

# **From Fundamental Research to Industrial Application: The Global Competitiveness of Swiss Universities**

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## **ABSTRACT**

The pivotal role academic institutions play today as essential drivers of innovation, which creates market value and warrants a high standard of living in a fiercely competitive global economy, is unparalleled. For Switzerland, where the cost of living is among the highest in the world, it is a must to perform at the very top now as the impact of deficits will only be felt years later. Therefore, one needs to ask if the academic institutions are performing at the required level? In a benchmark study, Swiss universities were compared with some of the world's leading research institutions through the analysis of 40 performance indicators with a focus on the efforts "Science to Market." Looking at higher education in Switzerland, it is notable that the student population has been growing disproportionately since 2010, due to the higher enrolment of foreign students. Furthermore, Swiss universities are known for their excellence in fundamental research including public/private partnership projects. This was confirmed, with the two Swiss Federal Institutes of Technology in front. However, when focusing on "Science to Market" efforts, the rankings were pretty low. Whether looking at invention disclosures, patent applications, technology licensing, university spin-offs, or venture capital deals, a significant weakness in the competitive position of Swiss universities vis-à-vis its global competitors became apparent.

## **KEYWORDS**

Swiss universities, international benchmark, global competition, war for talent, quality of academic research, Science to Market, public-private partnerships

## **INTRODUCTION**

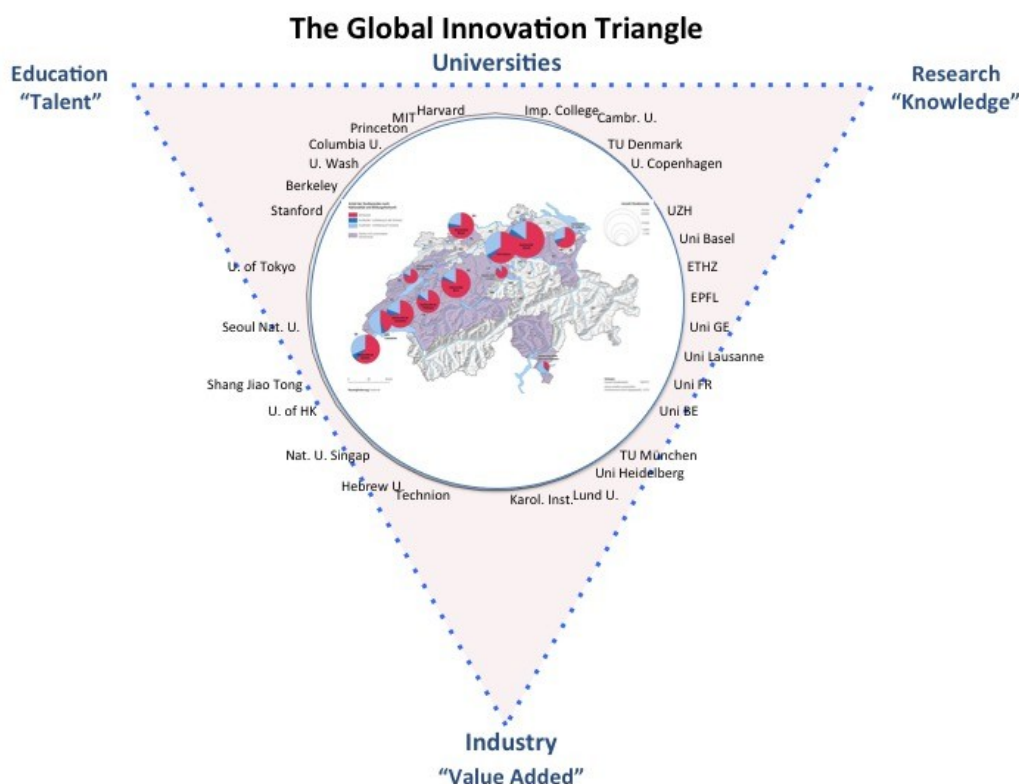
Today, academia is often at the epicenter of innovation. At every "Innovation Hotspot" of the world, there is at least one top-performing research university. Alongside this, past innovations under "Made in Switzerland," such as "Velcro" or the "World Wide Web," were the results of a synergistic interplay between university and industry. The surrounding businesses and industries are the primary beneficiaries of these efforts whether through the employment of emerging talents, research cooperations, or university spin-off companies. For decades, there was a disconnection between academic research and market application. While Swiss universities were expected to perform their fundamental research at a very high level, they were rather discouraged to look at opportunities for commercial application. So-called applied research was left entirely to the private sector. While this system seemed to work well in the past, academic research in many fields of science has become crucial for the market to lead in innovations. At the same time, the globalization of science and market has added a new element of competition among academic institutions worldwide and it is affecting the recruitment of talent, the overall economic development, and the standard of living at large.

