European countries. However, a relevant exception is represented once again by electronic sectors, whose degree of spatial concentration is substantially lower than the average value for the four European countries.

Regarding the evolution over time, the picture is rather mixed. Even within the same group of technologies one can find contrasting trends in the spatial diffusion of patenting activity. Beside sectors where innovative capabilities are diffusing to other cantons (for instance, measurement instruments, industrial automation and drugs), there are others in which such capabilities are undergoing a process of increasing concentration (for instance, biochemicals, industrial machinery and mechanical engineering).

A final issue which has been dealt with concerns the degree of similarity in the patterns of technological specialisation among Swiss cantons and border regions. This represents a relevant topic for two reasons at least. First of all, knowledge externalities and spillovers are likely to occur within spatially bounded regions, rather than flowing freely across regions and nations. Secondly, the particular position of Switzerland in the geographical map of Europe makes especially important to assess the degree of technological similarities with other European regions. In order to evaluate the position of Swiss cantons in this respect, we have calculated the degree of similarity in the technological specialisation between them and the regions located across the borders using the linear correlation coefficients in the percentage distribution of patenting activity across the 49 technological classes for the periods 1980-84 and 1989-93 (Table 23). Looking at this indicator, it emerges that a rather high degree of technological integration characterizes those cantons located at the border with Baden-Württemberg. The correlation coefficients are generally high and significant. This finding is not much surprising, resulting from a common specialisation of the two areas in mechanical engineering sectors. A certain similarity is also present between the western cantons (Geneve and Vaud) and Rhones Alpes. On the contrary, the technological specializations of canton Ticino and Italian border provinces (Como and Varese) appear relatively distant[20]. If this represents a negative aspect, hindering the exploitation of a common pool of knowledge externalities, and it partly explains the relatively poor performance of both areas within their respective national systems, it also constitutes a chance for them to revitalize their lagging economies.

TABLE 23 - TECHNOLOGICAL SIMILARITIES BETWEEN SWISS CANTONS AND BORDER REGIONS

CORRELATION COEFFICIENTS AMONG PERCENTAGE DISTRIBUTION IN 49 TECHNOLOGICAL CLASSES, 1980-84 AND 1989-93

Border Regions		Como	Varese	Lombardia	BW	Rh. Alpes	Alsace	Fr. Comte
		Corr.	Corr.	Corr.	Corr.	Corr.	Corr.	Corr.
Canton								
Ticino	1	-0.02	0.03	*0.38*				
	2	0.21	0.16	0.27				
Basel	1				0.11		*0.39*	
	2				0.02		-0.08	
Aargau	1				*0.65*			
	2				*0.63*			
Baselland	1				*0.36*			
	2				*0.61*			
Zürich	1				*0.73*			
	2				*0.77*			
Schaffhausen	1				*0.54*			
	2				*0.72*			
Thurgau	1				*0.30*			
	2				*0.40*			
Geneve	1					*0.39*		
	2					*0.39*		
Vaud	1					*0.49*		0.15
	2					*0.57*		0.05
Jura	1						0.29	-0.17
	2						*0.48*	0.02
Neuchatel	1							-0.06
	2							0.16

Source: EPO-Cespri database.

1=1980-84. 2=1989-93. Marked correlations significant at 5% level.

Conclusions

The results concerning the relationship between trade and technological performance are the following:

a) Switzerland appears to devote a relatively large amount of resources to technological activities. However, the performance at the aggregate level is not satisfactory in relative terms: from the technological perspective, Switzerland is not specialized in high-tech sectors and it presents a declining share of exports in high.-tech products.

b) However, if we analyze the picture at a more disaggregated level the evidence is less clear-cut. On the negative side, we find that Switzerland tends to concentrate its technological advantages not in fast-growing and high-tech sectors, but mostly in medium-growing and stable patent classes. On the positive side, we also find a few high-tech areas (notably, biotechnology and industrial automation) in which Switzerland has relative technological advantages.

c) Looking at the relationship between trade and technological performance, we find that there is a positive relation between the two variables (even if not very strong). It should be noted that such a positive link is not common to all industrialized countries (for example, see the cases of France, Uk and Japan). The patterns of specialisation both in technological and trade dimension are rather stable over time.

From the analysis of the sectoral organization of patenting activity, Switzerland emerges as rather concentrated and stable country, with low rates of entry of innovative firms compared with other major industrialized countries. This is especially true in some sectors of Swiss strength, like chemicals and pharmaceuticals, where a strong and stable core of firms account for the bulk of patenting activity. In these sectors, the relative technological advantage of Switzerland rests upon a few dominant firms which continuously accumulate innovative capabilities over time. On the contrary, the relative Swiss weakness in electronic sectors may be partly explained by too high degrees of turbulence (in terms of entry and exit and of stability over time in the accumulation of innovative capabilities by existing firms) in these fields compared with other industrialized countries.

