Annex 2

BiGGAR Economics

The Economic Contribution of the Institutions of the ETH Domain

A report to

ETH Board

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CONTENTS .... PAGE

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1 EXECUTIVE SUMMARY

In Spring 2017, BiGGAR Economics was invited by ETH Domain to assess the economic contribution created by its six members[1]. This report presents the findings of the study which has:

- demonstrated the **scale** of ETH Domain's economic contribution;
- demonstrated the **range** of impacts;
- established the **return** to private and public investment; and
- provided strong **evidence** for government and other agencies on the benefits and impacts associated with ETH Domain and its members.

With a combined operating revenue of CHF 3.6 billion, a staff complement of 21,000 people and 23,800 Bachelors and Masters students at the two Federal Institutes of Technology, the members of the ETH Domain have a significant presence in Switzerland. As well as major producers of spin-out companies and creators of patented technologies, the ETH Domain members contribute a significant slate of wider, non-quantifiable benefits which are valuable to individuals, government, society and science at large, on a global scale.

Importantly, this study set out to quantify the *economic* contribution made by the ETH Domain as far as it was possible to do so. However, it is important to acknowledge that the principal role of the organisation is concerned with *social* contributions that benefit science, society and the environment rather than creating economic impacts per se. Therefore there are other, highly significant impacts that arise from the work of the ETH Domain which cannot be quantified but which should not be overlooked. The organisation offers significantly more to science and society than that which is quantifiable in economic terms. A number of these are summarised briefly in section 0 on wider impacts.

Key Quantifiable Findings

The key finding of the report is that in 2016, the members of the ETH Domain supported an estimated **CHF 13.3 billion GVA[2]** and **98,700 jobs** in Switzerland alone. At a global level, their combined contribution was **CHF 16.5 billion GVA** and **123,800 jobs**.

This implies that in 2016 each person directly employed by the members of the ETH Domain supported almost five jobs in total throughout Switzerland and almost six jobs in total on a worldwide scale.

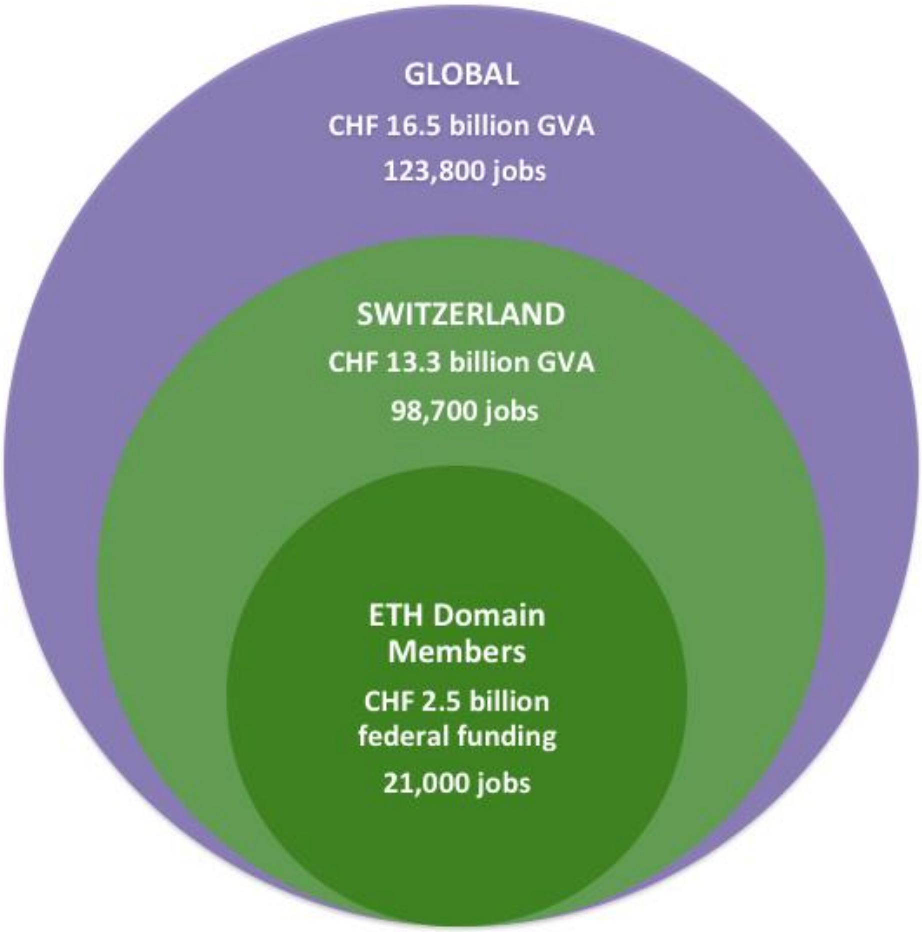
[1] ETH Zurich, EPFL, PSI, WSL, Empa and Eawag.
[2] Gross Value Added (GVA) is a measure of the value that an organisation, company or industry adds to the economy through its operations. In the case of universities and research institutions this is estimated by subtracting the non-staff operational expenditure (mainly represented by expenditure on goods and services) from the total income of the institutions.

The ETH Domain members received CHF 2.5 billion in federal funding in 2016[3]. This covers the financial requirements of the basic teaching and research facilities and the share of infrastructure investments for the government-owned property used by ETH Domain.

This gives a ratio of federal funding to impact of approximately CHF 1 : CHF 5 in Switzerland and approximately CHF 1 : CHF 7 globally.

The summary headline contributions are shown in Figure 1.1.

Figure 1.1 ETH Domain Members – Summary GVA and Employment Contribution, 2016



Source: BiGGAR Economics (Note: not to scale)

Sources of Contribution

There are two main types of economic contribution generated by the ETH Domain members: ***Incidental benefits*** and ***Purposeful benefits***. These are illustrated in Figure 1.2 and described below.

Incidental benefits arise from the core business of employing people and delivering services. In the case of the ETH Domain members, this amounts to 49% of the total GVA contribution generated in Switzerland. The incidental benefits are:

[3] This figure excludes the federal research contribution which is taken into account when discussing the impact of research in section 10.3

- **Core Contribution –** which includes the activity directly supported by the ETH Domain members expenditure in their supply chain, capital and infrastructure expenditure and staff expenditure in the economy. In 2016 this was estimated to generate CHF 5.7 billion GVA and 40,500 jobs in Switzerland.

- **Student Contribution** – there were 23,800 Bachelors and Masters students (including MAS/MBA students)[4] studying at the two Federal Institutes of Technology in 2016. Student expenditure, student employment (outside ETH Zurich and EPFL) and student volunteering generated a further CHF 765.2 million GVA and 7,400 jobs for the economy of Switzerland.

- **Tourism** – friends and family visiting staff and students as well as attendees to conferences and events hosted by the ETH Domain members generated an estimated CHF 65.8 million GVA and supported over 700 jobs in Switzerland.

Purposeful benefits arise from the value of the services delivered. This type of activity is conceived specifically with the aim of driving innovation and productivity growth within the economy. In the case of the ETH Domain members, this accounts for the remaining 51% of the total GVA contribution generated in Switzerland. The purposeful benefits are:

- **Commercialisation and Knowledge Transfer** – ETH Domain members undertake a wide range of commercialisation activity that supports innovation in Switzerland and beyond. This includes licensing technology and supporting the formation of new businesses (including the spin-off companies which were formed from the work of ETH and its staff). It was estimated that the commercialisation activities generated a total of CHF 2.2 billion GVA and 22,900 jobs in Switzerland. The ETH Domain members support knowledge transfer through their research, through services provided to businesses, through the internships that students undertake with businesses, by providing access to large scale research infrastructure and by supporting science parks. The knowledge transfer activities of the ETH Domain were estimated to generate CHF 3.0 billion GVA and 27,200 jobs in Switzerland.

  The unique characteristics of the Swiss innovation landscape, in particular the close collaborative relationships that exists between other academic institutions (both within Switzerland and abroad), links with government and joint working with industry, means that the full value of knowledge exchange activities is likely to be more than the sum of its parts.

- **Graduate Premium –** this contribution is conceptually different from the others in that it occurs over a much longer period of time. There are several aspects to the benefits of education to individuals and to society, some of which can be quantified and some cannot.

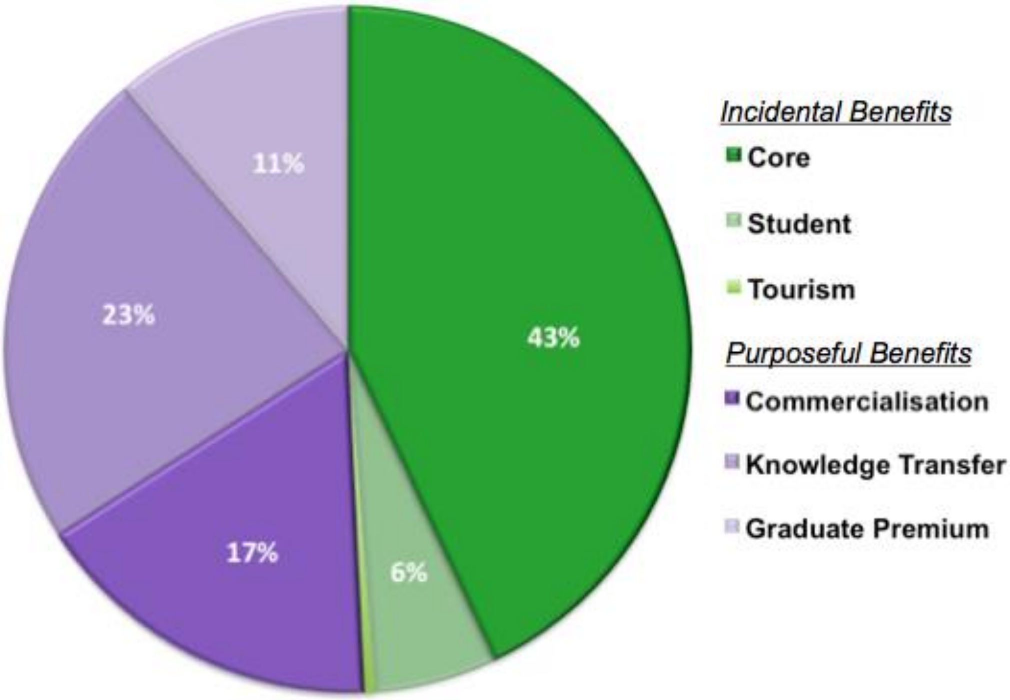
  The individual graduate premium that can be quantified in monetary terms recognises the increased earnings over a lifetime that stem from educating people to degree level. This contribution was estimated to be worth CHF 1.5 billion GVA in Switzerland, based on the 4,600 Masters, Doctoral and MAS/MBA qualifications awarded from the ETH Domain in 2016. Bachelors graduates have mainly been excluded from this calculation in order to avoid

[4] Doctoral students are not included in the student contribution as they are counted as staff and the impact arising from their expenditure is included in the section on core contribution.

double counting as approximately 96% proceed to a Masters course on completion of their first degree.

Non-quantifiably, there are wider benefits from attaining a higher education that are shown through studies on health and well-being and social cohesion as well as spill-over benefits within the workplace.

Figure 1.2 ETH Domain Members – GVA Contribution by Source, 2016 (%)



Total Contribution in Switzerland = CHF 13.3 billion

Source: BiGGAR Economics

Wider Impacts

As well as the teaching and research they deliver, there are other, wider benefits arising from the institutes of the ETH Domain to the individual, to government, to the economy, to science and to society as a whole. These are rightly included when considering the overall range of benefits that are attributable to the ETH Domain.

The ETH Domain members make an important contribution to the provision of public goods and, in doing so, underpin the nation's social responsibility to its people and to the environment. Several of the ETH Domain members are concerned with the quality and safety of the natural environment, improvements in ecology and the prevention of damage caused by natural disasters. Furthermore, certain economically and socially sensitive services are provided in Switzerland only by institutions of the ETH Domain.

Therefore the institutes of the ETH Domain support the public sector (the Confederation, the Cantons and the municipalities) with considerable services such as consulting, training and research projects which help them to carry out their tasks. A good example of this is the avalanche warning system which provides daily information on the location and risk of potentially devastating avalanches. This and many other services have an important role to play in supporting the social and environmental responsibilities within the country, contributing to a wider, indirect role in underpinning sectors that are vital to the national economy.

The ETH Domain members also make a crucial contribution to the research, development and innovation landscape in Switzerland. In particular, the members of the ETH Domain support and underpin the country's strong international reputation which contributes to the competitiveness of the Swiss economy. The research calibre and international reputation of the ETH Domain has also helped to attract foreign international investment in research and development to Switzerland. Prominent examples of this include Google, Disney and Nestlé choosing to establish research centres in Switzerland, in close proximity to or in partnership with members of the ETH Domain.

In addition, the institutions of the ETH Domain have a long-established and highly valued system of collaborative working that is regarded as a major factor behind the country's highly successful innovation system.

The ETH Domain members therefore have an influence that extends beyond teaching and research to impact on the economic, social and environmental quality in Switzerland, the progress of science and the health and social cohesion of the Swiss people.

Conclusion

Switzerland has a first class innovation system that is respected and acknowledged on an international scale. The institutions of the ETH Domain play a major role in developing and supporting this system due to the collaborative way in which they work, the quality and extent of their knowledge transfer activities and the quality of their graduates.

2 INTRODUCTION

BiGGAR Economics was commissioned by ETH Domain in February 2017 to identify and quantify the contribution that the organisation and its members made to the economy of Switzerland and abroad in 2016.

Background

The ETH Domain is composed of six member institutes, which together represent some of the most highly regarded research-intensive institutes in the world, attaining top positions in international rankings and attracting scientists and students from around the globe.

As a group of organisations, the ETH Domain makes a crucial contribution towards innovative power in Switzerland. This is vital for a competitive and successful economy and, as such, for employment and prosperity in the country.

ETH Domain Mission Statement

The ETH Domain strives to strengthen the competitiveness of Switzerland in the long term and contribute to the development of society through excellence in research, teaching and the knowledge and technology transfer.

It endeavours to serve as an exemplary beacon by assuming its share of responsibility for the management of urgent social challenges, the enhancement of the quality of life, and the long-term maintenance of our natural resources.

Source: The ETH Domain in Brief, 2017

The six members of ETH Domain are:

- ETH Zurich – the Swiss Federal Institute of Technology in Zurich;
- EPFL – the Swiss Federal Institute of Technology in Lausanne;
- PSI – the Paul Scherrer Institute;
- WSL – the Swiss Federal Institute for Forest, Snow and Landscape Research;
- Empa – the Swiss Federal Laboratories for Materials Science and Technology; and
- EAWAG – the Swiss Federal Institute of Aquatic Science and Technology.

They provide a very diverse, yet complementary group with different research mandates and focuses of activity. A description of the work of each organisation is contained in Appendix A. The key highlights of the ETH Domain in 2016 are summarised below.

ETH Domain – Highlights 2016

ETH Zurich opened its Arch_Tec_Lab in 2016 which concluded a six year project to create a prototype building using a largely digital planning and construction process. The building's 2,308m2 roof span with 48,624 timber elements was fully assembled by robots. The facility will function as a laboratory with real world conditions, emitting no emissions during use.

EPFL reported a strong performance in its start-up companies in 2016. As a group they increased in both number and in value. The list included MindMaze, the first Swiss "unicorn" with an estimated valuation of over CHF 1bn.

Eawag celebrated 100 years of lake research. The Lucerne Natural Research Society in Kastanienbaum founded a Hydrobiological Laboratory in 1916 which became part of Eawag in 1960. Following its expansion in the 1970s it became a significant place of research with an international reputation.

Empa opened a new Coating Competence Centre in close collaboration with industry. The Centre has been designed to take tailor-made surface technologies from the laboratory and turn them into marketable products. The aim is to give Swiss industrial firms an innovative edge over international competitors.

PSI opened its new, large-scale research installation - the Swiss X-ray Free Electron Laser (SwissFEL). It is part of a new generation of X-ray light sources which are expected to spur on important scientific breakthroughs in the fields of energy and the environment, information technology and health.

WSL concluded a seven year study into the effects of climate change on forests. It found that higher temperatures and increasing periods of drought are likely to afflict trees greatly.

Source: ETH Annual Report, 2016

In addition to the six members, the group includes the ETH Board (a strategic management body) and the Internal Appeals Commission of the ETH (an independent appeals body).

In 2016, the ETH Domain members employed approximately 21,000 people, of whom over 800 were professors. At the two Federal Institutes of Technology, 23,800 Bachelors and Masters students are educated.

The ETH Domain had an operating revenue of almost CHF 3.6 billion in 2016 of which the Federal Government contributed over CHF 2.5 billion, and research contributions, mandates and scientific services contributed almost CHF 0.8 billion.

In 2016 alone the ETH Domain spun out 50 companies, and developed 580 patents and licenses. The activities of the ETH Domain therefore generate economic impacts that are significant in both their scale, their quality and their range. This study sets out to quantify these impacts, both at the level of the Swiss economy and elsewhere throughout the world.

Study Objectives

The study has:

- demonstrated the **scale** of ETH Domain's economic contribution;

- demonstrated the **range** of impacts, distinguishing between those that are *incidental* and arise from the operations of the members and those that are *purposeful* and are associated with the outputs of each organisation;
- established the **return** to private and public investment; and
- provided strong **evidence** for government and other agencies on the benefits and impacts associated with ETH Domain and its members.

The reference year for all data is 2016. The study is intended to give a snapshot of the contributions made by the ETH Domain at the level of both the Swiss and the global economy at this time.

Report Structure

The remainder of this report is structured as follows:

- section three introduces the theoretical framework within which the economic contributions of the ETH Domain members are measured;
- section four describes the methodology and approach adopted for the study and discusses the classification of economic contributions into incidental benefits (sections 5 – 7) and purposeful benefits (sections 8 – 10);
- section five describes the economic contribution arising from the core activities of the ETH Domain members. This includes the contributions associated with direct income and employment, their combined expenditure on goods and services, staff spending and capital spending;
- section six describes the contributions associated with students whilst studying through spending in the local economy, working part-time in local businesses and volunteering;
- section seven assesses the combined contribution of the ETH Domain members to tourism from family visits to students and staff, business tourism and from expenditure at conferences and events hosted at each organisation;
- section eight discusses the economic contribution arising from the increased earnings generated during the working life of graduates as a result of having a university level education;
- section nine presents an analysis of the contribution that arises from the commercialisation work of all six members of ETH Domain;
- section ten analyses the contribution that arises through the ETH Domain's knowledge transfer activities;
- section eleven discusses the wider benefits that arise from the work of the ETH Domain and its members;
- section twelve presents a summary of the combined economic contribution of the ETH Domain members and draws conclusions from our research.

Appendix A presents a summary description of the work of each member institution, Appendix B provides a guide to abbreviations and terms used throughout the report and Appendix C provides a detailed Methodological Appendix.

3 THEORETICAL FRAMEWORK

In advanced economies, economic growth comes from productivity growth and this, in turn, is driven by the diffusion and exchange of knowledge. As a result, higher education and research institutes play a critical role in driving economic growth through their role as providers of knowledge and innovation.

This role was recognised more than 100 years ago in Switzerland when several of the universities and institutes that would later form the ETH Domain, were established. At the time a need for research and development was recognised which, through its diffusion, would drive economic growth and contribute towards modernising the economy.

This chapter begins by considering the role that academic research plays in stimulating productivity and, by extension, economic growth. It then presents a theoretical framework that describes the various ways in which universities and research institutes generate economic benefits and how these are classified into those that are incidental and those that are purposeful.

Productivity and Innovation

As producers of highly-skilled graduates and postgraduates, generators of world-class research and development and located at the centre of industry clusters, universities and research institutes contribute to economic growth. In recent years, a number of influential economists have published works that set out a theoretical and empirical case for the role that high level skills and innovation play in both boosting economic competitiveness and addressing inequality in society.

In the late 1950s Robert Solow published papers that showed that it was not the savings rate or increases in the factors of production (labour and capital) that determined the long-run growth rate, but increases in productivity. In the early 1960s Kenneth Arrow published papers on research and development and on learning by doing, which showed that almost all economic growth could be accounted for by innovation, both new ideas emerging from research and improving productivity through learning by doing during the process of production itself.

Building on this, the Nobel prize winning economist Joseph Stiglitz[5] has argued that productivity is the result of learning and consequently, a focal point of policy should be to increase learning within the economy. The observation is made that even within countries and within industries there can be large gaps between the most productive and the others.

This means that the diffusion of knowledge is as important as pushing the boundaries of knowledge. Moreover, since productivity growth is what drives growth in the economy, this indicates that there is considerable scope for higher rates of economic growth.

The scale of knowledge and innovation that takes place is also important because there are dynamic effects that come into play. New knowledge and innovation (the diffusion of knowledge) are both based on the foundations of prior knowledge and high levels of investment in knowledge and innovation give rise to an accelerating pace of innovation. In contrast, cutting levels of investment in

[5] Stiglitz and Greenwald (2014), *Creating a Learning Society: A New Approach to Growth, Development, and Social Progress*.

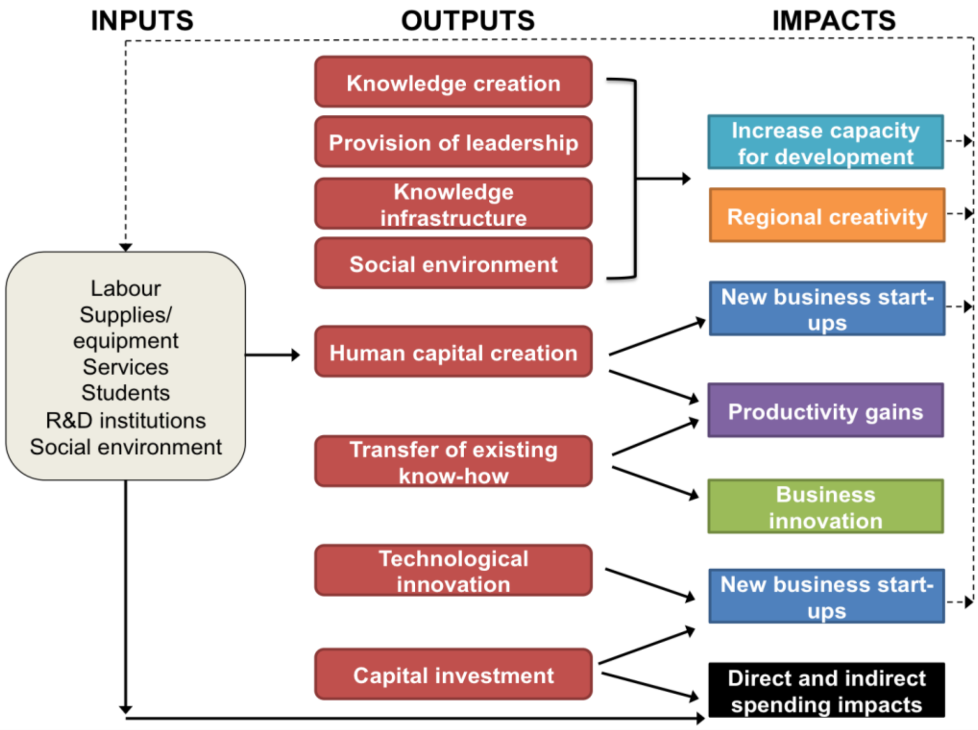
knowledge and innovation, will mean that the pace of innovation slows because underinvestment compounds over time.

In summary, knowledge and innovation are fundamental to economic growth, since it is productivity growth that drives economic growth and productivity growth is in turn driven by knowledge and its diffusion (innovation).

Framework

Universities and research institutes have wide and far-reaching impacts on the economy, which are often interrelated. The outputs and positive economic impacts associated with the core activities of universities and research institutes are illustrated in Figure 3.1.

Figure 3.1 University/Research Institution Outputs and Expected Economic Impacts



Source: Goldstein and Renault (2004), Contribution of Universities to Regional Economic Development: A Quasi-Experimental Approach.

The inputs of staff time (labour), supplies, equipment, research services and students create a set of outputs that range from the creation of knowledge and infrastructure to the transfer of existing know-how, technological innovation and capital investment.

Through these outputs, a set of impacts arise which result in economic growth and development. This includes productivity gains, business innovation, new business start-up activity and an increased capacity for development. All of this activity produces further direct and indirect impacts on the economy through expenditure and multiplier effects. Some of these outputs and impacts are discussed in more detail below.

3.1.1 Intellectual and Human Capital Creation

The two fundamental activities of universities and research institutes are the creation of both intellectual and human capital. They contribute to knowledge creation through undertaking basic and applied research that has given rise to the most influential technologies today and will continue to shape the technologies of the future. Universities also provide high quality graduates for the labour market that in turn increase the innovation potential of the economy, as well as leading to productivity gains for the economy.

3.1.2 Knowledge Infrastructure

Universities and research institutes also have a role to play in the production of knowledge infrastructures, which largely arise due to positive agglomeration effects. As an example, many research institutes, and companies choose to locate in close proximity to research intensive universities in order to benefit from informal knowledge sharing as well as frequent face-to face contact with academics involved in research. It is for this reason that areas with universities and research institutes also have large numbers of associated knowledge infrastructures such as science parks, which can ultimately develop into knowledge clusters.

3.1.3 Exchange of Existing Knowledge and Technological Innovation

Over and above these fundamental activities, universities and research institutes also work to exchange existing knowledge throughout the economy through their interactions with businesses such as through commissioned and joint research and further education, which increases productivity and business innovation. Universities and research institutes are also vital sources of technological innovation through the commercialisation activities that they undertake such as spin-out companies and intellectual property licensing.

