



Eurostars

The International Programme for Research Intensive SMEs

A Joint Swiss Danish Impact Study

Introduction

Denmark and Switzerland have invested in Eurostars projects since its launch in 2008. The purpose is to support innovative product development and international cooperation between firms and knowledge institutions.

Eureka, which facilitates the Eurostars system, have conducted several impact studies including all 36 Eurostars member states (not all are in EU). These studies have been based on European databases with few or no data on SME's with less than 20 employees. Given that Eurostars is aimed at SME's, many with less than 20 employees, this is a significant shortcoming.

This report is the first impact study of Eurostars in Denmark and Switzerland based on national register data covering all firms and their employees in the two countries. This allows us to extract new and valuable information about the firms and the impact of participating in Eurostars.

Denmark and Switzerland are well suited for a joined study such as this. As the report shows, there are many similarities between Eurostars projects in the two countries with respect to size of the program, the nature of the projects and the participants. Also both countries are small, open economies and generally characterized as knowledge intensive and highly productive. It is therefore natural to compare the findings for the two countries.

The report is the result of a joint study performed by DAMVAD Analytics from Denmark and ETH Zürich KOF and B,S,S. from Switzerland on behalf of The Innovation Fund Denmark, The Danish Agency for Science and Higher Education and The Swiss Secretariat for Education, Research and Innovation.

We have used similar data sources for the studies in the two countries. This is mainly data from Eureka about the program and the projects and firm level data from the statistical bureaus (referenced as register data). There are some differences in the data available in the two countries. In particular there are some limitations on Swiss register data with respect to available variables and firm coverage.

Generally, we apply the same analytical methods in the two countries. This includes the econometric analysis. However, the data availability in the two countries has some influence on the specific method we apply. Therefore, not all the presented results are directly comparable between the two countries.

It is our hope that the report provide new insights about Eurostars, which can be used to further develop the program.

We also hope future evaluations of Eurostars and other research and innovation programs will benefit from the findings. In particular we advice evaluators to consider if the available data is sufficient to apply the desired method.

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Executive Summary

Executive Summary

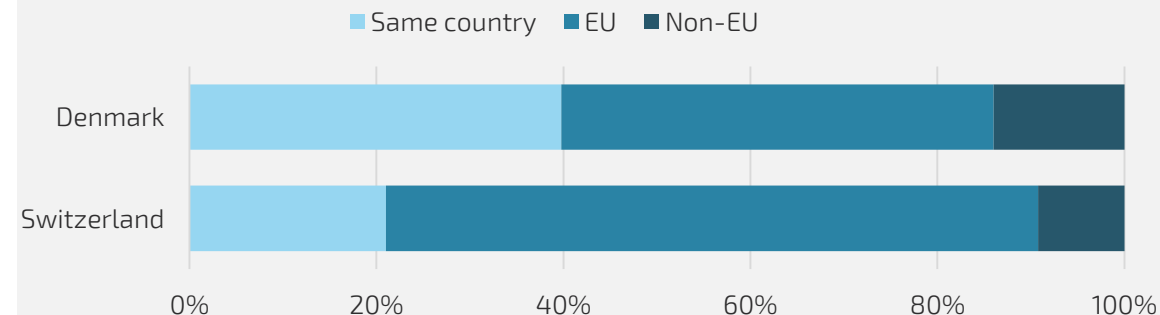
Eurostars has successfully attracted innovative SMEs in Switzerland and Denmark

The Eurostars programme has been successful in attracting Swiss and Danish firms to apply for direct financial innovation support. From 2008 to June 2018 Swiss organizations have participated 400 times in Eurostars projects and Danish organizations have participated 347 times.

The Eurostars programme particularly attracts small and young innovative firms – which is also a main purpose of Eurostars. Small and young firms face serious difficulties to realize financial funding for their innovative activities. It is the greatest innovation obstacle for small firms according to the Swiss Innovation Survey 2017 (Spescha & Wörter 2018) and recently outlined in the report on Venture Capital in Europe issued by Roland Berger, (Berger, 2019). Moreover, small firms have a strong growth potential. The direct innovation support provided by the Eurostars programme complements the national available funding schemes, which makes it in particular attractive for financially constraint small firms.

Generally, Eurostars funding areas matches the technology orientation of Danish and Swiss firms with their strength in Biotech and other technology-oriented industries. More than one third of the projects are in biotech. Other common areas are industrial technology and ICT.

Geographical region of partners' origin of main applicants



Eurostars allows SMEs to cooperate with other companies and universities in other countries

Eurostars is designed to promote cooperation between R&D-performing SMEs and larger firms, universities and research institutes.

The Eurostars programme also promotes cross-border cooperation. It is a requirement that the each project have partners from different countries. This is reflected by the fact that a majority of the partners of the *main applicants* are from other countries both inside and outside EU. This creates a potential for transfer of knowledge and technology, which may help the firms grow and become more productive.

Cooperating with foreign firms let the participants increase their network, which may allow them to unveil new potentials. For example new trade deals to increase export. These kinds of effects may also benefit rejected applicants.

Executive Summary

SMEs that participate in Eurostars grow after the projects start

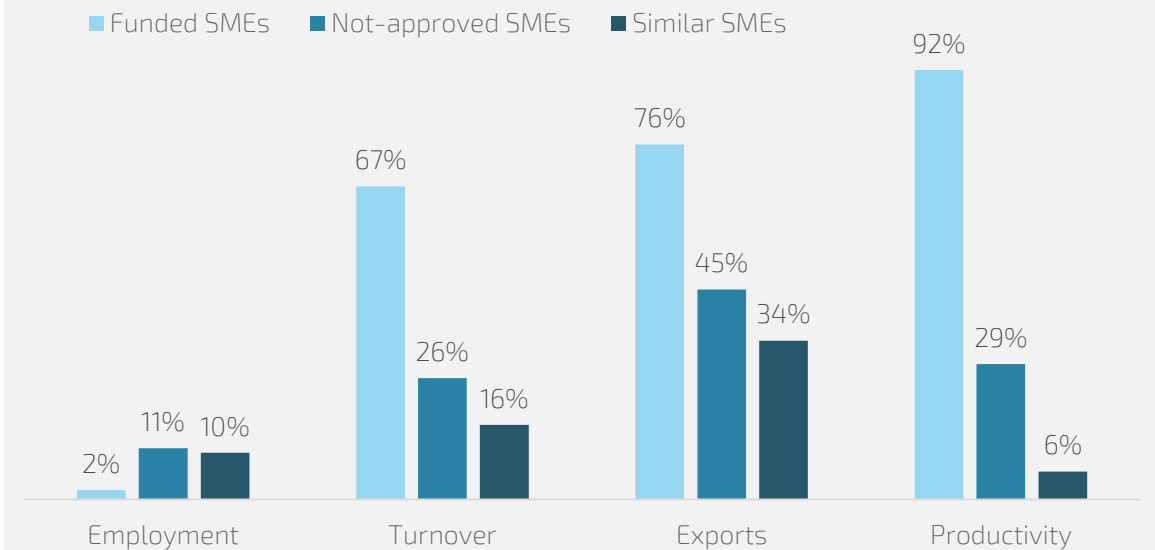
Evidence from Denmark, where we have access to more data than in Switzerland, shows that the SMEs that participate in Eurostars projects (the funded SMEs) have a high growth in turnover, exports and productivity (labor productivity) in the years immediately after the projects start. The turnover for the funded firms is on average 67% higher three years after the projects start compared to one year before the projects start – and exports is 76% higher. Compared to this the SMEs that applied for Eurostars projects, but were rejected, (not-approved) SMEs, grew slower, though faster than other SMEs of similar size and in the same sectors (Similar SMEs).

The funded SMEs growth is not directly a result of solutions and products developed in the Eurostars project. These projects takes three years to complete, and the firms are expected to use another couple of years to prepare the solutions for the market. Therefore, the growth is spurred by other factors, for example learning effects and the effects of obtaining new contacts in other companies and foreign countries. We do not yet have enough data to robustly calculate the growth after the projects end.

The not-approved SMEs may also benefit from learning effects and new contacts obtained in the application process. Furthermore, they may have started the project they applied for without the funding from Eurostars.

The funded SMEs have not grown significantly with respect to the number of employees.

Average growth (%) from one year before project start to three years after project start (two years after for productivity) for Danish SMEs



Executive Summary

Eurostars has a positive impact on employment according

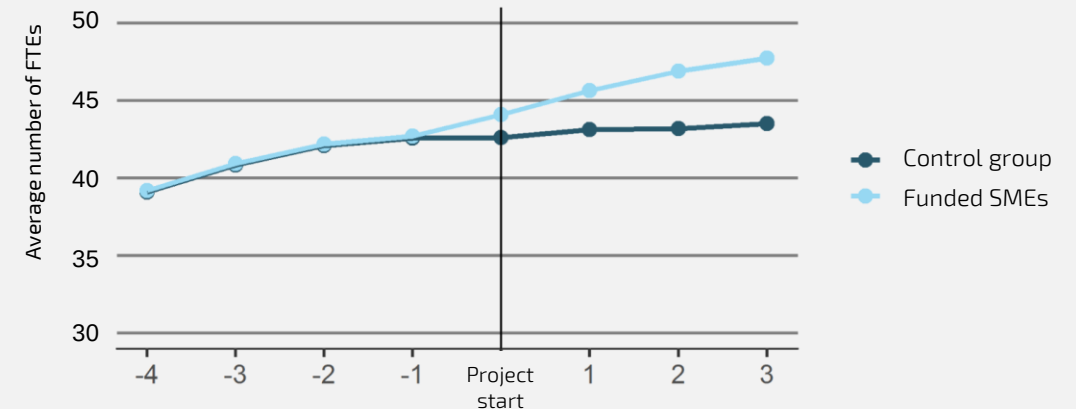
Comparing the economic outcomes of the different groups over time is not enough to conclude anything about the effect of participating in the Eurostars Programme, as the differences in growth may be due to other factors that affect growth. Therefore, we have applied econometric methods in order to identify and estimate the causal impact of Eurostars participation on firms' performance.

The figure to the right shows the evolution of average employment across a period of eight years for funded Swiss SMEs and a constructed control group: four years prior to three years after the project start year. The results suggest that Eurostars participation boosted employment in the first three years after the project start. If we take the figure at face value, the increase in employment appears to be around 5 FTEs.

Employing an econometric model, the estimated effect of Eurostars participation on employment is roughly 12 percent in the project start year and about 17 – 19 percent in the first three years after project start. These effects are statistically significant. In other words, Eurostars funding appears to have increased employment growth among approved SMEs quite substantially.

The econometric results on Danish data confirm that Eurostars has a positive impact on employment. The effects on turnover, exports, investments and labor productivity is less clear, and the results are quite sensitive to even small changes in the model. Partly because the results are based on a relatively small number of treated observations.

Employment growth between approved SMEs and control group SMEs in Switzerland



Executive Summary

Eurostars is well aligned with the national research and innovation programmes

Eurostars support SMEs and international projects in the early stage of research and innovation (R&I). The programme acts as a catalyst for engaging SMEs in more collaborative R&I-activities. We find that many Danish participants in Eurostars also participate in other key innovation programs, both national and Horizon 2020.

Generally we find that the share of firms that participate in these programs is higher after firms have completed a Eurostars project. Interestingly, the same is true for the rejected applicants. Many of these have participated in other programs after being rejected by Eurostars.

In Switzerland The Eurostars programme complements two other main R&I support programmes: Innosuisse R&D project support as well as Horizon 2020. By providing access to direct R&D funding for international breakthrough innovation projects, the Eurostars programme targets key objectives of the innovation policy in Switzerland,

These key objectives are:

- increasing SME's investments in R&I,
- stimulating SME's cooperation with universities, knowledge institutions and other companies
- facilitating Swiss participation in international cooperation
- strengthening the firms' absorptive capacity by increasing the highly educated workforce.

Learnings and recommendations for future studies

A key learning from this project is that it will take another couple of years before we have sufficient data to measure Eurostars impact on firms performance after the projects end. There are still too few firms that have reached the market with the new solutions and products, even though the programme started in 2008. There are three main reasons for this lack of data.

First of all, relatively few projects started in the initial years, and a large part of the projects started in 2015 and the following years. Secondly, it takes five years or more to complete the projects and implement the solutions or introduce new products to the market. And finally there is a lag of up to two years before data on firm performance is available from the statistical bureaus.

Future evaluations of the programme should add further indicators to the analyses to measure the programme's effectiveness in terms of RD investments and innovation output performance (e.g. Czarnitzki & Hussinger, 2018; Beck et al. 2016). To enable such an enriched evaluation, involved policy makers might initiate a systemic data monitoring, which could be guided by a data monitoring board consisting of policymakers and officers from statistical bureaus together with evaluation experts.

