BiGGAR Economics

The Economic Contribution of CSEM

A final report to

csem

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1 EXECUTIVE SUMMARY

In Spring 2018, BiGGAR Economics was invited by CSEM to assess its economic contribution.

CSEM was formed in 1984 through the merger of three research centres in Neuchâtel which focused on microtechnology and precision watchmaking. Since then it has been involved in developing and improving microtechnology platforms, maturing those technologies until they can add value to industrial clients, and then supporting the process of knowledge transfer.

Today CSEM has a total income of CHF 83.0 million, of which 30% comes from projects with industry. It employs 440 people across five locations and works with 190 industrial clients worldwide.

CSEM's mission is to ensure competitiveness through technology transfer, with a vision to develop technologies that make a difference. It is a national innovation accelerator, a catalyst for the transfer of technologies and know-how from fundamental research to industry.

1.1 Key Quantifiable Findings

The key finding of the report is that in 2017, CSEM's work supported over **CHF 1.2 billion GVA**[1] and **9,730 jobs** at a global level. Of this, CSEM contributed:

- **CHF 723.5 million GVA** and **5,810 jobs** in Europe; and
- **CHF 563.1 million GVA** and **4,500 jobs** in Switzerland.

CSEM received CHF 38.3 million in federal and cantonal funding in 2017. This gives a ratio of public funding (federal and cantonal) to impact of approximately:

- **CHF 1 : CHF 15** in Switzerland; and
- **CHF 1 : CHF 32** globally.

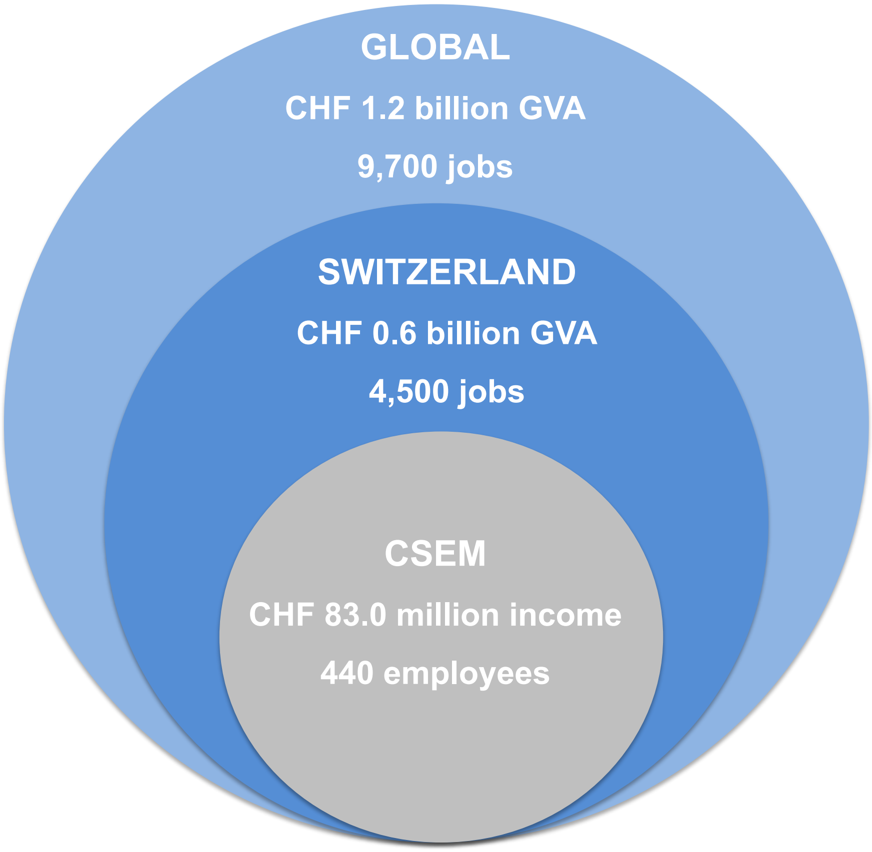
In addition:

- **each person directly employed** at CSEM supported around **10 jobs** in total in Switzerland; and
- **each person directly employed** at CSEM supported almost **22 jobs** in total at the level of the global economy.

The summary headline contributions are shown in Figure 1.1.

[1] 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 a university this is estimated by subtracting the non-staff operational expenditure (mainly represented by expenditure on goods and services) from the total income of the university.

Figure 1.1 CSEM – Summary GVA and Employment Contribution, 2017

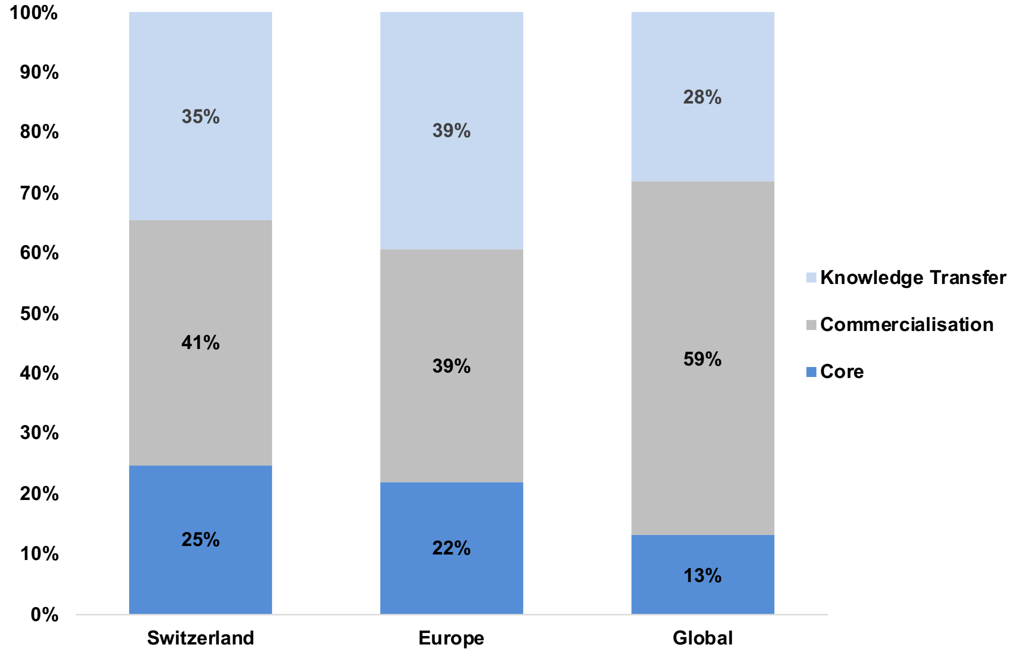


Source: BiGGAR Economics (Note: not to scale)

1.2 Sources of Contribution

There are two main groups of economic contribution generated by CSEM: ***incidental benefits*** and ***purposeful benefits***. These are illustrated in Figure 1.2 and described below.

Figure 1.2 CSEM – Economic Contribution by Source (GVA)



Source: BiGGAR Economics Analysis

Incidental benefits arise from the core business of employing people and operating buildings. In the case of CSEM, this amounts to 25% of the total GVA contribution in Switzerland and 13% of the total GVA contribution globally.

The incidental benefits come from the **core contribution –** which includes the activity directly supported by the institute's expenditure in their supply chain, capital and infrastructure expenditure and staff expenditure in the economy. In 2017, this was estimated to generate **CHF 138.9 million GVA** and **1,130 jobs in Switzerland** and **CHF 162.4 million GVA** and **1,330 jobs** globally.

Purposeful benefits arise from the scale and value of the **knowledge and technology transfer** and **commercialisation** activities delivered by CSEM. This type of activity is conceived specifically with the aim of driving innovation and productivity growth within the economy. In the case of CSEM, this accounts for the remaining 75% of the total GVA contribution generated in Switzerland and 87% of the contribution generated globally.

CSEM transfers existing knowledge throughout the economy through the research and consultancy services it provides to businesses. It was estimated that CSEM's knowledge and technology transfer activities generated a total of **CHF 194.5 million GVA** and **1,430 jobs** in Switzerland. At the global level it was estimated that CSEM's knowledge and technology transfer activities contribute **CHF 349.0 million GVA and 2,630 jobs**.

CSEM also undertakes a wide range of commercialisation activity that supports innovation in Switzerland and beyond. This includes licensing technology and supporting the formation of new spin-off businesses. It was estimated that CSEM's commercialisation activities generated a total of **CHF 229.7 million GVA** and **1,930 jobs** in Switzerland. At the global level it was estimated that CSEM's commercialisation activities contributed **CHF 727.4 million GVA and 5,770 jobs.**

Around 65% of the GVA and 61% of the employment supported by CSEM's spin-off companies is attributable to one spin-off, Heptagon. The commercialisation of scientific outputs is widely recognised to be a high-risk, high-reward activity; high-risk because the basis is novel science or technology, often disruptive in the market place, and high-reward since successful spin-out companies can have a transformative effect in their markets and so can have significant growth potential. The experience of CSEM and Heptagon is a good example of this phenomenon.

2 INTRODUCTION

BiGGAR Economics was commissioned by CSEM in Spring 2018 to identify and quantify the economic contribution it makes. The study focuses on the economic contribution that CSEM made in 2017 to Switzerland, Europe and globally.

2.1 CSEM

2.1.1 Background

CSEM was formed in 1984 through the merger of three research centres in Neuchâtel which focused on microtechnology and precision watchmaking. This was the result of a plan by the federal council to create a private research and development centre to maintain and extend Switzerland's pre-existing competitive advantage and to secure its position at the forefront of new technologies.

Since that time, CSEM has been involved in developing and improving microtechnology platforms, maturing those technologies until they can add value to industrial clients, and then supporting the process of knowledge transfer. This enables Swiss companies to maintain their internationally competitive position, while developing powerful R&D and engineering proficiency in Switzerland.

CSEM's mission is to ensure competitiveness through technology transfer. It is a national innovation accelerator, a catalyst for the transfer of technologies and know-how from fundamental research to industry. This role involves four principal tasks, these are to:

- to develop and maintain technology platforms;
- integrate and combine technologies into workable systems;
- mature technologies to the point where using them adds value to industrial clients; and
- support the process of transferring those technologies into industry.

CSEM achieves its goals through the creation of start-ups and joint ventures, and through working with a wide range of partners. This includes:

- academic partners such as École Polytechnique Fédérale de Lausanne (EPFL), ETH Zurich and Empa in Switzerland. Elsewhere in Europe CSEM works with the Fraunhofer Institutes, CEA-Leti and VTT; and
- industrial partners in Switzerland as well as worldwide, including SMEs, start-up companies and large and intermediate size companies.