3.1.4 Social Environment – The Ecosystem

Universities and research institutes can also create an impact on their local environment as their staff and students contribute to the overall vibrancy of the cities and towns they are located in.

In addition, they contribute to the attractiveness of a region as a knowledge centre and this wider role in underpinning the economy is something that should not be overlooked. Universities and research institutes provide a space for discussion and create connections between academia, students and companies that would not otherwise exist and therefore foster an environment for innovation. This creates clusters of people, which lead to the creation of entire research ecosystems which, in turn, draws more people.

In the case of ETH Domain, the members have a clear role in helping to attract investment into the five innovation sites around the country (Park Basel Area, Park Innovaare, Park Zurich, Park Biel/Bienne and Park Network West EPFL). This makes these areas attractive places in which to invest and, as a result, the universities and research institutes are vital in helping to draw and retain inward investment in the country.

In a marketplace for inward investment that is increasingly competitive on a global scale, this is a particular strength for the country and for Europe as a whole.

The international dimension of the research undertaken at universities and research institutes and the international character of the institutes themselves contributes to improving Switzerland's brand as a whole, making the country more interlinked and providing opportunities for partnerships with the wider global economy by attracting inward investment.

The ecosystems are entirely built on the world-class research undertaken by the universities and research institutes and it is this world-class research that attracts companies and investment into Switzerland, helping to catalyse innovation in local businesses. The fundamental research undertaken by them therefore creates the knowledge sectors of the future.

Incidental and Purposeful Benefits

The contributions associated with the ETH Domain members can be grouped into two main categories: ***incidental benefits*** and ***purposeful benefits***.

Incidental benefits result from the existence of any large organisation with a significant staff complement, an extensive supply chain and a large consumer base. These types of benefits occur regardless of the nature of the business or organisation and for this reason are thought of as incidental benefits. In the case of ETH Domain these include:

- the core operational effects of the ETH Domain members, including the people they employ, their expenditure and that of their employees on goods and services and their expenditure on capital and research infrastructure;
- the effects generated by students at the member organisations including the impact of student expenditure on goods and services and the contribution that students make to the local economies in which they live by working or undertaking voluntary activity during the course of their studies; and
- the contribution that visitors to the member organisations and their students and staff make to the Swiss tourism sector.

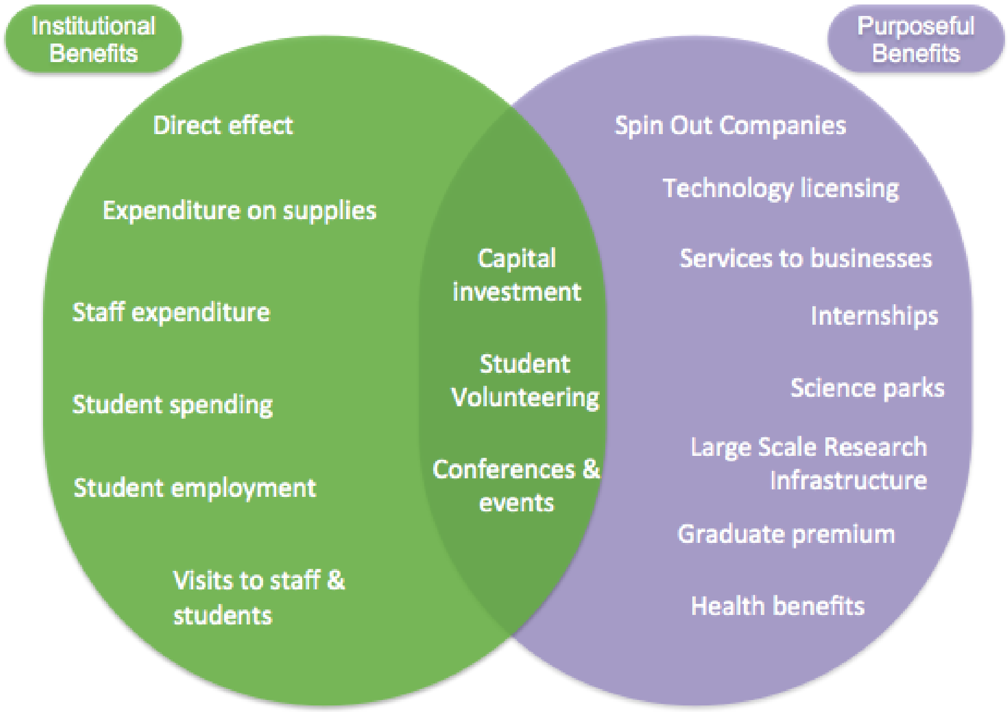
Purposeful benefits this type of activity is conceived specifically with the aim of driving innovation and productivity growth within the economy. These benefits are associated with the nature of the activity undertaken by the universities and research institutes rather than their existence as organisations and might therefore be described as "purposeful benefits". These include:

- the contribution that graduates from the ETH Domain members make to the productivity of the Swiss economy as a result of the skills and experience they gain during their time at these organisations;
- the economic value of the research undertaken by the ETH Domain members; and
- the contribution that the ETH Domain members make to long-term economic growth by supporting innovation and the creation and development of businesses within the Swiss economy.

The distinction between "incidental" and "purposeful" benefits is depicted in Figure 3.2 which illustrates that the distinction is not always clear-cut.

For example, some of the tourism benefits described in section 0 are associated with conferences and events that are directly related to core areas of research or knowledge exchange activity. Similarly, students and staff who decide to volunteer often do so independently of the member organisations – but their ability to do so often rests on skills or knowledge gained during their work or studies.

Figure 3.2 ETH Domain - Incidental and Purposeful Benefits



Source: BiGGAR Economics

Conclusion

The growth of advanced economies is associated with a role for universities and research institutes as providers of the intellectual and human capital required for a successful modern economy.

The origins of the ETH Domain members date back over 150 years to 1855 when ETH Zurich was formed as a national education institution of international standing attracting talent from all over the world. Through a successful combination of a cosmopolitan outlook with strong national roots, the institution became one of the driving forces behind Swiss industrialisation: bringing the necessary expertise into the country, training technical specialists and helping to set up ground breaking national infrastructures.

Similarly, EPFL in Lausanne can trace its origins back to 1853 when it began as a private technical school. Empa and WSL also have origins that date back over 100 years while Eawag is over 80 years old. Along with PSI which was established in 1988, all of these institutes were formed with a mandate to drive, research and knowledge in their respective fields and to find and disseminate solutions to identified national and global issues.

Therefore, as major drivers of knowledge and innovation, the ETH Domain members are fundamental to economic growth in Switzerland and beyond since it is productivity growth that drives economic growth and productivity growth is in turn driven by knowledge and its diffusion (innovation).

4 METHODOLOGY AND APPROACH

This chapter describes the overall approach undertaken during this study and the broad principles used to assess economic contribution. It also summarises the methodology used to quantify the economic contributions considered and discusses the parameters of the study. Primarily these centre around the benefits arising from the work of the ETH Domain members which are non-quantifiable.

Previous Uses of Method

BiGGAR Economics is an independent economic development consultancy based near Edinburgh in Scotland. Over the past decade, the company has become recognised for its market and thought-leadership on the contribution of higher education and research institutions at a regional, national and global scale.

The methodology followed is one that has been in wide usage for at least 20 years. During that time, BiGGAR Economics has worked with more than 70 leading institutions and groups of institutions in the UK, Ireland and Europe, assessing historic, current and potential future economic contributions. The approach used in this report has been developed and informed by this experience. Recent examples of our work in this field include:

- Flemish Universities (BIGGAR Economics, 2017);
- League of European Research Universities (BiGGAR Economics, 2014 & 2017);
- Universities Estonia (BiGGAR Economics, 2017);
- Finnish Universities (BiGGAR Economics, 2017);
- University of Oxford (BiGGAR Economics, 2016);
- University of St Andrews (BiGGAR Economics, 2016);
- Amsterdam Universities (BiGGAR Economics, 2014); and
- University of Edinburgh (BiGGAR Economics, 2008, 2012, 2014 & 2017).

Also relevant is our work for the Russell Group of 24 Universities in the UK which measured their combined impact of both capital projects[6], (2014) and research work[7] (2010).

Some other examples of similar studies undertaken by other organisations include the University of Birmingham (Oxford Economics, April 2013), the University of British Columbia (2009, Planning and Institutional Research), the University of Iowa (September 2010, Tripp Umbach), the University of Notre Dame, Indiana (September 2013, Appleseed). Also relevant is work by Universities Scotland[8] on the contribution of the sector to economic growth and a study by UniversitiesUK

[6] Financial Times (20 May 2014), *Russell Group universities invest £9bn to attract best students* (the report is being published at http://www.russellgroup.ac.uk)
[7] Russell Group (2010), *The economic impact of research conducted in Russell Group universities* (available at http://www.russellgroup.ac.uk)
[8] Universities Scotland (2013*), Grow Export Attract Support: Universities' contribution to Scotland's economic growth* (available at http://www.universities-scotland.ac.uk)

that demonstrates the contribution of the higher education sector to the UK economy[9].

The approach used for the economic impact of universities and research institutes is also consistent with Guidance issued by several governments and public sector organisations. For example, the methodology is consistent with the principles set out in European Commission Guidance[10] on major projects, which highlights the importance of assessing the fullest range of potential economic effects possible.

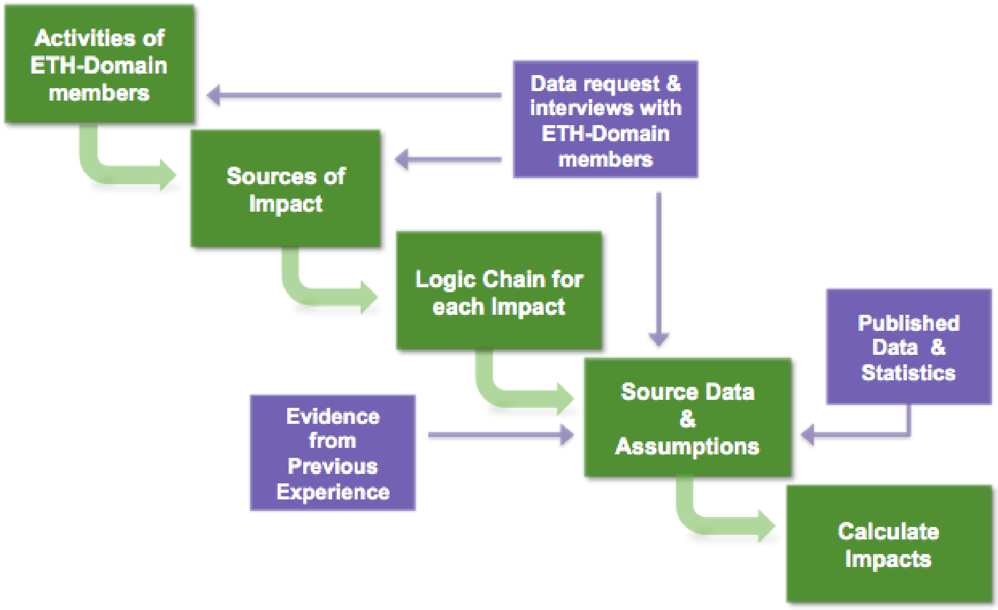
From this, BiGGAR Economics has established credibility with policy makers and sector organisations. Our impact studies have been used to demonstrate the value that universities and research institutions have to stakeholders, policy makers and the public as well as being used in support of funding applications.

Approach and Methodology

4.1.1 Overall Study Approach

The overarching objective of this research is to illustrate the scale and breadth of the economic contribution made by the ETH Domain members. The different steps involved in this process are illustrated in Figure 4.1.

Figure 4.1 Economic Contribution of ETH Domain: Study Approach



Source: BiGGAR Economics

The starting point for our analysis was to consider the various activities undertaken by the different members and to identify those that were likely to generate an economic contribution.

[9] Viewforth Consulting Ltd (April 2014), *The Impact of Universities on the UK Economy* (available at http://www.universitiesuk.ac.uk/highereducation)
[10] European Commission (July 2008), *Guide to Cost Benefit Analysis of Investment Projects* [in particular section 2.5 on Economic Analysis] (available at http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf)

Logic chains were then developed to describe how each type of activity generates economic value and these were then used to build an economic model that estimated the economic contribution of each institution.

The next step was to consider how the value generated by each type of activity might be measured and what data would be required to do this. For most types of activity two types of information were required: source information about the scale of activity and data that could be used as the basis for assumptions to measure the economic value generated by this activity.

Where possible, source data was obtained directly from the ETH Domain members through data requests and through face to face interviews with senior staff at each institution In cases where data was not available, an appropriate assumption was made based on the data provided by other ETH Domain members and/ or BiGGAR Economics' previous relevant experience of other comparable institutions elsewhere in the world.

Where it was necessary to make such an assumption and a range of potential values were available, the approach taken was to make a conservative assumption. For this reason it is likely that the values reported in this study tend to underestimate, rather than overestimate, the total contribution of the ETH Domain members.

The data required for the general assumptions used in the model was obtained either from published reports, official statistical sources or based on BiGGAR Economics' previous experience within the higher education sector. The key statistical sources used were the OECD's Input-Output Tables for Switzerland 2011 (multipliers calculated were Leontief Type 1 and Type 2) as well as data from the Swiss Federal Statistical Office. The various sources used are specified in the relevant sections of the report and in the Methodological Appendix.

This data was then used to populate the economic model and estimate the value of each source of contribution for each institution. Each type of contribution was then aggregated in order to produce an estimate of the total contribution of all ETH Domain members.

4.1.2 Units of Measurement

As far as possible this report has attempted to express the economic value generated by ETH Domain members using two widely accepted measures of economic contribution: jobs and gross value added (GVA).

- **Gross Value Added (GVA)** is a measure of the value that an organisation, company or industry adds to the economy through its operations. The report used the production approach to measuring this contribution, where the GVA is equal to the value of production less the value of the inputs used. Typically this is estimated by subtracting the non-labour costs of the organisation from the organisation's total revenue. In the case of ETH Domain members this is estimated by subtracting the non-staff operational expenditure (CHF 937.5 million) from the total income of the universities and research institutes (CHF 3.6 billion); and

- **employment** (jobs) is measured in terms of headcount jobs supported unless stated otherwise.

One of the reasons that these measures are so widely used is because they provide a convenient way of capturing the entire economic contribution of an organisation in a single number. While the appeal of such measures is easy to understand they do have parameters which should be kept in mind (Section 0).

4.1.3 Sources of Quantifiable Contributions

The economic contributions quantified in this report have been grouped into five themes:

- core contributions, including direct effects, supplier effects, staff spending and capital spending;
- student-related contributions from students spending, working part-time, and volunteering;
- the tourism contribution created by visitors to staff and students and attendance at conferences and events held at the ETH Domain member institutes;
- the life-time productivity gains from teaching and learning delivered by the ETH Domain on graduates;
- the contribution arising from the commercialisation and knowledge transfer activity undertaken by the ETH Domain members. This includes the contribution of technology licensing, spin-off companies, student internships, working with businesses and research infrastructure. Activity associated with the country’s science parks that has been influenced by their association with the ETH Domain members is also included in this category.

The methodology for each of these calculations is briefly described throughout the report as each contribution is discussed. A more detailed discussion is contained in the supplementary methodological appendix which accompanies this report.

4.1.4 Baseline Year, Measures and Geography

The economic contributions described in this report are for 2016, which is the latest year for which published data on income, staff and students was available from each institution at the time of writing in Spring 2017.

Each area of contribution requires the use of three types of economic assumptions:

- GVA to turnover ratio – this is used to estimate the GVA contribution of the spend in an area. The ratio for each sector for Switzerland is obtained from the OECD;
- turnover per employee – this is used to estimate the employment contribution of the spend in area. This is also obtained from the OECD and is available by sector for Switzerland; and
- GVA and employment multipliers – these are used to estimate the contribution of the initial direct economic contribution elsewhere in the supply chain and through the spending of the salaries associated with the direct economic contribution. These multipliers were estimated by BiGGAR Economics using OECD Input-Output tables for Switzerland.

These terms are defined further in Appendix B. The economic contributions quantified in this report are those at the level of the Swiss and the global economies.

4.1.5 Avoiding Double Counting

Given the approach summarised in Figure 3.1 above, it was necessary to make adjustments to some of the calculations, to avoid double counting. So, for example, where a spin-out company from one of the institutes also has a license agreement with them and is based on one of the research parks linked with the institutes, the associated contribution has been counted only once.

4.1.6 Economic Contribution and the Counterfactual

The question that arises from any study of economic contribution or impact that considers the outputs and impacts delivered by a given set of resources and inputs is what the counterfactual position could have been, that is, what outputs and contributions could have been achieved by using the same resources and inputs in a different way?

This study does not seek to directly compare the economic contribution of research institutes with that made by other organisations or sectors. Rather, the counterfactual position is to imagine an alternative situation where the ETH Domain members did not exist and where the activities that they undertake did not take place.

In practical terms, only those economic contributions that can be considered additional and attributable to the ETH Domain members have been included. So, for example, the economic contribution of student part-time work has been included, but adjustments have been made to exclude employment that could have been taken by non-student employees. Where the role of a member has been important in delivering economic benefits, but where other organisations or activities may also have been important drivers (for example, the development of research/science parks), only a part of the economic contribution has been attributed to the ETH Domain members.

4.1.7 Timescale of Contributions

Some of the activity undertaken by the ETH Domain members generates economic activity immediately. For example, purchases of goods and services made by the ETH Domain members generates activity amongst their suppliers almost immediately.

However, much of the work of the ETH Domain members produces an on-going dynamic economic contribution which will be realised over the course of several years. For example, ETH Domain members are collectively engaged in a wide range of world-leading research that will ultimately provide the foundations for the technologies upon which entirely new economic sectors will be based – from new materials technologies to innovative water treatments.

Although developing such technologies is fundamental to long-term competitiveness, it also involves considerable time-lags of the sort that are difficult to account for using traditional approaches to economic impact analysis.

Limitations in data availability mean that it is generally not possible to estimate the actual impact of historic activity that is realised in any particular year. To overcome this, the report makes the simplifying assumption that activity undertaken in 2016 generates impact in 2016. This is reasonable because although the impact of some activity that occurs in 2016 will not transpire until a later date, some of the impact that was realised in 2016 will have been generated by historic activity.

The timeframe of the economic contributions quantified in the report are summarised in Table 4-1.

Table 4-1 Timescale of Economic Contributions

Contributions realised in 2016	Contributions realised in the Future
Core Operations	Graduates
Students	Services to Businesses
Tourism	Health Benefits
Spin-offs	
Science Parks	
Licensing	
Student Internships	

4.1.8 Number Formats

This report has been produced using UK number formatting, i.e. CHF 1 billion is presented as CHF 1,000,000,000.00 where the symbol for the decimal marker is a point on a line[11].

Parameters of the Study

While every attempt has been made to measure the economic contribution of the ETH Domain members as consistently and accurately as possible, there are certain parameters to the study which should be considered.

The report aims to quantify the economic contribution that the ETH Domain makes using the two widely accepted measures of GVA and employment. However, using GVA and jobs as a basis for measuring economic contribution gives equal weight to all types of economic activity regardless of their wider value to society. This means that they cannot reflect the fact that some types of research activity are intrinsically more valuable to science and to society than others.

As well as this, it is not always possible to quantify all of the benefits of an organisation due to lack of available data. It is important to note therefore that what can be counted is not always the most important and as such there will be significant unquantifiable economic contributions.

For example, several members of the ETH Domain are engaged in research that provides public goods (the avalanche warning system provides a very good example) which benefits society, the environment and the economy in the widest sense. These services contribute very real benefits that cannot be measured in quantifiable terms.

In addition, through their work ETH Domain employees generate a wide variety of benefits for the Swiss economy and wider society. They help to improve the productivity of the workforce by providing high-quality education and training, stimulate innovation within the business base through their research and enable

[11] 22nd General Conference on Weights and Measures, 2003.

the development of new economic sectors that will provide the basis for future national competitive advantage.

ETH Domain members also make important contributions to other socially valuable outcomes, such as improving social cohesion, facilitating social mobility and encouraging greater civic engagement. The value of these outcomes to the individuals affected and society as a whole simply cannot be quantified. It is therefore essential that the economic contribution of ETH Domain members is understood as part of this wider context.

5 CORE CONTIBUTION

There are four elements to the core contribution from the ETH Domain members:

- the direct effect (income and employment);
- the income effect (impact of staff spending);
- the supplier effect (impact of expenditure on supplies and services and jobs supported by this spend); and
- the capital spending effect.

In terms of the framework for analysis set out in section 0, the benefits described in this chapter are considered to be "incidental benefits". The possible exception to this is capital investment, which is sometimes undertaken with the aim of achieving specific economic development objectives.

Direct Contribution

The direct contribution of a group of organisations (or a single organisation) is the value it adds to the economy and the number of jobs it supports in a given time frame.

In 2016, the six ETH Domain members had a combined operational revenue from all sources of CHF 3.6 billion. The largest element of this was the federal contribution which accounted for 71% of the total, with research contributions, mandates and scientific services accounting for a further 22% of income. The sources of revenue are shown in Table 5.1.

In addition, the ETH Domain members had a total employment headcount of 21,000 staff, which was equivalent to 18,200 full-time jobs (Table 5-2).

The economic value arising from this revenue and employment is measured using Gross Value Added (GVA), which can be estimated by subtracting all of the non-staff operating expenditure (amounting to CHF 973.5 million) from the total operational revenue of the ETH Domain members (amounting to CHF 3.6 billion). Non-staff operating expenditure is mainly represented by expenditure on goods and services, premises costs and other operating costs and this creates a further economic contribution which is discussed later in this section on supplier impacts. In simple terms, GVA is the value of the service created less the value of inputs used.

The direct GVA created by the ETH Domain members in 2016 was CHF 2.6 billion and the direct employment was 21,000 jobs. This is shown in Tables 5.2 and 5.3.

Table 5-1 ETH Domain: Combined Direct Effect Assumptions – Total Operating Revenue

	Total (CHF m)
Total federal contribution	2,529.9
Research contributions, mandates and scientific services	776.4
Donations and bequests	113.1
Other revenue	120.2
Tuition fees and other utilisation fees	35.5
Total Operating Revenue	3,575.2

Source: ETH Domain Members (Note – figures may not sum due to rounding)

Table 5-2 ETH Domain: Combined Direct Effect – Employment

	Total
ETH Domain employment (headcount)	21,004
ETH Domain employment (full-time equivalent jobs)	18,213

Source: ETH Domain Members

Table 5-3 ETH Domain: Combined Direct Effect – GVA

	Total (CHF m)
Total Operating Revenue	3,575.2
Less Non-staff operational costs (goods and materials, premises costs, other operating costs)	973.5
Direct GVA	2,601.6

Source ETH Domain Members

Staff Spending Contribution

The 21,000 staff employed directly by the ETH Domain members spend their wages and salaries in the wider economy and this also increases turnover and supports employment in local businesses and throughout Switzerland as a whole.

As doctoral students are employed as staff by ETH Zurich and EPFL, their expenditure contribution has been *included* here. To avoid double counting, doctoral students have, therefore, been *excluded* from the student impact calculations which are presented in section 6. However, the graduate premium calculations in section 8 measure the earnings premium from attaining university education at all levels and therefore, *include*s doctoral students as well as other graduates.

The total amount spent on staff (total personnel expenses) in 2016 was CHF 2.1 billion which included salaries and wages (CHF 1.8 billion), social insurance schemes and pension expenses (CHF 292.9 million) and other staff costs (CHF 37.4 million). This figure is the sum of the personnel expenses of all ETH members as reported by them in their annual accounts.

The economic contribution of this spend will depend on where staff spend their wages which in turn depends on where staff live. Data provided directly by the ETH Domain members indicates that 97% of staff live in Switzerland.

The second step is an assumption of how much of a person's wage is spent in each study area. This is an assumption about the location of people's expenditure and not an assumption about where the products that are purchased are originally from, as this is already accounted for in the economic multipliers. It was assumed that 95% of staff expenditure takes place in the national economy and 5% takes place abroad. This is based on OECD data from 2014 on the location of household final consumption expenditure[12].

An adjustment of 4% is then made to deduct the VAT element in this expenditure to ensure that the estimates are in line with OECD data[13]. This figure comes from a study by Lund University in 2015 on the VAT burden in Switzerland.

The key assumptions used in calculating this contribution are shown in Table 5-4.

Table 5-4 ETH Domain: Combined Staff Spending – Assumptions

Staff Numbers	
Number of jobs (headcount)	21,004
Total personnel expenses (CHF million)	2,089.4
Staff Location	
Switzerland	97%
Abroad	3%
VAT	
VAT as a proportion of staff expenditure	4%
Location of Spending	
Switzerland	95%
Abroad	5%
Total	100%

Source: ETH Domain Members and Lund University (2015).

The economic contribution of staff spending as measured by GVA and employment supported is estimated by applying the assumptions described above. Appropriate economic ratios and multipliers were then applied in order to estimate the economic contribution.

This results in a staff spending contribution of almost CHF 2.0 billion GVA and 11,900 jobs in Switzerland and a further CHF 530.1 million and 3,700 jobs abroad. These figures are summarised in Table 5-5.