Since Swiss universities are primarily financed by the public sector, the funding agencies are obligated to provide evidence that the taxpayers' investments are paying off by assessing the following questions: a) is academic research in Switzerland performing at a top-level from a global point of view? b) are the world's brightest talents studying in Switzerland? and c) do the universities actively seek the exploitation of the resulting innovation potential by industry? If so, the traditional funding mechanism of Swiss universities, in which the funding from the

public sector accounts for about 70 percent or more of the universities' overall expenditures, is reasonable because the university locations will generate dynamic visibility beyond national borders, trigger the interest of the champions in the global innovation economy, and motivate them to seek collaborations at Swiss locations.

In a recent international benchmark study<sup>1</sup> on behalf of the private foundation Fondation CH2048, the consulting firm TRIPLEYE Inc. analyzed the transfer of scientific discoveries among Swiss Universities to the market based on 40 performance indicators. The 8 largest Swiss Universities were compared with 22 of the world's leading universities in the United States of America, Europe, and Asia (Figure 1).

**Figure 1. The global innovation triangle including all universities analyzed in the benchmark study**



Source: von Arb (2020)

Note: The insert is a map of Switzerland with the locations of its universities.

## SWISS UNIVERSITIES ARE SMALL BUT GROWING

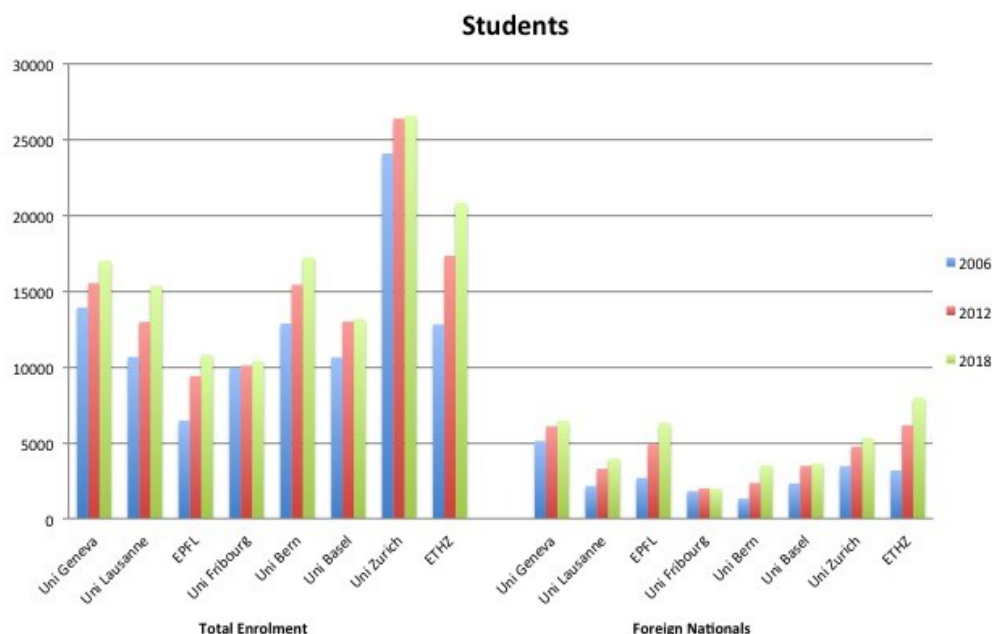
Swiss universities are among the smallest universities in the CH2048 Innovationsmonitoring 2020 benchmark study. However, the assumption that the student per professor/faculty ratio would be equally small is wrong. While small universities in the United States such as Princeton and Stanford have a student per professor/faculty ratio of less than 10, the ratio at the University of Geneva is more than 20 and at the Federal Institute of Technology in Zurich (ETHZ) there are 40 students per professor/faculty. Interestingly, a smaller student per professor ratio does not seem to impact the "employer reputation" of an academic institution in the private sector. It appears that it is primarily the "brand," the global reputation and recognition of an academic institution that shapes the "employer reputation." This may well be