Such enriched data would allow extending the evaluation of the programme in terms of providing more detailed evidence about the legitimacy of the programme and effectiveness of the policy design. Second, it would also allow for improved, evidence-based policy consulting. This would be possible by studying the effectiveness of the funding in terms of what projects to support (e.g. market vs. technology oriented projects; consortia of the projects) and what firms to support (e.g. SMEs vs. large firms; "picking winners vs. catching up").

Eurostars in Switzerland at a glance

The projects



Eurostars supports international R&D-projects where participants from Switzerland collaborate to develop new products, services and processes. Eurostars' raison d'être purpose is that the firms' level of innovation and thereby growth increases. The programme is aimed at SMEs, which often have financial and capacity constraints that larger firms may easier overcome (see e.g. Spescha & Wörter 2018).

The first projects in Switzerland started in 2008. A total of 400 projects with Swiss participants from industries and universities have started since then. Relatively few projects started in the first six years, but the number of annual projects with Swiss firm participation has so far topped in 2017 with 43 projects. The projects typically last about three years.

More than one third of the projects are in biotech. Other common areas are industrial technology and ICT, which makes up about 53 percent of the projects.

The participants



256 partners from Swiss enterprises, 93 partners from Swiss universities and 47 partners from other research institutes have participated in Eurostars projects. Several of these have participated in more than one Eurostars project.

236 of the firms are SMEs and 20 are large enterprises. 57% of the firm applications come from micro sized firms (fewer than 10 full time equivalent employees (FTEs)) and another 26% from small sized firms (fewer than 50 FTEs).

Two out of three Eurostars funded firms had a turnover of less than 2 million euro and a group of 23.2% firms had no earnings the year their project started.

Overall, the Eurostars firms have on average a similar turnover, but less employees compared to the average Swiss SMEs before the project starts.

The impact



We have tracked the Eurostars firms' performance to see if they grow faster than comparable firms. In particular, we investigate if their R&D investment, R&D employment, turnover, net profit and total employment and productivity increases faster than non-approved Eurostars SMEs as well as in terms of employment than the average Swiss SMEs.

Not conclusive, but there are substantial signals for the effectiveness of the programme. The econometric treatment analysis yield a substantial positive impact on employment. The difference-in-differences estimation isolates causal effects on employment that are observed at the time after project start and increase over time. Approximately, the increase amounts to 5 FTEs on average for the treated firms after three years after project start. The analysis is restricted to FTE employment due to data limitations.

A purely descriptive analysis compares the development of economic outcomes of funded Eurostars firms to non-approved Swiss Eurostars firms. We see that, on average, R&D investments, R&D employment and net profit increase after project start and are substantially higher in Eurostars firms than in rejected Swiss Eurostars SMEs. Average turnover increases as well, but remains below the level of non-approved Swiss Eurostars SMEs.

Eurostars in Denmark at a glance

The projects



Eurostars supports international R&D-projects where participants from Eurostars countries collaborate to develop new products, services and processes. Eurostars' raison d'être is that the firms' level of innovation and thereby growth increases. The program is aimed at SMEs, which often have financial and capacity constraints that larger firms may easier overcome.

The first projects in Denmark started in 2008. A total of 224 projects with Danish participants have started since then. Relatively few projects started in the first six years, but in 2015 the number of annual projects more than doubled and have so far topped in 2017 with 38 projects. The projects last about three years.

More than one third of the projects are in biotech. Other common areas are industrial technology and ICT, which makes up about 40 percent of the projects.

The participants



234 partners from Danish firms, 46 partners from universities and 62 partners from other research institutes have participated in Eurostars projects. Several of these have participated in more than one Eurostars project.

Almost all of the firms were SMEs and 9 out of 10 were small or micro sized (fewer than 50 employees).

Two out of three firms had a turnover of less than 2 million euro and a smaller group (4%) had no earnings the year their project started. This reflects that some of the firms are established to develop and market the technology in focus of the particular projects.

Overall, though, the Eurostars firms have significantly more employees as well as a higher turnover and export than average SMEs in Denmark.

The impact



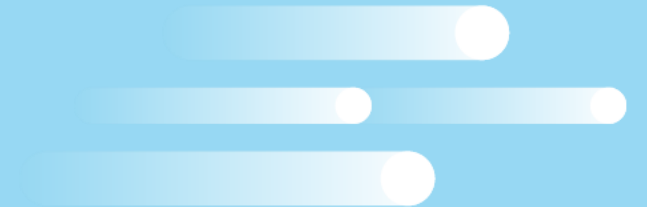
We have tracked the Eurostars firms' performance to see if they grow faster than comparable firms. In particular we wish to investigate if their turnover, exports, employment and productivity increases faster.

There are indications of a positive impact. The majority of the firms believe the projects were successful and overall they grow significantly faster than their peers in terms of employment, turnover, export and productivity in the years immediately after the projects start. Econometric analysis confirms that approved SMEs employ more people when we take account to other factors that may spur growth. But the econometric evidence of effects on turnover, export and productivity is less clear and not robust.

The impact measurement is limited by lack of data. Only few of the projects have reached the market yet. This is certainly true for the projects started after 2013 in Eurostars 2 given that the projects last 3 years and it takes an additional 2 years or more to reach the market and an additional 1-2 years before the impact can be detected in the national statistical databases. There are therefore yet too few observations to statistically conclude if Eurostars help firms perform better or not. In a couple of years there will be better data for the performance after the projects finish and even reach the market. It may be worth reexamining the possibilities for making a proper statistical evaluation in the fall 2020 or 2021.

Part 1 – Descriptive Analysis

1. Eurostars in the Danish & Swiss innovation landscape



What is a Eurostars project?

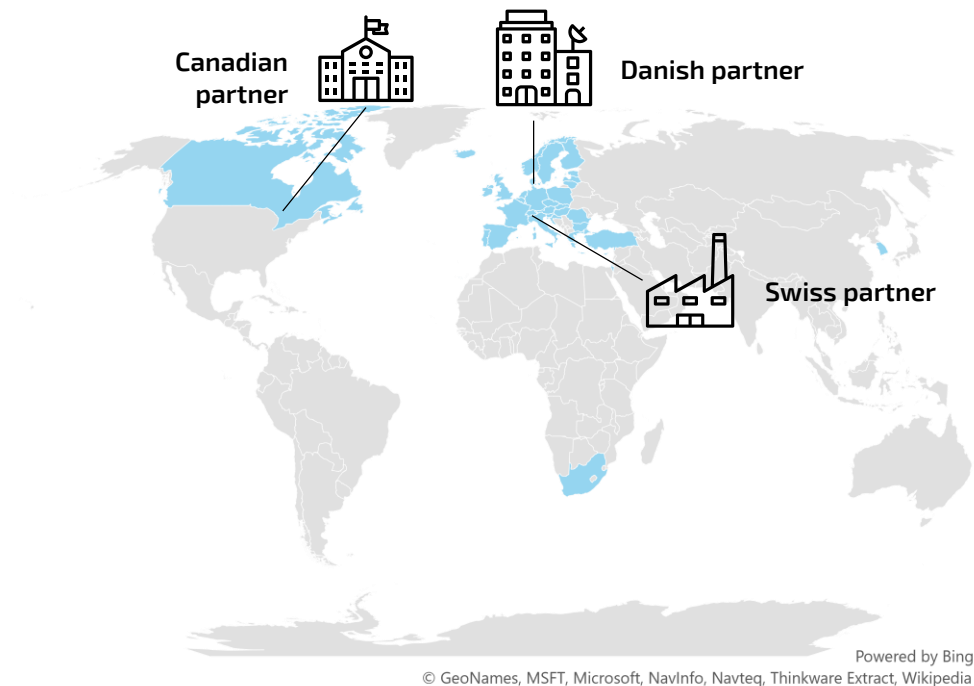
Eurostars is Europe's largest collaborative programme focused on applied research and development for small- and medium-sized enterprises (SMEs). The purpose is to promote innovation activities and international cooperation by enabling SMEs to conduct joint research and innovation. The programme is market oriented and product market introduction is expected within two years after project completion.

A Eurostars projects have a minimum of two participants from at least two Eurostars countries. The project leader («*main participant*») is an R&D-performing SME and a minimum of 50% of the project activities must be conducted by the R&D performing SMEs. However, other participants such as other SMEs, universities, research institutes and large companies can also participate in the programme.

The qualified projects are selected among a group of applicants after a thorough evaluation of the applications. This includes a preliminary eligibility check, an expert evaluation and a rating made by an independent panel of experts. The qualified applications with the highest ratings above a score threshold are approved for funding until the funding budget from the participating countries is spent.

Eurostars is a joint programme between EUREKA and the European Union and is funded by 36 of EUREKA's members and partner countries and the European Union through Horizon 2020. Most of the participating countries are European, however, Canada, Israel, Turkey, South Africa and South Korea are also part of the programme. The combined funding budget for Eurostars in Horizon 2020 is €1,2 billion. The Eurostars programme started in 2007 under the 7th EU Framework Programme for Research and Innovation.

Eurostars connects research intensive SMEs with other SMEs and other types of partners from 36 different countries – here is an illustrative example with three participants:

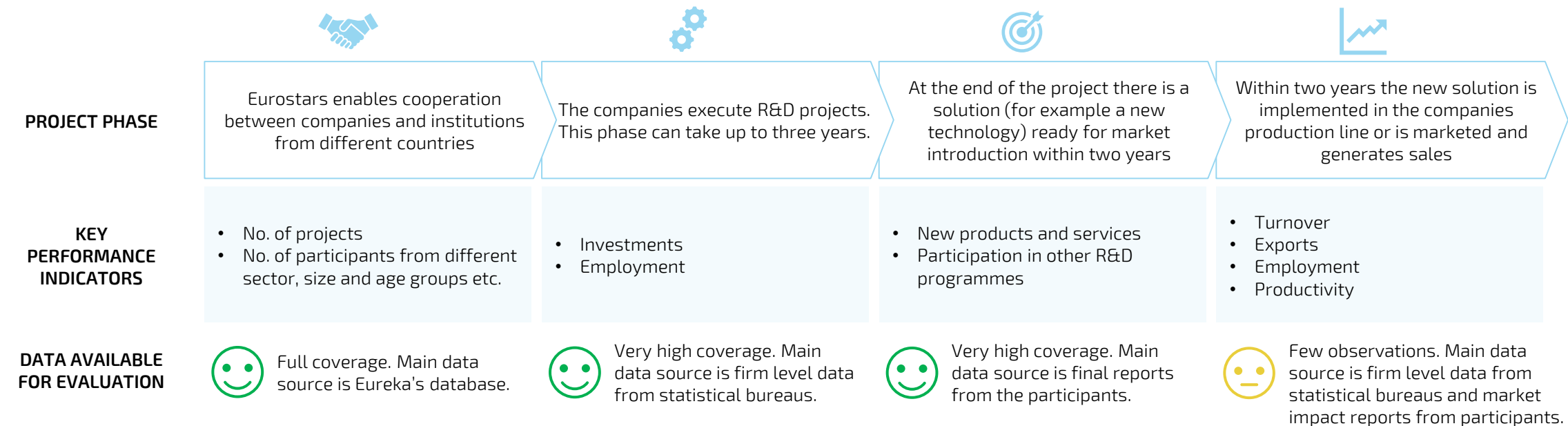


What kind of impact do we expect from Eurostars projects?

In this evaluation we examine if Eurostars have a positive impact on firms performance. The rationale for Eurostars is illustrated below including examples of the key performance indicators we use to measure the impact of Eurostars on the participating companies. We do not have sufficient data to measure the impact on all these indicators. This will be elaborated later in the report.

The projects last up to three years and thereafter it will typically take an additional two years to market the new solutions. For example a new product or service that generates sales or a new process or technology that benefits the firms productivity. Therefore, we expect to see the full impact of the projects five years or later after the projects start. But, we may see some changes before that as a result of learning and new contacts gained in the application phase and project phase. For example a participant may get new contacts in another country that leads to export of existing products and services. The rejected applicants may also benefit from learning and new connections from the application phase.

In this impact study we have access to unique firm and project level data from Eureka and national statistical bureaus. These data have detailed information about the firms before and during the projects. There are yet limited data for the firms' performance for the period after the new solutions reach the market. Therefore, it is not yet possible to fully determine the long term impact of Eurostars on firms' performance.