[12] Source: OECD (2014), Final consumption expenditure of households, https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE5

[13] Source: Lund University (2015), Taxing Consumption, An Analysis of the Distribution of the VAT burden in Switzerland, p.28

Table 5-5 ETH Domain: Combined Staff Spending – Total Contribution

Staff Spending Contribution	GVA (CHF m)	Employment
Switzerland	1,969.1	11,937
Abroad	530.1	3,676
Total	2,499.3	15,613

Source: BiGGAR Economics Analysis

5.1.1 Income Tax and Social Welfare Contribution

The staff employed by the ETH Domain make contributions to the social welfare system and to the federal government, cantons and municipalities through the income tax they pay.

It is possible to estimate the size of this contribution. In 2016 CHF 109.6 million was paid to social insurance schemes by the ETH Domain members. In addition, staff employed by the ETH Domain members pay VAT when they spend their salaries. This was estimated to amount to CHF 76.3 million.

The federal, cantonal and communal taxes paid were estimated based on the location of each of the ETH Domain members, the total salaries and wages paid, and data on the proportion of taxes paid[14]. It was estimated that this would account for CHF 334.5 million.

In this way it was estimated that staff employed by the ETH Domain contribute CHF 520.4 million in income tax and social welfare contributions.

Supplier Contribution

The supplier effect is the contribution occurring from buying in goods and services since these purchases generate GVA and support employment in businesses that supply the ETH Domain members.

The inputs used to estimate the supplier effect are shown in Table 5-6. In 2016, the ETH Domain members spent CHF 973.5 million on goods and materials, premises costs and other operating costs. Of this total, approximately 88% was spent on suppliers based in Switzerland and 12% was spent on suppliers based abroad. In cases where an institution was unable to provide full information about the location of their suppliers, an average was applied which was estimated from those who were able to supply this data.

Table 5-6 ETH Domain: Combined Supplier Effect – Assumptions

Amount Spent on Goods and Services	
Total Expenditure on Goods and Services, CHF million	973.5
Location of Suppliers	
Switzerland	88%
Abroad	12%
Total	100%

Source: ETH Domain Members

[14] Source: http://neuvoo.ch/tax-calculator

The supplier expenditure was then analysed by sector since the resulting GVA supported reflects the differing GVA to turnover ratios for each sector of the economy. The direct GVA contributions were estimated by dividing the expenditure in each sector by the appropriate GVA to turnover ratio. Direct employment was estimated by dividing the direct GVA by the turnover to employment ratio in the industries relevant to the expenditure.

The initial expenditure by the ETH Domain members creates multiplier effects throughout the economy, reflecting the increased demand from the suppliers of the ETH Domain members on down the supply chain. This is the indirect effect. As a result, the level of household income throughout the economy will increase due to increased employment. A proportion of this increased income will be re-spent on final goods and services, which is the induced effect. These multiplier effects were estimated by applying GVA and employment multipliers appropriate to the sectors in which the expenditure occurred.

The total supplier effect for the ETH Domain members is shown in Table 5-7. It is estimated that spending on goods and services by the ETH Domain members supports CHF 894.2 million GVA and 5,700 jobs in Switzerland and a further CHF 298.3 million GVA and 2,000 jobs outside the country.

Table 5-7 ETH Domain: Combined Supplier Effect Contribution (Direct & Multiplier)

Supplier Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	894.2	5,717
Abroad	298.3	2,046
Total	1,192.4	7,763

Source: BiGGAR Economics Analysis

Capital Contribution

There are two elements to the economic contribution made by capital expenditure from the ETH Domain members – money spent on buildings and estates and money spent on equipment (research infrastructure).

5.1.2 Estates Investment

Estates investment made by the ETH Domain members provides an important source of income and employment for the Swiss construction and maintenance industry. This figure changes from year to year, reflecting campus development plans and building renovations. To reduce any skewing effects arising from 2016 being an atypical year, an average figure for estates expenditure over the last five years (2012 – 2016 inclusive) has been used.

Over the last five years, the ETH Domain members spent an average of CHF 236.9 million per year on estates development and maintenance work. This income can be converted into GVA by applying a turnover to GVA ratio for the construction sector. The employment contribution of this expenditure is estimated by dividing the GVA contribution by an estimate of average GVA per employee in the construction sector.

The indirect contribution of this expenditure is then estimated by applying GVA and employment multipliers for the construction sector. In this way it is estimated that the total contribution of estates expenditure to provide and improve buildings for the ETH Domain members amounts to CHF 186.2 million GVA, and 1,700 jobs. Around 60% of this contribution occurs in Switzerland.

The assumptions used in this calculation are summarised in Table 5.8 and the resulting contributions are summarised in Table 5.9.

Table 5-8 ETH Domain: Combined Estates Expenditure – Assumptions

Estates Expenditure	
Average Annual Estates Expenditure, 2012-16 (CHF m)	150.3
Location of Spending	
Switzerland	75%
Abroad	25%
Total	100%

Source: ETH Domain Members

Table 5-9 ETH Domain: Combined Estates Contribution

Estates Expenditure Contribution	GVA (CHF m)	Employment
Switzerland	110.8	1,014
Abroad	75.5	678
Total	186.2	1,692

Source: BiGGAR Economics Analysis

5.1.3 Research Infrastructure

The members of the ETH Domain also invest in research infrastructure and equipment each year. Across the group this covers a very wide range of purchases including technical scientific equipment. The common theme is that this money is being invested in improving the infrastructure at the institutes, excluding investment in the physical buildings themselves.

As with estates expenditure, this figure varies from year to year reflecting the development plans of each institute. Again, to reduce any skewing effects arising from 2016 being an atypical year, an average figure for research and infrastructure expenditure over the last five years (2012 – 2016 inclusive) has been used.

The average annual expenditure on research infrastructure by all ETH Domain members between 2012 and 2016 was CHF 201.1 million. Table 5.10 summarises the assumptions made for these calculations.

Table 5-10 ETH Domain: Combined Research Infrastructure Spending – Assumptions

Expenditure on Research Infrastructure	
Average Annual Research Infrastructure Expenditure, 2012-16 (CHF million)	201.1

Source: ETH Domain Members

This investment supports a further round of GVA and jobs through multiplier effects which can be attributed to each location according to data provided by the ETH Domain members. In this way, it is estimated that expenditure on research infrastructure supports CHF 228.5 million GVA and around 1,300 jobs in Switzerland.

Table 5-11 ETH Domain: Combined Research Infrastructure Spending Contribution

Research Infrastructure Contribution	GVA (CHF m)	Employment
Switzerland	134.6	798
Abroad	93.9	535
Total	228.5	1,333

Source: BiGGAR Economics Analysis

5.1.4 Total Capital Expenditure Contribution

Summing together the estates and maintenance expenditure and the research infrastructure gives a combined total capital expenditure contribution that amounts to CHF 414.7 million GVA and 3,000 jobs globally. Approximately 60% of this contribution occurs in Switzerland. The combined capital expenditure impact is summarised in Table 5-12.

Table 5-12 ETH Domain: Combined Capital Spending Contribution

Estates Expenditure Contribution	GVA (CHF m)	Employment
Switzerland	110.8	1,014
Abroad	75.5	678
Total	186.2	1,692
Equipment Contribution	GVA (CHF m)	Employment
Switzerland	134.6	798
Abroad	93.9	535
Total	228.5	1,333
Total Capital Contribution	GVA (CHF m)	Employment
Switzerland	245.3	1,812
Abroad	169.4	1,213
Total	414.7	3,025

Source: BiGGAR Economics Analysis

Summary Core Contribution

The contribution associated with the core activity of receiving income, supporting employment, spending on goods and services and spending on capital projects results in an estimated core contribution of CHF 5.7 billion GVA and 40,500 jobs in Switzerland. These figures include the multiplier effects of the core activity. The remaining contributions occur outside the country.

The core contributions are summarised in Table 5-13.

Table 5-13 ETH Domain: Combined Core Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Direct	2,601.6	21,004
Staff Spending	1,969.1	11,937
Supplier	894.2	5,717
Estates & Research Infrastructure	245.3	1,812
Total Core Contribution	5,710.3	40,470
Abroad	GVA (CHF m)	Employment
Direct	-	-
Staff Spending	530.1	3,676
Supplier	298.3	2,046
Estates & Research Infrastructure	169.4	1,213
Total Core Contribution	997.8	6,936
Global (Total)	GVA (CHF m)	Employment
Direct	2,601.6	21,004
Staff Spending	2,499.3	15,613
Supplier	1,192.4	7,763
Estates & Research Infrastructure	414.7	3,025
Total Core Contribution	6,708.0	47,405

Source: BiGGAR Economics Analysis (numbers may not sum due to rounding)

6 STUDENT CONTRIBUTION

The contributions covered in this chapter are those associated with the bachelors and masters degree students at ETH Zurich and EPFL. There are three elements to this contribution:

- student spending – the employment and GVA contribution that arises from the combined expenditure of students while studying at university;
- the impact arising from students working part-time while studying for their degree; and
- student volunteering.

In terms of the framework for analysis set out in section 0 the benefits described in this chapter are considered “incidental benefits”. The possible exception to this is student volunteering, which is sometimes encouraged to support important regional development objectives.

Student Population

The combined bachelors and masters student population at ETH Zurich and EPFL in 2016 was 23,800 people (Table 6.1). Approximately 60% were studying for bachelors degrees and the remaining 40% were studying for masters degrees or MAS/MBA qualifications.

Doctoral students (6,134) have been *excluded* from this analysis as they are included in the staff figures for both institutions, therefore their impact is included in the staff spending figures in section 0. However, doctoral students have been *included* in the graduate premium calculations in section 8.

Table 6-1 ETH Zurich & EPFL: Student Population, 2016

	Total
Bachelors degree	14,352
Masters degree	8,637
MAS/MBA	828
Total	**23,817**

Source: ETH Zurich and EPFL

Student Spending

Students create an economic contribution through spending their income in local businesses. In turn these businesses are able to employ more staff which creates further multiplier effects in the local economy.

The total number of BA and MA students at the two universities in 2016 was 23,800, of which over half (56%) live in rented or wholly owned accommodation. A further 31% live with parents in a family home and 13% live in institution owned accommodation. It was further assumed that bachelors degree students who live outside the family home do so for 10 months a year, while masters students who live outside the family home do so for 12 months a year.

The expenditure levels of students differ according to where they live during term-time. A study published by the Swiss Federal Statistical Office in 2015 looked at the living costs of students at different universities[15] and provided expenditure profiles of students at both ETH Zurich and EPFL. The study found that, on average, EPFL students living away from home required CHF 1,709 per month to cover accommodation, food, clothing, health care, transport, leisure activities and other living expenses. For ETH Zurich students, the comparable figure was CHF 2,224, reflecting the higher cost of living in Zurich.

These profiles of expenditure were applied to the number of students at the two universities to provide an overall estimate for total student expenditure of CHF 489.0 million.

VAT was then removed from the expenditure figures to allow the estimates to be in line with OECD economic data. This was done by analysing the expenditure categories to establish those that incurred VAT and then eliminating this element from total expenditure as this money is not spent directly in the local economy. It was assumed that 100% of student spending occurred in Switzerland.

The key inputs used in making these calculations are shown in Table 6-2.

Table 6-2 ETH Zurich and EPFL: Student Spending – Assumptions

Total Number of Students		Value
Living with parents		7,285
Not living with parents		13,379
Institution owned accommodation		3,153
Total number of students		23,817
Monthly Student Expenditure (CHF)	**ETH Zurich**	**EPFL**
Living with parents	1,642	1,161
Not living with parents	2,224	1,709
Institution owned accommodation	1,433	1,052

Source: ETH Zurich & EPFL

We then estimated how much GVA this level of expenditure provided and how many jobs it supported across the relevant sectors of the economy using national level economic ratios for each sector. See the Supplementary Technical Appendix report for a more detailed description of the methodology used.

A further round of GVA and employment was supported indirectly through this level of spending (the indirect effect) and this was estimated by applying sector-specific multipliers to the direct contribution. Finally, these figures were added together to estimate the total contribution arising from student spending. The results are shown in Table 6-3.

[15] Conditions d'études et de vie dans les hautes écoles suisses, OFS, 2015. EPFL and ETH Zurich each requested data for their own students from the OFS and provided this directly to BiGGAR Economics.

Table 6-3 ETH Zurich & EPFL: Student Spending Contribution

Student Spending Contribution	GVA (CHF m)	Employment
Switzerland	466.7	3,972
Abroad	62.3	521
Total	529.0	4,492

Source: BiGGAR Economics Analysis

This results in a student spending contribution of CHF 466.7 million GVA and 4,000 jobs in Switzerland and a further CHF 62.3 million GVA and 500 jobs abroad.

Part-time Work

Students working part-time can make an important contribution to the local labour market by helping local businesses and organisations to deliver their goods and services.

Research published by the Swiss Federal Statistics Office, 2015 suggests that approximately 62% of students at EPFL and 57% of students at ETH Zurich work to supplement their income and that they work, on average, for 7.3 hours per week[16].

Consultations regarding the labour market conditions for the cities where the Universities are based suggests that the students are generally not displacing other potential employees; however, it is reasonable to assume that some jobs may otherwise have been filled by non-students. In order to reflect this we have taken a view on the additionality of student jobs and assume it is inversely related to the level of youth unemployment in each area. In this case, the level of additionality used is 74% for EPFL and 89% for ETH Zurich reflecting the different rates of youth unemployment in each location.

The analysis of the contribution of part-time work is based on the number of students living in each area as it is assumed that students take part-time jobs locally to where they live. The key assumptions used in calculating the contribution of student part-time work are shown in Table 6.4.

Table 6-4 ETH Zurich & EPFL: Student Part-time Working – Assumptions

	EPFL	ETH Zurich
Number of Bachelors & Masters Students	8,412	15,405
Percentage of students who undertake part-time work	62%	57%
Additionality of part-time work	74%	89%
Average hours worked per week	7.3	7.3

Source: ETH Zurich & EPFL, OFS, BiGGAR Economics

The value of the additional economic activity (GVA) supported by student employment is estimated by applying national ratios of GVA per employee for the sectors in which students typically work. Most typically students take up employment in the retail, restaurant, catering, hospitality and residential care sectors while studying for their degrees.

[16] Swiss Federal Statistics Office, 2015. *Conditions d'etudes at de vie dans les hautes ecoles Suisses*, Neuchatel

A further round of GVA and employment is then supported indirectly through this level of spending (the indirect effect) and this is estimated by applying sector-specific multipliers to the direct contribution.

This results in a total contribution from student employment of CHF 297.0 million GVA and 3,500 jobs in Switzerland and a further CHF 25.4 million GVA and 200 jobs abroad (Table 6-5).

Table 6-5 ETH Zurich & EPFL - Student Part-time Working – Contribution

Student Working Contribution	GVA (CHF m)	Employment
Switzerland	297.0	3,450
Abroad	25.4	231
Total	322.4	3,681

Source: BiGGAR Economics Analysis

Student Volunteering

Students make a contribution to society through volunteering. Based on data provided by the two universities, it is assumed that 45% of students at ETH Zurich and 33% of students at EPFL engage in voluntary work whilst studying.

It was further assumed that they volunteer for 1 hour per week and that the average monetary value of these hours is equivalent to the minimum wage in Switzerland of CHF 13.75 per hour. The assumptions used to arrive at the estimated contribution from student volunteering are shown in Table 6.6.

Table 6-6 ETH Zurich & EPFL: Student Volunteering – Assumptions

	EPFL	ETH Zurich
Number of Bachelors & Masters Students	8,412	15,405
Percentage of students who undertake voluntary work	33%	45%
Estimated number of hours volunteered per week	1	1
Estimated value per hour volunteered	CHF13.75	CHF13.75

Source: ETH Zurich & EPFL

The monetary value of the hours volunteered is estimated by multiplying the total number of hours volunteered by the wage that would be normally paid to a student. These inputs result in an estimate of the value of student volunteering of at least CHF 1.4 million GVA across Switzerland. The nature of this type of activity is that it will contribute to increasing the productivity of the organisation volunteered for (by contributing to service provision) and will therefore be a GVA contribution rather than an employment contribution. These contributions are summarised in Table 6.7.

Table 6-7 ETH Zurich & EPFL - Student Volunteering – Contribution

Switzerland	GVA (CHF m)
Student Volunteering	1.4

Source: BiGGAR Economics Analysis

In practice the value of student volunteering is greater than this figure suggests as the calculations are only an approximate method which captures the monetary value of the students' time. It does not reflect the wider community benefits such as:

- the value of volunteering to the service supported as many organisations could not run without these additional volunteers;
- the value of the services to the people who use them; and
- the value of the contributions on service users, as improvements in health and wellbeing will result in cost savings in health and social services.

Summary of Student Contributions

The contribution associated with student spending, student employment and student volunteering is estimated at CHF 852.9 million GVA and 8,200 jobs in total, of which 90% occurs in Switzerland (Table 6.8).

Table 6-8 ETH Zurich & EPFL: Total Student Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Student Spending	466.7	3,972
Student Working	297.0	3,450
Student Volunteering	1.4	-
Total Student Contribution	765.2	7,422
Abroad	**GVA (CHF m)**	**Employment**
Student Spending	62.3	521
Student Working	25.4	231
Student Volunteering	-	-
Total Student Contribution	87.7	752
Total	**GVA (CHF m)**	**Employment**
Student Spending	529.0	4,492
Student Working	322.4	3,681
Student Volunteering	1.4	-
Total Student Contribution	852.9	8,174

Source: BiGGAR Economics Analysis (numbers may not sum due to rounding)

7 TOURISM CONTRIBUTION

This section considers the contribution that the ETH Domain members make to tourism in Switzerland. This contribution arises from:

- visits from friends and family to staff and students; and
- visitors to conferences and events held at the institutes.

In terms of the framework for analysis set out in section 0, the benefits considered in this chapter are considered "incidental benefits". The possible exception to this is conferences and events, which are sometimes used as a way of supporting regional economic development.

Visits to Staff and Students

The presence of staff and students creates an economic contribution through visits from their friends and family who are not normally resident in the localities of the institutions. In 2016 the ETH Domain institutions had 44,149 staff and students based in Switzerland. These visitors spend money in the economy and this spending increases turnover in local businesses, which in turn supports local employment.

In order to estimate this contribution it is necessary to estimate the number of visits from friends and relatives (VFR) that students and staff will receive. Eurostat compile this information and data are available for Switzerland for visits in 2015. This source suggests that each staff and student member receives 0.19 visits per year from domestic friends and family members and 0.39 trips per year from visitors from outside Switzerland. The number of VFR trips per person is multiplied by the number of students and staff at each institute to provide an estimate of the number of visits stimulated by the ETH Domain members.

This total number of visits is multiplied by the average spend of tourists on a visiting friends and families trip. Data on average tourist spend for VFR trips is sourced from Eurostat for Switzerland. The economic contribution in the study areas was found by converting trip spend (turnover) to GVA and employment and applying multipliers to estimate the indirect and induced effect of this level of spending. The assumptions used and the contribution resulting is shown in Tables 7.1 and 7.2.

Table 7-1 ETH Domain: Visits to Staff and Students - Assumptions

Assumptions	Value
Total number staff & students in Switzerland	44,149
No. visits per staff/student - domestic	0.19
No. visits per staff/student - overseas	0.39
Weighted trip spend per visitor (CHF)	387.29

Source: ETH Domain member and Eurostat data for Switzerland, 2015

Table 7-2 ETH Domain: Visits to Staff and Students – Contribution

	GVA (CHF m)	Employment
Switzerland	11.1	124
Abroad	2.2	20
Total	13.2	144

Source: BiGGAR Economics Analysis

This results in an estimated contribution from visits to staff and students of CHF 11.1 million GVA and 100 jobs in Switzerland and CHF 13.2 million GVA and approximately 150 jobs globally.

Conference & Event Contribution

The ETH Domain members organise and/ or host conferences that generate an economic contribution by attracting delegates to the area who would not otherwise have visited. This brings additional revenue to the economy both inside and outside the institutions.

In 2016, the six institutes of the ETH Domain organised conferences and events that involved approximately 246,400 attendees. However, it has been assumed that delegates from Switzerland would have spent their money in the country regardless of the conference or event, therefore their expenditure is non additional at the country level and has been excluded from the calculations. Only delegates from outside Switzerland have been counted. Based on data provided by the ETH Domain members, an estimated 12% (29,500 delegates) were from outside the country.

These visits are converted into an expenditure estimate using data on average trip spend for a business visitor to Switzerland which is sourced from Eurostat. This source suggest that visitors from outside the country spend, on average, CHF 1,975 per trip. The key assumptions used in calculating this contribution are shown in Table 7.3.

Table 7-3 ETH Domain Members: Conference & Event Contribution – Assumptions

Assumption	Value
No. of delegates to conferences and events organised by ETH Domain members	246,400
Estimated % of International attendees	12%
Trip spend per business trip (CHF) – professional overseas	1,975

Source: ETH Domain Members and Eurostat data for Switzerland, 2015

The resulting tourism expenditure estimate is converted to additional GVA and employment by using ratios and multipliers appropriate to the sector.

This results in a contribution from conferences and event activities of an estimated CHF 54.7 million and over 600 jobs in Switzerland. The resulting contribution is presented in Table 7.4.

Table 7-4 ETH Domain Members: Conference & Event Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Conferences & Events	54.7	613

Source: BiGGAR Economics Analysis

Summary of Tourism Contributions

The contribution of the ETH Domain members to the economy through attracting visitors results in an estimated CHF 65.8 million GVA and 700 jobs per year in Switzerland (Table 7.7).

Table 7-5 ETH Domain: Tourism Contribution – Summary

Switzerland	GVA (CHF m)	Employment (jobs)
Visits to Staff and Students	11.1	124
Visits to Conferences & Events	54.7	613
Total Tourism Contribution	65.8	737
Abroad	GVA (CHF m)	Employment (jobs)
Visits to Staff and Students	2.2	20
Visits to Conferences & Events	-	-
Total Tourism Contribution	2.2	20
Total	GVA (CHF m)	Employment (jobs)
Visits to Staff and Students	13.2	144
Visits to Conferences & Events	54.7	613
Total Tourism Contribution	68.0	757

Source: BiGGAR Economics Analysis (numbers may not sum due to rounding)

8 GRADUATE PREMIUM

One of the most important ways in which the ETH Domain generates economic impact is through the long-term economic effects of their teaching activity, as realised through their graduates.

Graduate Premium

The skills and knowledge gained by students while studying at the ETH Domain enables students to become more productive employees after graduation. This enables them to contribute more to their employer and generate a greater benefit for the Swiss economy than they would otherwise be able to.

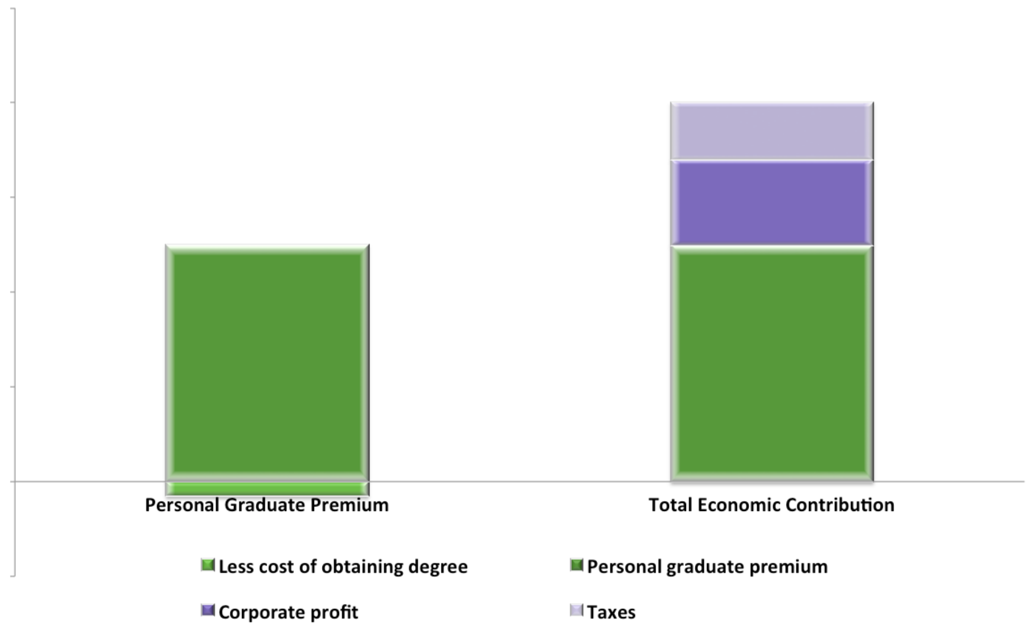
The GVA of this productivity gain includes the additional profits that employers of graduates are able to generate and the additional employment costs they are willing to pay in order to attract graduates of the required calibre.

Information about the earnings of graduates is available from the Swiss Federal Statistical Office and can be used to provide a measure of the additional contribution graduates make to the Swiss economy each year.

Unfortunately, information about the additional profits of graduate employers or the additional taxation revenue they help to generate is not readily available so the impact presented here is likely to underestimate the true productivity impact of learning. The total graduate premium presented here therefore relates to the combined *personal economic benefit* that the year's graduates will obtain rather than the *increase in national productivity* associated with the degree, which will be higher. It therefore does not include the corporate profit associated with each graduate or the taxes paid.

For these reasons (as illustrated in Figure 8.1) the contribution presented in this section is likely to underestimate the full contribution that graduates from the ETH Domain generate for the Swiss economy.