A number of well-known Swiss companies have supported CSEM since its inception. Many have become shareholders and continue to maintain links with the organisation.

2.1.2 Cross-cutting Areas of Activity

CSEM is committed to both applied and industry-commissioned R&D. It offers a bridge and catalyst for the transfer of technology and know-how between science and the economy, and continually adapts its research focus to meet industry's needs.

CSEM's five research themes are:

- microsystems technology – design, integration, and packaging of devices that sense and monitor our environment and aspects of our daily lives. Use of micro-electromechanical systems and advanced manufacturing technologies to develop innovative, complete, and reliable microsystems solutions for industry;
- systems – focusing on how to design, implement, manufacture, maintain, repair, and manage complex engineering systems over their lifetime cycles, taking into consideration resource limitations (in terms of processing and power consumption), miniaturization, precision, reliability, production cost, and environmental conditions. This includes applications such as industrial automation, scientific instrumentation and medical technologies (e.g. wearable devices);
- ultra-low-power integrated systems – addresses the key challenges and technologies required to build very-low-power (long autonomy), wirelessly interconnected, embedded smart systems or remote sensing nodes;
- surface engineering – focuses on the research and development of engineered surfaces and interfaces – with optimized (bio-) chemical, optical, and electrical properties leading to improved performance of the respective components. Applications include printed electronics and sensors, bio-surface engineering and nano surface engineering; and
- photovoltaics and energy management – aims to foster innovation and accelerate the pace of technology transfer in the fields of photovoltaics and energy storage and systems, as well as in new market segments such as energy scavenging and the Internet of Things.

2.1.3 Achievements and Awards

CSEM's work has been recognised by prestigious international organizations, through receiving many high-profile awards for its research at an international level. Example of its recent awards are:

- 2018 AMX Innovation Award (jointly with RUAG) – for a new design and manufacturing for SRAs used in satellites;
- 2017 Neode Prize (for major innovations in medical technologies) – for the development of a cuff-less blood pressure monitoring device oBPM™, which is a trademark of CSEM;
- 2016 Professor Ballif, Vice President Energy Systems, has been awarded the 2016 Becquerel Prize;
- 2017 Vision System Design Innovators Award – "Golden Palm" for an intelligent camera from CSEM: its Vision-in-Package system for real-time embedded facial recognition;
- 2017 Hermes Awards for Innovation – awarded to CSEM for its technological excellence. This award is given each year by the Club de Paris des Directeurs de l'innovation and the European Institute for Creative Strategies and Innovation;

- 2017 Swiss Fintech Convention – Biowatch won the 1st prize, pitching its disruptive vein based biometric solution. Development in partnership with CSEM in Neuchâtel and IDIAP Research Institute in Martigny; and
- 2014 Hermès innovation prize for CSEM's 30-year service to industry.

2.2 Report Structure

The remainder of this report is structured as follows:

- section three introduces the theoretical framework within which the economic contributions of CSEM are measured;
- section four outlines the methodology and approach adopted for the study and discusses the classification of economic contributions into incidental benefits (section 5) and purposeful benefits (sections 6 and 7).
- section five describes the economic contribution arising from the core activities of CSEM. This includes the contributions associated with direct income and employment, its expenditure on goods and services, staff spending and capital spending;
- section six describes the contributions associated with the institute's commercialisation work which covers the licensing of intellectual property developed at CSEM as well as the creation of new businesses (spin-off companies);
- section seven assesses the knowledge and technology transfer contribution associated with CSEM including consultancy, research commissioned by industry, and income from the CTI;
- section eight discusses the wider, non-quantifiable benefits of CSEM's activities;
- section nine presents a summary of the quantifiable contributions that arise from CSEM and the conclusions of the report;
- Appendix A provides a guide to abbreviations and terms used throughout the report; and
- Appendix B contains a Technical Appendix which provides further detail on how a number of the impacts are calculated.

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, research institutes play a critical role in driving economic growth through their role as providers of knowledge and innovation.

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

3.1 Productivity and Innovation

As generators of world-class research and development and located at the centre of industry clusters, 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 rather it was due to 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.

Building on this, the Nobel prize winning economist Joseph Stiglitz[2] 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 scale of knowledge and innovation that takes place is also important because there are dynamic effects that come into play. New knowledge (discovery) and the diffusion of knowledge (innovation) 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 knowledge and innovation, will mean that the pace of innovation slows because underinvestment compounds over time.

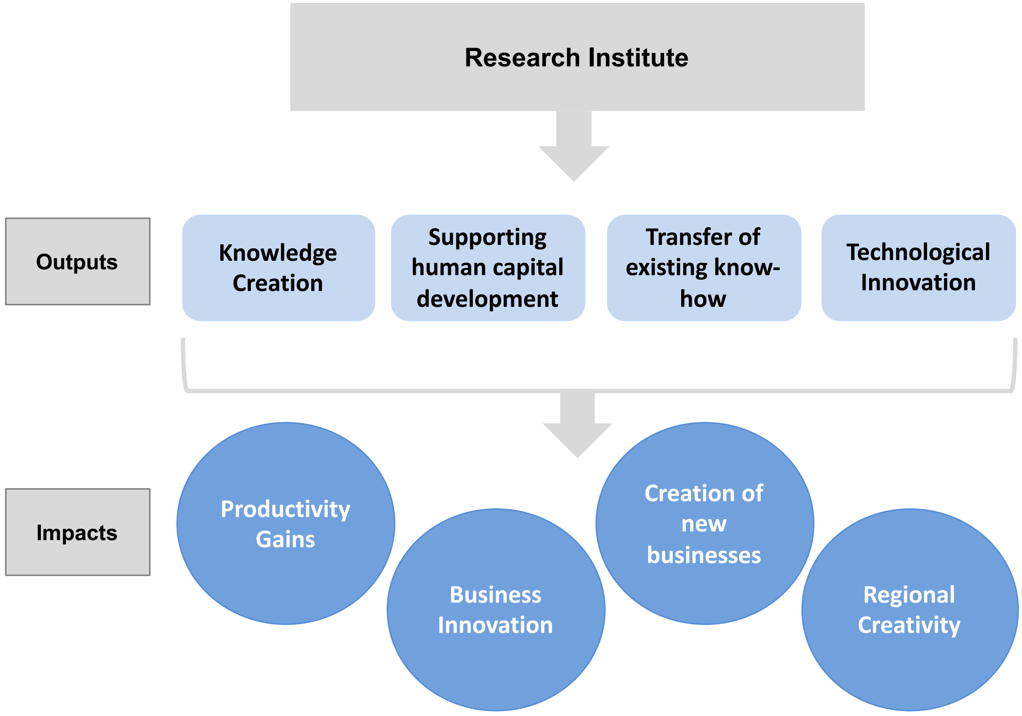
In summary, knowledge and innovation are fundamental to economic growth, since it is productivity growth that drives economic growth and productivity growth is in turn driven by knowledge and its diffusion (innovation).

3.2 Framework for Economic Impact

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

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

Figure 3.1 Research Institutions – Framework for Economic Impact



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

The fundamental activity of research institutes is the creation of intellectual capital. They contribute to knowledge creation by undertaking basic and applied research that give rise to the most influential technologies today and will continue to shape the technologies of the future. Alongside this, research institutes support human capital creation. Although they are not directly involved in teaching activity in the way that universities are, they nevertheless enable doctoral students to continue their research in an industrial context. In doing so, they equip students with highly practical and industry relevant experience. This in turn increases the innovation potential of the economy, as well as leading to productivity gains for the economy.

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

Research institutes can also create an impact on their local environment as their staff 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. The world-class research undertaken by research institutes attracts companies and investment into the country, helping to catalyse innovation in local businesses. The fundamental research undertaken by them therefore creates the knowledge sectors of the future.

3.3 Incidental and Purposeful Benefits

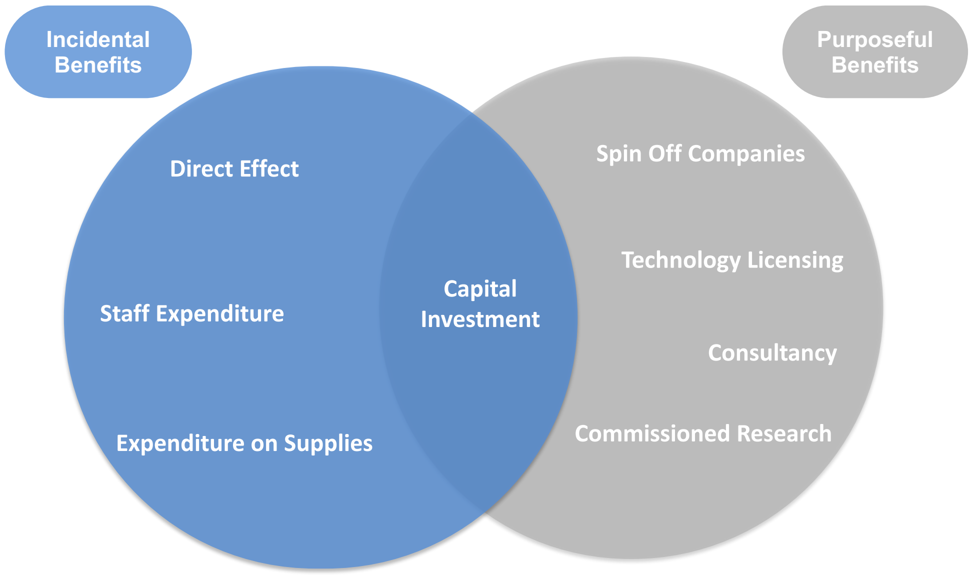
The contributions associated with CSEM can be grouped into two main categories: ***incidental benefits*** and ***purposeful benefits***.

Incidental benefits result from the existence of any 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 CSEM this includes the core operational effects of CSEM, including the people it employs, its expenditure and that of its employees on goods and services and its expenditure on capital and research infrastructure;

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 research institutes rather than their existence as organisations and might therefore be described as "purposeful benefits". This includes the economic value of the research undertaken by the CSEM members and the contribution that CSEM makes 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. Occasionally the distinction is not always clear cut, as in the case of capital investment which is sometimes undertaken with the aim of achieving specific economic development objectives.

Figure 3.2 CSEM – Incidental and Purposeful Benefits



Source: BiGGAR Economics

3.4 Conclusion

The growth of advanced economies is associated with a role for research institutes as providers of the intellectual and human capital required for a successful modern economy. CSEM has a mandate to drive research and knowledge in its field, therefore, as a driver of knowledge and innovation, it is 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).