<sup>1</sup> The present article is based entirely on the findings and original illustrations of the report CH2048 Innovationsmonitoring 2020 by the author Christoph A. von Arb

the reason why particularly the elite universities in the United States, Cambridge University and Imperial College in the United Kingdom, and Technical University in Munich are all highly ranked in this survey. They actively promote their global visibility and are thus able to position themselves ahead of the best Asian institutions in Japan, Singapore, and China. Regarding Switzerland, only ETHZ (rank 28) is among the top 50 of the world.

The availability of a highly educated talent pool is extremely important for an innovation-driven economy. In Switzerland, the highly-regarded “Dual Education System” used in the past meant that the enrollment levels and graduation rates in the tertiary sector remained low by international standards. It took federal reform of Swiss law on Vocational Training and Education at the Universities of Applied Sciences to initiate radical change. Since 2006, student enrollment at universities in Switzerland has been increasing dramatically and today the number of awarded Bachelor Degrees among the 25 to 34-year-olds is the highest of all OECD countries (Figure 2).

**Figure 2. Total number of students enrolled at Swiss universities in 2006, 2012 and 2018 and number of students originating from a country outside of Switzerland**



Source: von Arb (2020)

The growth in the student population is most pronounced at the two Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL). At EPFL, for instance, the number of students has almost doubled since 2006. It is important to note that this growth is to a large extent due to an increase in the enrollment of students from abroad.

Academic education and research cost a lot of money. If the expenditures of the universities are calculated on a “Per Faculty” basis, the values differ to a great extent: the Federal Institute of Technology in Zurich (ETHZ) and the Massachusetts Institute of Technology (MIT) are on top with 3.5 million US dollars each, while the Swiss universities in Fribourg and Geneva, as well as Imperial College in London and the University of Tokyo, have value, which is slightly below 1 million dollars per faculty.

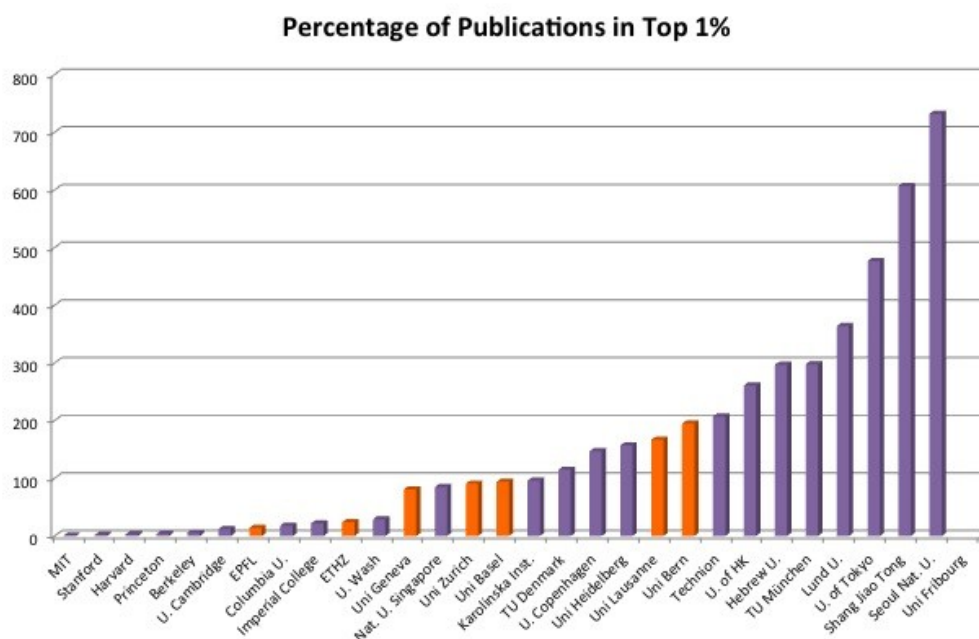
One might suspect that there would be a correlation between the number of students and financial expenditures, but that is not the case. This is particularly surprising from a Swiss