Figure 8.1 – Personal Graduate Premium Benefit Vs. Economic Benefit



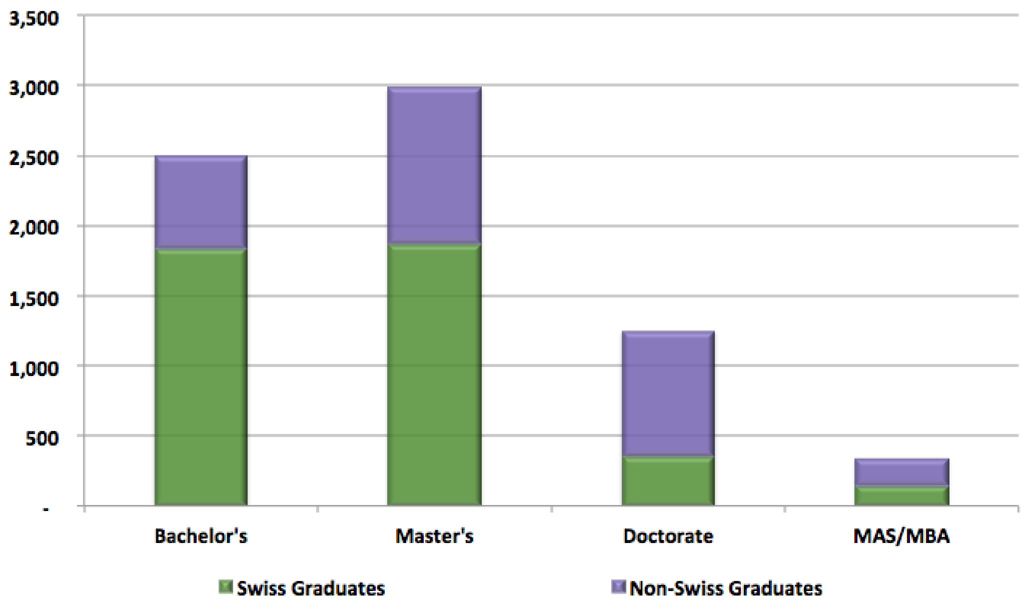
Source: BiGGAR Economics

Estimating the Graduate Premium

In 2016, there were a total of 7,091 graduates of the ETH Domain in 2016, of which 4,200 (59%) were Swiss and 2,891 (41%) were non-Swiss. The majority of graduates received a Masters degree (42%) followed by Bachelors degree (35%) Doctorate (18%) and Master of Advanced Studies/ MBA (5%).

Figure 8–2 illustrates the breakdown of graduates from the ETH Domain by the type of degree obtained and the split between Swiss graduates and those from abroad.

Figure 8–2: Graduates from the ETH Domain, 2016



Source: ETH Domain

The vast majority (96%) of students who complete a Bachelors degree within the ETH Domain go on to obtain a Masters level qualification, therefore to calculate the graduate premium we have *excluded* the majority of those with bachelors qualifications in order to avoid double counting**.** The numbers and percentage of graduates by degree type that have been included in the calculations is shown in Table 8.1.

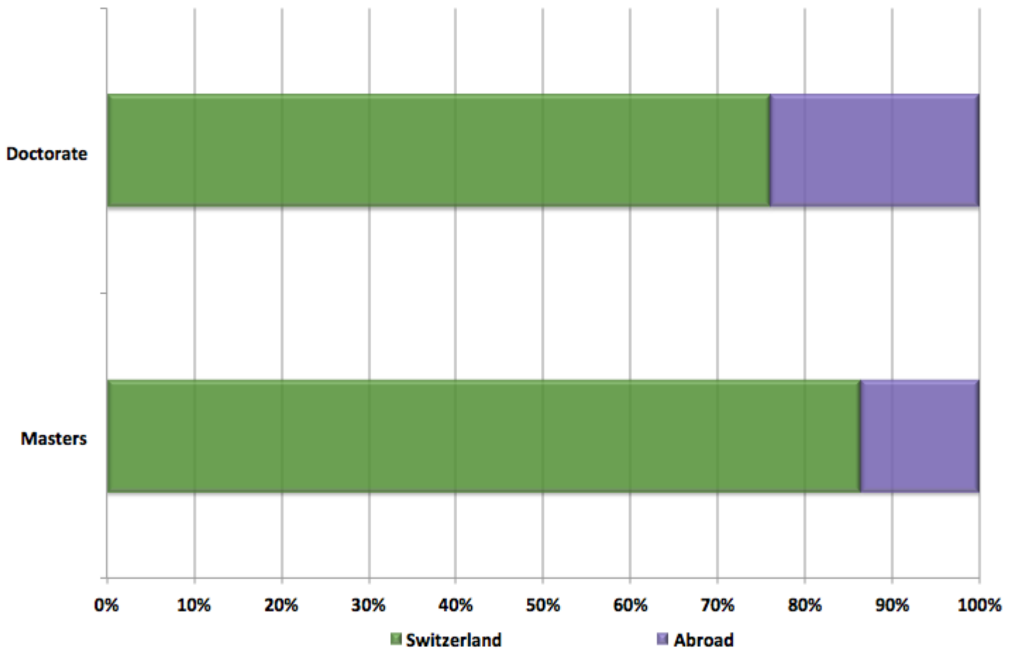
Table 8-1 ETH Domain: Graduates by Degree Type, 2016

	Total	% included in Graduate Premium Calculations
Bachelors	2,500	4%
Masters	2,989	100%
MAS/MBA	346	100%
PhD	1,256	100%
Total	7,091	66%

Source: ETH Zurich & EPFL

As can be seen in Figure 8–3 the majority of graduates of the ETH Domain stay in Switzerland after graduation, with 86% of Masters graduates and 76% of Doctoral graduates remaining in the country after graduation.

Figure 8–3: Graduate Destinations



Source: ETH Domain

8.1.1 Methodology

The graduate premium was estimated by comparing graduate earnings against a baseline level of earnings, which gives a counterfactual situation, i.e. if the student did not graduate from the ETH Domain they would have left secondary school without going to university. Therefore any additional earnings over this level would represent the graduate premium. There is a further distinction in earnings based on the highest qualification obtained. For example, there is a larger graduate premium associated with obtaining a PhD qualification compared with a Masters qualification and likewise there is a larger graduate premium associated with a Masters qualification compared with a Bachelors qualification.

Basic earnings were derived from Eurostat, which collects data on the median monthly earnings of those who have achieved 'upper secondary and post-secondary non-tertiary education', 'short-cycle tertiary education and Bachelors or equivalent' and 'Masters and Doctoral or equivalent' qualifications. The earnings associated with doctoral graduates were estimated based on data from the Swiss Federal Statistics Office (BFS), as they are higher than the premium associated with Masters graduates. This data was used to estimate the average earnings associated with graduates.

Table 8-2 outlines the monthly earnings of federal institute of technology and university graduates in Switzerland by degree type.

Table 8-2 ETH Domain: Graduates - Monthly Pay (CHF)

	Bachelors	Masters	PhD
ETH Domain	9,318	11,336	13,564

Source: BiGGAR Economics Analysis

As some subjects result in a higher level of earnings, the average earnings were then adjusted based on subject- specific data from the BFS. This was available at the Bachelors, Masters and PhD level, and reported the median earnings by subject five years after graduation.

As data on the earnings differential is on a per month basis, it was necessary to scale this up to reflect the total premium over a worker's lifetime. Furthermore the data do not consider the direct and indirect cost of obtaining a degree, such as the foregone earnings associated with attending university. Adjustments were made for these factors based on previous work undertaken by BiGGAR Economics on behalf of LERU.

Typically, the after tax earnings of a graduate are compared to the after tax earnings of a non-graduate (i.e. secondary school leaver) in order to establish a baseline of comparison for the graduate earnings premium. However, the high quality of the Swiss education system means that a variety of options exist for secondary school graduates who choose not to go to one of the federal institutes of technology.

In particular, high quality vocational qualifications are very common in Switzerland, and often include work-study elements as well as a higher level of specialisation than is typical in other OECD countries.[17] Vocational programmes at the upper secondary level are quite popular with graduation rates of over 70% from these programmes in 2014.[18] Switzerland also has one of the highest employment rates among OECD countries for 25-34 with a vocational education qualification, at 89%. This is also the same employment rate as for those with a tertiary degree.

Secondary school graduates can also choose to enrol in a University of Applied Sciences, which focuses more on applied and vocational teaching, in traditional subjects such as technology and business administration, newer subjects such as health, social work and applied psychology, and more creative subjects, such as theatre and design. Graduates of a University of Applied Sciences also experience high levels of employment, although this can differ significantly between subjects,[19]. They are also able to secure relatively high wages and this point is discussed further in Section 8.1.2.

Additionally, secondary school graduates may decide to go abroad and study elsewhere in Europe and the implications this situation has are discussed in Section 8.1.4.

Therefore there are several different options for baseline comparators against which to estimate the graduate premium from graduating from the ETH Domain. The implications of each one are discussed in the sections which follow.

8.1.2 University of Applied Sciences Baseline

Estimating the graduate premium compared to a University of Applied Sciences baseline used the same method as the secondary school baseline. However, as data was not available from Eurostat it was necessary to adjust the median monthly earnings using data on University of Applied Sciences earnings from the BFS. This suggests that the earnings baseline would be CHF 9,954.

It is noteworthy that this implies that graduates of the University of Applied Sciences earn higher wages than Bachelors of the ETH Domain. However, as

[17] OECD (2017), Education at a Glance - Switzerland
[18] OECD (2016), Education at a Glance - Switzerland
[19] Swiss Co-ordination Centre for Research in Education (2014), Swiss Education Report

96% of Bachelors graduates at ETH Zurich go on to do a Masters degree, this situation is unlikely to arise in practice and is statistically negligible when estimating the overall premium

Data on Bachelors and Masters earnings was compared to the earnings of a Bachelors graduate from a University of Applied Sciences. PhD earnings were compared to a Masters graduate of the ETH Domain. The monthly earnings and the baseline that they are compared to are given in the table below.

Table 8-3 ETH Domain: University of Applied Sciences – Monthly Income (CHF)

	Bachelors	Masters	PhD
ETH Domain	9,318	11,336	12,596
University of Applied Sciences Baseline	9,954	9,954	11,336

Source: BiGGAR Economics Analysis

Therefore it was estimated that the total graduate premium, when comparing to a University of Applied Sciences degree, would be CHF 1.9 billion, of which CHF 1.5 billion would be in Switzerland.

Table 8-4 ETH Domain: Graduate Premium - University of Applied Sciences Baseline

Graduate Premium	GVA (CHF bn)
Switzerland	1.5
Abroad	0.4
Total	1.9

Source: BiGGAR Economics Analysis

8.1.3 Secondary School Baseline

The data on earnings of secondary school graduates shows that they typically earn CHF 6,557 per month. When estimating the graduate premium for Masters graduates this was compared to Bachelors graduates, and PhD graduates were compared to Masters graduates.

Table 8-5 ETH Domain: Secondary School Education - Monthly Income (CHF)

	Bachelors	Masters	PhD
ETH Domain	9,318	11,336	12,596
Secondary School Baseline	6,557	9,318	11,336

Source: BiGGAR Economics Analysis

Therefore it was estimated that the graduate earnings premium was CHF 3.8 billion globally, of which CHF 2.9 billion was in Switzerland.

Table 8-6 ETH Domain: Graduate Premium - Secondary School Education Baseline

Graduate Premium	GVA (CHF bn)
Switzerland	2.9
Abroad	0.8
Total	3.8

Source: BiGGAR Economics Analysis

8.1.4 Other European Countries Baseline

In order to compare the graduate premium of ETH Domain students in Switzerland with the graduate premium in other European countries, mean monthly earnings data by level of education was sourced for Eurostat. Five countries were used as a comparison; the UK, Germany, Netherlands, Finland and Norway. For example, on average across these five countries Bachelors graduates earn 8,521 CHF per month. As the Eurostat data is not available at the PhD level, the PhD earnings premium is again estimated with a baseline of the Masters graduate.

Table 8-7 ETH Domain: Other European Countries - Monthly Income (CHF)

	Bachelors	Masters	PhD
ETH Domain	9,318	11,336	12,596
Other European Countries Baseline	8,521	10,089	11,336

Source: BiGGAR Economics Analysis

Therefore, it was estimated that the graduate premium compared to graduating in another other European country would be CHF 2.0 billion globally, and CHF 1.6 billion in Switzerland.

Table 8-8 ETH Domain: Graduate Premium - Other European Countries Baseline

Graduate Premium	GVA (CHF bn)
Switzerland	1.6
Abroad	0.5
Total	2.0

Source: BiGGAR Economics Analysis

8.1.5 Summary Graduate Premium

As discussed earlier, typically the earnings of graduates are compared to the earnings of non-graduates, i.e. secondary school leaver. However, due to the typical progression of students leaving secondary school in Switzerland the comparison between bachelors graduates of the Universities of Applied Sciences is more appropriate for the Swiss context. Therefore these figures are those used in this report.

In this way it was estimated that graduates of the ETH Domain have an estimated graduate premium contribution of CHF 1.9 billion in Switzerland and a further CHF 0.4 billion GVA contribution outside the country. As this contribution is a productivity gain it is measured in terms of GVA and consequently does not have associated employment gains.

Table 8-9 ETH Domain: Graduate Premium

Graduate Premium	GVA (CHF bn)
Switzerland	1.5
Abroad	0.4
Total	1.9

Source: BiGGAR Economics Analysis

Wider Benefits

8.1.6 Spill-over and Reverse Spill-over effects

The benefits of having a graduate in the workplace are not confined to just the graduate themselves. Spill-over and indeed reverse spill-over effects work together resulting in an overall benefit to the employer that permeates beyond the individual into the wider workplace.

Traditional spill-over effects assume a one-way transfer of knowledge from higher educated workers to those with secondary-level education. The concept of reverse spill-over effects suggests that the benefits can also work in the opposite direction: those with a degree-level education can become more productive through working with and learning from those with a more vocational skill set.

Recent research in Switzerland[20] has examined the effects on productivity (measured by earning) across differently educated workers. Countries such as Switzerland, Germany and Austria have both a formal vocational educational system (VET) and an academic education system. VET education is an alternative to going to university (tertiary education) and reflects a continued approach to training apprentices.

Researchers found that the two groups have different skills but that they can mutually benefit from working together. Workers with vocational degrees have “other” rather than “fewer” skills than workers with tertiary degrees and in this situation reverse spill-over effects often exist. The effect is most likely to occur in countries with more than one formal education system, such as Switzerland. The study also showed that the productivity of workers does not simply depend on their own knowledge and skills but also on the knowledge and skills of their co-workers. Therefore it pays to keep a mix of skills in the work force as the skills of the different groups can be mutually reinforcing.

They also suggest that increasing the number of workers with tertiary education may be an adequate strategy if jobs require only theoretical work or research but where production and implementation of knowledge is involved, it will pay to employ a number of highly skilled VET workers.

8.1.7 Societal Impacts

A further point to consider is that the additional benefits of having a graduate level education are not purely confined to increased earnings. There is a large body of literature that has explored the wider benefits of learning and the complex relationship it has across all aspects of life and well-being.

Within the framework of the European Lifelong Learning Indicators (ELLI) project, the Centre for the Wider Benefits of Learning at the University of London‘s Institute of Education[21] reviewed more than 200 international studies and research projects on the effects of learning in all phases and areas of life.

Their findings summarised the literature into five themes:

[20] Uschi Backes-Gellner Christian Rupietta Simone N. Tuor Sartore, 2017, “Reverse educational spillovers at the firm level”, Evidence-based HRM: a Global Forum for Empirical Scholarship, Vol. 5, Iss 1 pp. 80 – 106.

[21] Centre for Research on the Wider Benefits of Learning, Institute of Education, University of London, 2011, *The Wider Benefits of Learning Part2: Learning and Health*, Bertelsmann Stiftung.

- Learning and identity: all forms of learning in various phases over the course of a lifetime impact on an individual's self-confidence, self- esteem, resilience and the development of social skills;
- Learning and health: numerous studies have made clear the direct relationship between the duration and frequency of the learning processes in various phases of life and mental and physical well-being, health behaviour, life expectancy and other physical and mental health aspects;
- Learning, life satisfaction and happiness: there is a positive correlation between learning and happiness, well-being and personal optimism;
- Learning and community vitality: learning has a positive impact on social cohesiveness and community vitality through its influence on social mobility, active citizenship, social participation, tolerance and inter-cultural sensitivity. This theme also investigates the link between learning and lower levels of criminality; and
- Learning spill-overs and interplays: more complex reciprocal effects of learning and living processes. Positive learning experiences impact people's future learning behaviour, followed by the complex relationships between learning and occupational prospects. In addition, it explores the multifaceted impacts of learning on family situations. These include, for example, the influence of the educational and learning level of parents on the development of their children.

The message from this research is that the benefits of having undertaken a higher-level education extend well beyond the personal earnings premium. There is a much wider range of benefits to the individual, to the workplace and to society that are associated with higher education that cannot be measured in monetary terms but are, nonetheless, highly valuable.

9 COMMERCIALISATION

The ETH Domain supports technological innovation in Switzerland through the commercialisation activities it undertakes. This includes licensing of intellectual property developed at the ETH institutes as well as the creation of new businesses (spin-off companies) based on research undertaken at the ETH institutes.

Licensing

Licence agreements give companies the legal right to use a particular technology or other type of intellectual property, developed at the ETH institutes, to generate additional sales, reduce costs or otherwise improve profitability. In return, companies pay royalties to the ETH institutes. Without the initial research outcomes of the ETH institutes, the productivity gains would not be possible and therefore the benefits to the economy from this activity can be attributed to the ETH Domain. In 2016 the institutions of the ETH Domain received CHF 12.9 million in royalties from their license agreements. On average across the ETH Domain institutions, 60% of this income was from licence holders in Switzerland.

Table 9-1 ETH Domain: Licensing Contribution – Assumptions

Licensing income	
Total licensing income, CHF million	12.9
Location of license holders	
Switzerland	60%
Abroad	40%
Total	100%

Source: ETH Domain Members

The relationship between the royalty paid for a technology and the turnover the technology generates depends on the details of the licensing agreement and can vary considerably between agreements. In order to agree a licence, negotiators must first form a view of how much the IP is worth to the prospective licensee. There are a wide variety of variables that may inform this judgement but a training manual issued by the World Intellectual Property Organisation states that a common starting point is the “well known and widely quoted” 25% rule.

The 25% rule is a general rule of thumb according to which the licensor should receive around one quarter to one third of the profits accruing to the licensee and has been used by IP negotiators for at least 40 years. The rule is based on an empirical study first undertaken in the 1950s and updated in 2002[22]. The study found that royalty rates were typically around 25% of the licensee’s profits, which equates to around 5% of sales from products embodying the patented technology. This implies that royalties paid for a technology typically represent around 5% of the total turnover generated by that technology.

Applying this to the assumptions described above suggests that in 2016, intellectual property developed by the ETH Domain institutes enabled Swiss businesses to generate CHF 242.7 million turnover. The GVA and employment contribution were estimated by applying economic ratios for the sectors in which

[22] Goldscheider (2002), Use of the 25% rule in valuing IP, les Nouvelles.

licence agreements were made. The effect of subsequent spending rounds was captured by applying GVA and employment multipliers. The effect in each study area was estimated based on the location of the business that licenced each technology.

In this way it was estimated that the licensing activity of the ETH Domain contributed CHF 161.4 million GVA and 1,272 jobs in Switzerland and a further CHF 135.4 million GVA and 1,157 jobs outside the country.

Table 9-2 ETH Domain: Licensing Contribution

Licensing Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	161.4	1,272
Abroad	135.4	1,157
Total	296.7	2,429

Source: BiGGAR Economics Analysis

Spin-off Companies

The institutions of the ETH Domain support the formation of new businesses based on intellectual property developed at the institutes. These spin-off companies make an economic contribution to Switzerland through the turnover they generate and the employment they support.

In 2016 there were an estimated 659 active spin-out companies of the ETH Domain. The survival rate of ETH Domain spin-off companies is well above average.[23] All spin-off companies created prior to 2016 that continue to be active in 2016 have been included in this contribution. This is because these companies are generating turnover and supporting employment in 2016.

Table 9-3 ETH Domain: Spin-off Contribution – Assumptions

	Total
Number of active spin-offs	659
Number of jobs supported	6,604
Turnover generated	CHF 1.6 billion

Source: ETH Domain Members and BiGGAR Economics Analysis

The spin-off companies of the ETH Domain were estimated to employ 6,600 people and generate CHF 1.6 billion turnover. The total economic impact is the sum of the GVA and employment contribution of the spin-off companies themselves and the activity that these companies generate within their supply chain and through the spending of their staff. This has been estimated to be CHF 2.1 billion GVA and 21,614 jobs in Switzerland and a further CHF 190.2 million GVA and 2,772 jobs outside the country.

[23] Swiss Confederation (2017), Research and Innovation in Switzerland 2016

Table 9-4 ETH Domain: Spin-off Contribution

Spin-off Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	2,054.0	21,614
Abroad	190.2	2,772
Total	2,244.2	24,386

Source: BiGGAR Economics Analysis

Summary Commercialisation Contribution

The ETH Domain makes a significant economic contribution through its commercialisation activities, such as the creation of new companies and licensing of intellectual property. The total monetary value of this in 2016 was estimated to be CHF 2.5 billion GVA and 26,800 jobs globally. Of this, CHF 2.2 billion GVA and around 22,900 jobs were estimated to be in Switzerland.

Table 9-5 ETH Domain: Commercialisation Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Licensing	161.4	1,272
Spin-offs	2,054.0	21,614
Total Commercialisation Contribution	2,215.3	22,886
Abroad	GVA (CHF m)	Employment
Licensing	135.4	1,157
Spin-offs	190.2	2,772
Total Commercialisation Contribution	325.6	3,929
Global (Total)	GVA (CHF m)	Employment
Licensing	296.7	2,429
Spin-offs	2,244.2	24,386
Total Commercialisation Contribution	2,541.0	26,815

Source: BiGGAR Economics Analysis (numbers may not sum due to rounding)

10 KNOWLEDGE TRANSFER

Switzerland is one of the five most innovative economies in Europe with efficient knowledge and technology transfer cited as one of the main factors behind this[24]. The ETH Domain supports knowledge transfer by exchanging information, skills and research results with companies and public organisations. This allows businesses and organisations to utilise academic knowledge and generate economic benefits such as reducing the time taken to develop new products.

Internships

In 2016, over 3,600 students from the ETH Domain undertook an internship during the course of their studies, when they spent time working for a business or organisation in a sector that was relevant to their field of study. This amounted to almost 90,500 placement weeks. Around 60% of this figure is accounted for by 870 architecture and building science students at ETH Zurich who spend one year on placement and a further 300 students in architecture, civil and environmental engineering at EPFL who spend around seven months on placement from their respective courses.

Placements provide students with an opportunity to apply what they have learned while studying in a work setting and gain valuable work experience that should help to improve their employment prospects after they graduate.

Internships can also have a number of benefits for host businesses. There are four main types of benefits, those relating to:

- **the work undertaken by the student/graduate** – i.e. helping to implement new procedures or completing specific projects, by freeing up time of other staff, doing things that other staff did not have the time to do;
- **the outlook of the graduate or student** – i.e. the idea that students/graduates can bring a fresh perspective that can stimulate organisations to question whether they are doing things in the best way;
- **improved skills, knowledge or experience of existing staff –** e.g. the management experience gained by employees involved in organising or supervising placements, new skills picked up from the student/graduate and the potential for organisations to use placements to vet potential employees;
- **other benefits –** such as direct cost savings or the opportunity to develop a relationship with a higher education institution.

The value that a student delivers for their host organisation will depend on a number of factors including the duration of the placement, the skills of the individual and the nature of the work undertaken. It is however possible to estimate the impact of placements based on the amount of time that students spend working within their host organisations.

The nature and duration of student placements undertaken by students in Switzerland varies, but for the purposes of this analysis only placements of 12 weeks or longer were considered. This is because it was assumed that placements of a shorter duration would be primarily observational in nature.

[24] Swiss Confederation (2017), Research and Innovation in Switzerland 2016

To estimate the value of this impact it was first necessary to establish how much time students spent on placement and how many full time staff this time would be equivalent to. Students on placement are likely to be less productive than an average worker because they have less experience and require more supervision. The value that students added to their host organisations was then estimated by assuming that students contributed half of the GVA that an average worker in the same industry would generate over the same period of time. Appropriate multipliers were then applied to capture the effect of subsequent spending rounds.

Table 10-1 ETH Domain: Internships Contribution – Assumptions

	Value	Source
Total number of students participating in placements of >12 weeks	3,614	ETH Domain
Total number of weeks spent on placement	90,468	
% of placements undertaken outside Switzerland	43%	
Equivalent number of full time employees	870	BiGGAR Economics
Student productivity as % of fully trained member of staff	50%	

Using this approach it was estimated that ETH Domain students contributed CHF 225.7 million to the Swiss economy and supported 2,100 jobs as a result of undertaking internships during the course of their studies. This contribution is summarised in Table 10-2.

Table 10-2 ETH Domain: Internships Contribution

Internships Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	225.7	2,100
Abroad	92.2	881
Total	317.9	2,981

Source: BiGGAR Economics Analysis

Services for Businesses

The expertise of the ETH Domain institutes makes them well placed to support businesses and other organisations in Switzerland. There are three primary ways in which the ETH Domain institutes do this:

- collaborating with businesses or other organisations to undertake commissioned research;
- undertaking consultancy projects for businesses or public organisations (such as the CTI) to address specific problems; and
- delivering professional training and further education to help businesses develop the skills of their workforce.

In 2016 the ETH Domain institutes generated CHF 276.3 million by providing these types of services to businesses and other organisations. This figure includes only contracts which were newly awarded in 2016.