A catalyst for R&I activities – evidence from Denmark

The Eurostars program is well aligned with the key objectives for the Innovation Fund Denmark, which are to:

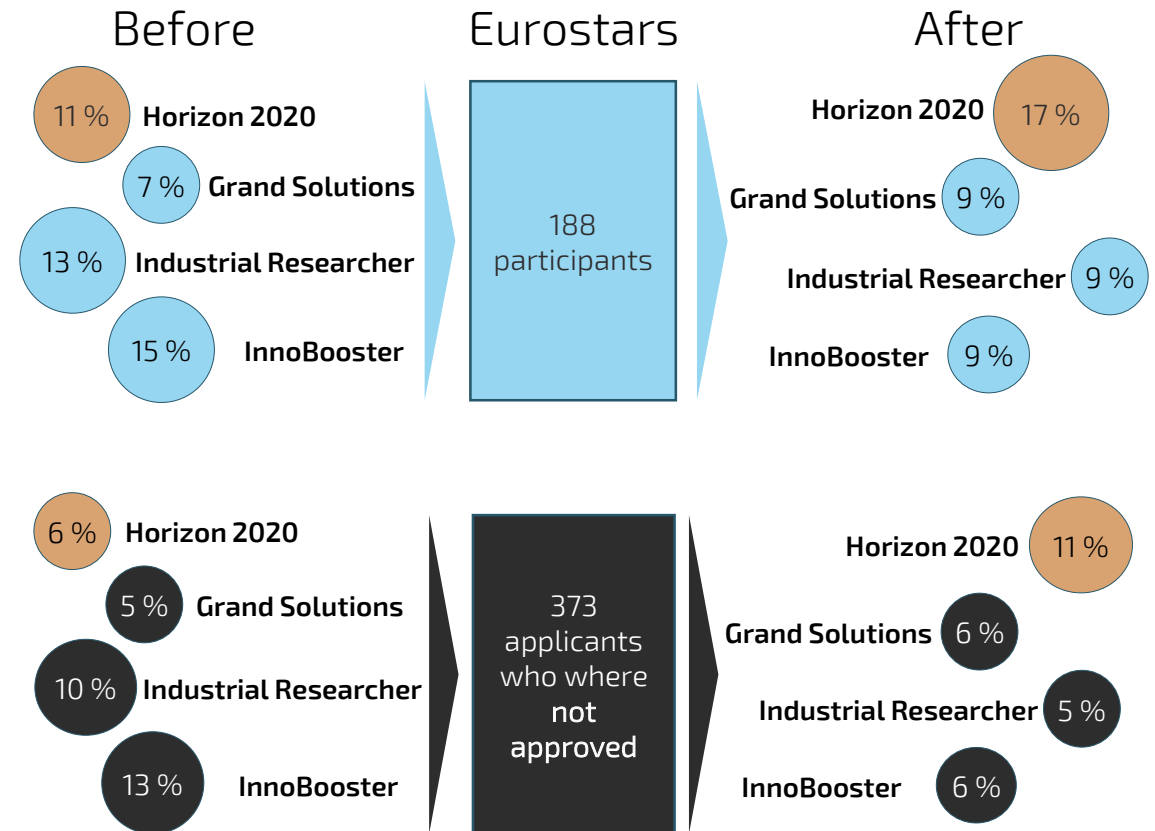
- increase SME's investments in research and innovation (R&I),
- facilitate SME's cooperation with universities, knowledge institutions and other companies on innovation and new technologies
- facilitate Danish participation in international cooperation on research and development of new technology and innovation
- increase the share of highly educated staff in companies.

Eurostars support SMEs and international projects in the early stage of R&I. The figures in the illustration indicates that Eurostars acts as a catalyst for engaging SMEs in more collaborative R&I activities, regardless whether the application results in rejections or approved.

A significant share of the Eurostars firms (participants) and rejected applicants have participated in 3 Danish programs and Horizon 2020.

Grand Solutions is a research and innovation programme often used by larger firms and organizations, Industrial Researcher invests in Industrial PhD and Postdoc projects, and InnoBooster is an SME program close to market. Horizon 2020 is the biggest EU Research and Innovation Programme.

Generally we find that the share of firms that participate in Horizon 2020 and Grand Solutions is higher after firms have completed a Eurostars project compared to before. This is true for both the participants and rejected applicants.



Source: Innovation Fund Denmark and Cordis

A catalyst for R&I activities in Switzerland

The Eurostars programme complements two other existing main Research & Innovation (R&I) support programmes: Innosuisse R&D project support (which provides practice-oriented indirect R&D subsidies particularly for SMEs) and Horizon 2020 (which is the 8th EU Framework Programme for Research and Innovation). By providing access to direct R&D funding for international breakthrough innovation projects, the Eurostars programme targets key objectives of the innovation policy in Switzerland, specifically:

- **increasing SME's investments in R&I**,
- **stimulating SME's cooperation** with universities, knowledge institutions and other companies
- **facilitating Swiss participation in international cooperation**
- **strengthening the firms' absorptive capacity** by increasing the highly educated workforce.

Recent studies have found empirical evidence of the effectiveness of Swiss innovation promotion in increasing private R&D investment and radical innovation performance in companies (Beck et al. 2016). However, these studies have highlighted that firms' engagement in collaboration lead to ambiguous results (e.g. Beck & Lopes Bento, 2016). In the past, R&D project support has been predominantly provided by Innosuisse. Innosuisse offers indirect financial support for firms, which means the (mostly national) scientific partner of a supported firm receives the financial aid.

Horizon 2020 introduced new programmes fostering the access of SME to finance innovation besides the financial support for Eurostars. They are a) the mono-beneficiary SME instruments and pilot calls of the European Innovation Council as well as b) the Fast Track to Innovation programme fostering R&D cooperation like Eurostars. Swiss SME can access these instruments only since 2017 due to the partial association of Switzerland to Horizon 2020 in the years 2014 – 2016. The participation figures of Swiss SME to the Horizon 2020 instruments show a similar positive trend as for Eurostars underlining the need of Swiss SME for finance to innovate.

The complementarity of Eurostars to the Horizon 2020 SME instruments lies in the facts that:

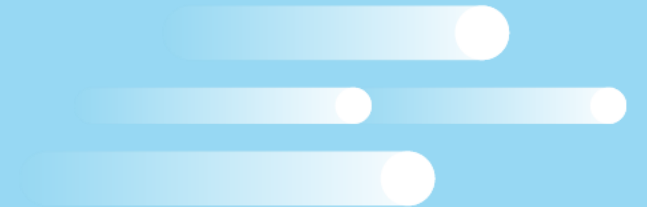
- the participation of Switzerland to Eurostars is open, whether or not Switzerland is associated to the EU Framework Programmes for R&I
- the combination of national and EU funding enlarges the financial volume allowing a success rate for funding of more than 30% compared to the Horizon 2020 programmes where the success rate can fall below 10%.
- Non-European countries such as Canada, South Korea and South Africa participate at Eurostars providing a more global cooperation than in the framework of Horizon 2020 programmes.

Eurostars addresses one of the major barriers of SMEs for innovation, which are the financial constraints (e.g. Spescha & Woerter, 2018). Through the international collaboration, Eurostars projects generate knowledge spillovers from international collaboration partners from industry and scientific institutions. As reported in the R&I report for Switzerland (Spescha & Woerter, 2018), Swiss firms have strengthened their collaboration with international partners over time, and there is an increasing importance of international knowledge sources for the promotion of innovation and productivity in Switzerland (Arvanitis et al., 2019).

Beyond the direct financial support, Eurostars enables companies to strengthen their absorptive capacity by increasing their highly educated workforce in R&D activities. Sufficient levels of absorptive capacity is the key performance drivers for Swiss private enterprises, which benefit from knowledge and technology exchange activities between private enterprises and scientific institutions (Beck, Hulfeld, Spescha & Woerter, forthcoming).

Notably, the Eurostars programme complements existing policy instruments by its international character, and the possibility to directly support innovation activities of R&D intensive Swiss firms (i.e. SMEs). It represents a milestone towards a more open innovation support policy in Switzerland by offering complementary funding tools and sophisticated project monitoring (see e.g. Bloom et al., 2019). Generally, we find that the Eurostars programme matches the key priorities of Swiss innovation policy, in particular, it serves as a catalyst for growth orientation, initiating international innovation activities, connecting with collaboration networks.

2. Participation in Eurostars



Number of approved firms in Eurostars projects

Since 2008 Swiss companies have been approved 256 times for Eurostars projects. In Denmark the number is 234.* The number of approved company projects per year has increased in both countries during the programme's lifespan. Since 2015 the number of annual projects has been above 30 in both countries.

Denmark and Switzerland have a similar number of approved projects per year. This is also true with respect to the status of the project, i.e. if the project is still ongoing or finalized.

Project status of all projects with company participation

Project status	Switzerland	Denmark
Finalized	143	120
Ongoing	113	114
Total	256	234

*Only projects approved before 31 July 2018 are included in the subsequent analyses. Notice, if the same firm has participated in two different projects, it is counted as 2 approvals in the figures and tables.

Fig. 1: Number of approved projects including a Swiss company

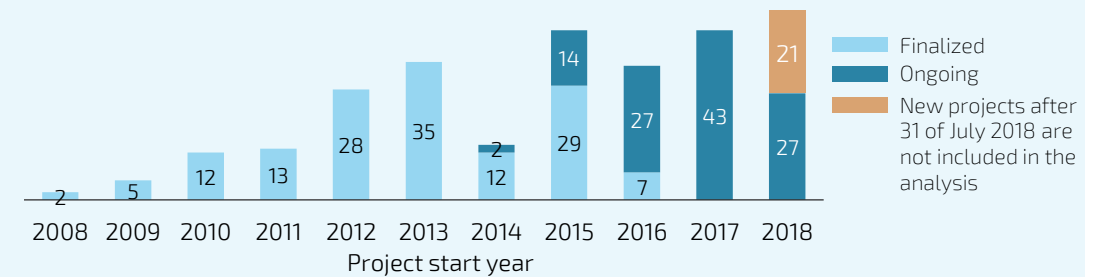


Fig. 2: Number of approved projects including a Danish company

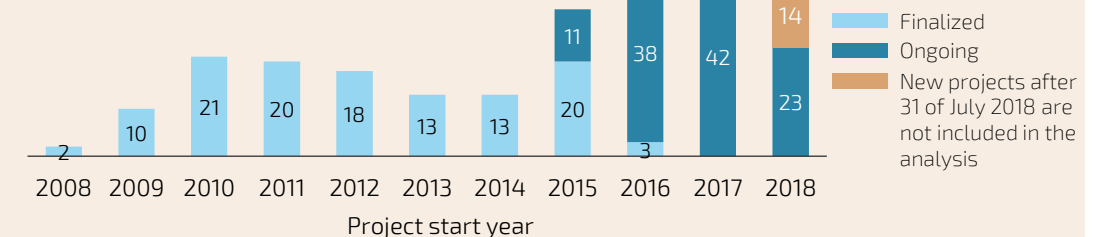


Fig. 1 and fig. 2 show the number of all Swiss and Danish firms for a given project start year that have been involved in approved projects and whether those projects have been finalized or are ongoing by the 31 of July 2018. If there is a project with two Swiss or Danish companies involved, the graph shows this as two "Swiss /Danish projects" in one year.

Project duration – Switzerland and Denmark

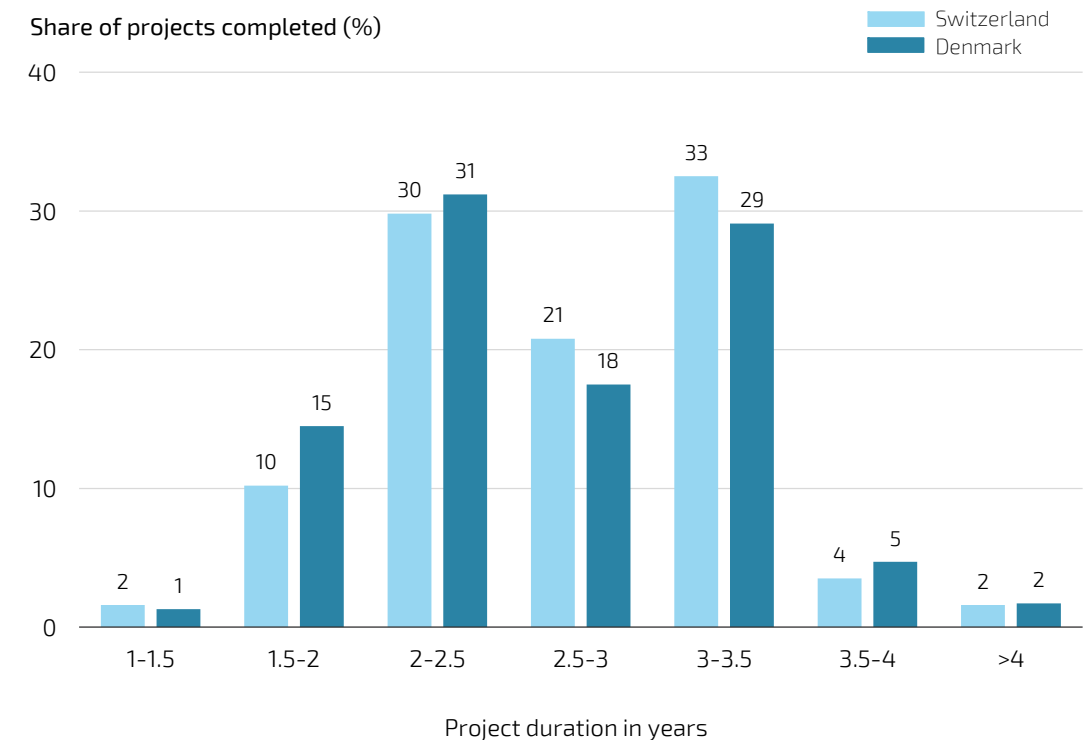
Eurostars projects are intended to last up to three years. Almost two-thirds of the projects in Switzerland and Denmark are finalized within three years from the project start. Some projects appear to have a longer duration due to substantiated delays in the project approved by the corresponding authorities.