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.

4.1 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 research institutions, universities and university groups in the UK 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:

- ETH Domain (BiGGAR Economics, 2017)
- Evaluation of Surrey 5G Innovation Centre (BiGGAR Economics, 2017)
- Flemish Universities (BIGGAR Economics, 2017)
- League of European Research Universities (BiGGAR Economics, 2014 & 2017)
- Universities Estonia (BiGGAR Economics, 2017)
- University of Edinburgh (BiGGAR Economics, 2008, 2012, 2014 & 2017)
- Finnish Universities (BiGGAR Economics, 2017)
- James Hutton Institute (BiGGAR Economics, 2016)
- University of Oxford (BiGGAR Economics, 2016)
- Moredun Group (BiGGAR Economics, 2014)
- Amsterdam Universities (BiGGAR Economics, 2014)
- Roslin Institute (BiGGAR Economics, 2013)

The approach used for the economic impact of research institutes and universities 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[3] 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

[3] 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)

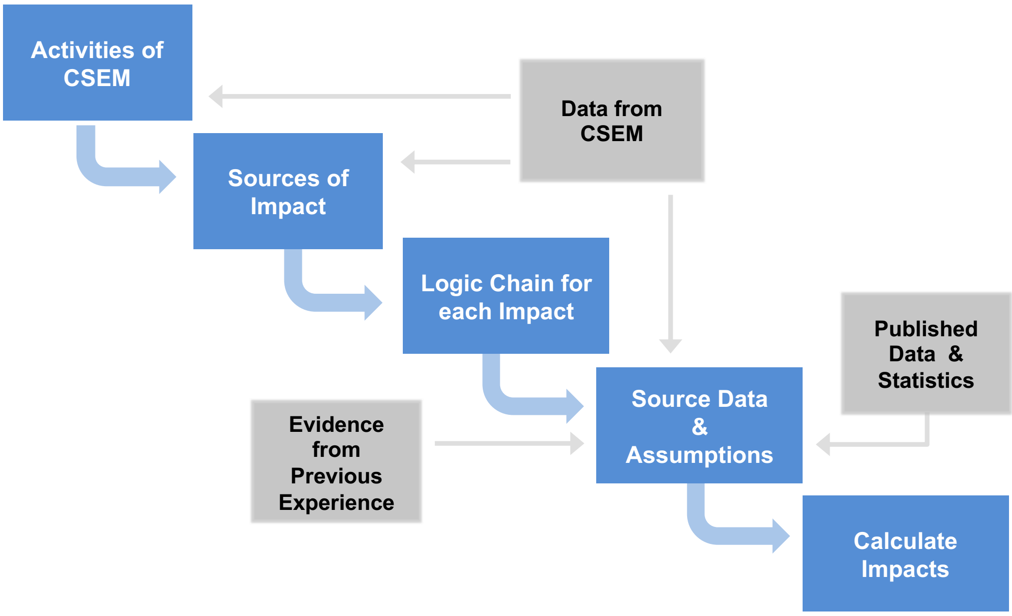
that research institutions and universities have to stakeholders, policy makers and the public as well as being used in support of funding applications.

4.2 Approach and Methodology

4.2.1 Overall Study Approach

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

Figure 4.1 – CSEM: Study Approach



Source: BiGGAR Economics

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

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

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.

All source data was obtained directly from CSEM. 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 research and 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 Technical Appendix.

This data was then used to populate the economic model and estimate the value of each source of economic contribution.

4.2.2 Sources of Quantifiable Contributions

The quantifiable economic contributions described in this report have been grouped into two themes:

- core contributions, including direct effects, supplier effects, staff spending and capital spending; and
- the contribution arising from the commercialisation and knowledge transfer activity undertaken by CSEM. This includes the contribution of CSEM's technology licensing, spin-off companies and research and consultancy services.

The methodology for each of these calculations is briefly described throughout the report as the contributions are discussed. A more detailed discussion is contained in the technical appendix at the end of this report.

4.2.3 Quantifying the Economic Contribution of CSEM

As far as possible the report has attempted to express the economic value generated by CSEM 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 CSEM this is estimated by subtracting the non-staff operational expenditure (CHF 25.9 million) from the total income of the institute (CHF 83.0 million); 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 4.3).

The economic contributions described in this report are for 2017, 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 2018.

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 for 2011.

These terms are defined further in Appendix A.

Unless stated otherwise, financial figures are expressed in CHF millions and are rounded to the nearest 1 decimal place. Jobs figures are rounded to the nearest 10 jobs.

The economic contributions quantified in this report are those at the level of the Swiss, European and the global economies.

4.2.4 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 the research institute with that made by other organisations or sectors. Rather, the counterfactual position is to imagine an alternative situation where CSEM did not exist and where the activities that they undertake did not take place.

In practical terms, only the economic contributions that can be considered additional and attributable to CSEM have been included. For example, in the cases where CSEM spin-offs have been bought over by other companies, only the economic activity at the time of acquisition has been considered.

4.2.5 Timescale of Contributions

Some of the activity undertaken CSEM generates economic activity immediately. For example, purchases of goods and services made by CSEM generates activity amongst its suppliers almost immediately.

However, much of CSEM's work produces an on-going dynamic economic contribution which will be realised over the course of several years. For example, CSEM is 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.

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 2017 generates impact in 2017. This is reasonable because although the impact of some activity that occurs in 2017 will not transpire until a later date, some of the impact that was realised in 2017 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 2017	Contributions realised in the Future
Core Operations	Research and Consultancy Services
Licensing	
Spin-offs	

4.2.6 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[4].

4.3 Parameters of the Study

While every attempt has been made to measure the economic contribution of CSEM 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 CSEM 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, there is a long-standing philosophy of collaboration between CSEM, government and industry and also with the institutions of the ETH Domain, such as EPFL, that generates a network effect that contributes very real benefits that cannot be measured in quantifiable terms.

In addition, through their work CSEM 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 the development of new economic sectors that will provide the basis for future national competitive advantage.

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 CSEM is understood as part of this wider context.

[4] 22nd General Conference on Weights and Measures, 2003.

5 CORE CONTRIBUTION

There are four elements to the core contribution from CSEM:

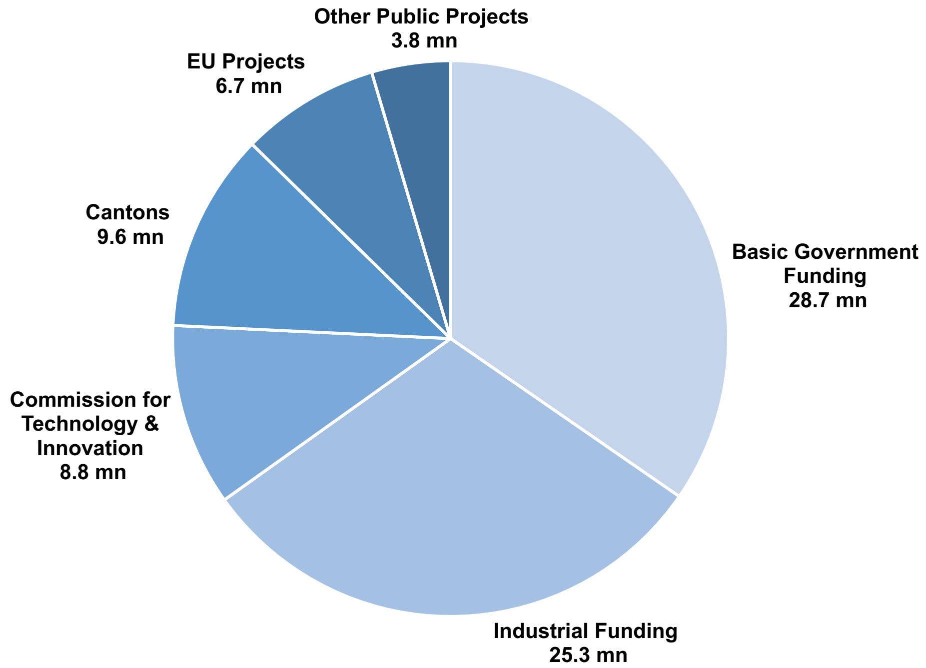
- direct effect – from the direct income and employment of CSEM;
- supplier effect – impact of CSEM's expenditure on supplies;
- income effect – impact of staff spending; and
- capital spending effect – impact of CSEM expenditure on estates and research infrastructure.

In terms of the framework for analysis set out in section 3.3, 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.

5.1 Direct Contribution

In 2017, CSEM had a combined operational revenue from all sources of CHF 83.0 million. The largest element of this was the federal contribution which accounted for 35% (CHF 28.7 million) of the total, with industrial funding accounting for a further 30% of income.

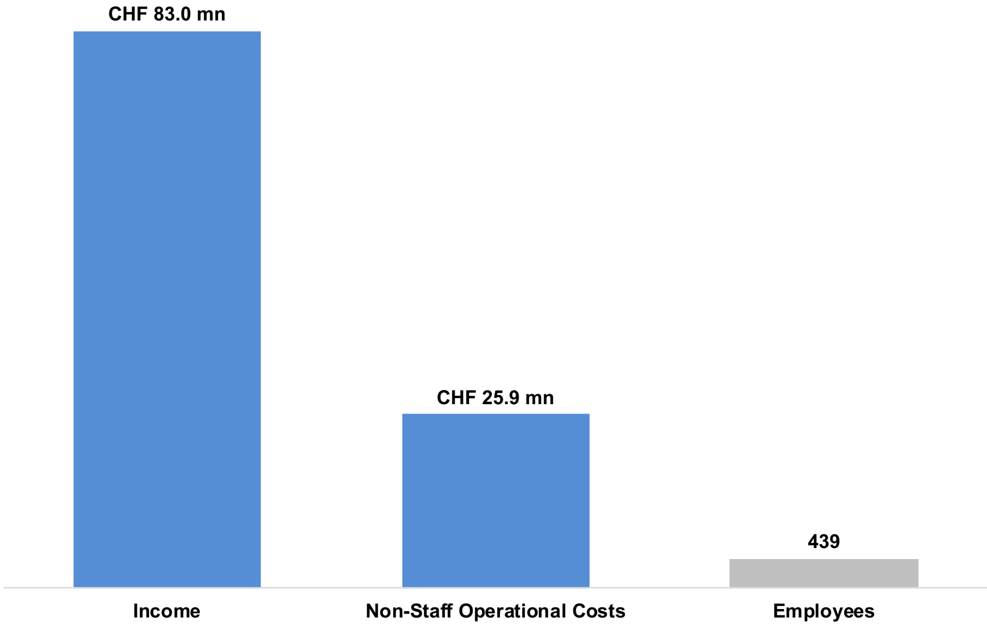
Figure 5.1 CSEM: Income by Source (CHF)



Source: Data provided by CSEM

The direct contribution of an organisation is the value it adds to the economy and the number of jobs it supports in a given time frame. In 2017, CSEM had a combined income of CHF 83.0 million and employed around 440 staff, equivalent to 400 full-time equivalent jobs. This is summarised in Figure 5.2.