Table 10-3 ETH Domain: Services for Businesses Contribution – Assumptions

		Value	Source
Total income from services for businesses, of which...		276.3	ETH Domain
	industry-oriented research	131.9	
	project-oriented third party funding (incl. cantons, municipalities, international organisations)	86.4	
	further education	7.8	
	Commission for Technology and Innovation	50.3	
GVA contribution from services for businesses		340%	PWC

The industry-oriented research funding accounts for 48% of the total research income received. This is awarded across all fields including architecture and building sciences, materials, engineering, computer and communication science, life sciences, basic sciences, natural sciences and energy.

A further 18% of the total figure comes from research funding from the Commission for Technology and Innovation (CTI) which has a mandate to promote innovation and scientific research. The CTI is active in three funding areas: R&D project funding, Start-up and Entrepreneurship and KTT Support. From 2013 to 2016 it is also promoted research into energy.

It is reasonable to assume that the businesses and organisations that invest in this type of support do so because they expected the projects to generate positive returns. Detailed information about the level of these returns is not available; however, an estimate can be made based on the findings of research from similar activity elsewhere.

In 2013 BiGGAR Economics undertook an evaluation of Interface, the agency responsible for brokering relationships between businesses (and other organisations) and universities in Scotland[25]. The connections that Interface has made have covered a range of different types of engagement from small consultancy projects and access to university equipment and facilities through to company sponsored PhDs. The BiGGAR Economics evaluation found that the costs to Interface's clients of participating in this programme was £12.9 million and the direct benefit to these organisations was £46.4 million GVA. Therefore the direct return to investment was 360%. In other words, every £1 invested by businesses generated £3.60 GVA in direct economic benefits.

This finding is similar to other studies done in similar areas. In 2009 PriceWaterhouseCoopers LLP undertook a study for the Department of Business, Enterprise & Regulatory Reform[26], which considered the impact of Regional Development Agency spending. One of the aspects of this report considered the GVA returns to business development and competitiveness interventions between 2002 and 2007. This found that interventions in "Science, R&D and innovation infrastructure had achieved cumulative GVA equivalent to 340% the cost of the projects and that this could increase to 870% if the long-term benefits

[25] BiGGAR Economics (2013), Evaluation of Interface, the knowledge connection for industry
[26] PriceWaterhouseCoopers, Impact of RDA spending – National report – Volume 1 – Main Report, March 2009, DBERR

were taken into account. This suggests that the 360% multiplier estimated by BiGGAR Economics could be conservative.

Although both of these studies related to activity undertaken in the UK rather than Switzerland, the nature of the collaboration considered in both studies is very similar so the findings of the research are likely to be applicable to this study. The economic contribution of the ETH Domain institutes working with businesses was modelled using the lowest of the range of possible assumptions (i.e. 340%).

These assumptions were applied to the total value of income received by the ETH Domain for delivering these services. This gives an estimate of the direct GVA contribution from the services to businesses provided by the ETH Domain.

The additional economic activity at these businesses from their interactions with the ETH Domain is also assumed to support additional employment, as this type of activity is generally investment in product and processes, rather than personal productivity. The total economic contribution was then calculated by applying sector appropriate multipliers to the direct contribution.

In this way it was estimated that the ETH Domain contributed CHF 2.3 billion and 21,800 jobs to Switzerland in 2016. A further CHF 1.1 billion and 11,200 jobs were supported outside the country.

Table 10-4 ETH Domain: Services for Businesses Contribution

Services for Businesses Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	2,325.5	21,787
Abroad	1,140.5	11,185
Total	3,466.0	32,971

Source: BiGGAR Economics Analysis

Large Scale Research Infrastructure Contribution

The remit of the ETH Domain also extends to the development of large scale research infrastructure. Although these are generally constructed with the purpose of increasing scientific understanding of the basic structures and principles of the universe, their development and construction can have further economic impacts, also known as technological spill-overs.

10.1.1 Benefits to Businesses in the Supply Chain

The challenging engineering problems presented by projects of this nature mean that suppliers are frequently required to develop or apply new technology. A study considering the benefits that may arise from constructing the Large Hadron Collider (LHC) classified technology on a five-point scale, with the most advanced being "high-tech products with a moderate to high specification activity intensity to customize product for LHC" and "products at the frontier of technology with an intensive customization and co-design involving CERN staff."[27]

Suppliers are then able to leverage this new technological and supply chain experience to generate increased sales and cost savings (referred to as economic utility). Several academic studies have been undertaken to estimate the ratio of economic utility to turnover as a result of contracts secured in the supply chain,

[27] Florio, M.; Forte, S.; Sirtori E. (2016), Forecasting the Socio-Economic Impact of the Large Hadron Collider: a Cost Benefit Analysis to 2025 and Beyond

and although there is some variation in values, with values as high as 4.5, the consensus is an economic utility/sales ratio of 3.

The first of these academic studies was carried out by CERN in 1975,[28] and was based on an extensive survey of suppliers. It found an economic utility/sales ratio of 3, which was subsequently confirmed by an updated study undertaken in 1984.[29] The original study also noted that the new technology had impacts in fields outside of particle physics, such as railways, power distribution and generation, refrigerators, material storage etc.

As the ETH Domain has recently completed the construction of the Swiss Free Electron Laser (SwissFEL) the economic contribution of this is considered here. Although the total cost of the project was in the region of CHF 275 million, the share in 2016 was CHF 50 million.

It was assumed that the share of Swiss contractors would be 50% of the total, and that 50% would be from abroad. A selection of representative industries were chosen, and it was assumed that turnover would increase by 3 times (based on the study by CERN). Appropriate GVA/turnover and turnover/employee ratios were applied, as well as economic multipliers to estimate the economic contribution. In this way, it was estimated that benefits to firms in the procurement chain from ETH Domain large scale research infrastructure contributed an estimated CHF 172.8 million GVA and 1,482 jobs.

Table 10-5 ETH Domain: Large Scale Research Infrastructure Contribution - Supply Chain

Supply Chain Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	73.2	628
Abroad	99.6	854
Total	172.8	1,482

10.1.2 Benefits to Businesses from Accessing Research Infrastructure

Although the research infrastructure developed by the ETH Domain is focused on increasing the stock of scientific knowledge, there can also be benefits associated with use by commercial clients. For example, businesses in the pharmaceutical or chemicals sectors can use the SwissFEL to examine the structure of molecules, or observe how molecules interact with each other.

However, there is no readily useable metric to quantify the impact of these benefits of research infrastructure to commercial clients. While economic impact studies of other large scale research infrastructure projects have been undertaken, these have tended to focus on the core impacts, and any impacts associated with knowledge exchange have been treated qualitatively[30]. This may be for several reasons, such as the heterogeneity of large scale research infrastructure, the relative cost of undertaking such a study, and the commercial sensitivity of turnover and employment data.

[28] Schmied (1975), A Study of the Economic Utility Resulting from CERN Contracts
[29] Bianchi-Streit, M. et al (1984), Economic Utility Resulting from CERN Contracts (Second Study)
[30] See SQW (2017), Sci-Tech Daresbury Campus Impact Study; ESRF (2013), The impact of the ESRF and its Upgrade Programme; Joubin, M, (2012), Les impacts socio-économiques des synchrotrons en Europe - L'example de SOLEIL

Although there is no ready metric for quantifying the impact, it does make sense that commercial clients would not undertake the analysis, without expecting a return at least equal to its cost, also know as the Willingness-to-Pay (WTP) principle. Based on consultation undertaken with members of the ETH Domain, it was therefore estimated that level of income and economic impact would be CHF 4.8 million in 2016.

Table 10-6 ETH Domain: Large Scale Research Infrastructure Contribution - Access to Research Infrastructure

Access to Research Infrastructure	GVA (CHF m)
Switzerland	4.5
Abroad	0.3
Total	4.8

Source: BiGGAR Economics Analysis

10.1.3 Health Benefits of Infrastructure (Centre for Proton Therapy)

The Centre for Proton Therapy hosts the worldwide first compact scanning gantry for the irradiation of deep-seated tumours with proton beam. The spot-scanning technique developed at the Centre for Proton Therapy has made it possible to irradiate malignant tumours situated deep inside in the body with extremely high precision and to successfully stop their growth, while sparing the healthy tissues surrounding the target.

Patient treatment has a long tradition at the institute. Patients with certain cancer diseases have been able to benefit from treatment with proton beams since as early as 1984. Protons are particularly suitable for the treatment of children and adolescents. A close collaboration with the University Children's Hospital in Zürich has made it possible to treat very young children under sedation since 2004.

The benefits of proton beam therapy for patients include reduced side effects of treatment, increased cure rates and reduced morbidity. Evidence from elsewhere indicates that proton therapy patients have the capacity to gain an average of 2.5 QALYs (Quality Adjusted Life Years) over their lifetime relative to conventional treatment.[31] This value is likely to be an underestimate of the total QALY gains per patient, as it does not include the non-chronic side effects of conventional radiotherapy.

It is possible to estimate the monetary value of this by applying the Department of Health in England's value of £60,000 (CHF 80,118) per QALY[32]. In 2016, the Centre for Proton Therapy treated 400 patients generating estimated health benefits of CHF 80.1 million.

[31] Department of Health (2012), National Proton Beam Therapy Service Development Programme: Value for money addendum to strategic outline case
[32] Department of Health (2012), National Proton Beam Therapy Service Development Programme: Strategic outline case

Table 10-7 ETH Domain: Health Benefits Contribution

Health Benefits Contribution	GVA (CHF m)
Switzerland	80.1
Abroad	-
Total	80.1

10.1.4 Total Large Scale Research Infrastructure Contribution

Summing together the benefits to businesses in the supply chain and the benefits to businesses from accessing the research infrastructure gives a combined total large scale research contribution of CHF 177.6 million GVA and 1,482 jobs globally.

Table 10-8 ETH Domain: Large Scale Research Infrastructure Contribution

Supply Chain Contribution	GVA (CHF m)	Employment
Switzerland	73.2	628
Abroad	99.6	854
Total	172.8	1,482
Access to Research Infrastructure Contribution	GVA (CHF m)	Employment
Switzerland	4.5	-
Abroad	0.3	-
Total	4.8	-
Health Benefits Contribution	GVA (CHF m)	Employment
Switzerland	80.1	-
Abroad	-	-
Total	80.1	-
Total Large Scale Research Infrastructure Contribution	GVA (CHF m)	Employment
Switzerland	157.8	628
Abroad	99.8	854
Total	257.7	1,482

Source: BiGGAR Economics Analysis

Science Parks

Some of the ETH Domain members are closely associated with particular science parks, including Technopark Zurich and EPFL Innovation Park. In some cases, these science parks are privately financed and in other cases they have been established directly by an ETH Domain member.

Science parks provide a physical environment in which researchers working in academia and the private sector can meet and exchange ideas with one another.

This helps to stimulate new ideas and facilitate opportunities for collaborative research. The overall aim is to create optimum conditions for innovation between local companies and academic researchers and also to attract new companies to locate there.

Ultimately the success of these parks is due to the academic partners involved, as without them the science parks would simply be a collection of businesses with little incentive or stimulus to collaborate. For this reason it is appropriate to include the value generated by these parks within this report. Science parks generate economic benefits by increasing the level of economic activity in an area as well as attracting more companies to an area.

The details provided by the ETH Domain members suggests that 3,376 science park employees have not been considered elsewhere in this study. Unlike spin-off companies most of the businesses that are located on the science parks would have existed even if the science park did not. This means that it would not be appropriate to attribute all of the economic impact of these businesses to the ETH Domain members.

If the science parks did not exist then it is possible that some of the businesses located on the science parks would have chosen to locate elsewhere in Europe or elsewhere in the world instead. It is also likely that colocation with ETH Domain members has enabled many of these businesses to achieve higher levels of growth than would otherwise have been possible.

In assessing the economic contribution of science parks, it was necessary to consider both of these factors and come to a view about the extent to which this impact was additional. These assumptions are discussed in further detail in the technical appendix. After accounting for this, the economic contribution of the science parks was estimated using a similar approach to the spin-offs contribution.

Using this approach, it was estimated that the involvement of ETH Domain members in science parks generated CHF 325.9 million GVA for the Swiss economy in 2016 and supported around 2,688 jobs.

Table 10-9 ETH Domain: Science Parks Contribution

Science Parks Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	325.9	2,688
Abroad	59.9	547
Total	385.8	3,235

Summary Knowledge Transfer Contribution

The ETH Domain makes a significant economic contribution through its knowledge transfer activities. The total monetary value of this in 2016 was estimated to be CHF 4.4 billion GVA and 40,700 jobs globally. Of this, CHF 3.0 billion GVA and 27,200 jobs were estimated to be in Switzerland.

Table 10-10 ETH Domain: Knowledge Transfer Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Internships	225.7	2,100
Services to Businesses	2,325.5	21,787
Large Scale Research Infrastructure	157.8	628
Science Parks	325.9	2,688
Total Knowledge Transfer Contribution	3,034.9	27,202
Abroad	GVA (CHF m)	Employment
Internships	92.2	881
Services to Businesses	1,140.5	11,185
Large Scale Research Infrastructure	99.8	854
Science Parks	59.9	547
Total Knowledge Transfer Contribution	1,392.4	13,467
Global (Total)	GVA (CHF m)	Employment
Internships	317.9	2,981
Services to Businesses	3,466.0	32,971
Large Scale Research Infrastructure	257.7	1,482
Science Parks	385.8	3,235
Total Knowledge Transfer Contribution	4,437.3	40,669

Source: BiGGAR Economics Analysis (numbers may not sum due to rounding)

11 WIDER BENEFITS

As well as the teaching and research they deliver, there are other, wider benefits arising from the institutes of the ETH Domain to the individual and to society as a whole. Some of these have already been described in section 8.1.7 on the wider benefits of higher education to the individual. However, other factors exist and are rightly included when considering the overall range of benefits that are attributable to the ETH Domain.

The range of factors described in this section include the contribution that the members make towards providing public goods for the safety and protection of society and the environment; their contribution to the research, development and innovation landscape in Switzerland; the appeal they have that helps to attract multinational companies and the spirit of collaborative working they encourage between education, industry and government.

Provision of Public Goods

Much of ETH Domain's work is concerned with the provision of public goods. The key characteristics of which are:

- Non-excludability – their benefits cannot be confined solely to those who have paid for it. Non-payers can enjoy the benefits of consumption at no financial cost: e.g. the provision of clean water in lakes and rivers;
- Non-rival consumption – consumption by one person does not restrict consumption by other consumers: it is available to all e.g. an avalanche warning system;
- Non-rejectable – the collective supply of a public good for all means that it cannot be rejected by people e.g. a flood defence system.

With these features, public goods are not likely to be provided by the private sector as they raise the issue of valuation and who will pay for them. Yet they are highly valuable to the wider public as well as providing the supporting foundations for sectors that are vital to the Swiss economy.

The work and services of the institutes supports the risk management of public authorities in Switzerland. A strong example of this is the avalanche warning system provided by WSL, which is described in Figure 11–1.

Figure 11–1: WSL's Avalanche Warning Service

Avalanche Warning Service

Avalanches rank among the most significant natural hazards in the Swiss mountains. As well as claiming lives, they can cause major disruption and devastation for rural communities. The WSL Institute for Snow and Avalanche Research (SLF) has been responsible for providing an avalanche warning service on behalf of the Swiss federal government since 1945.

The SLF's role is to:

- monitor and research the condition, origin and evolution of natural hazards, snow, permafrost and mountain ecological systems;
- develop concepts, strategies and specific measures to protect populations against natural hazards, in particular avalanches; and
- to develop sustainable solutions for socially relevant issues, in collaboration with partners in the scientific and social sectors.

Its most important product is the Avalanche Bulletin. This is a vital planning and decision-making tool for the benefit of safety officers in ski resorts and local authorities, snow sports enthusiasts and anyone spending time in the mountains in winter outside secured areas. A number of other products such as snow maps and weekly reports provide additional or more in-depth information about the snow and avalanche situation.

The Avalanche Bulletin is designed as an informed warning. It is published twice daily in winter and primarily contains a forecast of the avalanche danger in the Swiss Alps, Liechtenstein and, when there is sufficient snow cover, the Jura as well. It is available online and via the White Risk app. In summer, avalanche bulletins are only published as and when necessary..

Villages and roads can be protected from avalanches in a variety of ways. Refraining from building in vulnerable areas, preventing avalanche formation by planting forestry or erecting barriers, minimising avalanche impact by means of protective structures such as snow sheds, and artificially triggering avalanches using explosives before too much snow has accumulated are just a few of the possibilities. SLF investigates how these different approaches work and how they can best be combined, including from an economic and legal perspective.

Source: WSL Website,,2017

This, along with the work of several other ETH Domain institutions (particularly Eawag), is concerned with the quality and safety of the natural environment and therefore plays a vital role in supporting the health and safety of the Swiss people and the economy more widely. Table 11-1 sets out the target audiences for the knowledge and technology transfer activities of the four research institutes.

Table 11-1 – Target Audiences for Knowledge and Technology Transfer by the Research Institutes

	industry	utilities	local, Cantonal, Federal agencies	individuals interest groups consumers
PSI	novel technologies	process safety	process safety	
EMPA	novel materials novel processes	life cycle analysis material safety	materials safety failure analysis air quality monitoring	novel materials materials safety failure analysis
WSL	assessment of sustainable resource use		hazard warning resource & impact assessment	hazard warning resource & impact assessment
Eawag	novel technologies & monitoring tools	novel treatment processes	resource & impact assessment	resource & impact assessment

Sources: PSI, EMPA, WSL and Eawag

Energy is another sector where the work of the ETH Domain members is paving the way for new and improved methods for producing sustainable energy both now and into the future. This fits well with the aim of the aim of the Swiss government to reduce greenhouse gas emissions and to become carbon neutral by 2020. However, it is not possible to assign an economic value to services such as these which are public goods.

Research and Innovation in Switzerland

The World Economic Forum's Global Competitiveness Report for 2016-17[33] assesses the competitiveness landscape of 138 economies, providing insight into the drivers of their productivity and prosperity. It found that Switzerland, along with Singapore and the United States are the three most competitive economies in the world with Switzerland ranking in the top position for the eighth consecutive year.

The Global Competitiveness Index (GCI) is drawn together from a weighted average of 12 indicators which are grouped into the three themes: Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors. Switzerland is placed in top position globally on all measures for Innovation and Sophistication.

The report notes that Switzerland arguably possesses one of the world's most fertile innovation ecosystems, combining a very conducive policy environment and infrastructure, academic excellence, an unmatched capacity to attract the best talent, and large multinationals that are often leaders in their sector. This is complemented by a dense network of small- and medium-sized enterprises across sectors that have a reputation for quality and strive for innovation. Furthermore, the intense collaboration that exists between the academic and business worlds yields innovative products with commercial applications.

[33] K Schwab, 2017, The Global Competitiveness Report 2016-2017, World Economic Forum

A report by the SBFI on Research and Innovation in Switzerland 2016 also reinforces this message[34] and examines the factors behind Switzerland's success. The key messages from this are summarised in Figure 11–2.

Figure 11–2 Factors of Success in Swiss Innovation

This study was a first endeavour to present a comprehensive picture of research and innovation in Switzerland, describe systematic interactions and identify unique characteristics compared with other countries. It found that the Swiss research and innovation system is highly efficient in both a national and international context.

The key elements of the country's success are briefly summarised as:

- **its globally competitive business sector** – supported by the diversity and density of local knowledge, specialist networks and attractive framework conditions, Swiss SMEs are more innovative, on average, than their counterparts in other European countries;
- **high-quality, publicly-funded education and research institutions** – Switzerland has an excellent dual-track education system that closely coordinates training curriculums with the needs of the labour market. The education system produces highly skilled people at all levels of qualification along the value chain; and
- **efficient knowledge and technology transfer** – technology transfer offices with differing institutional structures have been set up to efficiently promote and support knowledge and technology transfer.

Source: Research and Innovation in Switzerland 2016, Swiss Confederation

Through the activities, reputation and quality of its membership, the ETH Domain plays a major role in creating and supporting the conditions that feature strongly in the success of Switzerland's research and innovation landscape. The role of the Federal Institutes of Technology (ETH Domain) is especially acknowledged by the report's authors as one of the key engines of the technological and scientific implementation of knowledge in Switzerland through its activities that embrace areas of strategic importance to Switzerland's competitiveness, e.g. the life sciences, nanotechnology, and ICT. ETH Zurich and EPFL are the only two higher education institutions outside the UAS sector to offer engineering syllabuses[35].

The report also references a study by the European Commission in 2015 that ranks Switzerland as one of the five most innovative economies in Europe (in order of ranking: Switzerland, Sweden, Denmark, Finland, and Germany[36].

Attracting International Investment in R&D

A large proportion of private sector research and innovation is conducted by multinational enterprises. In turn, they make a substantial contribution towards GDP (around 36% in Switzerland's case). They also create opportunities for skilled jobs, maintain ties with various international innovation actors and

[34] Federal Department of Economic Affairs, Education and Research EAER, 2016*, Research and Innovation in Switzerland 2016*, SBFI
[35] Ibid. p.41.
[36] Ibid p.42.

collaborate with higher education and research institutions and regional companies to generate and disseminate new knowledge.

At an international level, countries and cities have become increasingly competitive in attempting to attract mobile foreign direct investment due to the many benefits they bring.

The SBFI study referred to above investigated the main reasons why multinationals established research and innovation activities in Switzerland. These are:

- the excellent access to highly qualified specialists; and
- the proximity to cutting-edge research centres, "*above all the Federal Institutes of Technology in Zurich (ETH Zurich) and Lausanne (EPFL)*[37]".

Tax advantages are an additional factor conducive to setting up research and innovation activities in Switzerland.

A good example of Switzerland's appeal to multinational companies is the presence of IBM Research in Zurich which is one of the organisation's 12 global research labs, and one of its two research locations in Europe (the other being Ireland).

IBM has maintained a research laboratory in Switzerland since 1956 when it was set up as the first European branch of IBM Research. Their mission, in addition to pursuing cutting-edge research for tomorrow's information technology, is to cultivate close relationships with academic and industrial partners, be one of the premier places to work for world-class researchers, to promote women in IT and science, and to help drive Europe's innovation agenda[38].

Together with ETH Zurich, IBM Research shares the Binnig and Rohrer Nanotechnology Centre in Zurich which provides cutting-edge, collaborative infrastructure designed specifically for advancing nanoscience. The two organisations share the facility for both joint and individual research projects.

Further examples include Google establishing its first artificial intelligence research lab outside the US in Switzerland, which involves around 2,200 collaborators. As well as this, Disney Research have a research lab in Zurich, which it explicitly states is in order to have easy access to one of the ETH Domain members. The research lab maintains close ties with the computer graphics department of the ETH institute in question. The Nestlé Institute of Health Sciences was established in 2011 on the campus of one of the ETH Domain members and is part of Nestlé's global R&D network. The Institute undertakes fundamental research for the understanding of health and disease and for developing science-based targeted nutritional solutions for the maintenance of health.

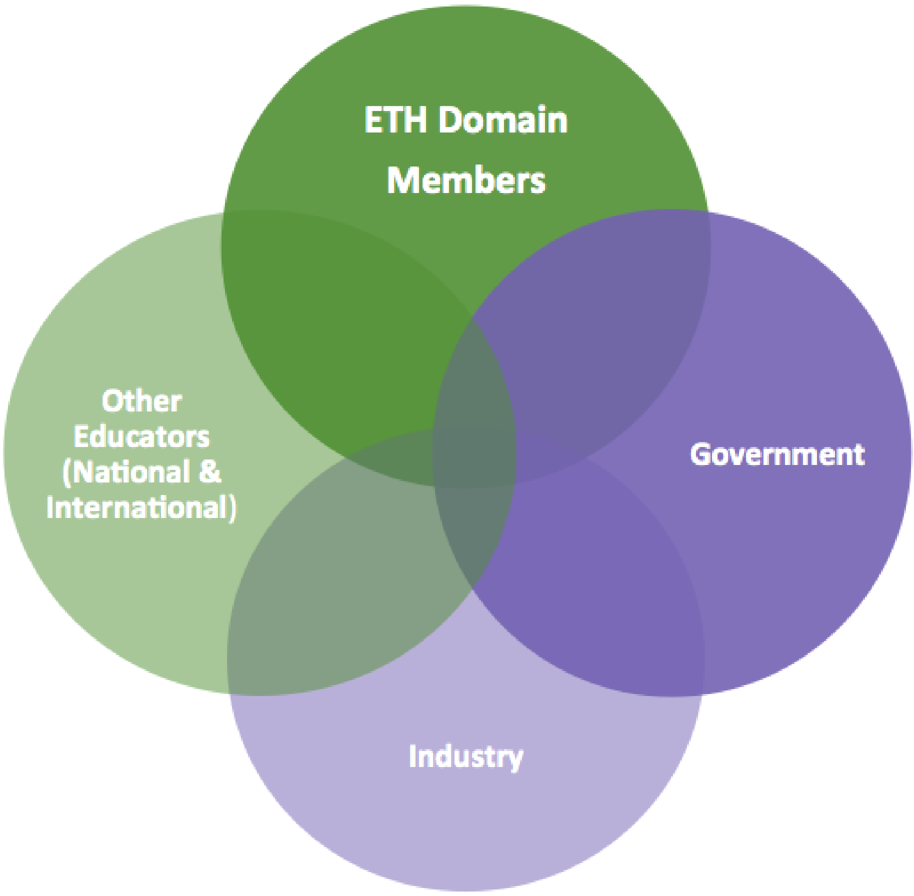
Collaborative Working

The institutions of the ETH Doman have a long-established and highly valued system of collaborative working which is regarded as a major factor behind the country's highly successful innovation system.