The project duration is very similar in Denmark and Switzerland. The average duration for Eurostars projects is approximately 30 months in both Denmark and Switzerland. Half of the projects have been finalized before 30 months (2.5 years), both in Denmark and Switzerland.

Project duration	Switzerland	Denmark
Mean	30.6 months	30.0 months
Median	2.5 years	2.5 years
Minimum	0.5 years	1 year
Maximum	4.5 years	4 years

Project duration of Eurostars projects

Share of projects completed (%)



Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Technological areas

The Eurostars programme classifies the projects according to five different technological areas. In terms of technological areas, Denmark and Switzerland show very similar characteristics. Figure 1 shows the number of approved projects of Swiss companies per technological area from 2008-2018 according to the year of the project start. Figure 2 shows the numbers for Denmark.

For Switzerland, from the beginning of the programme in 2008 until 2018, **86 (34%) of approved projects** – in which a Swiss firm has been involved – **have been assigned to Biotech**, 75 projects (29%) to Industrial, 62 projects (24%) to ICT, 19 projects (7%) to Environment and 14 projects (5%) to Energy.

For Denmark, **93 (40%) of approved projects have been assigned to Biotech**, 59 projects (25%) to Industrial, 42 projects (18%) to ICT, 22 projects (9%) to Environment and 18 projects (8%) to Energy.

Technological area of approved projects

Technological area	Switzerland	Denmark
Biotech	86 (33.7%)	93 (39.7 %)
Energy	14 (5.5 %)	18 (7.7 %)
Environment	19 (7.4 %)	22 (9.4 %)
ICT	62 (24.2 %)	42 (18.0 %)
Industrial	75 (29.3 %)	59 (25.2 %)
Total	256 (100 %)	234 (100%)

Fig. 1: Switzerland, number of approved projects by Tech Area

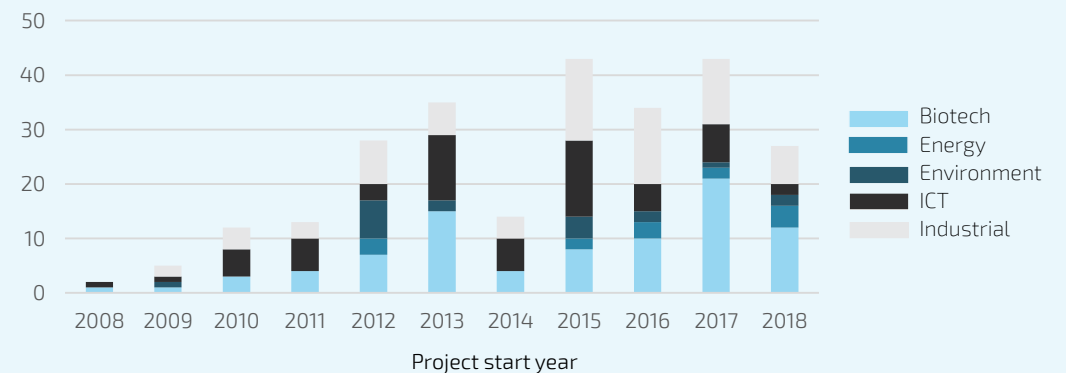
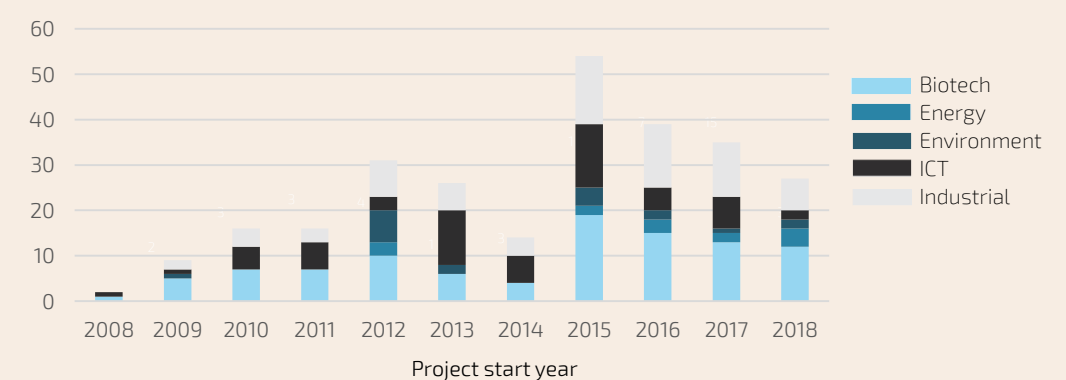


Fig. 2: Denmark, number of approved projects by Tech Area

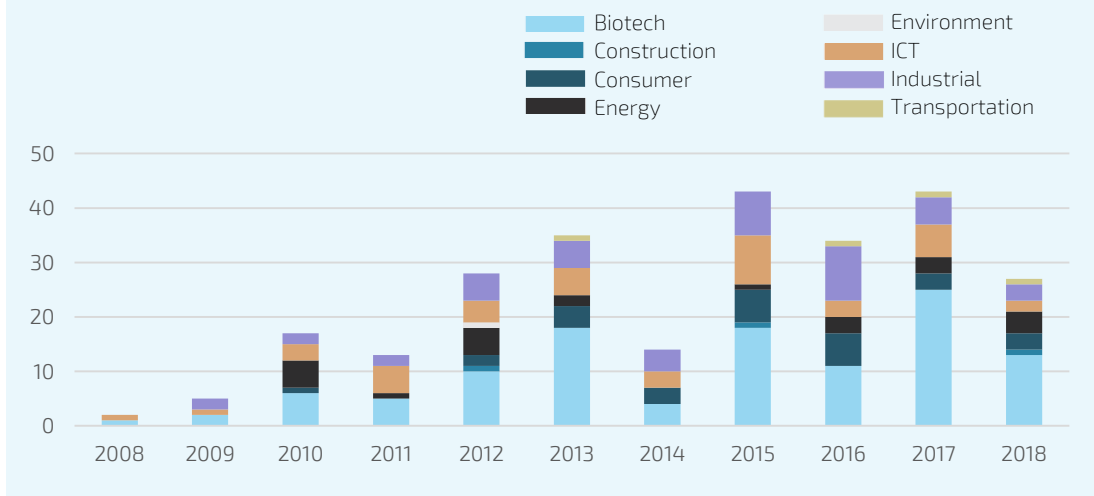


Both figures and table: Data source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Fig. 1 shows the number of approved project from Swiss companies per technological area in the year of the project start from 2008-2018. Fig. 2 indicates the number for Denmark from 2008-2018. The table summarizes the absolute number and percentages of the specific technological areas.

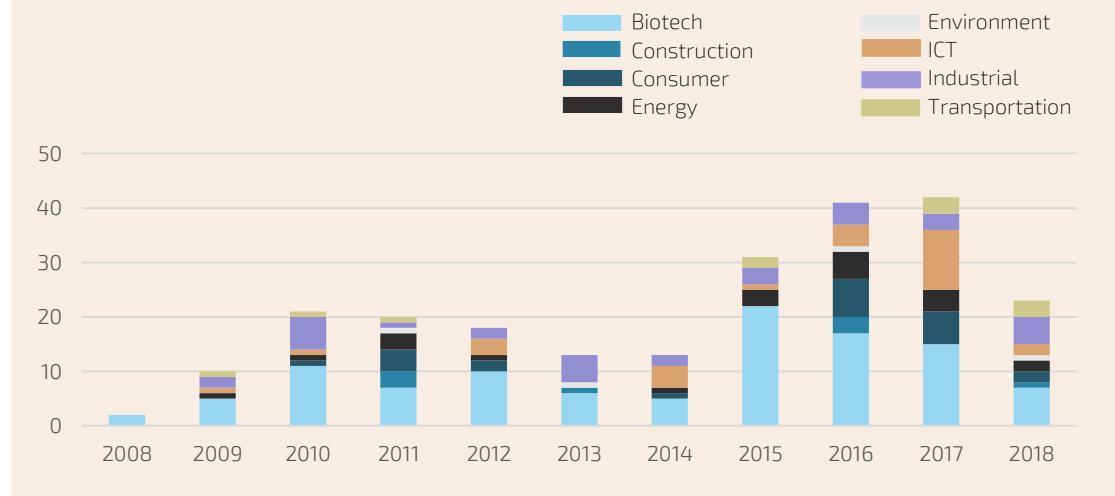
Market areas of approved Eurostars projects

Fig. 1: Number of Swiss approved projects by market area



Beyond the technological area, approved projects in the Eurostars programme are classified according to the market area of the involved companies. Alike the technological areas, Denmark and Switzerland are also very similar in terms of market areas of the approved projects. Figure 1 indicates the number of approved projects of Swiss companies per market area from 2008-2018 according to the year the project starts. Figure 2 shows the numbers for Denmark. The table summarizes the absolute number and percentages of the specific market areas.

Fig.2: Number of Danish approved projects by market area



Market area	Switzerland	Denmark	Market area	Switzerland	Denmark
Biotech	113 (44.1%)	107 (45.7%)	Consumer	28 (10.9%)	23 (9.8%)
Environment	1 (0.4%)	4 (1.7%)	Industrial	46 (18.0%)	33 (14.1%)
Construction	3 (1.2 %)	8 (3.4%)	Energy	19 (7.4%)	21 (9.0%)
ICT	42 (16.4%)	27 (11.6%)	Transportation	4 (1.6%)	11 (4.7%)
Total				256 (100%)	234 (100%)

Both figures and table: Data source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Fig. 1 shows the number of approved project from Swiss companies per market area in the year of the project start from 2008-2018. Fig. 2 indicates the number for Denmark from 2008-2018. The table summarizes the absolute number and percentages of the specific market areas the companies operate. If there is a project with two Swiss or Danish companies involved, this is indicated as two "Swiss/Danish projects" in one year.

Eurostars financial support for approved projects

The average public funding per firm partner amounts to 182k EUR in Switzerland and to 189k EUR in Denmark. This is close to the overall average of 181K EUR of the entire Eurostars programme. The average public funding for approved projects varies from 44k EUR in 2010 to 260K EUR in 2014 in Switzerland and ranges from 119k EUR to 377K EUR in Denmark.

Fig. 1: Committed funding for Swiss and Danish companies in approved projects

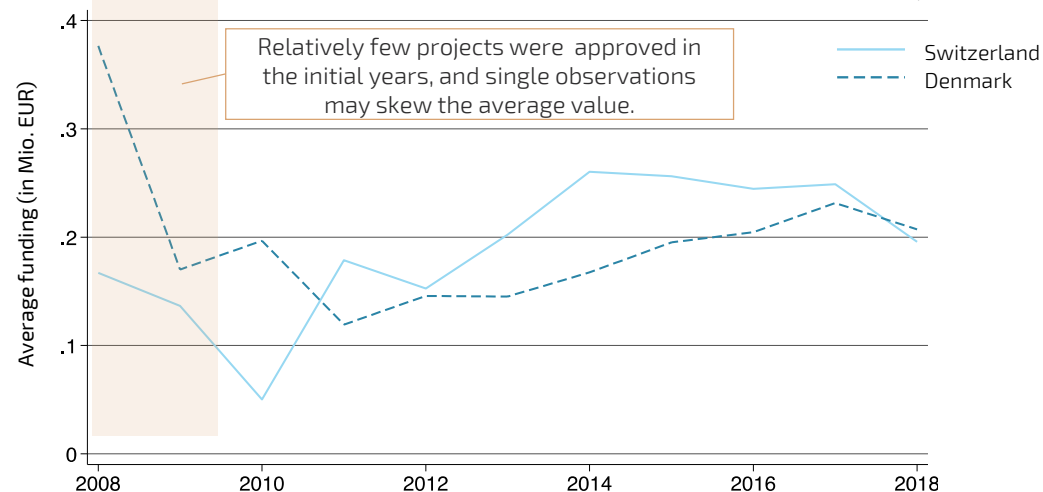


Fig. 1 shows the mean of financial support in Switzerland and Denmark obtained for the approved project per year.