Figure 5.2 CSEM: Direct Effect – Assumptions



Source: Data provided by CSEM

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 25.9 million) from the total operational revenue of CSEM (amounting to CHF 83.0 billion). Non-staff operating expenditure is mainly represented by expenditure on goods and services 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 to create it.

The direct GVA created by CSEM in 2017 was therefore CHF 57.1 million and the direct employment was 440 jobs. This is shown in Table 5.1 and Table 5.2.

Table 5.1 CSEM: Direct Effect – GVA

	Total (CHF m)
Total Operating Revenue	83.0
Less Non-staff operational costs (goods and materials, premises costs, other operating costs)	25.9
Direct GVA	57.1

Source: BiGGAR Economics Calculations based on CSEM data

Table 5.2 CSEM: Direct Effect – Employment

	Total
CSEM Employment (headcount)	440
CSEM Employment (full-time equivalent jobs)	400

Source: Data provided by CSEM

5.2 Supplier Contribution

CSEM purchases goods and services which generates turnover and supports employment in the businesses which supply it.

The inputs used to estimate the supplier effect are shown in Table 5.3. In 2017, CSEM spent CHF 25.9 million on goods and materials, premises costs and other operating costs. Of this total, approximately 87% was spent on suppliers based in Switzerland, 11% was spent on suppliers based elsewhere in Europe and the remaining 2% was spent on suppliers based outside Europe.

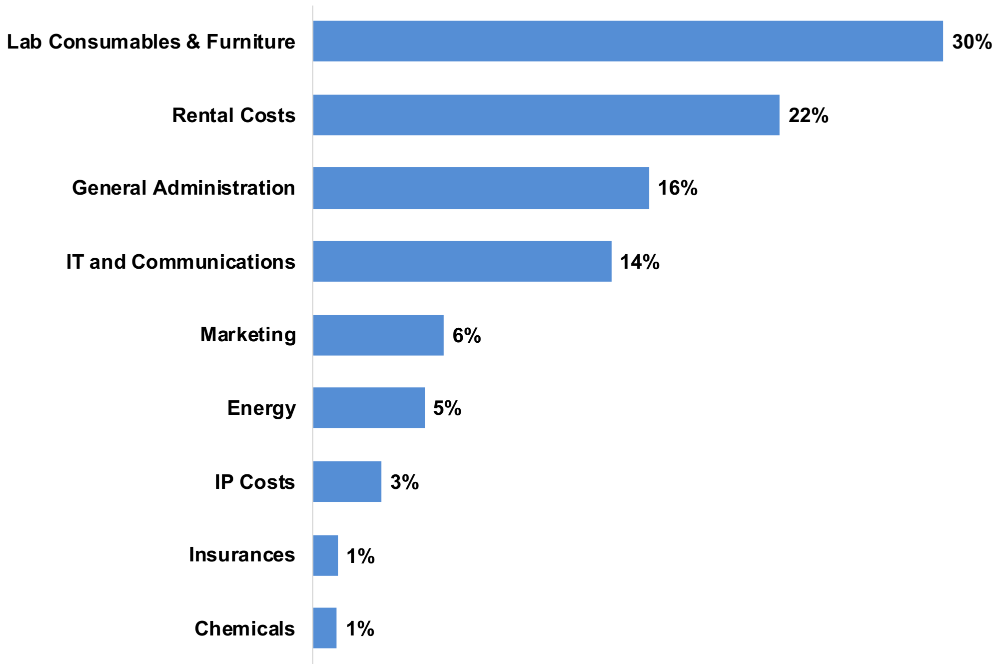
Table 5.3 CSEM: Supplier Effect – Assumptions

Amount Spent on Goods and Services	
Total Expenditure on Goods and Services, CHF million	25.9
Location of Suppliers	
Switzerland	87%
Elsewhere in Europe	11%
Outside Europe	2%

Source: Data provided by CSEM

Information provided by CSEM indicated that the largest category of expenditure was lab consumables and furniture (30%), followed by rental costs (20%).

Figure 5.3 CSEM: Supplier Effect – Expenditure on Supplies by Category



Source: Data provided by CSEM

An appropriate economic sector was allocated to each category of expenditure as the resulting GVA and employment supported will vary according to the differing GVA to turnover and turnover per employee ratios in each sector. The direct GVA contribution was estimated by dividing the expenditure in each sector by the appropriate GVA to turnover ratio. Direct employment was estimated by dividing the spend in each sector by the sector appropriate turnover to employment ratio.

The initial expenditure on goods and services by CSEM creates multiplier effects throughout the economy, reflecting the increased demand from their suppliers throughout 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. Further details on the methodological approach can be found in the Technical Appendix.

The total supplier effect for CSEM is shown in Table 5.4. It is estimated that CSEM's expenditure on goods and services supports CHF 33.9 million GVA and 250 jobs globally, of which CHF 25.9 million GVA and 190 jobs occur in Switzerland.

Table 5.4 CSEM: Supplier Effect Contribution

Supplier Contribution	GVA (CHF m)	Employment (jobs)
Switzerland	25.9	190
Europe	32.6	240
Global	33.9	250

Source: BiGGAR Economics Analysis

5.3 Staff Spending Contribution

The 440 staff employed directly by CSEM spend their wages and salaries in the wider economy. This increases turnover and supports employment in local businesses and throughout Switzerland as a whole.

In 2017, CSEM spent CHF 53.2 million in staff costs, giving an average personnel cost per employee of CHF 120,900. This reflects CSEM's highly educated workforce where two-thirds of staff have either a masters' degree or a doctorate qualification.[5]

The economic contribution resulting from staff spending will depend on where staff spend their wages which in turn depends on where staff live. Data provided directly CSEM indicate that 97% of staff live in Switzerland and the remaining 3% live in Europe.

The second step is to make an assumption regarding 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, a further 4% takes place throughout Europe and the remaining 1% is spent outside Europe. This is based on OECD data from 2014 on the location of household final consumption expenditure[6].

[5] CSEM (2016), CSEM Annual Report 2016
[6] Source: OECD (2014), Final consumption expenditure of households, https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE5

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[7]. 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 5.5.

Table 5.5 CSEM: Staff Spending – Assumptions

Staff Numbers	
Number of jobs (headcount)	440
Total personnel expenses (CHF million)	53.2
Staff Location	
Switzerland	97%
Europe	3%
VAT	
VAT as a proportion of staff expenditure	4%
Location of Spending	
Switzerland	95%
Elsewhere in Europe	4%
Outside Europe	1%

Source: CSEM, Lund University (2015) and OECD.

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 total economic contribution. Further details on the methodological approach can be found in the Technical Appendix.

This results in a staff spending contribution of almost CHF 66.5 million GVA and around 600 jobs globally of which CHF 64.5 million GVA and 580 jobs are in Europe. The contribution in Switzerland is CHF 53.4 million and around 490 jobs which accounts for around 80% of the total impact from staff spending. These figures are summarised in Table 5.6.

Table 5.6 CSEM: Staff Spending – Total Contribution

Staff Spending Contribution	GVA (CHF m)	Employment
Switzerland	53.4	490
Europe	64.5	580
Global	66.5	600

Source: BiGGAR Economics Analysis

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

5.4 Capital Contribution

There are two elements to the economic contribution made by CSEM's capital expenditure – spend on real estate and spend on equipment (research infrastructure).

Estates investment made by CSEM provides a source of income and employment for the Swiss construction and maintenance industry. This figure changes from year to year, reflecting development plans and building renovations. To reduce any skewing effects arising from 2017 being an atypical year, an average figure for estates expenditure over the ten year period from 2013 to 2022 (inclusive) has been used to capture the effect resulting from both recent investments which those which are planned for the near future.

Over the last five years, CSEM spent an average of CHF 2.9 million per year on estates development and maintenance work. A significant proportion of this investment was to upgrade their clean room facilities, enabling the centre to offer a cleanroom, module testing, and production laboratories covering over a thousand square meters. This allows researchers to continue their work exploring the development of solar energy uses for the economy and society.

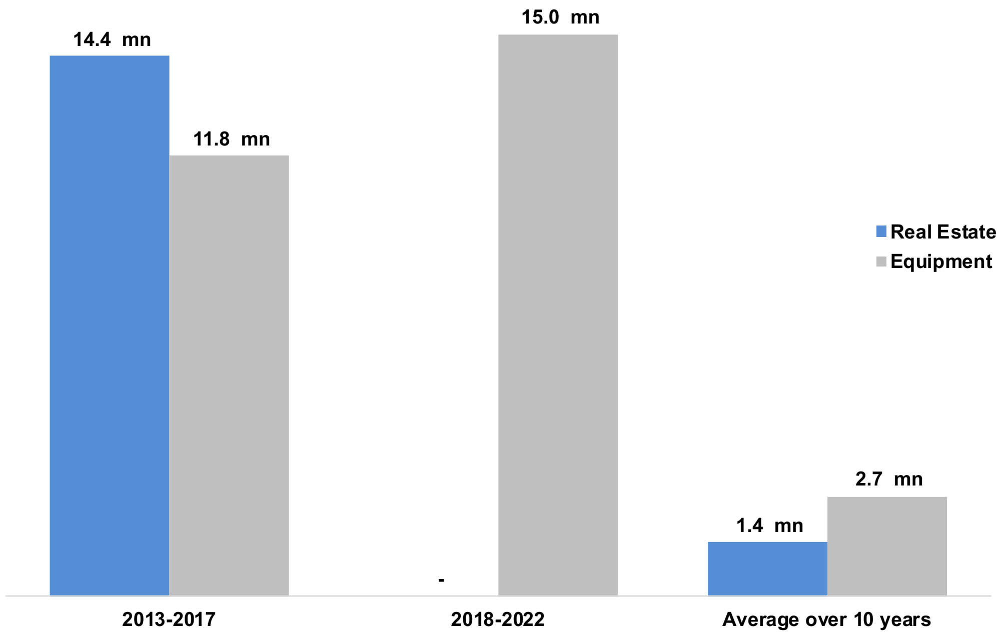
No major investment is planned on estates infrastructure over the forthcoming 5 years (2018 – 202 inclusive), therefore the average figure for estates investment for the 10-year period from 2013 to 2022 is CHF 1.4 million.