[37] Ibid, p18.
[38] Source: IBM Research website: https://www.zurich.ibm.com

Collaboration operates on several levels: between the members of the ETH domain, between ETH and government, between ETH and industry and between ETH and other education and research institutions both in Switzerland and abroad. This is illustrated conceptually in Figure 11.3.

Figure 11.3: Collaborative Working in Switzerland



Source: BiGGAR Economics

This is a variation on the Triple Helix[39] approach to economic development whereby education, industry and government work together in a complex and dynamic series of interactions that generate new knowledge, encourage innovation and, as a result, contribute to economic development. In the Swiss case, the ETH Domain members are key drivers in the innovation process.

This has led to the observation that a second academic revolution is well underway with the role of academia now extending far beyond teaching and research. Higher education and research institutions now incorporate a third mission into their strategies: to be active players in economic development

[39] The Triple Helix concept was developed originally by Henry Etzkowitz and Loet Leydesdorff in the 1990s as a result of their preliminary studies on the role of the academy and of complex systems dynamics. Over the years the concept has been spread through academic papers, books and special issues in the scientific press.

through the creation of scientific and technological knowledge and, consequently, of innovation[40].

In the Triple Helix approach, the interactions between the three sectors enable the rapid identification of and response to the frequent changes that occur in a society organised around knowledge. These interactions occur at many levels and result in: (a) internal transformation in the respective sectors; (b) the influence of organisations in one sector on organisations in the other sectors; (c) the creation of new structures; and (d) a recursive effect among the three sectors.

The concept of the Triple Helix provides an analytical tool for identifying and evaluating the behaviour in the education, university, industry and government spheres to develop appropriate policies and strategies to promote innovation and the economic development it supports. It can be also an 'inspiration' for policy makers not only to develop policies to support the R&D infrastructure, as in previous approaches to national innovation systems, but also to improve the linkages between the three spheres.

Research groups act as quasi-firms and cooperate with actors in other sectors. Thus the 'entrepreneurial university' emerges, and the inter-sectoral linkages take on a new hybrid configuration. Products of this new configuration include spin-off companies, incubators and technology parks, intellectual property and technology commercialisation offices. The outcome is that innovation becomes a more embedded and valued part of the economy instead of being an isolated undertaking by a single organisation. This culture has been well established and continues to be developed by the ETH Domain.

The international dimension is particularly important in the Swiss model as the institutions pride themselves as having an outward looking approach to research and collaboration which helps them to harness the potential offered by global academic thinking in the widest sense possible.

Summary

The benefits described here cannot be quantified in economic terms but they are highly valuable nonetheless. They have an influence that extends beyond teaching and research to impact on the economic and environmental quality of the country and the health, safety and social cohesion of its people.

The breadth and uniqueness of their work across the fields of science, technology, energy and the environment underpins sectors that are key to the Swiss economy.

[40] M Amaral, 2011, *The Triple Helix in the economic development of cities, regions and countries*, in Industry and Higher Education, Vol 25, No 5

12 SUMMARY OF CONTRIBUTIONS

This chapter summarises the quantifiable economic contribution of the ETH Domain members within Switzerland, abroad and in total.

Total Quantified Contribution

By bringing together the various sources of economic contribution discussed in this report it can be estimated that, in 2016, the six members of the ETH Domain contributed **CHF 16.5 billion GVA** to the global economy and supported a total of **123,800 jobs**.

The contribution in Switzerland was **CHF 13.3 billion GVA** and **98,700 jobs**.

This implies that each person directly employed by the institutes of the ETH Domain supported almost five jobs throughout Switzerland and almost six jobs in total on a worldwide scale.

The total income of the ETH Domain members in 2016 was CHF 3.6 billion and so the ratio of total income to total impact in Switzerland was CHF 1 : CHF 4. The ratio of total income to total global impact is CHF 1 : CHF 5.

The federal funding contribution to the six ETH Domain members in 2016 was CHF 2.5 billion which gives a ratio of federal funding to impact of CHF1 : CHF 5 in Switzerland and CHF 1 : CHF 7 globally.

A breakdown of the total contribution by GVA and by employment is provided in Table 12-1 and Table 12-2 respectively.

Table 12-1 – ETH Domain Members– Summary Contribution – GVA, CHF million

	Switzerland	Abroad	Total
Direct Effect	2,601.6	-	2,601.6
Staff Spending Effect	1,969.1	530.1	2,499.3
Supplier Effect	894.2	298.3	1,192.4
Capital Investment	245.3	169.4	414.7
Core Operations	**5,710.3**	**997.8**	**6,708.0**
Student Spending	466.7	62.3	529.0
Part-time Work	297.0	25.4	322.4
Student Volunteering	1.4	-	1.4
Student	**765.2**	**87.7**	**852.9**
Visits to Staff & Students	11.1	2.2	13.2
Conferences & Events	54.7	-	54.7
Tourism	**65.8**	**2.2**	**68.0**
Technology Licensing	161.4	135.4	296.7
Spin-offs	2,054.0	190.2	2,244.2
Commercialisation	**2,215.3**	**325.6**	**2,541.0**
Internships	225.7	92.2	317.9
Services to Businesses	2,325.5	1140.5	3,466.0
Large Scale Research Infrastructure	157.8	99.8	257.7
Science Parks	325.9	59.9	385.8
Knowledge Transfer	**3,034.9**	**1,392.4**	**4,427.3**
Sub-Total	**11,791.5**	**2,805.7**	**14,597.2**
Graduate Premium	1,494.6	447.1	1,939.7
TOTAL	**13,284.1**	**3,252.8**	**16,536.9**

Source: BiGGAR Economics Analysis, figures may not total due to rounding

Table 12-2 – ETH Domain Members– Summary Contribution – Jobs

	Switzerland	Abroad	Total
Direct Effect	21,004	-	21,004
Staff Spending Effect	11,937	3,676	15,613
Supplier Effect	5,717	2,046	7,763
Capital Investment	1,812	1,213	3,025
Core Operations	**40,470**	**6,936**	**47,405**
Student Spending	3,972	521	4,492
Part-time Work	3,450	231	3,681
Student Volunteering	-	-	-
Student Contribution	**7,422**	**752**	**8,174**
Visits to Staff & Students	124	20	144
Conferences & Events	613	-	613
Tourism Contribution	**737**	**20**	**757**
Technology Licensing	1,272	1,157	2,429
Spin-outs	21,614	2,772	24,386
Commercialisation	**22,886**	**3,929**	**26,815**
Internships	2,100	881	2,981
Services to Businesses	21,787	11,185	32,971
Large Scale Research Infrastructure	628	854	1,482
Science Parks	2,688	547	3,235
Knowledge Transfer Contribution	**27,202**	**13,467**	**40,669**
Sub-Total	**98,717**	**25,104**	**123,820**
Graduate Premium	-	-	-
TOTAL	**98,717**	**25,104**	**123,820**

Source: BiGGAR Economics Analysis

Higher education makes a fundamentally important difference: to individuals, through improved life chances and opportunities; to the economy, through innovation and skills; and to society, increasing knowledge, through research discoveries and increasing social mobility and cohesion.

The figures in Table 12-1 and Table 12-2 reflect the estimated economic contribution made by the members of the ETH Domain in terms of GVA and jobs. However, it is important to note that their total contribution is much wider than that which can be measured in quantifiable terms. The nature and quality of their wider benefits should be included in the overall assessment of the total economic contribution to give a more rounded view of the true value of the ETH Domain.

Comparisons

The scale of the economic contribution made by the institutions of the ETH Domain can be put in some context by reflecting on the findings of other broadly similar studies undertaken by BiGGAR Economics and others that considered the economic contribution made by groups of universities.

On employment, the ratio of direct jobs to total employment contribution is 1 job : 4 jobs for ETH Domain. This is similar to the ratio for the Finnish Universities which was also 1 direct job : 4 total jobs and less than the ratio for the LERU universities of 1 : 6.

On GVA, the ratio of direct GVA to total GVA is CHF 1: CHF 5 for the ETH Domain. This ratio is different to the ratio of federal funding to impact as it considers the direct GVA of the institutions. The direct GVA is estimated by considering the *total* income of the institutions less their operating revenue.

The direct GVA to total GVA ratio for the ETH Domain is less than the ratios for both the Finnish Universities and the LERU universities which were €1 : €8 and €1 : €7 respectively.

However, while these comparisons are interesting to note, it is important to highlight that a true "like for like" comparison *cannot* be drawn. This is for several reasons:

- the unique nature of the ETH Domain means that it includes several research institutes which differ significantly from research universities in their scale, the nature of their work and their linkages into the national economy;
- universities have a large number of graduates and, by extension, create a significant economic contribution through the associated graduate premium. Research institutes do not serve this function;
- due to the nature of the higher education system in Switzerland, the graduate premium associated with graduates from the ETH Zurich and EPFL has been compared with the graduates from the universities of applied sciences in Switzerland rather than school leavers as is the case in other studies. Had this method been adopted for Switzerland, the graduate premium would have been CHF 3.8 billion instead of CHF 1.9 billion;
- although each study follows a similar approach, data sources and methods of compiling data differ from country to country. This makes a direct comparisons unrealistic;
- input-output ratios differ between countries reflecting the differences in national economies and the extent to which they trade with other countries. Part of the total impact comes from the interaction of the institutions with the national economy and part comes from the nature of the economy itself which is beyond the control of the ETH institutions;
- due to the medical research undertaken by many universities and their associations with hospitals, the contribution that results from health research is a significant feature for some of the comparator studies and this does not feature with the ETH Domain institutions to the same extent.

For these reasons it is more appropriate to consider the ETH Domain on its own merits, as a unique, renowned and highly valued source of knowledge and research expertise for which there is no direct parallel.

13 APPENDIX A: OVERVIEW OF ETH DOMAIN

ETH Domain

The ETH Domain consists of two Federal Institutes of Technology (ETH Zurich and EPFL in Lausanne) and four research institutes (Eawag, Empa, WSL and PSI).

The ETH Domain is managed according to an effect-oriented model. Historically, the political authorities specified performance standards to be met and key financial parameters, while the ETH Domain was responsible for implementing the specifications in its capacity as a service provider. From April 2017 the performance standards have been replaced by four strategic goals which have been approved by the Federal Government for the ETH Domain for 2017–2020.

The four goals are:

- the **quality of education** has top priority – first-class research-based education with the best possible student/teacher ratio has top priority for ETH members;
- **research infrastructures** for the whole of Switzerland – State-of-the-art research infrastructures are crucial for the international competitiveness of Swiss research and innovation. The institutions of the ETH Domain maintain these infrastructures at the cutting edge, operate them efficiently and make them available to science and business;
- **four strategic areas of research** – to enable Switzerland to acquire the necessary know-how in fields of research that are pioneering and increasingly relevant to society, economy and the environment, and to boost its competitiveness, the ETH Board has defined four strategic fields of research which it wants to move forward in the longer term: “energy”, “personalised medicine and medical technologies”, “big data and digital sciences” and “advanced manufacturing”; and
- Attractive **working conditions** – the institutions of the ETH Domain require outstanding members of staff to accomplish their statutory mission and to achieve their strategic objectives. To win new employees and foster existing ones, they must be able to rely on working conditions that are as attractive as possible. This includes a progressive pay policy that remains capable of competing with the private sector and the federal administration.

ETH Zurich

13.1.1 History:

ETH Zurich is currently one of the world’s leading technical universities. Its origins date back to 1855 when it was founded as a place of innovation and knowledge, intended to be a driving force of industrialisation in Switzerland. In addition to two campuses in Zurich, it has further departments and centres throughout the country as well as a research facility in Singapore.

The institution’s track record of scientific excellence includes 21 Nobel Prize winners (including Albert Einstein and Wolfgang Pauli); one Fields medal winner and two Pritzker Prize winners[41]. Mainly these are in the field of chemistry, physics and medicine.

13.1.2 Scale & Structure:

The University had 19,815 students (headcount) in 2016 of which 20.2% were doctoral students. The University had 9,100 full-time equivalent staff. The University had an operating revenue of CHF 1.8 billion in 2016, of which the Federal Government contributed CHF 1.3 billion (72.9%). The balance comes from third-party funding which forms a steadily increasing share of the total.

ETH Zurich has 16 departments which are organised into the following five areas: architecture and civil engineering; engineering sciences; natural sciences and mathematics; system-oriented natural sciences and management and social sciences.

13.1.3 Rankings

The University is placed in the top 10 universities globally by THE and QS rankings for 2018: a position it has maintained for several years. Its rank in the fields of natural sciences, engineering and technology is also in the top 10 globally based on QS rankings.

13.1.4 Research and Innovation

ETH scientists make important contributions to research in a number of areas:

- **Medicine** – by contributing to the development of technologies for prognostics, diagnostics and therapy;
- **Data** – by developing new approaches to data science and machine learning in order to secure and evaluate enormous amounts of data;
- **Sustainability** – food security, energy supply and climate change, the sustainable design of habitats and the careful handling of natural resources are among the greatest global challenges. ETH Zurich has studied these topics intensively for decades and is today a leader in energy, nutrition and environmental research; and
- **Manufacturing technologies** – a company’s economic success depends on its ability to develop innovative products and ensure cost-effective production. ETH Zurich’s research contributes to the development of future-oriented production processes and manufacturing technologies.

ETH Zurich works with over 60 industry partners, including its partnership with Disney Research Zurich which was founded in 2008 near ETH Zurich's main campus. The facility is headed by an ETH Professor and involves 30 senior scientists and researchers, 25 ETH PhD students, 60 ETH Master projects and 200 research projects. It has resulted in 90 patents being filed and the production of over 80 scientific publications. It was the Winner of the Tech Oscar in 2013.

[41] ETH Zurich, Annual Report 2016.

EPFL

13.1.5 History

With origins dating back to 1853 when it began as a private institution, the EPFL first became a federal institute under its current name in 1969. It is a technical university in Lausanne that specialises in natural sciences and engineering.

13.1.6 Scale & Structure

In 2016 the EPFL had almost 5,900 staff (scientific, administrative and technical staff as well as PhD students) and over 8,400 bachelor and masters students.

Teaching and research is organised into seven schools: architecture, civil and environmental engineering; basic sciences; engineering; computer and communication sciences; life sciences; management of technology and the college of humanities.

13.1.7 Rankings

Several university ranking sources place the EPFL among the top performing institutions globally. The Times World University (THE) rankings placed the EPFL as the top university in the world under 50 years of age in 2017. It regularly ranks in the top 10 on a global scale in natural sciences, engineering and technology based on the THE, Leiden, QS and ARWU (Shanghai) rankings.

13.1.8 Research and Innovation

EPFL is the birthplace of the modern computer mouse, as well as ambitious scientific projects and sustainable innovations such as the transparent-dye solar cells, the solar-powered aircraft Solar Impulse, the ultra-fast yacht Hydroptère, and the EU flagship programme the Human Brain Project (HBP). Much of EPFL's research is focused on sustainability, such as its research projects focusing on turning biofuel waste into valuable molecules for biofuel and developing ways to store solar energy cheaply and efficiently.

The campus also includes the “EPFL Innovation Park”, which currently hosts over 120 start-ups, 23 large companies and around 20 services providers.

EAWAG

13.1.9 History

Eawag is the Swiss Federal Institute of Aquatic Science and Technology. It was formed in 1936 with a legal mandate to focus on solving water-related problems faced in Switzerland and worldwide by conducting research, education and expert consulting in aquatic science.

Over time, Eawag has evolved into an internationally recognised water research institute. Its expertise in the combination of natural sciences, engineering and social sciences enables comprehensive research into water in relatively untouched natural bodies of water, right through to fully automated waste water management systems.

In collaboration with universities, other research institutions, public bodies, industry and non-governmental organisations, Eawag works to harmonise ecological, economic and social interests in respect of water usage. The Institute thus serves as a bridge between the scientific world and the 'real world'.

13.1.10 Scale & Structure

In 2016, Eawag had a staff headcount of 497 people (447 ftes) from 40 nationalities, based at two sites in Zurich (Dubendorf) and Lucerne (Kastanienbaum). It's total income for 2016 was CHF 79.5 million.

As well as supporting the education of students at Eawag, 143 staff from the institute are involved in delivering almost 5,000 hours of education per year at other Swiss universities, technical universities and technical colleges. Eawag also run summer schools and practice-oriented courses to extend their programme of teaching and learning.

13.1.11 Research and Innovation

At Eawag the research activity focuses on how to secure a balance between humanity's use of water and the preservation and strengthening of the aquatic ecosystem. Over time the institute has continuously developed and enhanced numerous methods to treat waste water and this has been done against a background of a continuing need to find the most cost-effective treatment possible to manage the risks posed by water pollution.

The research departments of Eawag are dedicated to three key areas of research:

- **Water for human welfare** – Eawag seeks solutions that use optimal approaches, technologies and strategies to promote the provision of safe drinking water and wastewater disposal. These are crucial for not only maintaining human health and welfare but also for protecting the water environment;
- **Water for ecosystem function** – pressures on aquatic ecosystems are constantly increasing as a result of population density and growth, intensive agriculture and use of hydro-power. In Switzerland, 15 out of the 86 original native species of fish have become extinct and over 60% of all aquatic plant species are considered to be endangered. Eawag's research examines the causes of biodiversity loss and searches for measures that allow ecosystems and their functions to be preserved in the long-term; and
- **Strategies for making trade-offs and resolving competing demands** – in all countries there is a need to manage the available supply of safe water with the many demands for its use in a way that minimises negative impacts on the natural environment. Eawag's research seeks to identify and find solutions to this conflict.

In 2016 Eawag built an installation with 36 test pools on its grounds in Dübendorf, in order to transfer and apply findings from fundamental research to natural bodies of water. It is the only facility of its kind in Europe and it allows researchers to investigate questions about the way ecosystems work and how biodiversity is changing, under controlled environmental conditions.

Eawag also provides outstanding scientific expertise on water and sanitation for low- and middle- income countries through training local experts and collaborating with local universities, professional bodies and authorities.

EMPA

13.1.12 History

With roots dating back to 1880, Empa, the Swiss Federal Laboratory for Materials Science and Technology is an interdisciplinary research institute for materials science and technology. It finds solutions for industry and society in the fields of nanostructured materials and surfaces, environmental technologies, energy and sustainable technologies, as well as bio- and medical technologies.

13.1.13 Scale & Structure

In 2016, Empa's income was CHF 193.7 million and it employed almost 1,000 staff (940 ftes) which included 30 professors, as well as some 200 doctoral students and 40 trainees.

As well as supporting the education of students at Empa, around 110 staff from the institute are involved in delivering almost 3,500 hours of education per year at other Swiss universities, technical universities and technical colleges.

13.1.14 Research and Innovation

The research focus areas of Empa are:

- **Nanostructured Materials** – advanced materials with improved and/or novel properties are a prerequisite for most technological innovations and mandatory to meet the increasing demands of a growing global population in areas such as energy, the environment and personal health;
- **Sustainable Built Environment** – Empa research is carried out at different levels, starting from the development of new materials to the design of advanced systems and their integration into buildings and structures. They also look at entire cities and their interaction with the environment. Key issues at all levels are the minimization of the environmental footprint and the enhancement of comfort and safety offered by the built environment to its users;
- **Health and Performance** – this research aims to provide innovative and sustainable technologies and products for the textile, biotech and medtech industries at the interface of materials and life sciences;
- **Natural Resources and Pollutants** – research into finding the most efficient ways of satisfying the demand for natural resources while minimising the production of pollutants which damage the environment; and
- **Energy** – this research focus area combines all the research areas on new materials, technologies, models and concepts that create options for a sustainable energy future.

Working with industry partners and via spin-offs, Empa converts its research into marketable innovations through its 30 technical laboratories and its Research and Technology Platforms NEST, move, eHub and its Coating Competence Centre. Each one helps to make the Swiss economy more competitive. Moreover, it creates a scientific basis for the sustainable development of society.

WSL

13.1.15 History

WSL is the Swiss Federal Institute for Forest, Snow and Landscape Research. It was formed from the merger of the Central Institute for Forest Research (formed in 1885) in Zurich and the Snow Laboratory in Davos (founded 1936).

WSL investigates changes to the terrestrial environment, and the use and protection of natural habitats and cultural landscapes. It monitors the condition and progress of forests, landscape, biodiversity, natural hazards and snow and ice, and develops sustainable solutions for socially relevant problems – in collaboration with its partners from academia and society.

13.1.16 Scale & Structure

In 2016, WSL's income was CHF 77.6 million and it employed 495 people (432 ftes) at sites in Birmensdorf, Davos, Lausanne, Cadenazzo and Sion. About a quarter of the employees work at the WSL Institute for Snow and Avalanche Research (SLF) in Davos.

As well as supporting the education of students at WSL, 107 staff members from the institute are involved in delivering just over 3,200 hours of education per year at other Swiss universities, technical universities and technical colleges.

13.1.17 Research and Innovation

Research at the institute centres around five themes:

- **Forest Research** – WSL has from the very start been concerned with the sustainable use of the natural resources of wood, water, snow, landscape and soil. Therefore, a key research focus at the institute is the influence of soil, water, air, climate, plants and animals on the growth and development processes in forests, with a special focus on assessing the effects climate changes as well as the impact of political decisions on energy choices;

- **Landscapes** – WSL investigates the causes of changes in the landscape and the effects these have on humans and the environment. This research provides a sound scientific basis for sustainable landscape development, which aims to protect landscape quality and to foster the identification of the population with their everyday landscape. The political commitment to energy change increases the importance of the landscape as a resource for energy production and leads to increasing WSL research priorities on this topic;

- **Biodiversity** – as biodiversity in Switzerland is steadily decreasing, WSL has been developing a scientific basis for monitoring and enhancing biodiversity so that restorative steps can be taken. This will result in an ecosystem which support stable and fertile soil;

- **Natural Hazards** – avalanches, rockfall and debris flow, can cause substantial damage to people, property and landscapes in Switzerland. WSL has established several unique experimental stations to find out more about the processes involved in these natural hazards in order to improve protection measures and warning systems when such events occur; and

- **Snow and Ice** – WSL investigate snow, ice and permafrost in relation to their importance as a natural resource for winter tourism and as a source for potable water and hydropower. They also conduct extensive research into the snow microstructure as well as into the exchange processes that take place between soil, snow and the atmosphere. This is key to a greater understanding of the avalanche formation processes as well as to the role of the snow and ice masses for the earth's climate.

The WSL is a founding member of the Swiss Polar Institute (SPI). The SPI has coordinated and promoted Swiss research in the Arctic and Antarctic since 2016. As high mountain ranges constitute the "third pole", WSL can provide the benefit of its wealth of expertise and experience, such as in the area of snow, permafrost, glaciology or the ecology of tundra-like habitats in climate change.

WSL provides an interface between research and practice, including subject-specific knowledge and expertise in the form of reports, advice and regulations as well as educational training. Clients range from public institutions, such as civil engineering offices or political institutions, to private organisations, such as engineering offices or mountain railway companies. Additionally, SLF's expertise is often requested in judicial courts to provide information about avalanche accidents. For all kinds of snow sports people can benefit from products and services provided by the WSL Institute for Snow and Avalanche Research.

PSI

13.1.18 History

The Paul Scherrer Institute (PSI) is the largest research centre for natural sciences and engineering in Switzerland. It carries out top-level research in the fields of matter and materials, energy and the environment, and human health. By carrying out fundamental and applied research, the PSI has been working on sustainable solutions for central questions of society, the economy and science since 1988.

It operates large-scale research facilities that are unique in Switzerland – and in some cases in the world – such as the SINQ Neutron Source, the Swiss Light Source, and the Swiss Muon Source. These facilities can be hired by external organisations (public and private) for their own, approved, research purposes.

13.1.19 Scale & Structure

In 2016, PSI had an income of CHF 459.9 million and employed 2,049 people (1,929 ftes). In addition, each year, over 2,500 researchers from Switzerland and all over the world come to perform experiments using the facilities at the PSI.

As well as supporting the education of students at PSI, 100 staff members from the institute are involved in delivering around 6,000 hours of education per year at other Swiss universities, technical universities and technical colleges.

13.1.20 Research and Innovation

Research at PSI is undertaken across five main research areas:

- **Research with Neutrons and Muons** – research covers a wide range of activities from particle physics to solid state physics (magnetism, superconductivity), materials sciences and soft condensed matter;

- **Synchrotron Radiation and Nanotechnology** – this research division comprises 14 laboratories which support and collaborate with external users as well as undertaking in house research;
- **Energy and Environment** – research comprises all aspects of human energy use, with the ultimate goal of promoting development towards a sustainable energy supply system. Technologies are being advanced for the utilization of renewable energy sources, low-loss energy storage, efficient conversion, and low emission energy use;
- **Nuclear Energy and Safety** – PSI has a long tradition in energy research and in the field of nuclear energy, PSI has a unique position in Switzerland. This is due to its infrastructure, namely the Hot Laboratory with so-called hot cells, which provide well equipped and shielded zones for work and research on radioactive material. There are three main topics of research: safety of currently operating light-water reactors; safety characteristics of future reactor concepts and related fuel cycles; and long-term safety of deep geological repositories for nuclear wastes of all kind; and
- **Biology and Chemistry** – the Laboratory of Biomolecular Research (LBR) works on research in the areas of cell and structural biology and biomolecular imaging. The Centre of Radiopharmaceutical Sciences undertakes research in the fields of tracer preparation and in vivo imaging of tissues, in particular of disseminated tumours that cannot be removed surgically or by external radiation therapy.