perspective, where a significant part of the public sector's subsidies is actually calculated according to the enrollment of students. Nevertheless, the high level of government support may very well contribute to the fact that the income generated from private donations and gifts by academic institutions in Switzerland is among the lowest of all universities in this study; this could be interpreted as a disincentive for universities to actively seek to expand this kind of revenue stream.

## TOP PERFORMANCE IN FUNDAMENTAL RESEARCH

In general, publications in highly selective peer review journals with a large number of citations are a must in order to gain recognition in academic research (Figure 3).

**Figure 3. Ranking of universities according to the percentage of most cited scientific publications among the top 1 percent**



Source: von Arb (2020)

These lists of publications greatly influence the decision-making process in research grant applications. Looking at the so-called citation index, the quality of fundamental research at Swiss universities must be pretty high, which also confirms the relatively high rankings of Swiss academia in ARWU<sup>2</sup>.

Nevertheless, here, too, the differences among the institutions are substantial and show the two Swiss Federal Institutes of Technology often on top in the most relevant fields of science. Among the most important research areas from an industrial application point of view are the Medical and Pharmaceutical Sciences, Biology, Earth Sciences, Physics as well as the Computer Sciences and Engineering. In three of them – namely in Computer Sciences and Engineering, in Physics and the Earth Sciences – ETHZ ranks among the top 50 in the world, while EPFL ranks among the top 50 in two areas. The Universities of Basel (Pharmaceutical sciences), Bern (Earth Sciences), Geneva (Physics), and Zurich (Biology) rank among the top 50 of the world in one research area.

<sup>2</sup> Academic Ranking of World Universities

In one of the most prominent and very quickly evolving research areas of today – Mathematics and Computer Sciences – the two Swiss Federal Institutes of Technology have been able to improve their ranking in recent years, while the University of Zurich lost terrain. With a global ranking of 250 in 2019, the largest Swiss University was at the end of all benchmark universities.

Interestingly, a similar trend can be observed when looking at the patent literature. In the period of 1980 – 2015, the high quality of fundamental research at Swiss Universities resulted in a strong resonance in the patent literature with the University of Geneva at the forefront. However, when looking at the year 2019, only the two Federal Institutes of Technology are still showing a good performance. The University of Zurich dropped from the 6th position in the study to number 14, while all other Swiss universities were not even included in the top 100 institutions.