CSEM also invests in research infrastructure and equipment each year. This covers a very wide range of purchases including technical scientific equipment. The common theme is that it represents investment in improving the infrastructure at the institute, excluding investment in physical buildings.

As with estates expenditure, this figure varies from year to year reflecting CSEM's development plans. Again, in order to reduce any skewing effects arising from 2017 being an atypical year, an average figure for research and infrastructure expenditure over the ten year period from 2013 – 2022 (inclusive) has been used. The average annual expenditure on research infrastructure by CSEM between 2013 and 2022 was CHF 2.7 million.

The assumptions used in estimating the capital contribution of CSEM are summarised in Figure 5.4.

Figure 5.4 CSEM: Capital Contribution – Expenditure on Real Estate and Equipment



Source: Data provided by CSEM

This expenditure can be converted into GVA by applying a turnover to GVA ratio for the construction sector and equipment sector accordingly. The employment contribution of this expenditure is estimated by dividing the expenditure by a turnover to employment ratio for the construction sector and equipment sector accordingly.

The economic contribution in each study area was estimated based on the location capital suppliers. Information provided by CSEM indicates that around 60% of CSEM's capital suppliers are based in Switzerland and a further 35% are based elsewhere in Europe. The indirect contribution of the expenditure is then estimated by applying GVA and employment multipliers for the construction and machinery sectors accordingly.

The resulting contributions are summarised in Table 5.9. In this way it is estimated that the total annual contribution that arises from CSEM's real estate expenditure amounts to CHF 1.8 million GVA and 20 jobs globally. Around 50% of this contribution occurs in Switzerland.

It is also estimated that expenditure on research infrastructure supports CHF 3.0 million GVA and around 20 jobs globally. As with the estates contribution, around 50% of the contribution arising from expenditure on research infrastructure occurs in Switzerland.

Summing together the investment in estates and research infrastructure gives a combined total capital expenditure contribution that amounts to CHF 4.8 million GVA and 40 jobs globally.

Table 5.7 CSEM: Capital Contribution

Estates Expenditure Contribution	GVA (CHF m)	Employment
Switzerland	0.9	10
Europe	1.7	20
Global	1.8	20
Research Infrastructure Contribution	**GVA (CHF m)**	**Employment**
Switzerland	1.5	10
Europe	2.8	20
Global	3.0	20
Total Capital Contribution	**GVA (CHF m)**	**Employment**
Switzerland	2.5	20
Europe	4.5	40
Global	4.8	40

Source: BiGGAR Economics Analysis

5.5 Summary Core Contribution

CSEM's core activities of generating income, supporting employment, spending on goods and services and spending capital projects results in an estimated core contribution of CHF 138.9 million GVA and 1,130 jobs in Switzerland. These figures include the multiplier effects of the core activity and represent around 85% of the total (global) core impact arising from CSEM.

The core contributions are summarised in Table 5.8.

Table 5.8 CSEM: Core Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Direct	57.1	440
Supplier Effect	25.9	190
Staff Spending Effect	53.4	490
Estates & Research Infrastructure	2.5	20
Total Core Contribution	**138.9**	**1,130**
Europe	GVA (CHF m)	Employment
Direct	57.1	440
Supplier Effect	32.6	240
Staff Spending Effect	64.4	580
Estates & Research Infrastructure	4.5	40
Total Core Contribution	**158.6**	**1,300**
Global	GVA (CHF m)	Employment
Direct	57.1	440
Supplier Effect	33.9	250
Staff Spending Effect	66.5	600
Estates & Research Infrastructure	4.8	40
Total Core Contribution	**162.4**	**1,330**

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

6 COMMERCIALISATION

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

6.1 Licensing

Licence agreements give companies the legal right to use a particular technology, or other type of intellectual property developed by CSEM, to generate additional sales, reduce costs or otherwise improve profitability. In return, companies pay royalties to CSEM.

Without the initial research outcomes produced by CSEM, the productivity gains would not be possible. Therefore, the benefits to the economy from this activity can be attributed to CSEM.

In 2017, CSEM received CHF 1.4 million in royalties from their license agreements. Approximately, 10% of this income was from licence holders in Switzerland, a further 20% was from licence holders elsewhere in Europe and 70% was from licence holders from outside Europe.

Table 6.1 CSEM: Licensing Contribution – Assumptions

Licensing Income	
Total licensing income, CHF million	1.4
Location of License Holders	
Switzerland	10%
Elsewhere in Europe	20%
Outside Europe	70%

Source: CSEM

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. This 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[8]. 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. These guidelines imply 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 2017, intellectual property developed by CSEM enabled Swiss businesses to generate CHF 32.9

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

million turnover. The GVA and employment contribution were estimated by applying economic ratios for the sectors in which 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 CSEM contributed CHF 38.0 million GVA and 290 jobs globally, of which CHF 11.1 million GVA and 80 jobs occur in Europe. The contribution from licensing is worth CHF 3.2 million GVA and 20 jobs in Switzerland.

Table 6.2 CSEM: Licensing Contribution

Licensing Contribution	GVA (CHF m)	Employment
Switzerland	3.2	20
Europe	11.1	80
Global	38.0	290

Source: BiGGAR Economics Analysis

6.2 Spin-off Companies

CSEM supports the formation of new businesses based on intellectual property developed at the institute. These spin-off companies make an economic contribution to Switzerland through the turnover they generate and the employment they support.

In 2017 there were an estimated 33 active spin-out companies associated with CSEM. All spin-out companies created prior to 2017 that continue to be active in 2017 (the reference year) have been included in this contribution. This is because these companies continue to generate turnover and support employment in the reference year.

From analysis of the data provided, five of the spin-out companies have been taken over since they were established and they have grown substantially since this time. For these companies, their scale (in terms of employment and turnover) has been counted at the time they were taken over in order to more accurately reflect the level of economic activity that is attributable to CSEM rather than the new parent owner. For example, Heptagon is the largest of CSEM's spin-off companies and was acquired by AMS in 2016. In order to determine the level of economic activity that can be attributed to CSEM rather than AMS, it was necessary to consider the number of people employed by Heptagon at the time it was acquired. At the time of its acquisition, Heptagon employed 830 people globally[9] and information provided by CSEM indicated that 80 of these employees were based in Switzerland. Therefore in the analysis only the economic contribution of these 830 employees were considered as they can be attributed to CSEM.

The 33 spin-off companies from CSEM were therefore estimated to employ 1,410 people and generate CHF 585.1 million turnover in 2017. Around 44% of the employees in CSEM's spin-offs are based in Switzerland. Two of CSEM's spin-off companies have employees based elsewhere in Europe. In addition, CSEM's largest spin-off, Heptagon, employs 750 people in Singapore and one of CSEM's spin-offs, AVA, has offices outside Europe, in San Francisco.

[9] Source: http://tech.eu/brief/ams-heptagon/

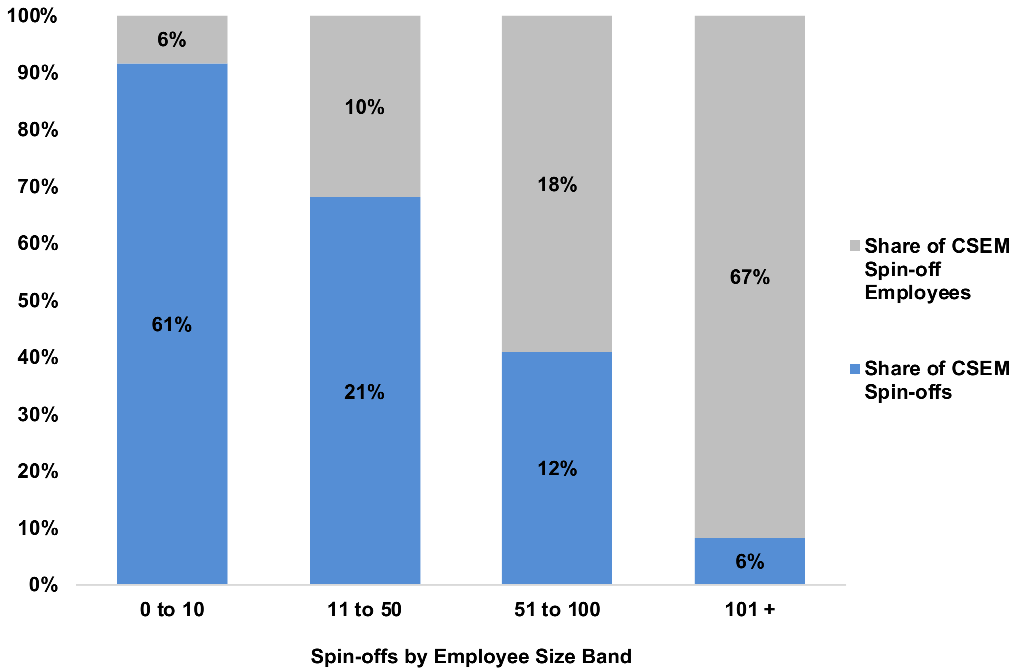
Table 6.3 CSEM: Spin-off Contribution – Assumptions

	Total
Number of active spin-offs	33
Number of jobs supported in Switzerland	623
Number of jobs supported in Europe	640
Number of jobs supported globally	1,413
Turnover generated	CHF 585.1 million

Source: CSEM and BiGGAR Economics Analysis

Figure 6.1 provides further information about the size of CSEM's spin-offs. This shows that 61% of CSEM's spin-offs are small companies employing between one and 10 people. It also indicates that around 6% of CSEM's spin-offs employ more than 100 people but these companies account for 67% of total employment supported by CSEM spin-offs.

Figure 6.1 CSEM Spin-off Companies



Source: Data provided by CSEM

Figure 6.2 provides a case study of two successful CSEM spin-offs in order to illustrate how the research and development undertaken at CSEM is translated into commercial outputs.

Figure 6.2 Case Study: CSEM Spin-offs

Xemics

XEMICS was established in 1997 as a spin out from CSEM. It specialised in low-power, low-voltage design across core technologies aimed at adding value to next generation, highly integrated battery powered wireless and sensing applications.

By 2004, XEMICS generated net sales of around $23 million, mostly from custom and standard integrated circuits products for battery powered applications, remote metering, embedded systems and medical devices and was a fabless developer of ultra-low power analog, radio frequency and digital integrated circuits.