In addition to its research, the PSI operates the only installation in Switzerland for the treatment of specific types of cancer using protons, known as the Centre for Proton Therapy.

In 2016, PSI started operating the next large-scale research installation, the X-ray free electron laser SwissFEL, which allows one to see very brief changes in atomic and molecular structures. This will enable researchers to gain insights that are not possible with the methods that are currently available. The first pilot experiments are planned for 2017.

14 APPENDIX B: ABBREVIATIONS AND TERMS

This section contains a list of common abbreviations and terms used in this report.

Assumptions are the data upon which the economic contribution calculations are based.

FTE (or fte) – Full Time Equivalent is a unit that measures employed persons or students in a way that makes them comparable although they may work or study a different number of hours per week. The unit is obtained by comparing an employee's or student's average number of hours worked to the average number of hours of a full-time worker or student. A full-time person is therefore counted as one FTE, while a part-time worker / student gets a score in proportion to the hours he or she works or studies. For example, a part-time worker employed for 20 hours a week where full-time work consists of 40 hours, is counted as 0.5 FTE.

GDP – Gross Domestic Product refers to the market value of all final goods and services produced within a country in a given period.

Gross Value Added (GVA) is a measure of the value that an organisation, company or industry adds to the economy through its operations. In the case of the ETH Domain members this is estimated by subtracting the non-staff operational expenditure (mainly represented by expenditure on goods and services) from their total income.

This report uses the production approach to measuring the GVA contribution, where the GVA is equal to the value of the service produced less the value of the inputs used. Typically this is estimated by subtracting the non-labour (goods and services) costs of the organisation from the organisation's total income.

Multipliers – every expenditure and employment has a multiplier effect throughout the economy. Multipliers are a numeric way of describing the secondary impacts that stem from a business, industry, service or organisation. For example, an employment multiplier of 1.8 suggests that for every 10 employees in Organisation A, 8 additional jobs would be created in other supplier industries such that 18 total jobs are supported by Organisation A.

Direct effect – this relates to the income and employees directly engaged by the ETH Domain members.

Indirect effect – this arises from the business-to-business transactions required to satisfy the direct effect. It is a second round impact that would not occur were it not for the ETH Domain members and it relates to the businesses engaged in their supply chain for goods and services.

Induced effect – as a result of the direct and indirect effects the level of household income throughout the economy will increase as a result of increased employment. A proportion of this increased income will be re-spent on final goods and services, which is the induced effect

Multipliers differ between sectors and countries. Each country calculates their individual multipliers in the form of Input-Output tables which form part of the national accounts. The Input-Output tables are quantitative techniques that represent the interdependencies between different branches of a national economy. The multipliers used in this report have been calculated from the OECD Input-Output Tables 2011 for Switzerland.

Spin-outs are companies that are created to commercialise an organisation's intellectual property; usually involving a licensing agreement and/or staff transfer.

Start-ups are businesses that are set up by the staff of an organisation and/or former students. Although such companies will draw on the experience acquired by the founders during their time at university or research institution, they have no formal intellectual property relationship with the ETH Domain members.

Turnover/employee is a ratio of the amount of turnover required to support one full-time equivalent job for one year. It varies by sector depending on the relative labour intensities of different industries e.g. agriculture is a relatively labour intensive process compared to oil refining therefore the amount of turnover required to support an oil refining job is much higher than that required to support an agricultural job. The ratios used in this report are calculated from the OECD Input-Output Tables for Switzerland, 2011.

Turnover/GVA is a ratio of the amount of turnover required to produce a certain amount of GVA in each sector. This relationship varies between sectors and countries.

15 APPENDIX C: METHODOLOGICAL APPENDIX

This Methodological Appendix describes in more detail, the approach and assumptions that are used in the calculation of some of the key economic contributions of the ETH Domain. The calculations that are described in more detail in this Appendix are those for which the approach is too complicated to be included in the main body of the report. Those contributions that have been described fully in the main report have been omitted from this Appendix.

Core Contributions

15.1.1 Direct Effect

The direct contribution is estimated by subtracting all of the non-staff operating expenditure from the total operational income of the ETH Domain members.

In 2016 the ETH Domain members had a total income of CHF 3.6 billion as outlined in Table 15-1.

Table 15-1 – ETH Domain Income

Category	CHF (m)
Total federal contribution	2,529.9
Tuition fees and other utilisation fees	35.5
Research contributions, mandates and scientific services	776.4
Donations and bequests	113.1
Other income	120.2
Total Revenue	**3,575.2**

Source: Financial Statements of ETH Domain Members

15.1.2 Expenditure on Supplies

The ETH Domain has an impact on the economy through the goods and services that it purchases from its supplier.

In 2016 the ETH Domain's non-staff operating expenditure amounted to CHF 973.5 million, as summarised in Table 15-2. Non-staff operating expenditure excludes staff costs, interest payments, depreciation, expenditure on capital projects and any payments to students, such as scholarships or bursaries.

Table 15-2 – ETH Domain Expenditure on Supplies

Category	CHF (m)
Expenses for goods and materials	137.3
Premises costs	405.2
Other operating costs	431.0
Total Expenditure on Supplies	**973.5**

Source: Financial Statements of ETH Domain Members

In order to estimate the economic contribution of this it is necessary to categorise the supplier spend data provided by the ETH Domain into the industries used for economic ratios and multipliers. This is so that sector appropriate economic ratios and multipliers can be applied in order to estimate the GVA and employment contribution from this spend.

Previous work undertaken by BiGGAR Economics on behalf of LERU found that the largest category of supplier spend was in the professional, scientific and technical activities sector. A complete breakdown of supplier expenditure by category is provided in the table below.

Table 15-3 – Supplier Expenditure by Summary Category

Industrial Category	Proportion
Administrative and support service activities	16%
Professional, scientific and technical activities	27%
Real estate activities	5%
Information and communication	3%
Accommodation and food service activities	5%
Transportation and storage	4%
Wholesale and retail trade; repair of motor vehicles and motorcycles	16%
Construction	1%
Electricity, gas, steam and air conditioning supply	4%
Other	19%
Total	100%

Source: BiGGAR Economics analysis of LERU Members

The spend in each sector supports different GVA depending on the turnover to GVA ratio for that sector. The direct GVA contribution was estimated by dividing the expenditure in each sector by the appropriate turnover to GVA ratio. Direct employment was estimated by dividing spend in each sector by the appropriate turnover/employment ratio. Indirect effects were estimated by applying sector appropriate Type 2 multipliers.

In order to calculate the economic contribution by study area it is necessary to know where the suppliers of the ETH Domain are located. Data provided by the members of the ETH domain indicates that 88% of suppliers are located in Switzerland. As a general rule, where one institution was not able to provide data the average of the data provided by the remaining institutions was applied.

The economic contribution associated with this expenditure was estimated in line with the methodology described in Table 15.4.

Table 15.4 – Economic Contribution of Expenditure on Supplies

Formulas
$$GVA = \sum_a (Exp_{(a)} / \frac{T_{i(a)}}{G_{i(a)}} * M(G)_i^2)$$
$$Employment = \sum_a (Exp_{(a)} / \frac{T_{i(a)}}{E_{i(a)}} * M(E)_i^2)$$
Inputs
$$Exp_{(a)} = Expenditure\ \ on\ commodity\ (a)$$
$$\frac{T_{i(a)}}{G_{i(a)}} = \frac{Turnover}{GVA}\ ratio\ in\ industry\ associated\ with\ commodity\ (a)$$
$$\frac{T_{i(a)}}{E_{i(a)}} = \frac{Turnover}{Employment}\ ratio\ in\ industry\ associated\ with\ commodity\ (a)$$
$$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$$
$$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$$

15.1.3 Staff Spending

The staff employed by the ETH Domain have an impact on the economy by spending their salaries. In 2016, personnel expenses at the ETH Domain amounted to CHF 2.1 billion.

Table 15-5 – ETH Domain Personnel Expenses

Category	CHF (m)
Salaries and wages	1,759.1
Social insurance schemes and pension expenses	292.9
Other staff costs	37.4
Total Personnel Expenses	**2,089.4**

Source: Financial Statements of ETH Domain Members

The level of salary paid in each study area was assumed to be proportional to the number of staff that live in each area. Data provided by the ETH Domain indicates that 97% of staff live in Switzerland. This was applied to the staff salaries paid by the ETH Domain in order to estimate how much of the staff spending occurs in each study area.

The second step is an assumption of how much of a person's wage is spent in each study area. This is an assumption about the location of people's expenditure and not an assumption about where the products that are purchased are originally from, as this is already accounted for in the economic multipliers. Analysis of OECD data on the final consumption expenditure of Swiss households indicated that 95% of spending takes place in the national economy and 99% in Europe[42]. This allows for an estimate of total staff expenditure in each of the study areas.

The total spending does not account for savings made from salaries paid in 2016. Deducting savings would underestimate the impact associated with staff wages, since some earnings from past savings will have been spent in 2016. On this basis, this simplifying assumption is reasonable. However, account is taken of taxation and the 'spending' associated with taxes paid has been calculated separately.

The economic ratios used in the analysis are taken from the OECD Input-Output Tables. As the OECD does not include Value Added Tax (VAT) in its turnover figures[43], it was necessary to deduct VAT from the total staff salaries paid. A study undertaken by Lund University[44] indicates that 3.65% of general household expenditure in Switzerland is spent on VAT, and this proportion of spend was therefore excluded.

Employees spend their wages on a wide variety of goods and services. OCED data on the final consumption expenditure of Swiss households also provides a breakdown of household spending by category. This is summarised in Table 15-6.

Table 15-6 – Household Spending by Category in Switzerland

Household Spending Category	Proportion
Food and non-alcoholic beverages	9%
Alcoholic beverages, tobacco and narcotics	4%
Clothing and footwear	3%
Housing	19%
Water, electricity, gas and other fuels	6%
Furnishings, household equipment and routine maintenance of the house	4%
Health	15%
Transport	9%
Communications	3%
Recreation and culture	9%
Education	1%
Restaurants and hotels	7%
Miscellaneous goods and services	12%
Total	100%

Source: OECD (2014), Final consumption expenditure of households - Switzerland

[42] OECD (2014), Final consumption expenditure of households, Available at: https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE5
[43] OECD (1999), The OECD Input Output Database
[44] Lund University (2015), Taxing Consumption, An Analysis of the Distribution of the VAT Burden in Switzerland

Each category listed in Table 15-6 was assigned a matching economic sector. Based on this and the proportion of spend in each category it was then possible to calculate an overall weighted turnover/GVA and turnover/employee ratio as well as Type 2 employment and GVA multipliers.

Table 15.7 – Calculating Staff Spending Contribution

Formulas

$$GVA = SE_{Study\ Area} / \frac{T_s}{G_s} * M(G)_s^2$$

$$Employment = SE_{Study\ Area} / \frac{T_s}{E_s} * M(E)_s^2$$

Inputs

$$\frac{T_s}{G_s} = \frac{Turnover}{GVA}\ ratio\ for\ staff\ spending$$

$$\frac{T_s}{E_s} = \frac{Turnover}{Employment}\ ratio\ for\ staff\ spending$$

$$M(E)_s^2 = Type\ 2\ Employment\ Multiplier\ for\ staff\ spending$$

$$M(G)_s^2 = Type\ 2\ GVA\ Multiplier\ for\ staff\ spending$$

$$SE_{Study\ Area} = Value\ of\ staff\ expenditure\ (less\ VAT)\ spent\ in\ each\ study\ area$$

15.1.4 Capital Contribution

Over the last five years, the ETH Domain members spent an average of CHF 351.4 million per year on estates development, maintenance work and research infrastructure. Data provided by some of the ETH Domain members indicated that on average 57% of capital spending was on research infrastructure. It was therefore possible to estimate that over the last five years the ETH Domain members spent on average CHF 150.3 million on estates spending and CHF 201.1 million on research infrastructure.

75% of the ETH Domain's capital suppliers were located in Switzerland. The first step in estimating this contribution is to attribute the ETH Domain's estates and research infrastructure spending by study area.

This expenditure can be converted into GVA by applying economic ratios and multipliers. For the estates spending contribution, economic ratios and multipliers for the construction sector were used. For the research infrastructure contribution economic ratios and multipliers for the machinery and equipment sector were used.

Table 15-8 summarises the key assumptions used to estimate this impact.

Table 15-8 – Capital Spending Assumptions

Capital Expenditure	CHF (m)
Average annual capital spend (2012-2016)	351.4
% of capital spending on research infrastructure	57%
Capital Expenditure by Category	
Average annual estates spend (2012-2016)	150.3
Average annual research infrastructure spend (2012-2016)	201.1
Location of Capital Suppliers	
Switzerland	75%
Abroad	25%

Source: Financial Statement of ETH Domain and data provided by the ETH members

Table 15.9 – Calculating Capital Spending Contribution

Formulas

$$GVA = \sum_a \left(\langle Estates\ expenditure \rangle \ / \ \frac{T_C}{G_C} * M(G)_C^2 \right) + \left(\langle Research\ expenditure \rangle \ / \ \frac{T_M}{G_M} * M(G)_M^2 \right.$$

$$Employment = \sum_a \left(\langle Estates\ expenditure \rangle \ / \ \frac{T_C}{E_C} * M(E)_C^2 \right) + \left(\langle Research\ expenditure \rangle \ / \ \frac{T_M}{E_M} * M(E)_M^2 \right.$$

Inputs

$$\frac{T_C}{G_c} = \frac{Turnover}{GVA}\ ratio\ in\ the\ construction\ industry$$

$$\frac{T_C}{E_c} = \frac{Turnover}{Employment}\ ratio\ in\ the\ construction\ industry$$

$$M(E)_C^2 = Type\ 2\ Employment\ Multiplier\ in\ construction\ industry$$

$$M(G)_C^2 = Type\ 2\ GVA\ Multiplier\ in\ construction\ industry$$

$$\langle Estates\ expenditure \rangle = Average\ estates\ expenditure\ over\ 5\ years$$

$$\frac{T_M}{G_M} = \frac{Turnover}{GVA}\ ratio\ in\ the\ manufacturing\ industry$$

$$\langle Research\ expenditure \rangle = Average\ research\ infrastructure\ spend\ over\ 5\ years$$

Student Contributions

15.1.5 Student Spending

Expenditure levels of students differ according to where they live during term-time. A study published by the Swiss Federal Statistical Office in 2015 looked at the living costs of students at different universities and provided expenditure profiles of students at both ETH Zurich and EPFL. Data was also provided on student expenditure by accommodation type (e.g. private rented/living with parents).

As with the staff spending contribution it was necessary to exclude spending on VAT. VAT was therefore deducted from VAT applicable items.

Table 15-10 shows the VAT rates of the key categories of student expenditure. Not all categories of expenditure have been included in the analysis. For example, students will pay fees to the respective ETH institution, however this expenditure will be captured in the income of each of the institutions. This expenditure has therefore been excluded from the analysis. Likewise, spending on accommodation has been excluded for those students who live in university accommodation.

Table 15-10 – Monthly Average Student Expenditure Profile

Type of Expenditure	VAT Rate	Included in Analysis
Accommodation	8%	Yes
Food	2.5%	Yes
Transportation	8%	Yes
Communication	8%	Yes
Health cost	0%	Yes
Childcare	0%	Yes
Social/leisure activities	8%	Yes
Other regular living costs (incl clothes)	8%	Yes
Fees	8%	No
Other regular study expenses	2.5%	Yes
Total	CHF 1,201	

Source: BiGGAR Economics and http://www.vatlive.com/country-guides/europe/switzerland/swiss-vat-compliance-and-rates/

These assumptions are used to estimate the total level of additional expenditure from students in each of the study areas for each of the types of expenditure. This expenditure is then applied to the methodology given in Table 15.11 in order to estimate the overall economic contribution of student expenditure.

Table 15.11 – Economic Contribution of Student Expenditure

Formulas
$$GVA = M(G)_i^2 * \sum_a (Exp_{(a)} * \frac{T_{i(a)}}{G_{i(a)}})$$ $$Employment = M(E)_i^2 * \sum_a (Exp_{(a)} * \frac{E_{i(a)}}{E_{i(a)}})$$
Inputs
$$Exp_{(a)} = Expenditure\ \ on\ commodity\ (a)$$ $$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$$ $$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$$ $$\frac{T_{i(a)}}{G_{i(a)}} = \frac{Turnover}{GVA}\ ratio\ in\ industry\ assocaited\ with\ commodity\ (a)$$ $$\frac{T_{i(a)}}{E_{i(a)}} = \frac{Turnover}{Employment}\ ratio\ in\ industry\ assocaited\ with\ commodity\ (a)$$

15.1.6 Student Part-Time Work

The economic contribution of students that work part-time is estimated by applying the average GVA per employee to the number of equivalent average employees in each sector where students work. It is assumed that students are employed in the same study area in which they reside.

Student employment is not all additional. Some of the employment that the students could take up by residents at the local area. The proportion of student employment is assumed to be inversely proportional to the level of youth unemployment in the area. That is, the higher the level of youth unemployment the lower the additionality as more people in the area are likely to be in a position to fill these roles.

However, a proportion of student part time workers will always be additional, regardless of the level of youth unemployment. These are students employed in position in which their status as a student of the ETH Domain is a positive attribute, for example this could include students who are employed as tutors for local children. Therefore a floor of 10% additionality has been set.

The additionality of youth unemployment will vary between each of the study areas based on the different levels of youth unemployment in these areas. The formula used to calculate part time employment additionality is given in the table below.

Table 15.12 – Calculations of Student Labour Additionality

Formulas
$LSA_{(Study\ Area)} = 10\% + (1 - \frac{1}{50\%} * Min\{YUR_{(StudyArea)}, 50\%\}) * (1 - 10\%)$
Inputs
$LSA_{(Study\ Area)} = Labour\ Supply\ Additionality\ in\ study\ area$
$YUR_{(Study\ Area)} = Youth\ Unemployment\ Rate\ in\ study\ area$

The resulting additionality is shown in Table 15.13.

Table 15.13 – Student Part Time Employment Additionality

Study Area	Youth Unemployment*	Student Work Additionality
Region Lemain	14.2%	74%
Surich	6.3%	89%

*Source: BiGGAR Economics Analysis, *Eurostat - General and Regional Statistics - Regional Statistics by NUTS classification - Regional labour market statistics - Regional unemployment LFS Annual series - Unemployment rates by sex, age and NUTS 2 region*

The industries that students work in play a significant role in their economic output. As part of their study on student employment, the Department for Business, Innovation and Skills surveyed the industries that the students worked in. The industrial split is given in the table below and enables the economic ratios and multipliers to be matched with the appropriate sectors.

Table 15.14 – Industries of Student Employment

Sector	Proportion of Student Employment
Arts, entertainment and recreation	6.2%
Retail trade, except of motor vehicles and motorcycles	37.6%
Residential Care Activities	12.1%
Office administrative, office support and other business support activities	6.0%
Education (private provision only-excludes local authority and central govt bodies)	3.6%
Services to buildings and landscape activities	1.8%
Food and beverage service activities	32.6%
Total	100%

Source: BiGGAR Economics analysis of BIS Research Paper Number 142: Working While Studying (October 2013)

Although this source analyses student employment in the UK, it has been assumed that students in Switzerland are likely to undertake part-time work in similar sectors of the economy. The hours that the students worked in these sectors was translated into the equivalent number of employees in these sector.

The induced impacts associated with student expenditure are already considered as part of the student expenditure calculations and therefore the multiplier impacts are limited to the indirect Type 1 Multipliers, which only consider the implications for the supply chain.

The GVA contribution of these additional jobs was estimated by applying an estimate of the average GVA/employee for sectors in which students typically work. Indirect effects were then captured by applying appropriate multipliers. This methodology is outlined in Table 15.15.

Table 15.15 – Calculations of Student Part-time Work Contribution

Formulas
$$Employment = M(E)_i^1 * (SW * \frac{\langle Hrs_{St} \rangle}{\langle Hrs_i \rangle} * LSA_{(Study\ Area)} * \frac{\langle Months\ studying \rangle}{12})$$
$$GVA = M(G)_i^1 * (Employment * \frac{G_i}{E_i})$$
Inputs
$$LSA_{(Study\ Area)} = Labour\ Supply\ Additionality\ in\ study\ area$$
$$Employment_{(Equivalent)} = Equivalent\ employment\ in\ industries\ of\ student\ work$$
$$SW = Number\ of\ students\ with\ part\ time\ job$$
$$M(E)_i^1 = Type\ 1\ Employment\ Multiplier\ in\ industry(i)$$
$$M(G)_i^1 = Type\ 1\ GVA\ Multiplier\ in\ industry(i)$$
$$\langle Hrs_{St} \rangle = Average\ weekly\ hours\ worked\ by\ students$$
$$\langle Hrs_i \rangle = Average\ weekly\ hours\ of\ employment\ in\ industries\ of\ student\ work$$
$$\langle Months\ studying \rangle = Average\ months\ of\ the\ year\ spent\ at\ University$$
$$\frac{G_i}{E_i} = \frac{GVA}{Employment}\ ratio\ in\ industries\ of\ student\ work$$

Tourism Contribution

15.1.7 Visits to Staff and Students

The friends and relatives who visit the staff and students of the ETH Domain bring additional tourism to Switzerland that can be attributed to the ETH Domain.

In order to calculate this contribution, it is necessary to estimate the number of visits from friends and relatives (VFR) that students and staff will receive. Eurostat compile data on the number of VFR trips from domestic or from overseas visitors. The level of spend per trip and the number of VFR trips per person are given in Table 15.16.

Table 15.16 – Visiting Friends and Relatives Spend and Frequency

	Spend per trip (S)	VFR Trips per person (T)
Domestic	CHF 100.0	0.19
Overseas	CHF 525.3	0.39

Source: Eurostat data for 2015

The number of domestic VFR trips per person is multiplied by the number of students and staff at the ETH Domain to provide an estimate of the visits stimulated by the ETH Domain. This total number of visits is multiplied by the average spend of domestic and overseas tourists on a visiting friends and families trip.

Eurostat also provides data on tourism expenditure by category, as summarised in Table 15.17. Each of the categories below were assigned an appropriate economic sector. In this way it was possible to calculate overall weighted economic ratios and multipliers for tourism spending which were applied to the total expenditure of VFR visitors.

Table 15.17 – Tourism Expenditure in Switzerland by Category

Expenditure	% of Expenditure
Transport	31%
Restaurants/cafes	20%
Accommodation	35%
Durables and valuable goods	1%
Other expenditure	12%
Total expenditure	100%

Source: Eurostat data for 2015

Table 15.18 – Calculations of Visits to Staff and Students Contribution

Formulas
$$Visitor\ Spend = (N_{Students} + N_{Staff}) * T_{(S)} * S_{(S)}$$ $$GVA = Visitor\ Spend * \frac{T_i}{G_i}$$
Inputs
$$N_{Students} = Number\ of\ students$$ $$N_{Staff} = Number\ of\ staff$$ $$T_{(S)} = VFR\ Trips\ per\ person\ in\ Switzerland$$ $$S_{(S)} = VFR\ spend\ per\ trip\ in\ Switzerland$$ $$\frac{T_i}{G_i} = \frac{Turnover}{GVA}\ ratio\ in\ industries\ of\ tourism\ spend$$

15.1.8 Conferences and Events

The ETH Domain members provided data on the number of delegates attending events that they hosted throughout the year. These delegates who are additional to the area would contribute to the tourism economy through their expenditure. Only attendees from overseas have been considered as additional. In addition, it has been assumed that 50% of conference and event attendees have already been counted elsewhere and have therefore been excluded here. For example, a visitor taking a tour of one of the ETH Domain institutions may also be visiting a member of staff or student.

The total visitor expenditure associated with conferences and events was estimated by applying the spend per trip to the overall additional visitors. The economic contribution of this increased tourism spend was then calculated by applying the weighted economic ratios and multipliers for tourism expenditure.

Table 15.19 – Calculations of conference and event contribution

Formulas
$$Visitor\ Spend = (A_{All} - A_D - A_E) * S_{(S)}$$ $$GVA = Visitor\ Spend * \frac{T_i}{G_i}$$
Inputs
$$A_{All} = Attendees$$ $$A_D = Domestic\ attendees$$ $$A_E = Attendees\ counted\ elsewhere$$ $$\frac{T_i}{G_i} = \frac{Turnover}{GVA}\ ratio\ in\ industries\ of\ tourism\ spend$$

Graduate Premium

The Graduate Premium is a measure of the value of the learning and education that is given to the students during their time at University.

15.1.9 Estimating Graduate Premium by Subject

The first stage in quantifying the graduate premium associated with the ETH institutions was to consider the additional earnings that a student could accrue over their lifetime compared to what they would likely have achieved if they had not undertaken that course of study.

The earnings data of graduates of Swiss higher education institutions is provided by the national statistics agency, BFS. The average earnings, five years after graduation for those students of the ETH institutions are given in the table below. Note that there is a small number of graduates in employment at some subject levels, and therefore the average earnings for Swiss universities has been used.

Table 15.20 – Earnings Data by Education Level - Annual Gross income CHF by Subject

Degree Type	Bachelors	Masters	PhD
			ETH Lausanne
Technical Sciences	82,000*	85,000	110,000
Exact and Natural Sciences	82,000*	83,300	98,000
			ETH Zurich
Humanities and Social Sciences	82,000*	91,700*	100,000*
Technical Sciences	82,000*	90,000	110,000
Exact and Natural Sciences	82,000*	90,000	106,000
Medicine and Pharmacy	82,000*	95,900	108,000*
Interdisciplinary and Others	82,000*	94,500	-
			Both Institutions
Average	82,000	87,750	105,000

*Source: © BFS, Befragung der Hochschulabsolvent/innen * Average for UH Universities used as individual University level data is not available*

In particular, it should be noted that there were not many graduates in employment after five years who held a Bachelors degree as their highest qualification. This is because the vast majority of students who complete a Bachelors degree go on to obtain a Masters level qualification. Within the ETH it was estimated that 96% of Bachelors Graduates move on to a Masters degree.