Fig. 2: Committed funding per partner for Swiss and Danish companies in approved projects

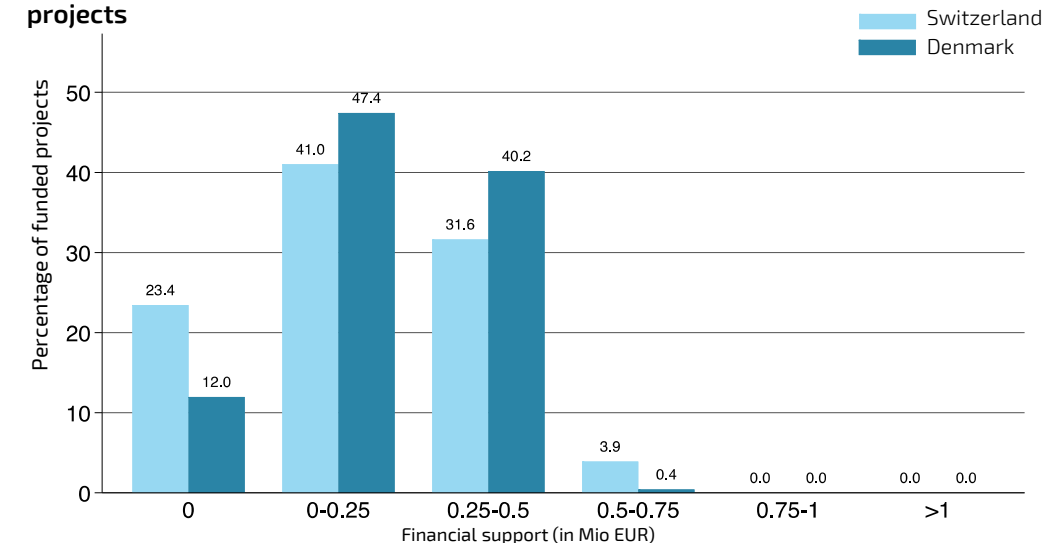


Fig. 2 shows financial support grouped into classes. The money obtained by Swiss or Danish companies is defined by the committed public funding received from Eurostars.

Project cost coverage in Switzerland and Denmark

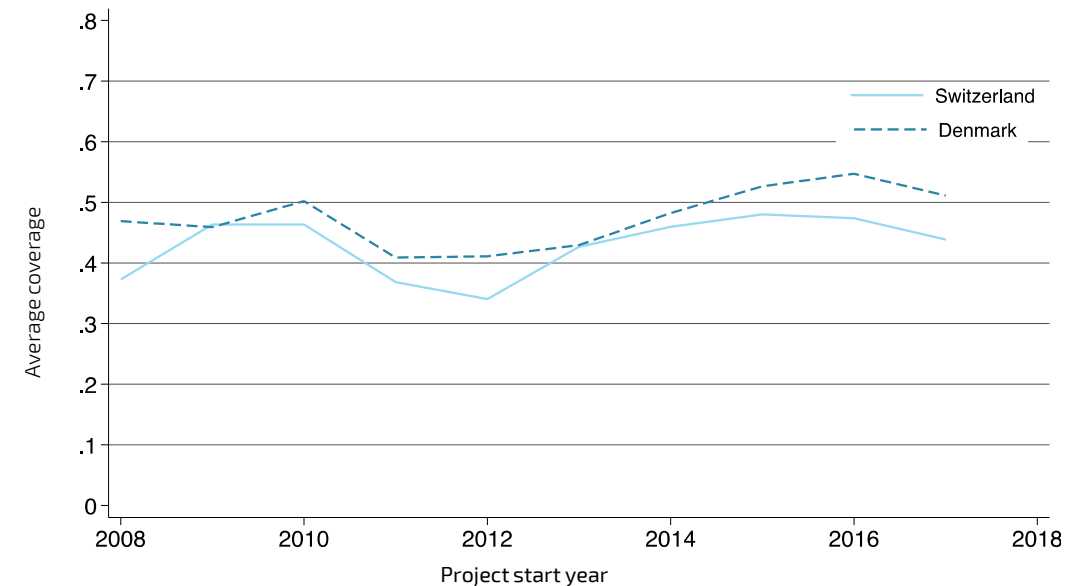
The Eurostars programme provides direct financial support for the approved projects. The graph on the right shows the average funding rate of the projects per Danish and Swiss partners. The funding rate corresponds to the percentage of total project costs covered by Eurostar's committed financial support per partner.

In Switzerland the average funding rate is 43.6% compared to 49.1% in Denmark (period from 2008-2017). The funding rates varies between 34.0% and 48.0% for Swiss firms, and between 40.9% to 54.7% for Danish firms.

Overall in all Eurostars countries, on average around 45.8% of the total projects costs are covered by the Eurostars programme (period from 2011 to 2017).

The development of the average cost coverages does not differ systematically in Denmark and Switzerland, and hence we conclude that the project cost coverage does not introduce a systematic bias in the impact of funding. However, it can be seen that the funding rates are a little bit higher in Denmark compared to Switzerland.

Average coverage of total project costs through public funding (per partner)



The figure shows the funding ratio of the approved projects per partner, meaning the percentage of total project costs covered by Eurostar's committed financial support. The figures for 2018 are not presented due to missing information..

Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Project evaluation scores

Submitted applications are evaluated by an expert panel on a score from 0 to 600. Over all the scores for Swiss and Danish applications are remarkably similar. This finding rules out that the systematic differences in the quality of the projects might possibly affect the effect of funding.

The actual scores range from 0 to 545 in Switzerland, respectively to 541 in Denmark. Figure 1 groups Swiss and Danish firm applicants depending on their achieved evaluation scores for their Eurostars application.

Further data shows us that (not presented here), the average evaluation score of all applicants is 383 in Switzerland and 387 in Denmark. Half of the submitted Eurostars applications obtain scores above 406 in Switzerland and 408 in Denmark.

Fig. 1: Project evaluation scores, firm applicants

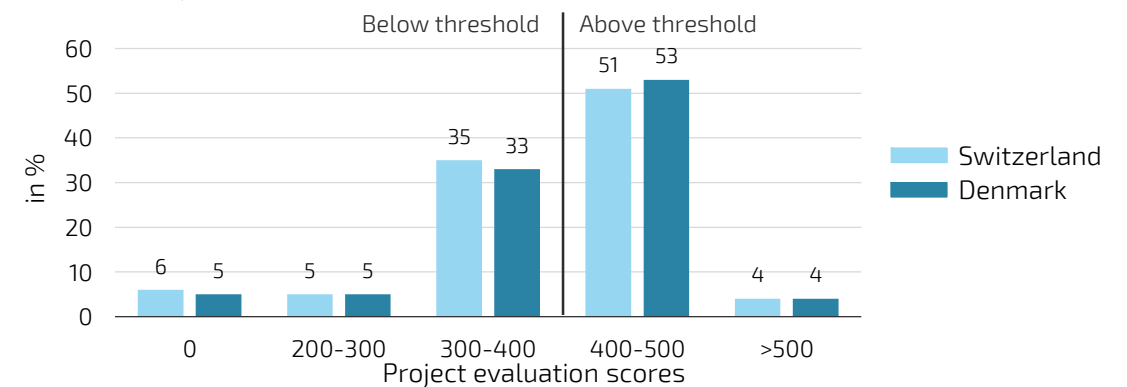
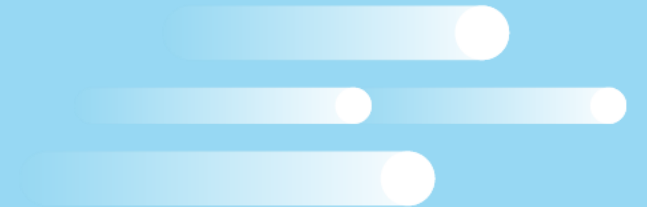


Fig. 1 Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung. Fig. 1 groups Swiss and Danish Firm applicants into groups depending on their score for their Eurostars application.

3. The Danish & Swiss companies in Eurostars



Most Eurostars companies have less than 50 employees

Most companies in Eurostars projects are small or micro sized, which is defined as less than 50 full time employees (FTEs). 9 out of 10 Eurostars companies in Denmark and Switzerland have less than 50 FTEs. This is in line with the purpose of the Eurostars Programme that mainly funds and supports SMEs and their partners. There are few companies larger than 250 FTEs, and they participate as partnering companies. Regarding size, the companies (applicants) with non-approved project proposals are similar to the companies that were approved.

Fig 1: Size of Swiss Eurostars companies at start of project

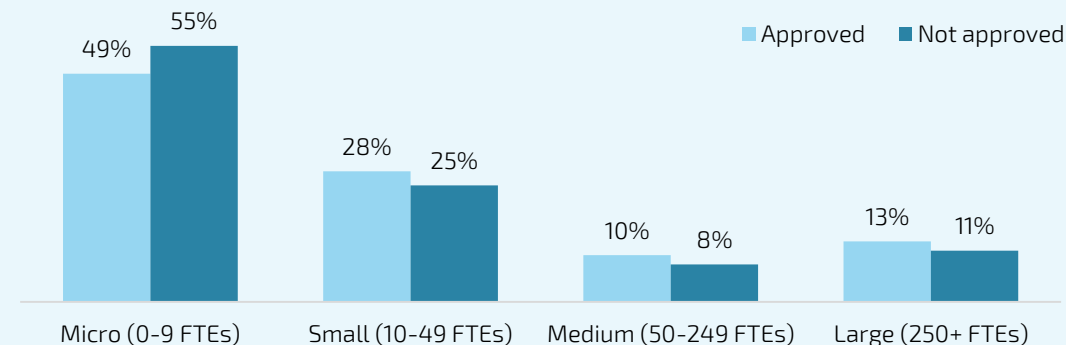
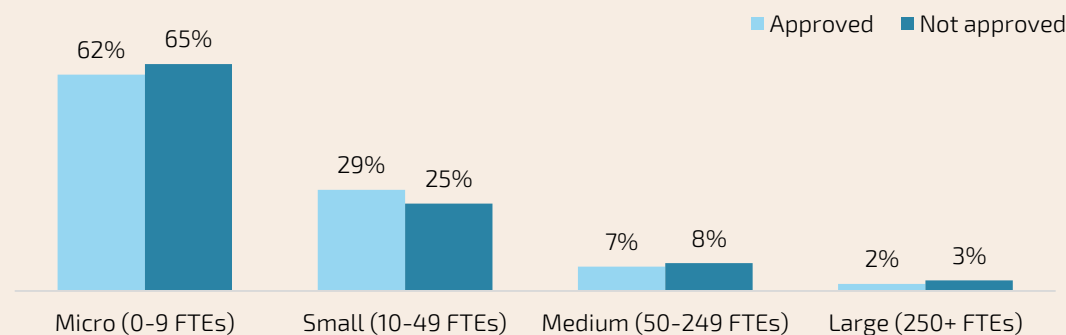


Fig 2: Size of Danish Eurostars companies at start of project



Source: Eureka; Statistics Denmark; CVR; Swiss Federal Statistical Office (SF50).

The majority has a turnover of less than 2 million EUR

Approximately 7 out of 10 Eurostars participants in Switzerland and Denmark had a turnover of less than 2 million EUR the year their project started. This is in line with the Eurostars Programme targeting SME's.

In Denmark, 4 percent did not earn anything the year their project started. In Switzerland it is 23 percent. It is not clear what causes this difference, but part of it is likely driven by minor differences in the data used for the two countries.

Given the descriptive information in the figure, there seems to be no discrimination in terms of realized turnover in order to get the project approved. This means firm applicants with with non-approved projects are similar in turnover to approved enterprises.

Fig 1: Turnover of Swiss Eurostars companies at start of project (euro)

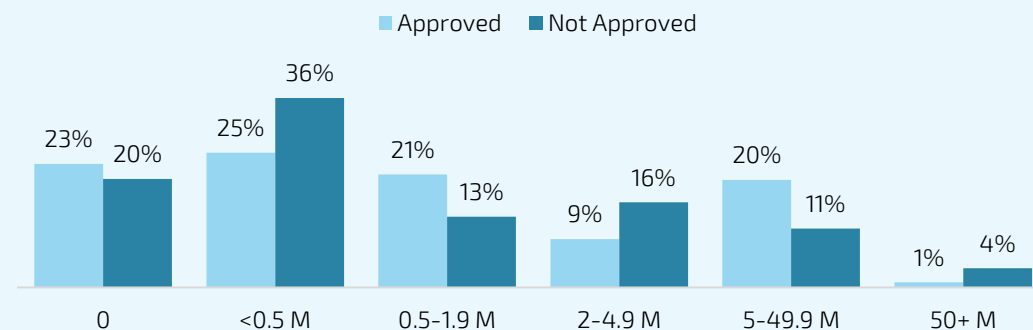
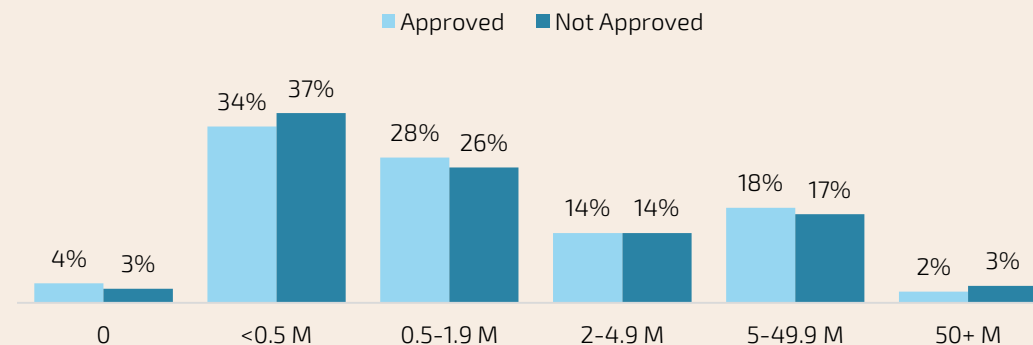


Fig 2: Turnover of Danish Eurostars companies at start of project (euro)



Source: Eureka; Statistics Denmark; CVR; Swiss Federal Statistical Office (SFSO).