## **PUBLIC-PRIVATE PARTNERSHIPS IN RESEARCH: UNIVERSITY OF BASEL IN FRONT**

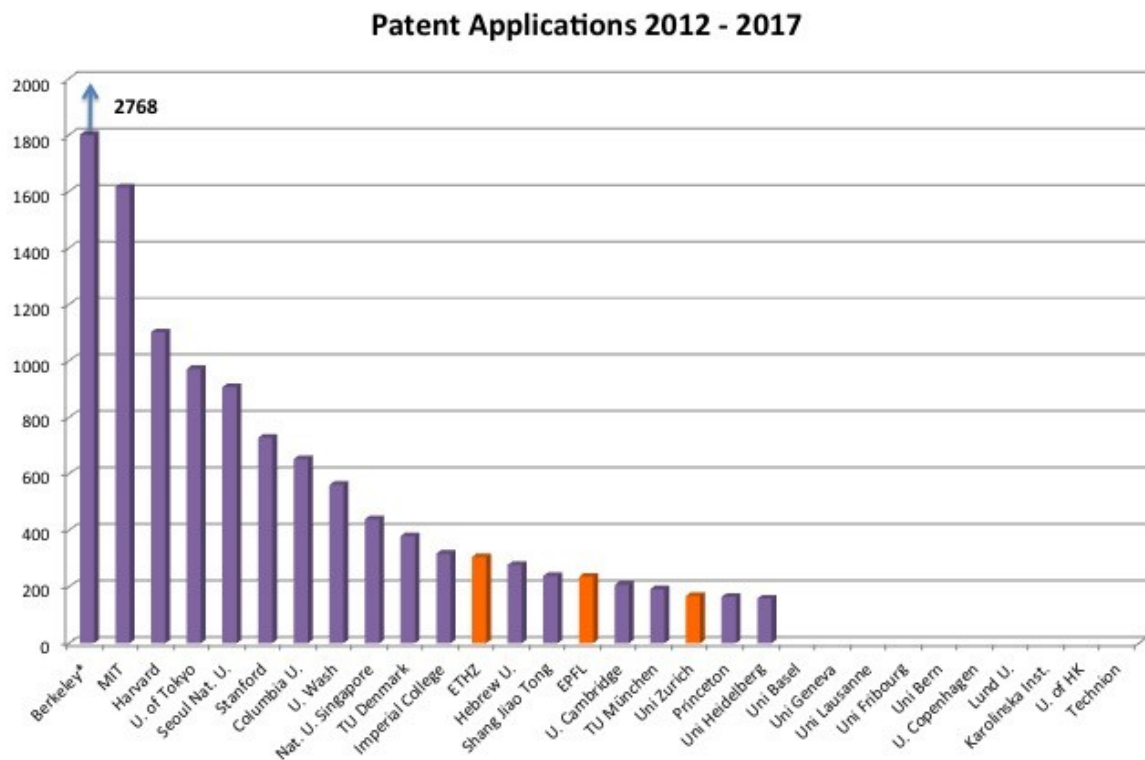
Another important indicator showing the universities' active pursuit to take their science research results to the market is the number of joint projects between universities and private sector entities. In a survey of more than 1,000 universities, the University of Basel is the front-runner in Switzerland: 9 percent of its scientific publications are co-publications with an author from the private sector, the same as Stanford University and MIT. Seoul National University has 7.5 percent, which is by far the highest value of all Asian benchmark universities and it ranks 7<sup>th</sup> in the world when comparing the PPP numbers in Physical Sciences and Engineering. The excellent position of the University of Basel is primarily due to Biomedical and Health related research collaborations. Furthermore, the University of Zurich ranks among the top 50 in the world for this area. The two Swiss Federal Institutes of Technology have a strong focus on Mathematics and Computer Sciences with the global rankings 9 (ETHZ) and 48 (EPFL), while the other Swiss universities are all at the end of the benchmark comparison in this prominent field.

The income generated by the universities with PPP projects is considerable: in 2018, the relatively small EPFL took in USD 70 million. This is significantly more than ETHZ received (USD 55 million). But the income of the University of Zurich (USD 120 million) was by far the highest in Switzerland, which is even remarkable from a global perspective. For instance, MIT took in USD 140 million, Tokyo University USD 80 million, Seoul National University USD 62 million. At the University of Basel, the funding amounted to a mere USD 42 million.

## **ONLY A FEW PROVEN INNOVATIONS**

Nowadays, at many universities, it is mandatory for scientists to report significant discoveries in research work. The employing academic institutions are, in most cases, the owners of the intellectual property (or the research work) unless it is privately mandated. Making the number of the invention declarations public and showcasing their performance in this sector on the global market has become a valuable asset for many universities, however, there are also other universities, including Seoul National University, that do not even publish related numbers in their annual reports. Of the ones that do, is it not surprising that technical universities such as the Swiss Federal Institutes of Technology have the highest numbers of invention declarations among the chosen benchmark universities, while at the University of Lausanne for instance it is only a small percentage of that.

**Figure 4. Number of patent applications by universities between 2012 and 2017.** The value for the Uni of Berkeley represents the amount of patent applications of the entire University of California system.