The next step was to consider how the different annual earnings translated into a lifetime graduate premium. To do this, the lifetime graduate premium in the UK[45] was used. The lifetime graduate premium of a UK graduate, compared to an individual with secondary level education, was estimated to be £101,442. This is equivalent to CHF 152,828. A postgraduate student would in the UK would have a lifetime premium of £70,000, which is equivalent to CHF 105,459.

Table 15.21 – Lifetime Graduate Premium of UK Graduates

Currency	Bachelors	Masters
GBP	101,442	70,000
CHF	152,828	105,459

Source: UK Gove (BIS)

The next step was to adjust this premium for the comparative earnings premium between education levels for the UK and Switzerland. At this point it was necessary to consider three methods.

- Secondary School Education - in which the earnings at each point were compared to that at one education level below;
- University of Applied Science - in which the earnings of Bachelors and Masters were compared with Bachelor degree holders from the Swiss universities of applied science; and

[45] UK Gov, Department of Business, Innovation and Skills, The Returns to Higher Education Qualifications, 2011

- Other European - in which the earnings difference of graduates in Switzerland was assumed to be in line with other European countries, namely Germany, the Netherlands, Finland and Norway.

The counterfactual used in each case is given below.

Table 15.22 – Counterfactual Baseline Monthly Earnings - Euros

Counterfactual Baseline	Bachelors	Masters	PhD
Secondary School Education	6,557	9,318	11,336
University of Applied Sciences	9,954	9,954	11,336
Other European Countries	8,521	10,089	11,336
ETH Universities (Average)	9,318	11,336	13,564

Source: BiGGAR Economics Calculation based on Eurostat Mean Monthly Earnings by Educational Attainment

The lifetime premium of each subject was calculated based on their deviation from the average for annual earnings of graduates of that level. For example, Masters graduates who held degrees in Medicine and Pharmacy, earned more than the average Masters graduates. Therefore their graduate premium was greater than average at this level. The magnitude of the difference varied between which counterfactual was used, as the driver of the premium was not just the annual earnings of a graduate, but how much greater that was than the appropriate counterfactual earnings figure.

The resulting lifetime graduate premium by subject area and level of study is given in the table below, where the counterfactual is Secondary School Education.

Table 15.23 – Individual Graduate Premium (CHF) - Secondary School Counterfactual

Degree Type	Bachelors	Masters	PhD
			ETH Lausanne
Technical Sciences	381,643	302,565	1,420,945
Exact and Natural Sciences	381,643	262,602	654,592
			ETH Zurich
Humanities and Social Sciences	381,643	460,065	782,318
Technical Sciences	381,643	420,102	1,165,494
Exact and Natural Sciences	381,643	420,102	1,420,945
Medicine and Pharmacy	381,643	558,797	1,293,219
Interdisciplinary and Others	381,643	525,886	-

Source: BiGGAR Economics Calculation

The resulting lifetime graduate premium by subject area and level of study is given in the table below, where the counterfactual is a Bachelors Degree from the University of Applied Sciences.

Table 15.24 – Individual Graduate Premium (CHF) - University of Applied Sciences Counterfactual

Degree Type	Bachelors	Masters	PhD
			ETH Lausanne
Technical Sciences	-3,518	186,770	972,867
Exact and Natural Sciences	-3,518	146,807	448,175
			ETH Zurich
Humanities and Social Sciences	-3,518	344,270	535,624
Technical Sciences	-3,518	304,307	797,970
Exact and Natural Sciences	-3,518	304,307	972,867
Medicine and Pharmacy	-3,518	443,001	885,419
Interdisciplinary and Others	-3,518	410,091	-

Source: BiGGAR Economics Calculation

The resulting lifetime graduate premium by subject area and level of study is given in the table below, where the counterfactual is in line with the earnings differences between education levels in other European countries.

Table 15.25 – Individual Graduate Premium (CHF) - Other European Countries Counterfactual

Degree Type	Bachelors	Masters	PhD
			ETH Lausanne
Technical Sciences	110,137	162,279	878,100
Exact and Natural Sciences	110,137	122,316	404,518
			ETH Zurich
Humanities and Social Sciences	110,137	319,779	483,448
Technical Sciences	110,137	279,817	720,239
Exact and Natural Sciences	110,137	279,817	878,100
Medicine and Pharmacy	110,137	418,511	799,170
Interdisciplinary and Others	110,137	385,600	-

Source: BiGGAR Economics Calculation

15.1.10 Estimating Total Graduate Premium

The total economic contribution from the graduate premium that is quantified in the study is the sum of the premiums of the graduates in each of the study areas. This is summarised in Table 15.26

Table 15.26 – Calculations of graduate premium contribution

Formulas
$$GVA = \sum_{d} (G_d * P_d)$$
Inputs
$G_d = Number\ of\ gradautes\ in\ with\ degree\ (d)$ $P_d = Graduate\ premium\ for\ with\ degree\ (d)$

Commercialisation

15.1.11 Licensing

The starting point for calculating the impact generated by licensing activity is to consider the royalties or licence fees that the institution receives from licence holders; this reflects the value of the licence to the licence holder. However, as licence holders retain a proportion of the income generated by the licence this income only reflects a proportion of the total value of the technology. In order to estimate the full impact of the technology, it is necessary to estimate how much turnover the licences generate within the license holding company.

The relationship between the royalty paid for a technology and the turnover it generates depends on the details of the licensing agreement and can vary considerably from company to company. In order to agree a licence, negotiators must first form a view of how much the intellectual property (IP) is worth to the prospective licensee. There are a wide variety of variables that may inform this judgement but a training manual issued by the World Intellectual Property Organisation states that a common starting point is the "well known and widely quoted" 25% rule[46].

The 25% rule is a general rule of thumb according to which the licensor should receive around one quarter to one third of the profits accruing to the licensee and has been used by IP negotiators for at least 40 years. The rule is based on an empirical study first undertaken in the 1950s and updated in 2002. The study found that royalty rates were typically around 25% of the licensee's profits, which equates to around 5% of sales from products embodying the patented technology. This implies that royalties paid for a technology typically represent around 5% of the total turnover generated by that technology.

In 2002 Goldscheider et al[47] undertook further empirical analysis to test the continued validity of the 25% rule. The analysis was based on more than 1,500 licensing agreements from 15 different sectors between the late 1980s and the year 2000. The study found that although royalty rates ranged between 2.8% in

[46] World Intellectual Property Organisation (2005), Exchanging Value - Negotiating Technology Licensing Agreements: A Training Manual.
[47] Goldscheider, Jarosz and Mulhern (2002), Use of the 25% rule in valuing IP, les Nouvelles.

the food sector to 8% in the media and entertainment sector, on the whole they differed very little from those used in the 1950s. The sectors considered in the Goldscheider analysis, along with the respective royalty rates are summarised in Table 15.27.

Table 15.27 – Royalty Rates by Sector

Sector	Median Royalty Rate
Automotive	4.0%
Chemicals	3.6%
Computers	4.0%
Consumer Goods	5.0%
Electronics	4.0%
Energy and Environment	5.0%
Food	2.8%
Healthcare Products	4.8%
Internet	7.5%
Machine Tools	4.5%
Media and Entertainment	8.0%
Pharmaceutical and Biotechnology	5.1%
Semiconductors	3.2%
Software	6.8%
Telecom	4.7%

Source: Goldscheider et al (2002), Use of the 25% rule in valuing IP.

The economic contribution of licencing activity undertaken by the ETH Domain members was estimated by applying these royalty rates to the total amount of licensing income received by ETH Domain members.

The employment supported by this turnover can be estimated by dividing the additional turnover generated by an estimate of turnover per employment for the relevant sector. The GVA of the licensing activity can be estimated by multiplying the additional turnover by an estimate of the turnover/GVA ratio for the relevant sector.

Table 15.28 – Calculations for Licensing Contribution

Formulas
$Rev(L_i) = \frac{Income\ (L_i)}{Rate_i}$
$GVA(L) = \sum_i M(G)_i^2 * \frac{Rev\ (L_i)}{({}^{T_i}/_{G_i})}$
$Employment(L) = \sum_i M(E)_i^2 * \frac{Rev\ (L_i)}{({}^{T_i}/_{E_i})}$
Inputs
$GVA(L) = Total\ GVA\ associated\ with\ licences$
$Rev(L_i) = Revenue\ generated\ from\ licences\ in\ industry\ (i)$
$\left({}^{T_i}/_{G_i}\right) = \frac{Turnover}{GVA} ratio\ in\ industry\ (i)$
$\left({}^{T_i}/_{E_i}\right) = The \frac{Turnover}{Employment} ratio\ in\ industry\ (i)$
$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$
$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$
$Rate_i = Royalty\ rate\ for\ industry(i)$
$Income(L_i) = Income\ to\ the\ institute\ from\ licences\ in\ industry\ (i)$

Knowledge Transfer

15.1.12 Internships

A number of courses require students to undertake internships. These internships have an impact on the economy through the students' contribution to the companies that they are placed with. Only internships that are longer than 12 weeks are included as internships shorter than this would not allow students enough time to learn enough about the organisation's activity and make a contribution.

The employment contribution of internships can be estimated by calculating the FTE equivalent of the weeks spent undertaking internships. The GVA contribution of this can be estimated by multiplying the fte equivalent by the GVA/employee ratio in the sector in which internships are undertaken.

The contribution of these students to the organisations that they are placed in is lower than the average output that would be expected by a worker due to a student having less experience. To reflect this it is assumed that the GVA of students undertaking an internship is 50% of the average workers' GVA.

The multiplier effects were then estimated by applying Type 1 employment and GVA multipliers.

Table 15.29 – Calculations of Student Internships Contribution

Formulas
$$GVA = \sum_i \frac{G_i}{E_i} * \frac{\sum(Weeks)_i}{52}$$
Inputs
$$\frac{G_i}{E_i} = \frac{GVA}{Employment}\ ratio\ in\ industries\ of\ student\ placement$$ $$(Weeks)_i = Number\ of\ weeks\ student\ spends\ on\ placement\ in\ industry\ (i)$$

15.1.13 Services to Businesses

In 2016 the ETH Domain institutes generated CHF 276.3 million by providing services to businesses and other organisations.

Table 15.30 – Calculations and Inputs for Services to Businesses Contribution

Formulas
$$GVA(SB) = M(G)_i^2 * \sum_i 340\% * Income(SB_i)$$ $$Employment(SB) = M(E)_i^2 * \sum_i \frac{GVA(C_{SB})}{\left({G_i}/{E_i}\right)}$$
Inputs
$$GVA(SB) = Total\ GVA\ associated\ with\ Services\ to\ Businesses$$ $$GVA(SB_i) = GVA\ associated\ with\ SB\ in\ industry\ (i)$$ $$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$$ $$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$$ $$Employment(SB) = Total\ Employment\ associated\ with\ SB$$ $$\left({G_i}/{E_i}\right) = The \frac{GVA}{Employment} ratio\ in\ industry\ (i)$$ $$Income(C_i) = Income\ to\ ETH\ Domain\ from\ Services\ to\ Businesses\ in\ industry\ (i)$$

15.1.14 Science Parks

The main assumption to be made was how much of the economic activity that was created at these science parks could be attributable to the members of the ETH Domain. Many of the companies would have found properties elsewhere in the country if the science parks were not available. Larger companies that did chose to move into the country as a result of the science park would have been likely to find somewhere else in the world to operate if that particular science park was not available.

Previous studies by BiGGAR Economics, particularly one carried out for the University of Surrey in 2013, found that approximately 1/3 of the economic activity in its science park was attributable to the University. As the additionality for the rest of the world would be less than that for the individual countries, this was assumed to be 15%. These additionality assumptions were applied to each science park.

Table 15.31 – Science Park Additionality

Study Area	Additionality
Switzerland	33%
Global	15%

Source: BiGGAR Economics

The direct economic contribution of each science park was calculated based on total employment data provided by the ETH Domain members.

It was also important to take account of double counting. All employees in ETH Domain spin-off companies located on the science parks were excluded. As well as this all ETH Domain employees working on the science park were excluded as their contribution has already been considered. The turnover of tenants in the science park can be estimated by applying sector appropriate turnover/employment ratios.

Table 15.32 – Calculations and Inputs for Science Park Contribution

Formulas

$$GVA(SP) = SPA_{(Study\ area)} * Turnover\ (SP) / \left(T_{(i)} / G_{(i)} \right) * M(G)_i^2$$

$$Employment\ (SP) = SPA_{(Study\ area)} * Direct\ Employment\ (SP) * M(E)_i^2$$

Inputs

$$Turnover\ (SP) = Annual\ Turnover\ of\ Science\ Park$$

$$Direct\ Employment\ (SP) = Employment\ in\ SP\ excl\ ETH\ employees\ \&\ spin-off\ companies$$

$$\left(T_{(i)} / G_{(i)} \right) = The \frac{Turnover}{GVA} ratio\ of\ the\ industry\ (i)$$

$$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$$

$$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$$

$$SPA_{(Study\ area)} = Science\ Park\ additionality\ in\ the\ study\ area$$

$$GVA(SP) = Total\ GVA\ of\ Science\ Park$$

$$Employment\ (SP) = Total\ Employment\ of\ Science\ Park$$

Economic Ratios and Multipliers

15.1.15 Economic Ratios

The main economic ratios are derived from the total turnover, employment and GVA for sectors across the economy. These ratios are derived from the OECD (2011), Input-Output Tables for Switzerland and are summarised below.

Table 15.33 – Economic Ratios

Industry	Turnover/GVA	Turnover/Employee	GVA/Employee
Agriculture, hunting, forestry and fishing	2.54	79,794	31,433
Basic metals	3.48	347,556	99,859
Chemicals and chemical products	3.41	1,047,005	306,747
Coke, refined petroleum products and nuclear fuel	12.98	3,059,591	235,673
Computer and related activities	1.83	232,250	126,863
Computer, Electronic and optical equipment	2.60	462,794	178,000
Construction	2.13	218,516	102,373
Education	1.37	184,295	134,503
Electrical machinery and apparatus, nec	4.29	414,623	96,708
Electricity, gas and water supply	3.18	1,145,046	360,268
Fabricated metal products	2.09	237,407	113,434
Financial intermediation	1.83	489,364	267,727
Food products, beverages and tobacco	3.06	608,612	199,036
Health and social work	1.47	107,426	73,324
Hotels and restaurants	1.95	95,147	48,718
Industries working with Academia	2.52	367,817.80	125,317.15
LERU Supply Chain	2.05	379,123	189,982
Machinery and equipment, nec	2.53	370,957	146,434
Manufacturing	3.47	587,566.50	148,779.95
Manufacturing nec; recycling	2.78	279,083	100,335
Mining and quarrying	2.25	418,209	186,030
Motor vehicles, trailers and semi-trailers	2.83	505,891	178,783
Other community, social and personal services	2.22	88,577	39,909
Other non-metallic mineral products	2.38	321,301	135,120
Other transport equipment	2.70	394,315	146,077
Post and	1.92	356,072	185,824

telecommunications			
Public administration and defence; compulsory social security	1.37	187,662	136,566
Pulp, paper, paper products, printing and publishing	2.23	261,750	117,561
R&D and other business activities	1.74	172,092	98,907
Real estate activities	1.41	1,097,877	775,923
Renting of machinery and equipment	3.74	1,254,760	335,687
Rubber and plastics products	2.70	329,237	121,807
Textiles, textile products, leather and footwear	2.64	256,697	97,404
Transport and storage	2.82	295,703	104,772
Wholesale and retail trade; repairs	1.54	162,973	106,001
Wood and products of wood and cork	2.53	257,965	101,935

Source: BiGGAR Economics based on OECD Input-Output Tables Switzerland

15.1.16 Economic Multipliers

The economic contribution associated with the indirect and induced impacts are captured in the economic multipliers.

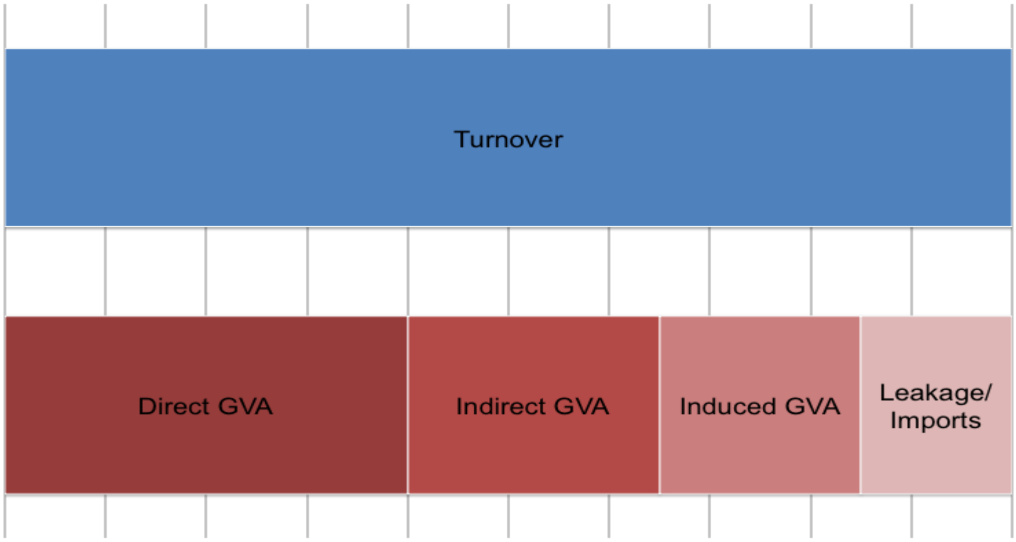
There are two types of multiplier. Type 1 (M_1) multipliers only consider the economic impact in the supply chain, whereas Type 2 (M_2) multipliers also include the spending of the staff involved in the process. The multipliers are expressed as the final figure for both GVA and Employment. For example, if there is a T_2 GVA Multiplier of 1.75, then CHF 1.00 of direct GVA (D_{GVA}) would result in CHF 1.75 of total GVA (T_{GVA}) impact. Therefore in order to extract the pure multiplier effect it is necessary to subtract 1 from the initial figure given as the multiplier.

$$T_{GVA} = \underbrace{D_{GVA}}_{\text{Direct GVA}} + \underbrace{(M_1 - 1) * D_{GVA}}_{\text{Indirect GVA}} + \underbrace{(M_2 - M_1) * D_{GVA}}_{\text{Induced GVA}}$$

The multipliers are important because only the Gross Value Added were considered. However, the final value of a product includes the values added at each stage of the supply chain. The multipliers enables the total economic activity supported to be estimated.

The relationship between the initial turnover and the final GVA varies between sectors and countries. In a totally closed economy (no imports/exports) the sum of the Direct and indirect GVA would equal the value of the final turnover. In this closed economy, the induced GVA would mean additional impact, spurned on by the original expenditure. However, most countries are not closed and therefore the Direct and Indirect GVA will equal less than the turnover. The induced GVA may make up for some of this gap, however there is still likely to be leakage, especially in industries with a high GVA/Turnover ratio.

Figure 15.1 Relationship between Turnover, GVA and Multipliers



The economic multipliers were calculated using the Input Output Tables for Switzerland, which are provided by the OECD. The multipliers that were calculated using input output tables were Leontief Type 1 GVA and Employment Multipliers and Leontief Type 2 GVA and Employment Multipliers. Type 2 multipliers consider the impact of supply chain and staff expenditure and Type 1 multipliers just consider supply chain expenditure.

The methodology followed for the calculation of the Type 1 & Type 2 Multipliers is described below. More detail on the methodology is given in the Scottish Government's Input-Output Methodology Guide[48].

In order to calculate the GVA and employment multipliers, the values in the Input-Output tables were converted to their equivalent direct GVA and employment statistics for each industry using the ratios described in Section 7.1.

For those industries that are based on a combination of sectors, namely LERU Supply Chain and Industries working with Academia, the multipliers were not calculated directly from the Input Output tables but were based on weighted averages of the sectors involved. These industries are marked with a (*) in the table below.

The direct requirements matrix considers how much input from each sector is required to produce one unit of output from the first sector. The level of input that is required by industry is taken from the consolidated Input-Output tables.

For example, if the Accommodation and food service activities sector had a total output of CHF 1,000 and this required CHF 50 of goods and services bought from

[48] The Scottish Government, *Input-Output Methodology Guide,* September 2011 (available http://www.gov.scot/Resource/Doc/919/0116738.pdf)

the Construction (C) sector, the direct requirements entry for the Construction sector in Accommodation and food Services would be 0.05.

$$A_{FB} = \frac{Input\ of\ (A) consumed\ by\ industry\ (F)}{Total\ output\ of\ industry\ (F)}$$

$$A_{FB} = \frac{50}{1{,}000}$$

$$A_{FB} = 0.05$$

Completing this operation for each entry in the Input Output matrix gives the resulting square A Matrix.

$$A = \begin{bmatrix} A_{AA} & \cdots & A_{MA} \\ \vdots & \ddots & \vdots \\ A_{AM} & \cdots & A_{MM} \end{bmatrix}$$

In order to calculate the GVA and employment multipliers, the values in the Input-Output tables were converted to their equivalent direct GVA and employment statistics for each industry using the ratios described earlier.

The identity matrix is the equivalent of '1' in matrix algebra. Therefore when any matrix (M) multiplied by the identity matrix (I) the result is the original matrix (M), in the same way that if any number is multiplied by '1', the result is the original number.

The identity matrix is simply one that has all entries as 0, apart from those on the diagonal, which have a value of 1.

$$I = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & 1 & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$$

Also as with numbers, the inverse of any number (x) is the one that gives the result below. For example, the inverse of 2 is 0.5.

$$x * x^{-1} = 1$$

Therefore the inverse of any matrix (M) is the one, which gives the result below.

$$M * M^{-1} = I$$

The Leontief Matrix is the Inverse of the Identity matrix minus the A Matrix.

$$L = (I - A)^{-1}$$

In the formula above *L* is the Leontief Inverse Matrix, *I* is the Identify Matrix and *A* is the direct requirements matrix.

The overall multiplier for any industry is the sum of its headed column in the Leontief Matrix.

$$L(A) = \sum_{i=A}^{M} L_{Ai}$$

The resulting multipliers are given in the table below.

Table 15-34 – Economic Multipliers

Multiplier Industry	Type 1 Employment	Type 1 GVA	Type 2 Employment	Type 2 GVA
Agriculture, hunting, forestry and fishing	1.35	1.83	1.48	2.33
Basic metals	1.68	1.83	2.28	2.56
Chemicals and chemical products	5.73	2.61	8.10	3.55
Coke, refined petroleum products and nuclear fuel	16.65	8.10	22.87	11.28
Computer and related activities	1.65	1.65	2.43	2.39
Computer, Electronic and optical equipment	2.32	1.86	3.34	2.55
Construction	1.54	1.58	2.12	2.26
Education	1.27	1.23	1.91	1.80
Electrical machinery and apparatus, nec	2.14	2.40	2.93	3.38
Electricity, gas and water supply	3.71	2.42	5.21	2.93
Fabricated metal products	1.45	1.47	2.02	2.07
Financial intermediation	1.92	1.59	2.99	2.07
Food products, beverages and tobacco	4.38	2.26	5.57	2.98
Health and social work	1.16	1.25	1.51	1.82
Hotels and restaurants	1.28	1.61	1.53	2.23
Industries working with Academia	2.27	1.86	3.11	2.58
LERU Supply Chain	1.79	1.60	2.56	2.16
Machinery and equipment, nec	1.93	1.76	2.77	2.45
Manufacturing	3.31	2.30	4.56	3.20
Manufacturing nec; recycling	1.63	1.69	2.19	2.37
Mining and quarrying	2.19	1.73	3.03	2.28
Motor vehicles, trailers and semi-trailers	1.76	1.51	2.68	2.13
Other community, social and personal services	1.38	1.77	1.56	2.32
Other non-metallic mineral products	1.70	1.62	2.40	2.25
Other transport equipment	1.98	1.80	2.83	2.51
Post and telecommunications	1.75	1.58	2.63	2.15

Public administration and defence; compulsory social security	1.36	1.27	1.81	1.66
Pulp, paper, paper products, printing and publishing	1.69	1.64	2.31	2.28
R&D and other business activities	1.54	1.57	2.09	2.23
Real estate activities	2.61	1.30	4.12	1.53
Renting of machinery and equipment	5.20	2.34	6.85	2.93
Rubber and plastics products	1.63	1.63	2.28	2.27
Textiles, textile products, leather and footwear	1.49	1.56	1.98	2.17
Transport and storage	2.13	2.20	2.87	3.05
Wholesale and retail trade; repairs	1.29	1.33	1.73	1.83
Wood and products of wood and cork	1.81	1.86	2.55	2.74

Source: BiGGAR Economics based on OECD (2011), Input-Output Tables Switzerland

There is likely to be a high degree of variance between the size of multiplier considering how much leakage that there is within any particular geography. In order to address this, our current method is to adjust each multiplier (for each industry and both Type 1 and Type 2) by the same proportion. These proportions are given below.

Table 15.35 – Geographic Multipliers as % of Switzerland

Area	Multiplier
Switzerland	100%
Global	130%

Source: BiGGAR Economics