It was acquired by the SEMTECH Corporation of California in 2005, for $43 million, to enhance their competitive edge in high performance analog circuit design.

AVA

The Ava Fertility Tracker is a medical device that is worn by women who want to monitor their health for trying to conceive or getting to know their bodies. AVA was founded in 2014 and first launched its app and bracelet in 2016. It was designated as the best Swiss startup in 2017.

Swiss company AVA sought out CSEM for its expertise in human vital-sign monitoring and low-power, high-performance electronics. With the support of the CTI, the two partners developed the technology for measuring nine key physiological parameters that can be used to predict fertility. Clinical studies showed that the fertility wristband identified, with 89% reliability, the five-day window of fertility for women in their menstrual cycle.

The company employs 35 people in Switzerland with a further 20 employees based in San Francisco.

Sources: CSEM Annual Report, 2016, CSEM and Ava websites

The total economic impact arising from the CSEM spin-offs is the sum of the GVA and employment contribution of the companies themselves and the activity that these companies generate within their supply chains and through the spending of their staff in the wider economy. This can be estimated using turnover to GVA and turnover to employment ratios appropriate to the business sectors they operate in. The wider effect of the direct contribution is then estimated using multipliers associated with the sectors of the spin-off companies.

The resulting economic contribution associated with CSEM's spin-off companies is estimated to be CHF 689.3 million GVA and 5,480 jobs globally, of which CHF 269.2 million GVA and 2,300 jobs occur in Europe. The contribution in Switzerland is estimated to be worth CHF 226.5 million GVA and 1,910 jobs.

In particular, around 65% of the GVA and 61% of the employment supported by CSEM's spin-off companies is attributable to one spin-off, Heptagon. The commercialisation of scientific outputs is widely recognised to be a high-risk, high-reward activity; high-risk because the basis is novel science or technology, often disruptive in the market place, and high-reward since successful spin-out companies can have a transformative effect in their markets and so can have significant growth potential. The experience of CSEM and Heptagon is a good example of this phenomenon and is described further in Figure 6.3.

Table 6.4 CSEM: Spin-off Contribution

Spin-off Contribution	GVA (CHF m)	Employment
Switzerland	226.5	1,910
Europe	660.7	5,240
Global	689.3	5,480

Source: BiGGAR Economics Analysis

Figure 6.3 Case Study: CSEM Spin-offs – Heptagon

Heptagon

Heptagon began as a spin-off from CSEM in 1993. Since its foundation, it has created several generations of innovative products and new processes involving micro-optic components and technology. Initially this resulted in products for telecom and datacom applications. This was followed by rapid development in the field of mobile and smartphone technology which created a second wave of products and technology in the area of optical sensing for smartphones. It has a wealth of intellectual property in optical packaging, including more than 250 patent families.

In 2016, Heptagon was integrated into the AMS Group Ltd, for around €845 million. AMS had already acquired another CSEM start-up two years earlier – the 3-D imaging specialist Mesa. At the time of its acquisition by AMS, Heptagon employed 830 people, 80 of whom were based in Switzerland.

Heptagon is seen as a world-leading micro-optics company that has produced over 2 billion micro-lenses. This new identity ensures that CSEM technology will reach the homes of millions of users over the coming years.

Sources: CSEM Annual Report, 2016, Heptagon website and http://tech.eu/brief/ams-heptagon/

6.3 Summary Commercialisation Contribution

CSEM makes a significant economic contribution through its commercialisation activities of licensing intellectual property and creating new companies. The value of this activity in 2017 was estimated to be CHF 727.4 million GVA and 5,770 jobs globally. Of this, CHF 229.7 million GVA and 1,930 jobs were estimated to be in Switzerland.

At the global level, around 95% of CSEM's commercialisation contribution arises from its spin-off companies (with the remaining 5% accounted for by CSEM's licensing activity). In particular, around 65% of the GVA and 61% of employment supported by CSEM's spin-off companies is attributable to one spin-off, Heptagon, reflecting the high-risk and high-reward nature of commercialisation activity.

Table 6.5 CSEM: Commercialisation Contribution – Summary

Switzerland	GVA (CHF m)	Employment
Licensing	3.2	20
Spin-offs	226.5	1,910
Total Commercialisation Contribution	**229.7**	**1,930**
Europe	GVA (CHF m)	Employment
Licensing	11.1	80
Spin-offs	269.2	2,300
Total Commercialisation Contribution	**280.3**	**2,380**
Global	GVA (CHF m)	Employment
Licensing	38.0	290
Spin-offs	689.3	5,480
Total Commercialisation Contribution	**727.4**	**5,770**

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

7 KNOWLEDGE AND TECHNOLOGY TRANSFER

CSEM also transfers existing knowledge and technology throughout the economy through its interactions with businesses. It does this by exchanging information, know-how and research results with companies. This allows businesses to utilise academic knowledge and technology and generate economic benefits such as reducing the time taken to develop new products.

7.1 Research and Consultancy Services

CSEM's cutting edge research and expertise makes it well placed to provide research and consultancy services for industry. There are two primary ways that CSEM works with businesses:

- collaborating with the private sector to undertake commissioned industry-oriented research and consultancy; and
- commissioned research with businesses supported by the Commission for Technology and Innovation (CTI) which is now operating as Innosuisse – see Figure 7.1.

Figure 7.1 Commision for Technology and Innovation

CTI (now Innosuisse)

Until 31 December 2017, the CTI was the Swiss Confederation's innovation promotion agency, responsible for encouraging science-based innovation in Switzerland by providing consultancy and networking services and financial resources to help turn scientific research into economic impacts.

From 1 January 2018, Innosuisse took over the functions of the CTI in Switzerland. Like its predecessor, Innosuisse exists to support science-based innovation projects carried out by companies (particularly SMEs) working with public-sector research partners. Innosuisse supports projects if the innovation could not be implemented and market potential would not be tapped into without funding.

Innosuisse funding covers the research partner's salary and, under certain conditions, material costs as well as a contribution to overheads. The company provides at least the same amount of funding and thus bears the costs for its project itself.

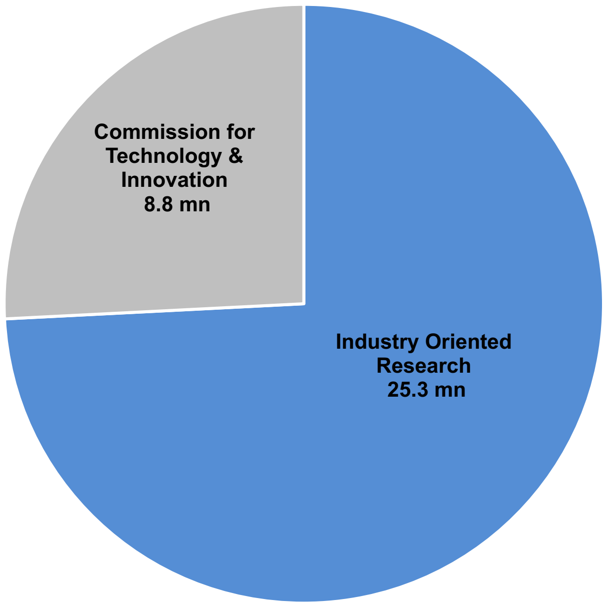
To be supported, a project must meet a market need and provide economic benefits or create social value. Applications are assigned to one of five primary funding areas as well as interdisciplinary projects. The funding areas are: energy and environment; engineering; ICT; life sciences and social sciences & business management.

Sources: www.sbfi.admin.ch and www.innosuisse.ch

In 2017, CSEM generated CHF 34.1 million by providing these types of services to businesses and other organisations. This figure includes only contracts which were newly awarded in 2017.

As shown in Figure 7.2, income from industry-oriented research accounts for 74% (CHF 25.3 million) of the total research and consultancy services income received. The CTI (now Innosuisse) accounts for the remaining 26% (CHF 8.8 million).

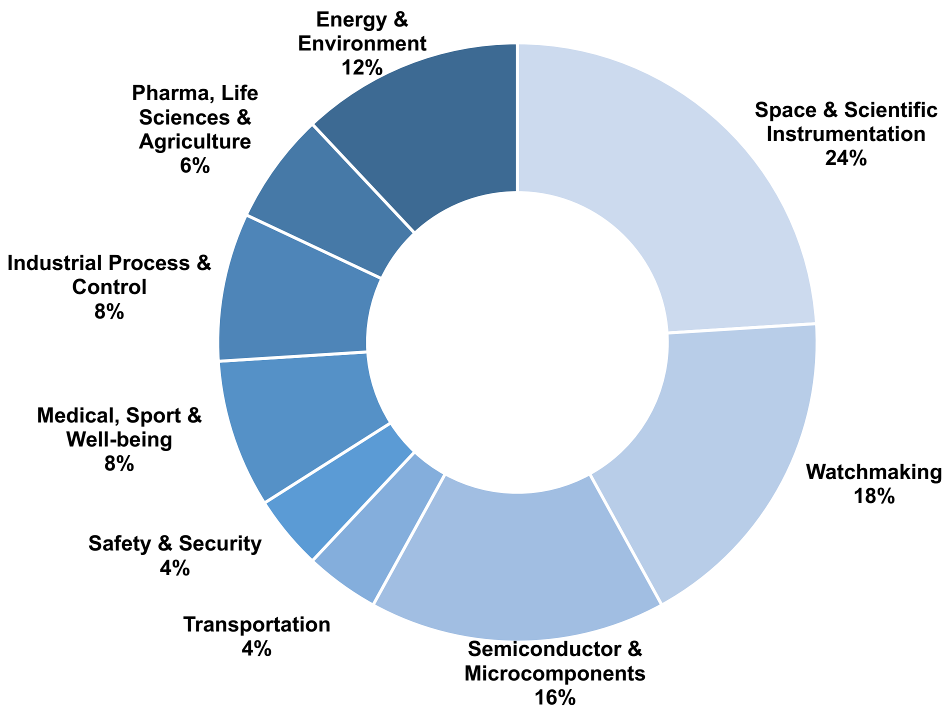
Figure 7.2 CSEM Research & Consultancy Services Income by Category



Source: Data provided by CSEM

CSEM's industrial funding comes from around nine different sectors. Space and scientific instrumentation provided around 24% of CSEM's industrial income in 2016, followed by watchmaking (18%) and then semiconductor and microcomponents (16%). The proportion of CSEM's industrial funding by sector for 2016 is outlined in CSEM's Annual Report and has been reproduced in Figure 7.3.