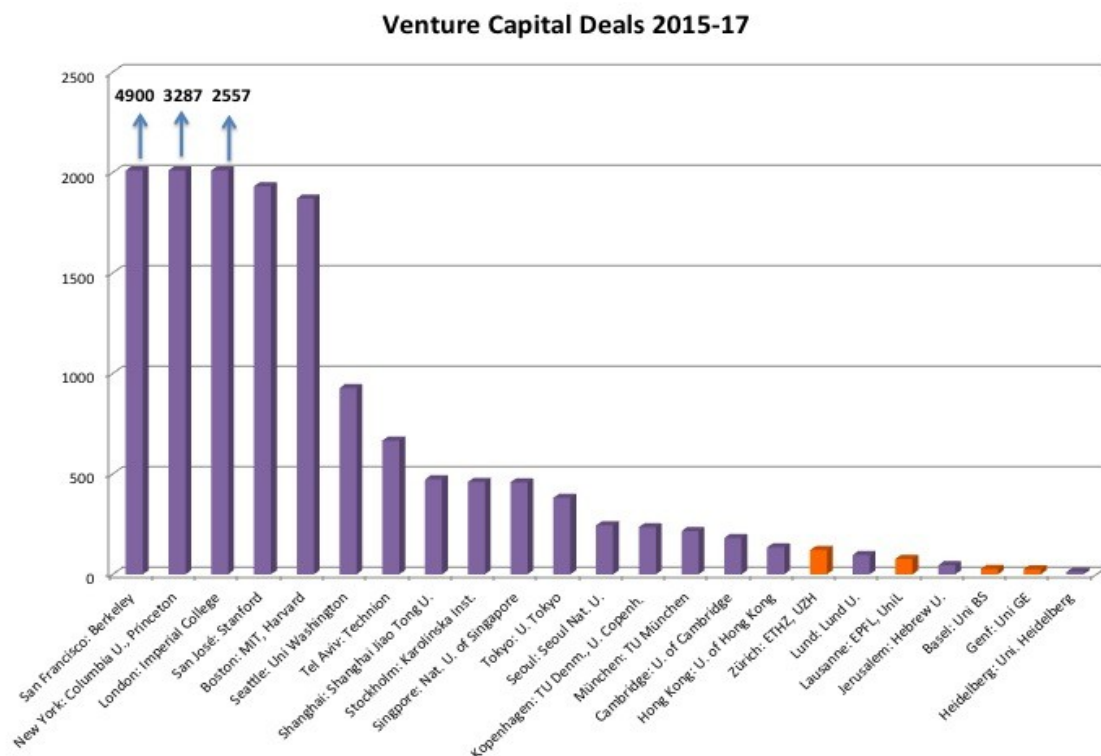
Source: von Arb (2020)

If an invention is considered to have a significant potential for a commercial application, universities move a step further and submit a formal application to patent the invention. The results for the patent applications (Figure 4) are comparable to the invention declarations. When the patent applications are based on the number of faculty, both Swiss Federal Institutes of Technology are ranked right behind MIT.

However, the fact that only 12 percent of their patent applications are in the field of Engineering and Computer Sciences, while a good 25 percent are in the field of Medical and Pharmaceutical Sciences is rather surprising. Of all the other Swiss universities, none is included in the world's top 100 for patent applications per faculty except for the formidable value of the University of Zurich. It is ranked as number 10 in the benchmark study. Even more impressive is the value of Seoul National University (ranking 6) ahead of Stanford University and the University of Tokyo.

A further important step to incorporate scientific research into the market is the active promotion of a start-up culture at academic institutions. The unsatisfactory results of the Swiss universities are not impressive considering the institutions have not been actively engaged in promoting such innovative culture. The current status of universities' venture capital activities is rather sobering: The numbers of VC deals (Figure 5) at the four Swiss locations Zurich, Basel, Geneva, and Lausanne are 50 to 100 times lower than at the locations in the United States, London, or Shanghai. The differences are even more dramatic when it comes to a comparison of actual VC investments, where the values differs by a factor of 1,000.