Note: The figure shows the turnover in the project start year. For not approved projects, the project start date is the intended project start date in the application form.

Both young and older companies participate in Eurostars

Both young and older companies participate in Eurostars. In terms of age, 43% of the Swiss and 36% of the Danish companies were established at least 10 years before their project started. At the end 8% and 16% of the participants in Switzerland and Denmark are less than one year old. This reflects that the participants are both new companies with new ideas and settled companies that know how to navigate the market and the field of research.

Fig 1: Age of Swiss Eurostars companies at start of project

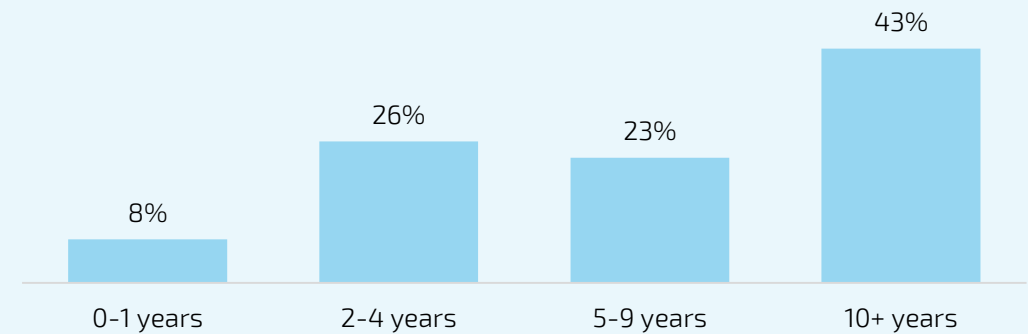
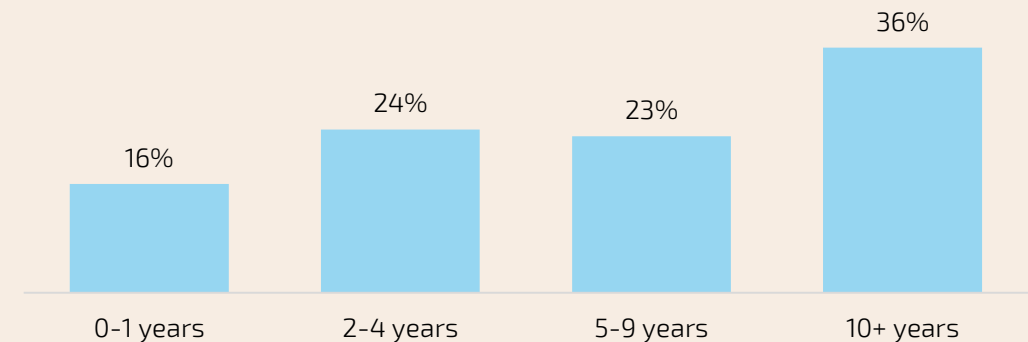


Fig 2: Age of Danish Eurostars companies at start of project



Source: Eureka; Statistics Denmark; CVR; Swiss Federal Statistical Office (SFSO).

The role of Eurostars applicants

A Eurostars applicant is characterized by its role within the Eurostars consortium. The project leader must be a R&D intensive SME and takes the role of a «main participant» within the project whereas the other applicants take the role of a «partner».

Literature points out that the role of a partner affects the outcome of a consortium participants (see e.g. Gulati, 1995). Figure 1 shows the percentages of applicants by the role as a main participant or partner. Figure 2 shows the number of projects with a Swiss and Danish main participant per project start year.

71% of Swiss applicants act as a partner, 28% as a main applicant (project leader). 65% of Danish applicants are a partner, and 34% are a main applicant (project leader) within a Eurostars consortium.

The number of approved projects where a Swiss or Danish applicant act as a main participant has continuously risen since the start of the Eurostars programme in 2007. In 2017, 18 projects started with a Swiss main participant and 23 projects with a Danish main participant.

Fig. 1: Role of applicants, all applicants

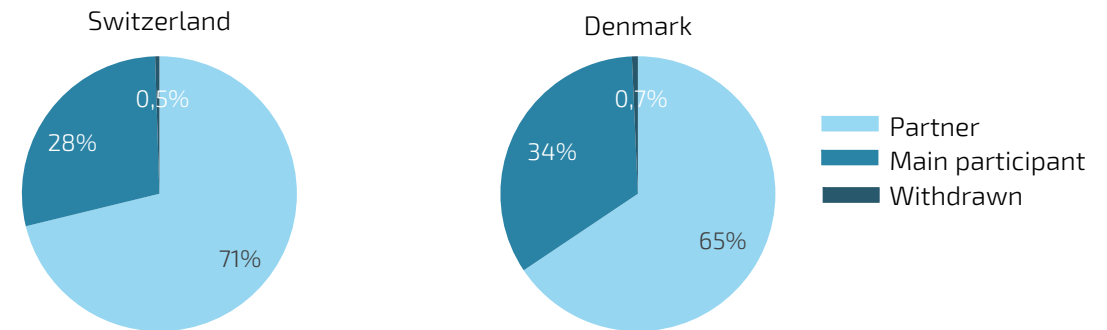


Fig. 2: Main participants, number of approved projects

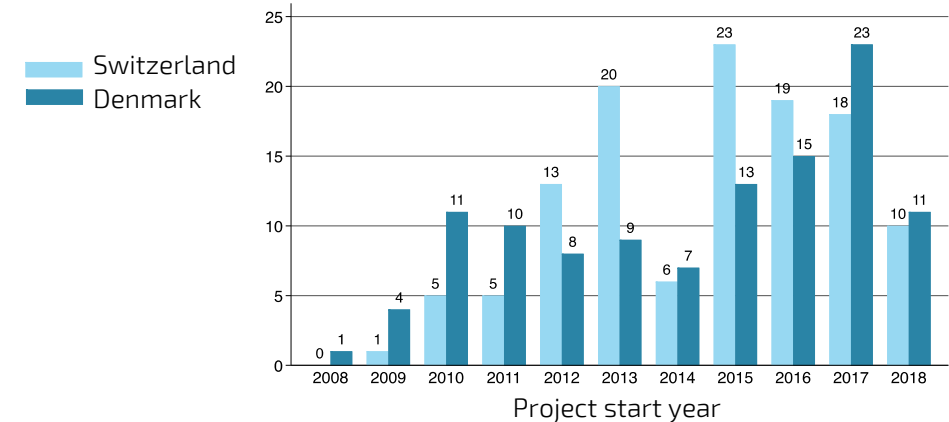


Fig. 1 & 2 Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Relatively many project coordinators

Each Eurostars project has a coordinator who syndicates the project. The coordinator often has relatively large influence on the project, and may arguably get relatively large benefits from the project. However, this hypothesis has not been tested in this analysis.

About 40% of the projects with Swiss partners have a Swiss coordinator. And for Denmark the share is 55%.

Fig. 1: Distribution of Coordinators 2008-2018 in funded projects with Swiss partners

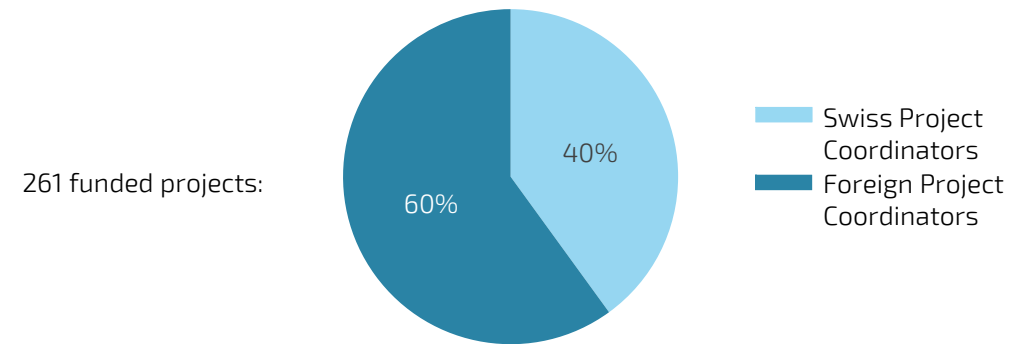


Fig. 2: Distribution of Coordinators 2008-2018 in funded projects with Danish partners

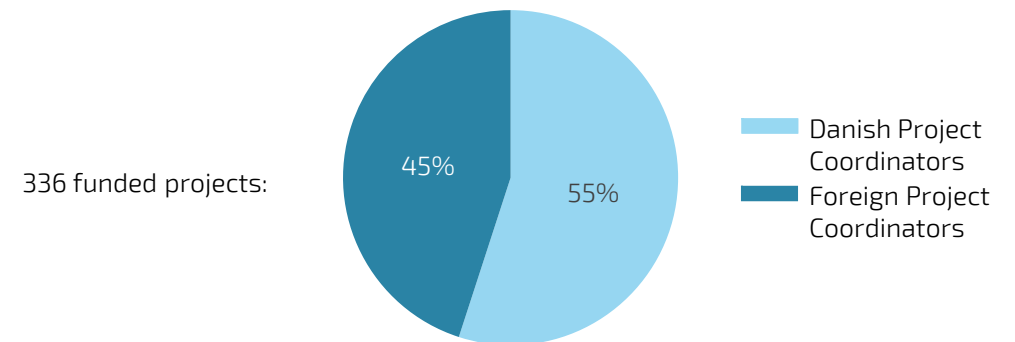


Fig. 1 & 2 Data Source: Eureka. Calculations: Eureka.

The organizations that participate in Eurostar projects

Swiss organizations have participated 400 times in Eurostars projects since the first Swiss projects in 2008. Of these, 224 are finalized. Note, that since more than one organization can participate in the same project, this number is higher than the total number of projects.

As shown in Table 1, the programme is mostly used by R&D intensive SMEs (R&D SMEs). Universities and other research institutes are frequently chosen as project partner.

Tab. 1: Swiss organisations in approved projects, number of participations

Type of organisation	In approved projects	In finalized approved projects
Large company	20 (5%)	8 (3.57%)
Other	4 (1%)	2 (0.9%)
R&D SME	230 (57.5%)	132 (58.9%)
Research Institute	47 (11.75%)	29 (12.9%)
SME	6 (1.5%)	3 (1.3%)
University	93 (23.25%)	50 (22.3%)
Total	400 (100%)	224 (100%)

The general picture is similar in Denmark. Danish organizations have participated in Eurostars projects 347 times. Most users are R&D intensive SMEs.

Universities participate relatively less, but this is countered by more participations by research institutes. The Danish Research and Technology Organizations (GTS) participate in several projects and contribute with knowledge and technical equipment, that to some extent are handled by universities in other countries.

Tab. 2: Danish organisations in approved projects, number of participations

Type of organisation	In approved projects	In finalized approved projects
Large company	15 (4.3%)	6 (3%)
Other	5 (1.45%)	0 (0%)
R&D SME	209 (60%)	107 (61%)
Research Institute	62 (18%)	41 (23%)
SME	10 (3%)	7 (4%)
University	46 (13.25%)	15 (9%)
Total	347 (100%)	176 (100%)

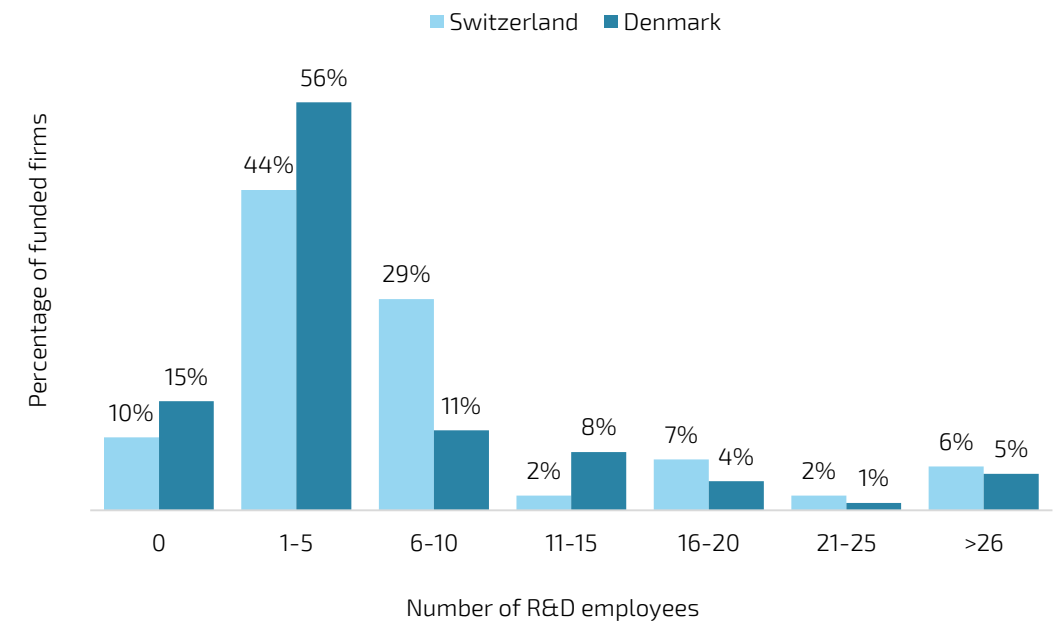
Tab. 1 & Tab. 2 Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung

R&D - Employees

Around 80% in Switzerland and 90% in Denmark of all participating firms in Eurostars have less than 50 FTEs – around half of the Eurostars firms in Switzerland and around 60% in Denmark have less than 10 FTEs. Given this background, Eurostars firms with approved projects are characterized by a relatively high number of dedicated R&D employees compared to their total employment. These findings hold for both countries, Switzerland and Denmark alike.