Figure 7.3 – CSEM Industrial Income by Sector, 2016



Source: Data sourced from CSEM Annual Report, 2016

A significant amount of CSEM's research work centers around watchmaking: developing innovative watch technologies, new watchmaking materials and new manufacturing processes. This stems from the institute's origins in the merger of three horological research labs. A case study on watchmaking is presented in Table 7.2 which illustrates the importance of CSEM's role in this field.

Figure 7.4 CSEM and Watchmaking

Watchmaking activities have been at the heart of CSEM since the centre was created in 1984 through the merger of three horological research labs – CEH, FSRM, and LSRH.

With its headquarters in Switzerland's Watch Valley, in the canton of Neuchâtel, and with a significant number of renowned Swiss watchmakers as its shareholders, CSEM continues to strive to develop innovative watch technologies, new watchmaking materials, and manufacturing processes, as well as ground-breaking new movements.

CSEM's cutting-edge methods for working with and machining silicon have led to the development of a number of watch components that are already making timepieces more precise and reliable – contributing in the process to mechanical watchmaking's greatest renaissance in the last 50 years. Their long-standing expertise in wearable technologies and microelectronics is at the origins of the smartwatch industry, for which CSEM is one of the key technology providers.

CSEM have worked with Patek Philippe, the last independent, family-owned Genevan quality watch manufacturer which has resulted in the launch of the company's Advance Research series of timepieces. The research and development work has been accomplished together with Swatch group (which owns brands such as Omega, Breguet, Tissot and Longines) and another major watchmaker and both have been able to commercially exploit the technology.

Patek Philippe view their collaboration with CSEM as an important driving force for innovation and a way of giving access to state-of-the-art technology and know-how, enabling them to position the company at the technological forefront of watchmaking innovation.

Sources: CSEM, Patek Philippe and Watchpro Websites

7.2 Quantifying the Economic Contribution of CSEM's Research and Consultancy Services

It is reasonable to assume that the organisations that invest in this type of support do so because they expected the projects to generate positive returns.

Data gathered in a study commissioned by CSEM[10] on the characteristics of the enterprises it works with provides some indication of the types of benefits to companies from interacting with CSEM. Around 26% of firms in the sample stated that the number of employees they had, had grown as a consequence of working with CSEM. This would suggest that co-operation with CSEM had led to real economic gains for companies (perhaps in terms of additional sales) for which additional employees might be required.

In addition, more than 50% of the firms that reported new scientific publications and patent applications stated that these had been generated in cooperation with CSEM. As well as this, 38% of firms with sales of new products reported that these sales were closely associated with CSEM activities. All of this would indicate that

[10] KOF (2012), Characteristics of enterprises cooperating with CSEM and the contribution of CSEM activities to the behaviour and the performance of cooperating enterprises.

companies interacting with CSEM enhance their propensity for innovation, leading to greater sales and knock-on effects in terms of employment.

Whilst this provides useful information on the benefits to firms from interacting with CSEM, it does not provide enough detail on the level of returns that companies achieve; however, an estimate can be made based on the findings of research from elsewhere.

One approach would be to use a 'technology multiplier', which depicts the relationship between total embodied R&D and intramural R&D, taking into account the direct and indirect technology diffusion in the region. The most recent estimate for this multiplier is 1.98 in the Euro zone[11]. This would mean that for each euro of intramural R&D expenditures in the Euro zone, 1.98 euro of embodied technology is created. However, this approach is developed at country level, not at the level of institutions such as CSEM.

It is therefore worth considering multipliers based on previous studies on business interaction with academia, as these would be more applicable at the level of a research institute. In 2013, BiGGAR Economics undertook an evaluation of Interface, the agency responsible for brokering relationships between businesses (and other organisations) and universities in Scotland[12]. 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 that look at similar fields of work. In 2009 PriceWaterhouseCoopers LLP undertook a study for the Department of Business, Enterprise & Regulatory Reform[13], 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 were taken into account. This suggests that the 1.98 multiplier estimated by Knell and the 360% multiplier estimated by BiGGAR Economics could be conservative.

Although both of the BiGGAR Economics and PWC 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 arising from research work carried out by CSEM was modelled using the middle of the range of possible assumptions (i.e. 340%).

These assumptions were applied to the total value of research and consultancy income received by CSEM for delivering these services. This gives an estimate of

[11] Knell (2008). Product-embodied technological diffusion and intersectoral linkages in Europe.
[12] BiGGAR Economics (2013), Evaluation of Interface, the knowledge connection for industry
[13] PriceWaterhouseCoopers, Impact of RDA spending – National report – Volume 1 – Main Report, March 2009, DBERR

the direct GVA contribution from the research and consultancy services provided by CSEM.

The additional economic activity created by CSEM 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 order to estimate the contribution in each study area it was necessary to consider the location of CSEM's clients. This is summarised in Table 7.1 and is based on information provided by CSEM. For example, in the case of industry-oriented research, around 54% of CSEM's private sector clients were from Switzerland.

Table 7.1 CSEM: Location of Research and Consultancy Services Clients

	Industry-oriented research	CTI
% of clients from Switzerland	54%	100%
% of clients from elsewhere in Europe	24%	0%
% of clients from outside Europe	22%	0%

Source: CSEM

In this way it was estimated that CSEM contributed CHF 349.0 million and 2,630 jobs globally through its research and consultancy assignments in 2017. The contribution in Switzerland amounted to CHF 194.5 million and 1,430 jobs.

Table 7.2 CSEM: Research and Consultancy Services Contribution

Research & Consultancy Services Contribution	GVA (CHF m)	Employment
Switzerland	194.5	1,430
Europe	284.5	2,140
Global	349.0	2,630

Source: BiGGAR Economics Analysis

8 WIDER BENEFITS

As far as possible this report has attempted to quantify the economic benefits associated with CSEM. There are however wider benefits arising from CSEM's activities which it is not possible to quantify. Although these benefits are unquantifiable, they are nonetheless important and are discussed further in this chapter.

8.1 Supporting the Development of Human Capital

Although the development of human capital is not one of CSEM's primary functions, it nevertheless has an important role to play in this regard.

Since CSEM works closely with industry and much of its research is targeted towards practical real-world issues, doctoral and postdoctoral researchers working at CSEM gain valuable, industry-oriented experience. The skills and experience that they gain during their time at CSEM are invaluable for their future career progression and their future employers. This better equips researchers to assume demanding positions and tasks in business and industry after they leave CSEM and helps maximise the knowledge impact of science and innovation in industry.

Many of CSEM's employees and researchers go on to work in industry after leaving their positions at CSEM. Many of them take up positions with high levels of responsibility, such as at management level, in product development or in strategic development and therefore go on to play a crucial role in industry in Switzerland.

The IDEA[14] study estimates that across four of its nine research and technology organisations, between one third and two thirds of the staff leaving each year transfer to private companies. It would be reasonable to assume that a similar number of staff leave CSEM each year to work in industry. This suggests that CSEM is therefore responsible for the transfer of highly educated and, crucially, highly experienced employees with significant practical know-how, into private industry each year, creating an important human capital effect.

As well as this, CSEM works closely with the two Swiss Federal Institutes of Technology, EPFL and ETH Zurich as well as the Universities of Applied Sciences and the Universities of Fribourg, Geneva, Lausanne, Neuchâtel and Zurich. One of the many ways this partnership approach is manifested is through CSEM staff delivering teaching at the polytechnics and universities. This allows the students at these universities to benefit from the specialist, cutting edge knowledge of CSEM staff and gain insight into the latest research and technology developments.

8.2 Local Benefits

CSEM brings a number of benefits to each of the local areas it is located in. For example, CSEM organises events and conferences in partnership with other organisations and attracts other business visitors to the area. This helps to attract local and international visitors, which supports the local tourism sector through additional spending on accommodation, transport, food and drink etc.

A further example can be seen through CSEM's presence and activities in Neuchâtel contributing to the canton's position as a key hub for microengineering in Switzerland. This has helped to attract other organisations and companies to the area. For example, EPFL opened its Institute of Microtechnology in Microcity in

[14] IDEA (2015), The Economic Footprint of 9 European RTOs – Prepared for EARTO

2014, next to CSEM and the start-up incubator NEODE. CSEM has also supported the development of this incubator and is one of its shareholders.

These examples serve to highlight how CSEM supports economic activity in the local areas in which it is based.

9 SUMMARY AND CONCLUSIONS

This chapter summarises the quantifiable economic contribution made by CSEM within Switzerland, across Europe and throughout the world.

9.1 Total Quantifiable Contribution

By bringing together the various sources of economic contribution discussed in this report it can be estimated that, in 2017, CSEM contributed:

- CHF 1.2 billion GVA to the global economy and supported around 9,730 jobs;
- CHF 723.5 million GVA to the European economy (including Switzerland) and around 5,810 jobs; and
- CHF 563.1 million GVA and 4,500 jobs to the Swiss economy.

This implies that:

- each person directly employed by CSEM supports around ten jobs throughout Switzerland and almost 22 jobs in total on a worldwide scale;
- the direct GVA effect of CSEM in 2017 was CHF 57.1 million and its total GVA impact was CHF 563.1 million in Switzerland and CHF 1.2 billion globally. This means that for every 1 CHF generated through its direct operations, CSEM supports CHF 10 in Switzerland and CHF 22 globally;
- the total income of CSEM in 2017 was CHF 83.0 million and so the ratio of total income to total impact was CHF 1 : CHF 7 in Switzerland and CHF 1 : CHF 15 globally; and
- total federal and cantonal funding received by CSEM in 2017 was CHF 38.3 million and so the ratio of public funding (federal and cantonal) to impact is approximately CHF 1 : CHF 15 in Switzerland and CHF 1 : CHF 32 globally.

A breakdown of the total contribution by GVA and by employment is provided in Table 9.1 and Table 9.2 respectively.