**Figure 5. Number of venture capital deals at locations of the benchmark universities between 2015 and 2017**



Source: von Arb (2020)

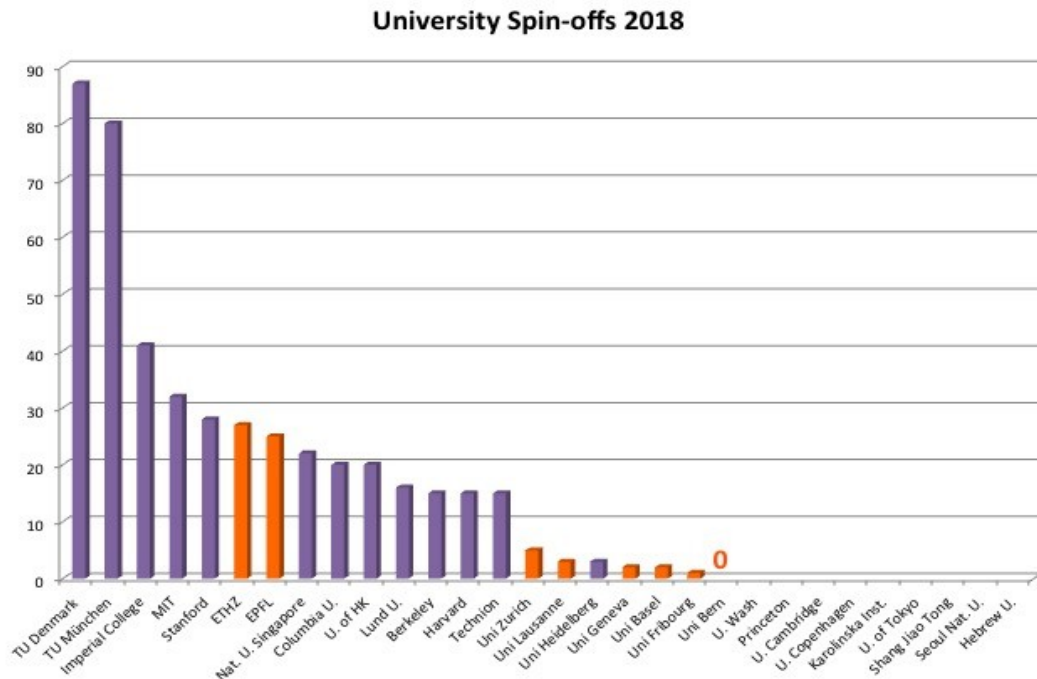
The only positive note is that the VC investments at the locations in Zurich, Basel, and Lausanne have seen an above-average increase (between 400-700 percent) in the years 2007-2017, although the increase is still lagging behind all Asian locations including Seoul (+1,500%).

When it comes to the comparison –of the numbers of startup companies, it is important to remember that most of them are not sSpin-offs from universities (Figure 6). True spin-offs originating from an academic institution must be verified as such. Unfortunately, many universities do not publish relevant information about their spin-offs. Among the ones that do, the two Swiss Federal Institutes of Technology have been showing a positive trend since 2006, recording 25 spin-offs in 2018 at which they are not much behind MIT and Stanford University. This is quite contrary to the other Swiss universities, where the number of spin-offs varied between 0 and 5.

Yet even launching a spin-off company does not guarantee that innovation will be successful in the market. Still, many founders of startup companies dream of becoming a Unicorn. This refers to a startup company with a market valuation of USD 1 billion or more, a status the company will lose if the company goes public or is sold. A specific category for startup companies with an estimated market potential valuation of that magnitude did not even exist 20 years ago, which indicates how much the dynamics in the startup sector have changed. In 2019, more than 350 start-ups across the world attained the Unicorns status (Figure 7).