In absolute numbers, **54% of firms in Switzerland, respectively 71% in Denmark have less than 6 R&D employees**. Notably, only 6% (Switzerland) and 5% (Denmark) of participating Eurostars firms have more than 25 employees assigned to R&D activities.

Number of R&D employees in funded firms in Switzerland and Denmark



The figure shows the distribution of Swiss and Danish firms with approved projects classified by the number of R&D employees.

Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Consortium size involving a Swiss or Danish main participant

The diversity of the collaboration alliance has an important role for the success of the collaboration (e.g. Beck & Schenker-Wicki, 2014; Gulati, 1995). According to the literature the main project leader provides a strong signal to the environment, and motivates other partners to engage in a collaboration (Lokshin et al., 2011).

The figures indicate the number of approved projects of all Swiss (Fig. 1) and all Danish main participants (Fig. 2) and show with how many partners they have been collaborating in the project.

While the number of approved projects with a Swiss or Danish main participant has been constantly increasing over time, the number of collaborating partners within a project has rather been stable over time and it is similar between Denmark and Switzerland. **In Switzerland, 83% of the main participants collaborate with up to three partners, respectively 88% in Denmark.**

Fig. 1: Number of cooperation partners of projects with a Swiss main participant

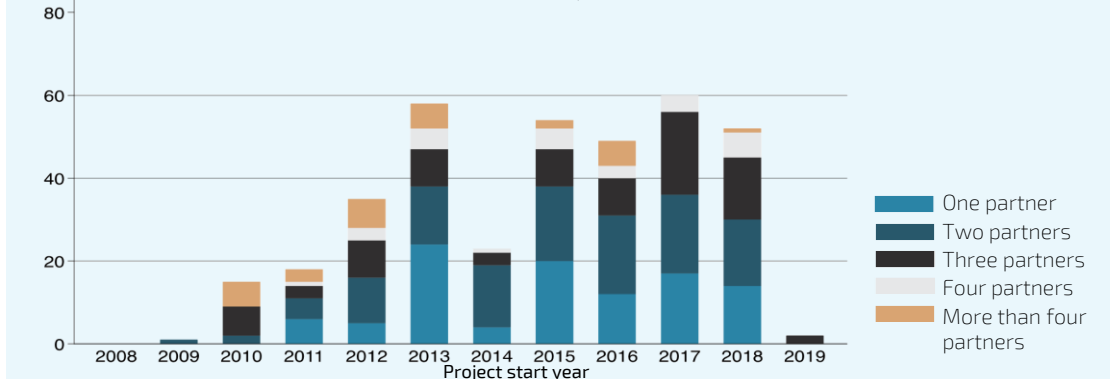


Fig. 2: Number of cooperation partners of projects with a Danish main participant

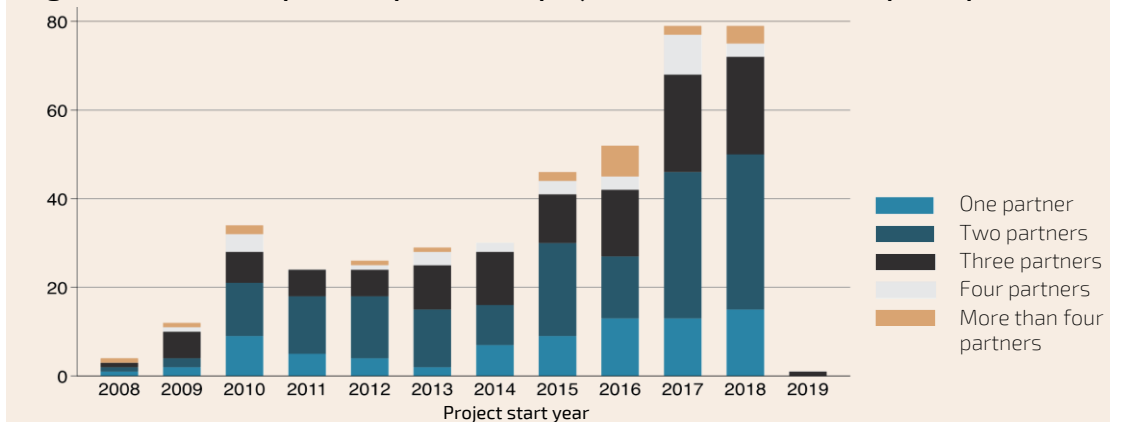


Fig. 1 & 2 Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung. Figures 1 & 2 show the number of approved projects of all Swiss (Fig. 1) and Danish main participants (Fig. 2) and with how many partners they have been working in the project.

Partners' organisation types involving a Swiss and Danish main participant

The alliance partner portfolio has a strong impact on innovation generated by the collaboration consortium (e.g. Beck & Lopes-Bento, 2016; Phelps, 2010; Sampson, R. C. (2007). We are to characterize the consortium by different organisation types such as R&D intensive SMEs, large companies, universities and other research institutions.

Figures 1 & 2 show the type of organisation a Swiss main participant (Fig. 1) and Danish main participant (Figure 2) collaborates within the consortium.

For example, 42% of the organizations that Swiss main participants collaborate with are R&D intensive SMEs. 46% are universities or research institutes.

The picture is similar for Danish main participants. 46% of their partners are R&D intensive SMEs and 38% are universities or research institutes.

In sum, the composition of the consortium appears comparable among Swiss and Danish main participants.

Fig. 1: Organization types, partners of Swiss main participants

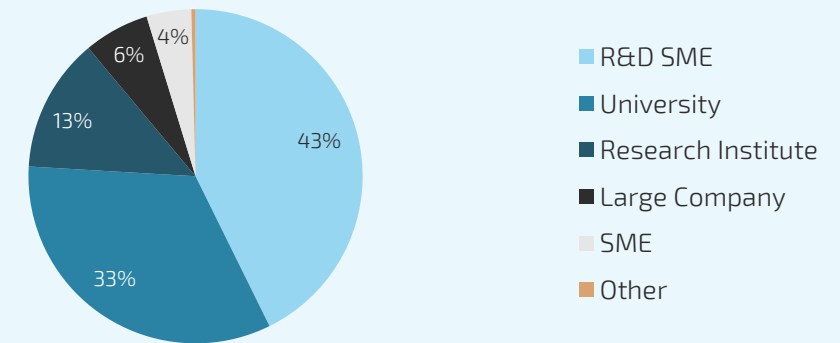


Fig. 2: Organization types, partners of Danish main participants

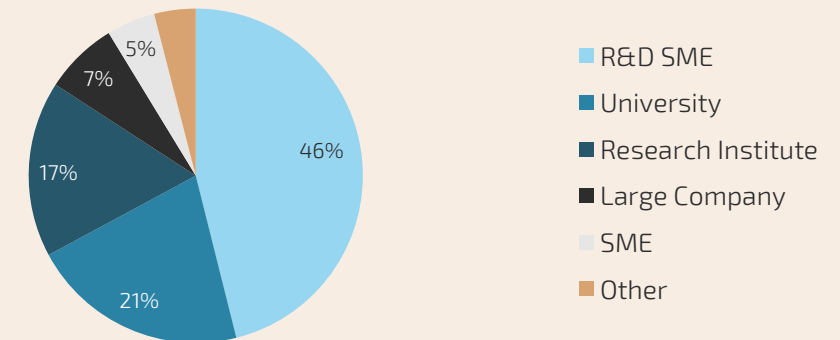


Fig. 1 & 2 Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B.S.S. Volkswirtschaftliche Beratung. The figures show the type of organisation a Swiss main participant (Fig. 1) and Danish main participant (Fig. 2) collaborates within the consortium. The pool of partners refers to all organisation types, and is regardless of the status of the project or whether the project has been approved or not.

Partners' geographical region of origin

The figures show the partners' geographical region of origin of Swiss (Fig. 1) and Danish main participants (Fig. 2).

As can be seen from Figure 1, the majority of partners of Swiss main participants originates from abroad. Only about 20% of the partners come from Switzerland. Most of the foreign partners come from EU-member countries.

Fig. 1: Geographical region of partners' origin of Swiss Main participants

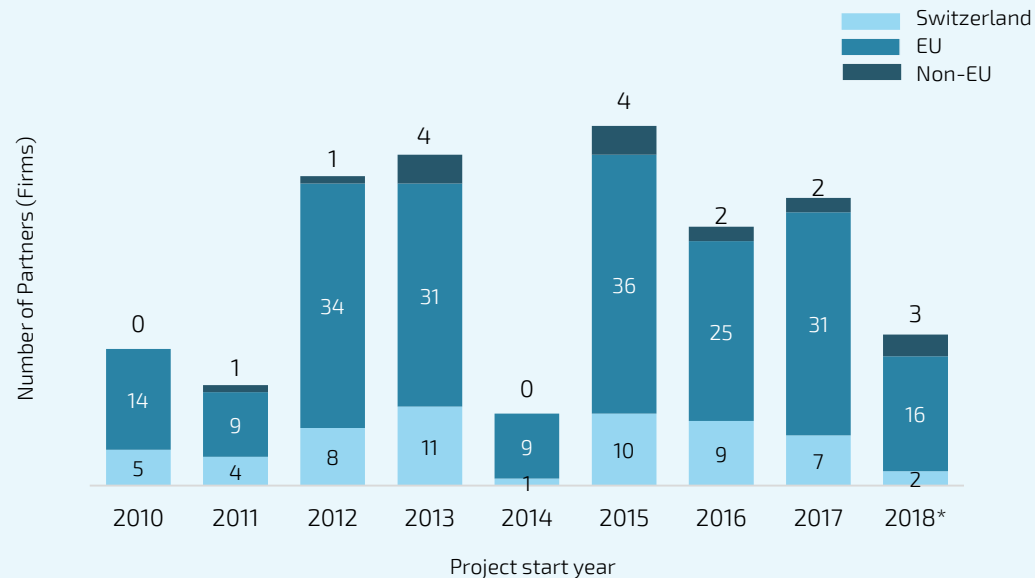


Figure 2 draws a similar picture for Denmark. However, the share of partners originating from Denmark is higher (33%). About 13% of the partners come from countries outside EU, namely Canada, Israel, Turkey, South Africa and South Korea, which also participate in Eurostars.

Both figures highlight the openness of the economy in Switzerland and Denmark in particular when it comes to the transfer of knowledge and technology.