Table 9.1 CSEM: Summary Contribution – GVA (CHF million)

	Switzerland	Europe	Global
Direct Effect	57.1	57.1	57.1
Supplier Effect	25.9	32.6	33.9
Staff Spending Effect	53.4	64.4	66.5
Estates and Research Infrastructure	2.5	4.5	4.8
Core Operations	**138.9**	**158.6**	**162.4**
Technology Licensing	3.2	11.1	38.0
Spin-offs	226.5	269.2	689.3
Commercialisation	**229.7**	**280.3**	**727.4**
Knowledge Transfer (Research & Consultancy Services)	**194.5**	**284.5**	**349.0**
TOTAL	**563.1**	**723.5**	**1,238.8**

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

Table 9.2 CSEM: Summary Contribution – Employment (Jobs)

	Switzerland	Europe	Global
Direct Effect	440	440	440
Supplier Effect	190	240	250
Staff Spending Effect	490	580	600
Estates and Research Infrastructure	20	40	40
Core Operations	**1,130**	**1,300**	**1,330**
Technology Licensing	20	80	290
Spin-offs	1,910	2,300	5,480
Commercialisation	**1,930**	**2,380**	**5,770**
Knowledge Transfer (Research & Consultancy Services)	**1,430**	**2,140**	**2,630**
TOTAL	**4,500**	**5,810**	**9,730**

Source: BiGGAR Economics Analysis

9.2 Conclusions

This report has demonstrated that CSEM generates a huge economic impact in terms of GVA and jobs supported for Switzerland, Europe and globally.

CSEM's importance for the Swiss economy can be seen through the CHF 563.1 million GVA and 4,500 jobs it supports in Switzerland. Most notably, the impact it generates is roughly 10 times greater than the direct impact of CSEM itself. Underpinning this impact is CSEM's success in building close partnerships with industry across numerous sectors. Fundamental to this is the cutting-edge specialist research it undertakes and the novel technologies and uses that it directs this research towards. This makes CSEM's work exceptionally important in terms of the value it brings not just to academia and research but the value it can create in translating its research into industry.

This distinctive trait of CSEM means that its impact transcends Switzerland and has global reach. Therefore, as well as its close collaboration with Swiss companies, CSEM's work has enabled it to interact with companies globally and helped it to establish companies (based on its research and technology) which are globally significant. As a result, CSEM is estimated to support CHF 1.2 billion GVA and 9,700 jobs globally, creating impact around 22 times its direct impact.

Switzerland is one of the five most innovative economies in Europe with efficient knowledge and technology transfer and highly quality research institutions cited as two of the main factors behind this[15]. Through the research that CSEM undertakes, its commercialisation activities, and its research and consultancy services for businesses, CSEM undoubtedly plays an important role in supporting the success of Switzerland's research and innovation landscape.

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

10 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 CSEM, 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 CSEM.

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 CSEM 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 for Switzerland for 2011.

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 the research institution, they have no formal intellectual property relationship with CSEM.

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.

11 APPENDIX C: TECHNICAL APPENDIX

This Technical Appendix describes in more detail, the approach and assumptions that are used in the calculation of some of the key economic contributions of CSEM. 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.

11.1 Core Contributions

11.1.1 Supplier Effect

The economic contribution associated with this expenditure was estimated in line with the methodology described in Table 11.1. Each of the categories of supplier spend (Figure 5.3), were assigned a matching economic sector in order to apply appropriate economic ratios and multipliers. The average Type 2 GVA multiplier across these sectors was 2.3 and the average Type 2 employment multiplier was 3.4.

Table 11.1 – 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
$Exp_{(a)} = Expenditure\ on\ commodity\ (a)$
$\frac{T_{i(a)}}{G_{i(a)}} = \frac{Turnover}{GVA}\ ratio\ in\ industry\ associated\ with\ commodity\ (a)$
$\frac{T_{i(a)}}{E_{i(a)}} = \frac{Turnover}{Employment}\ ratio\ in\ industry\ associated\ with\ commodity\ (a)$
$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry (i)$
$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry (i)$

11.1.2 Staff Spending Effect

In order to estimate this contribution, it was necessary to consider 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[16] . This allows for an estimate of total staff expenditure in each of the study areas.

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[17], it was necessary to deduct VAT from the total staff salaries paid. A study undertaken by Lund University[18] 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 11.2.

Table 11.2 – 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

Each category listed in Table 11.2 was assigned a matching economic sector in order to apply appropriate economic ratios and multipliers. The average Type 2 GVA multiplier across these sectors was 2.1 and the average Type 2 employment multiplier was 2.3.

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

Table 11.3 – 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
$$\frac{T_s}{G_s} = \frac{Turnover}{GVA}\ ratio\ for\ staff\ spending$$ $$\frac{T_s}{E_s} = \frac{Turnover}{Employment}\ ratio\ for\ staff\ spending$$ $$M(E)_s^2 = Type\ 2\ Employment\ Multiplier\ for\ staff\ spending$$ $$M(G)_s^2 = Type\ 2\ GVA\ Multiplier\ for\ staff\ spending$$ $$SE_{Study\ Area} = Value\ of\ staff\ expenditure\ (less\ VAT)\ spent\ in\ each\ study\ area$$

11.1.3 Estates and Research Infrastructure Contribution

The economic contribution associated with this expenditure was estimated in line with the methodology described in Table 11.4.

Table 11.4 – 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
$$\frac{T_C}{G_c} = \frac{Turnover}{GVA}\ ratio\ in\ the\ construction\ industry$$ $$\frac{T_C}{E_c} = \frac{Turnover}{Employment}\ ratio\ in\ the\ construction\ industry$$ $$M(E)_C^2 = Type\ 2\ Employment\ Multiplier\ in\ construction\ industry$$ $$M(G)_C^2 = Type\ 2\ GVA\ Multiplier\ in\ construction\ industry$$ $$\langle Estates\ expenditure \rangle = Average\ estates\ expenditure\ over\ 10\ years$$ $$\frac{T_M}{G_M} = \frac{Turnover}{GVA}\ ratio\ in\ the\ manufacturing\ industry$$ $$\langle Research\ expenditure \rangle = Average\ research\ infrastructure\ spend\ over\ 10\ years$$

11.2 Commercialisation

11.2.1 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[19].

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[20] 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 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 11.5.

Table 11.5 – 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.

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

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

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 11.6 – 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

$$GVA(L) = Total\ GVA\ associated\ with\ licences$$

$$Rev(L_i) = Revenue\ generated\ from\ licences\ in\ industry\ (i)$$

$$\left({}^{T_i}/_{G_i}\right) = \frac{Turnover}{GVA} ratio\ in\ industry\ (i)$$

$$\left({}^{T_i}/_{E_i}\right) = The \frac{Turnover}{Employment} ratio\ in\ industry\ (i)$$

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

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

$$Rate_i = Royalty\ rate\ for\ industry(i)$$

$$Income(L_i) = Income\ to\ the\ institute\ from\ licences\ in\ industry\ (i)$$

11.3 Knowledge Transfer – Research and Consultancy Services

The economic contribution associated with this expenditure was estimated in line with the methodology described in Table 11.4.

Table 11.7 – Calculations and Inputs for Research & Consultancy Services Contribution

Formulas
$$GVA(RC) = M(G)_i^2 * \sum_i 340\% * Income(RC_i)$$
$$Employment(RC) = M(E)_i^2 * \sum_i \frac{GVA(C_{RC})}{({G_i}/{E_i})}$$
Inputs
$GVA(RC) = Total\ GVA\ associated\ with\ Research\ \&\ Consultancy\ Services$
$GVA(RC_i) = GVA\ associated\ with\ RC\ in\ industry\ (i)$
$M(E)_i^2 = Type\ 2\ Employment\ Multiplier\ in\ industry(i)$
$M(G)_i^2 = Type\ 2\ GVA\ Multiplier\ in\ industry(i)$
$Employment(RC) = Total\ Employment\ associated\ with\ RC$
$\left({G_i}/{E_i}\right) = The \frac{GVA}{Employment} ratio\ in\ industry\ (i)$
$Income(RC_i) = Income\ to\ CSEM\ from\ Research\ \&\ Consultancy\ Services\ in\ industry\ (i)$

11.4 Economic Ratios and Multipliers

11.4.1 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 11.8 – 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
Machinery and equipment, nec	2.53	370,957	146,434
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 telecommunications	1.92	356,072	185,824
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
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 telecommunications	1.92	356,072	185,824
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

11.4.2 Economic Multipliers

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

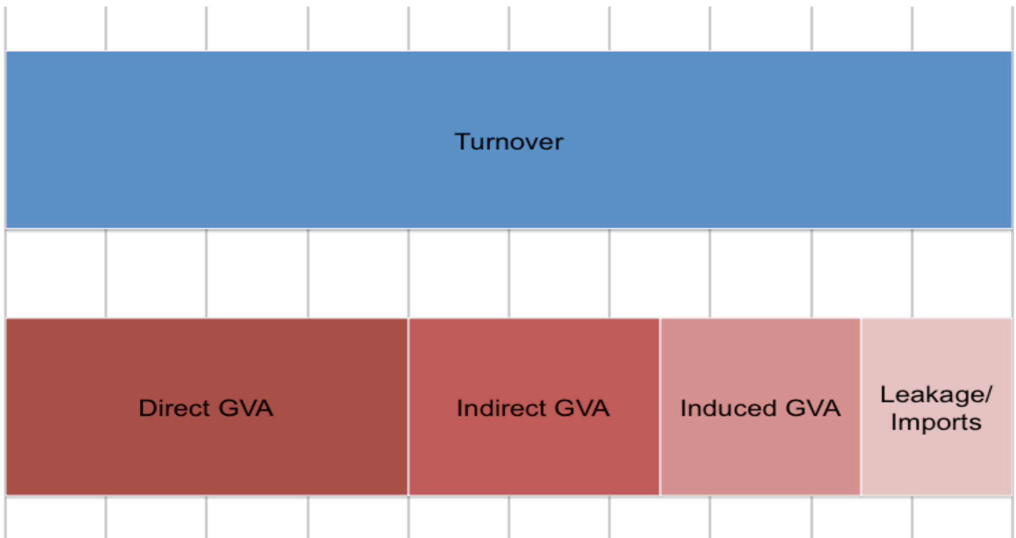
There are two types of multiplier. Type 1 (M_1) multipliers only consider the economic impact in the supply chain, whereas Type 2 (M_2) multipliers also include the spending of the staff involved in the process. The multipliers are expressed as the final figure for both GVA and Employment. For example, if there is a T_2 GVA Multiplier of 1.75, then €1.00 of direct GVA (D_{GVA}) would result in €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.

$$T_{GVA} = D_{GVA} + (M_1 - 1) * D_{GVA} + (M_2 - M_1) * D_{GVA}$$

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 11.1 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[21].

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 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 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.

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

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

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 11.9 – Economic Ratios for Switzerland

	Type 1		Type 2	
Multiplier Industry	Employment	GVA	Employment	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 11.10 – Geographic Multipliers as % of Switzerland

Area	Multiplier
Switzerland	100%
Europe	125%
Global	130%

Source: BiGGAR Economics