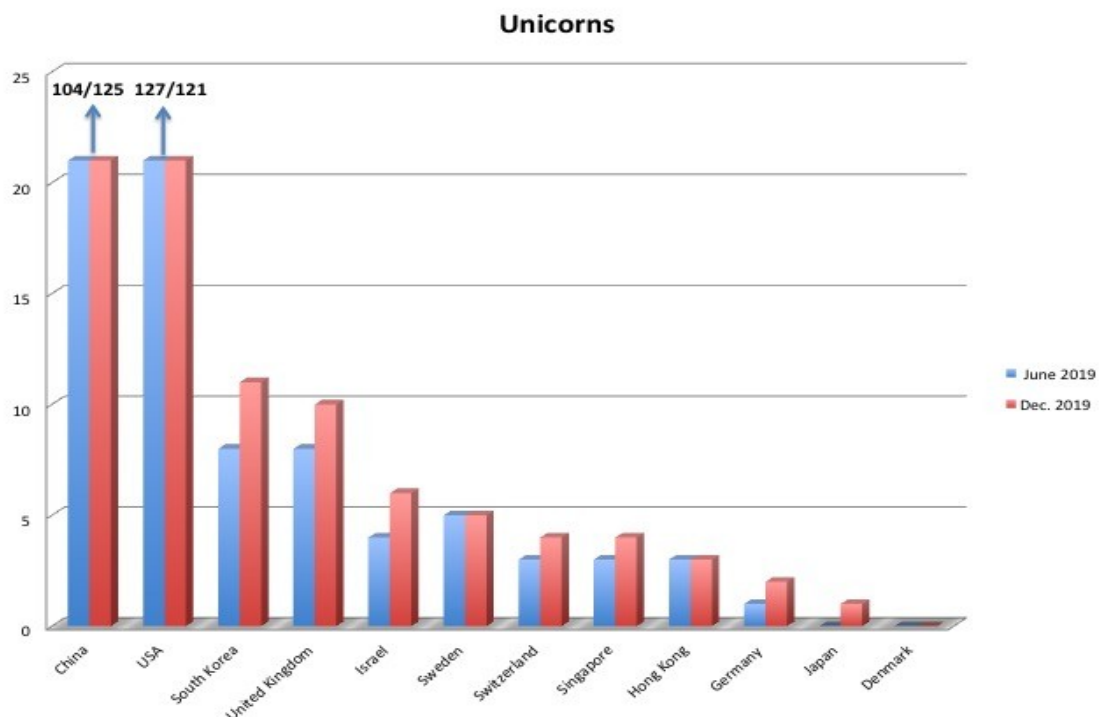
**Figure 6. Number of university spin-off companies founded in 2018**



Source: von Arb (2020)

Two-thirds were located in the USA and China, 10 each in South Korea and the United Kingdom, and 2 in Germany. In Switzerland, there were 4 and at least one was a direct university spin-off (EPFL). This is clear progress considering that only 3 years earlier, in 2016, no start-ups have yet earned the Unicorn title in Switzerland.

**Figure 7. Number of startup companies in benchmark countries reaching the valuation of a Unicorn status according to a global survey from June 2019 and in December 2019**



Source: von Arb (2020)



The very dynamic evolution of Unicorns was also exemplified by the two readings, which were done only half a year apart.

## CONCLUSION

The international benchmark study “CH-2048 Innovations monitoring 2020,” which used 40 different performance indicators, yields a highly detailed “Science to Market” profile of some of the world’s top research universities. Regarding the Swiss universities, the findings confirm, on the one hand, the traditional strengths mainly in fundamental research. On the other hand, they point to some distinct weaknesses in the “Science to Market” sector. Since developed countries are increasingly “science based” and are depending on its contributions in order to maintain a high standard of living, it is very important to watch and monitor the evolution on a continuous basis from a global point of view. The universities, which are among the main providers of new scientific knowledge need to completely abandon any “Ivory Tower” mentality and take all necessary measures to facilitate the symbiotic process between universities and the corporate sector to eliminate existing deficiencies and also for the sake of securing their own global competitiveness as their counterparts, particularly in Asian countries are catching up.

Swiss universities seem to be increasingly aware of these challenges and have begun to take action in recent years. This does not only become apparent when looking at their long-term strategies. Already today, concrete measures and projects are being formulated and implemented. In order to maintain a competitive position, it is a must to encourage the efforts to screen academic research results that provide economic merits, to run fundraising campaigns, and to promote public-private partnerships from which society at large, the principal funder of the universities in Switzerland, can benefit from it.

To that end, the policymakers need to constantly look for new and creative approaches and funding opportunities to encourage universities to shape their academic portfolio in a way that will facilitate the academic advancement to secure a sustainable future for the world from a larger perspective. In this way, Swiss universities will continue to maintain their impartial position and contribute to lead essential reflections and understanding in a perpetually changing world.

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