Finally, the analysis of the geographical distribution of patenting activity points out that Switzerland is characterized by relatively high levels of spatial diffusion of innovative activities compared with other European countries. However, patenting activity tends to concentrate in northern and central cantons, while southern cantons contribute to a negligible fraction of national patenting activity. In this respect, an interesting result which has emerged is the high degree of similarity in the sectoral patterns of technological specialisation between northern cantons and German border regions, whereas southern cantons (particularly, Ticino) presents a technological specialisation rather distant from Italian border provinces.

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Notes

[1] It must be pointed out that EPO assigns patents to IPC classes according to "function-oriented" criteria.

[2] This concordance has jointly been developed by Cespri, Enea and Politecnico-Milan. For fuller details and discussion concerning the methodology used to construct the high-technology classes, see Oecd (1994) and Amendola and Perrucci (1995).

[3] A database on EPO patents at the firm level is available at Cespri for seven countries: Italy, Uk, France, Germany, United States, Japan and Switzerland. For contributions that have drawn upon such database see Malerba and Orsenigo (1995), Breschi (1995).

[4] Using a different methodology, Schmoch, Grupp and Laube (1996) reached similar conclusions.

[5] In order to avoid a bias in favour of the countries patenting in their home market ("domestic market" effect), it is common practice in many studies on patenting to calculate RTAs excluding from the totals the patents of the host country. In the case of EPO patents, this problem may be less important, being EPO a supranational institution. Nonetheless, it must be pointed out that a certain bias in favour of Germany may be still present, as EPO is located in Munich. Notwithstanding that, in this paper we will not try to correct for this effect.

[6] The most recent and reliable data available on European patenting refer to 1993, whereas the time-series on exports provided by the OECD-Impex database is available up to 1992. In order to provide an up-to-date picture of Switzerland's sectoral specialisation, we have calculated RTAs and RCAs over two slightly different periods.

[7] The stability in the sectoral patterns of technological and trade specialisation is consistent with the results found by Amendola, Guerrieri and Padoan (1993).

[8] On this point, our results differ from those found by Schmoch, Grupp and Laube (1996). Using patent applications at the German Patent Office, they find in fact that in the pharmaceutical sector defined by the IPC class A61K Switzerland has a relative technological advantage.

[9] There is of course a close relationship between high-technology classes, considered in the previous section, and fast-growing technological groups. As a matter of fact, most of high-tech classes can be found in fast growing patent classes.

[10] Similar results have been reached by Archibugi and Pianta (1992). Using US patent data, they show that Germany and Switzerland concentrate their technological strengths in groups where world patenting is stagnant or declining.

[11] For example, in Krugman (1995, pg.345-346): "In sum, the empirical evidence on the actual pattern of international trade has, over time, tended to reinforce the view that patterns of comparative advantage are largely driven by differences in production functions. That is, technological differences are a major engine of trade."

[12] For a similar view see van Hulst, Mulder and Soete (1991).

[13] A three factor analysis with time added has been performed. However, the third factor was not significant.

[14] This is an outlier robust non-parametric regression method to fit flexible functional forms on the data (see Hardle (1990). The bandwith adopted is 0.8.

[15] Information on the weakness of the relationship is given by the partial correlation coefficient not shown in the table.

[16] The USPO patent database used by Malerba and Orsenigo (1994) comprises four countries: France, Germany, Italy and United Kingdom. The EPO patent database used by Malerba and Orsenigo (1995) refers instead to six countries: France, Germany, Italy, United Kingdom, Japan and United States. In what follows, we will refer to results emerging from this latter database.

[17] In this section, the analysis is restricted to the 49 technological classes (WS49) in which all patents have been aggregated. Moreover, the period 1978-91 has been chosen to compare our results with those found by Malerba and Orsenigo (1995) for the group of G6 countries.

[18] The average values of the four indicators for the group of G6 countries have been drawn from Malerba and Orsenigo (1995).

[19] The analysis has been restricted to the 37 technological classes for which it has been possible to elaborate a concordance table between IPC and SITC codes. Moreover, in principal component analysis, CONCENTRATION and STABILITY have been calculated over the period 1980-93, whereas STABILITY and ENTRY have been calculated over the periods 1980-84 and 1989-93. The choice of this time period seemed to be better to compare results from principal component analysis with trade data (RCA).

[20] It should be noted that the results just discussed do not change if similarity between regions is measured with revealed technological advantages (RTA), instead of the percentage distribution across the 49 classes. Similarly, the results do not change if the rank instead of linear correlation coefficient is used.