Fig. 2: Geographical region of partners' origin of Danish Main participants

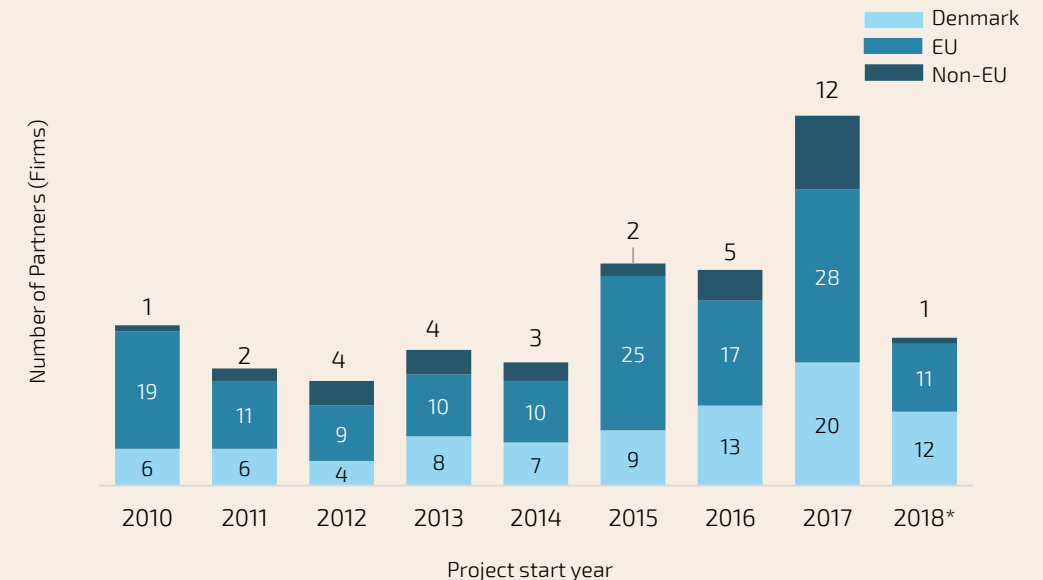
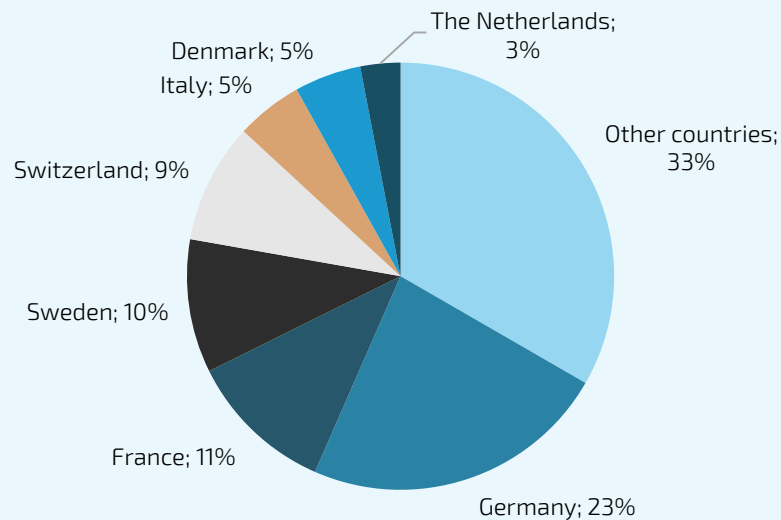


Fig. 1 & 2 Data Source: Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B.S.S. Volkswirtschaftliche Beratung. The figures show the partners' geographical region of Swiss (Fig. 1) and Danish main participants (Fig. 2). The pool of partners refers to all firm partners, and is regardless of the project status or whether or not the project has been approved.

Partners' country of origin involving a Swiss or Danish Main applicant

Fig. 1: Country of origin of the partners of Swiss main participants



The figures show the partners' country of origin of Swiss (Fig. 1) and Danish (Fig. 2) Main partners.

Figure 1 exhibits that **91% of firms as a partner of Swiss main participants come from outside Switzerland**. A considering number of firms come from neighbouring countries such as Germany (23%), France (11%), and Italy (5%). Notably, 15% of the partners come from Nordic countries, such as Sweden (10%) and Denmark (5%).

Fig. 2: Country of origin of the partners of Danish main participants

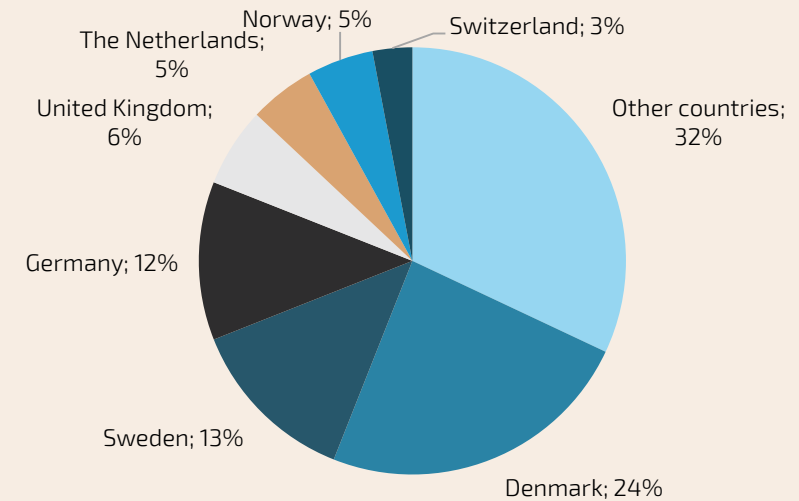


Fig. 2 mirrors the picture in the case of Denmark, however only **76% of firms as a partner of Danish main participants come from outside Denmark**. Many firms come from neighbouring countries such as Sweden (13%), Germany (13%) or Norway (5%). Notably, 6% of the partners come from the UK.

More than 4 out of 5 achieve successful project result

Almost all Eurostars firms submit a Final Reports (FIR) when the projects are finalized. The FIRs are mandatory and each participant has to fill them out right after project end or face a reduction in the funding. The questions in the FIR focus primarily on the results of the projects. For example, the participants are asked if the outcomes of the project are what they expected before submitting the application and if the project results are successfully achieved. According to the FIRs, 4 out of 5 participants agree that the project result is successfully achieved, meaning that the majority have had a immediate positive result from participating in the Eurostars Programme.

Fig. 1: 85% of Swiss participants say the project result was successfully achieved

Question: "Is the project result (product, process/services) successfully achieved?"

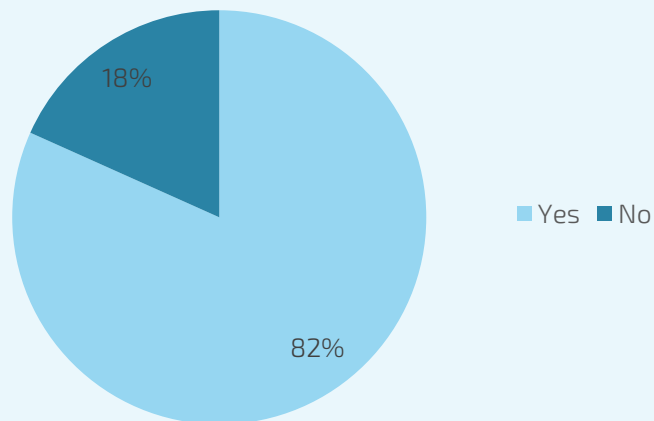
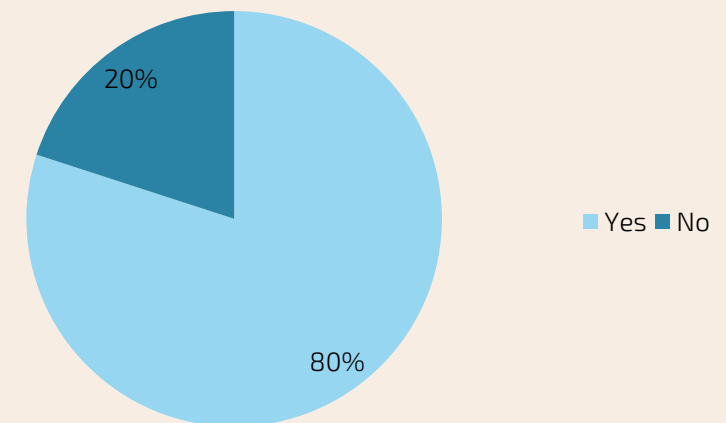


Fig. 2: 80% of Danish participants say the project result was successfully achieved

Question: "Is the project result (product, process/services) successfully achieved?"



Case: A Danish-Swiss project

Eurostars promotes international cooperation. The project SensiScreen Lung is one of many examples of how companies, universities and other organizations have joined forces to develop new solutions. In this project PentaBase, a Danish biotech company, collaborated with Danish Technological Institute and Instituto Cantonale Di Patologia, a Swiss reference laboratory. The project ran from 2013 to 2016. There was high expectations for this project. The application received the best evaluation out of 600 applications.

Pentabase has participated in five Eurostars projects. When they began they had 3 full time employees – they now have 14.

PentaBase needed access to clinical trials to develop new method to screen for lung cancer

The purpose of the project was to carry out sensitive diagnostics for lung cancer patients using biopsies to be able to monitor the patients. PentaBase applied for the Eurostars Programme as they needed access to clinical trials to carry out the project, and they found the best way to get this was to team up with a hospital, that had access to patients. The Swiss laboratory had this.

Outcome and impact

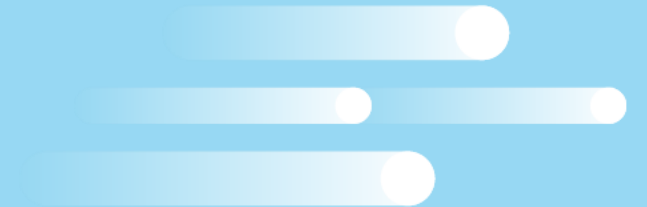
PentaBase introduced a new screening method to the market in the fall 2018, approximately two years after the project end. The product generates turnover, half of which comes from exports, and they have increased staff with 3 full time employees as a result of the project. They expect to increase their total revenue by 40 percent the following year, of which 30 percent can be credited to this project/product.

In addition, the project have resulted in an expansion of PentaBase's network, a patent and three forthcoming articles. However, the product has only been on the market for less than a year, and therefore the full impact have absolutely not been realized yet.

According to PentaBase, they could not have developed the product without the help and funding they received from Eurostars. At least not at the same speed.



4. Descriptive economic indicators



How we measure the impact of the Eurostars programme

The purpose of this report is to present Eurostars and to evaluate whether Eurostars helps companies improve their economic performance. In other words whether the companies perform better than if they had not participated – or essentially if the Eurostars programme did not exist.

The challenge is to choose a proper control group that are as similar as possible to the Eurostars firms. We use descriptive comparisons as well as advanced statistical methods to identify these control groups. In this section we mainly use two different control groups chosen among i) the rejected applicants (*not approved*) and ii) all other SMEs. For Denmark we use an additional control group, namely SMEs that are similar to the Eurostars SMEs in terms of size and sector.

Using the non-approved applicants as a control group disregards the catalytic impact of the application process, including the dialogue with foreign partners. As mentioned in the European Commission's evaluation of Eurostars 1, the rejected applicants may have been able to find other public funding in order to undertake the project – or financed the project by other means (Makarow, 2014).

We have chosen to focus on Eurostars effect on SME's performance. There are two main reasons for this. First, the main purpose of Eurostars is to help SMEs innovate and grow. Secondly, the effect on large companies is difficult to isolate because the projects are relatively small compared with the myriad of activities of large companies.

Considering the descriptive comparisons of economic indicators, we show the development of the outcomes from one year prior to the project start until two or three years after project start depending on data availability. We aim at investigating if the groups show a specific trend.

We evaluate the development of Eurostars SMEs using the following economic indicators derived from the Swiss Federal Statistical Office (SFSO) and Statistics Denmark: Employment, R&D employment (only CHE), Education level (only DNK), Turnover, Export (only DNK) and Labour productivity (only DNK).

The full impact of Eurostars have not been realized yet. This is certainly true for the newer projects, but also for the older projects. For some projects it may take up to some years to realize the full impact. Also, – as noted above – for many projects we only have data on the economic performance for a few years after project start – and there is a severe lack of data for the years after project end. For these reasons we are not able to isolate the full funding effects from the Eurostars programme.

In this section (4) we will look descriptively at the economic outcomes over time. In the next section (5) we use econometric analysis to handle issues with dissimilarity between participating firms and the comparison group.

R&D employment in Swiss Eurostars SMEs

When a company participates in a Eurostars project, what we expect to see is an increase in R&D employment. When the project has been approved, the company can invest in the project according to the plan in the proposal and expect reimbursements from Eureka. In order to perform these new tasks, R&D labour demand tends to increase.

With a rise in investments, we might expect employment to increase in participating firms. **In general, funded Swiss SMEs employ more R&D workforce than the non-approved and average Eurostars Swiss SMEs after project start.** The composition of firms in the approved and non-approved firm groups might however have changed considerably over the years.

Number of observations in subgroups

Number of Observations	Approved Swiss SMEs	Not Approved Swiss SMEs	All Eurostars Swiss SMEs
t=-1	8	12	20
t=0	13	4	17
t=1	4	6	10
t=2	7	9	16

Average R&D employment before and after project start (FTE)



Note: The years before and after the project start are indicated by "Years t = [-1, 0, 1, 2]". The above figures include all firms that are available in the R&D statistics of the SFSO data in the given year relative to project start. The number of firms in each group differs from year to year (see page Tab. 1). The light blue solid line shows average R&D employment for the approved firms available in the Swiss firm data one year before until two years after participation, whereas the dashed lines show the average R&D employment for the non-approved firms, respectively all Swiss Eurostars SMEs available one year before until two years after project start.

Data source: R&D statistics (SFSO), Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Employment in Swiss Eurostars SMEs

The effects of Eurostars funding can also go beyond the R&D workforce, and can stimulate additional employment growth. This might be the case if the project cannot be carried out by existing labour resources in the company but requires that the firms hire more employees – and to some extent employees with other competences.

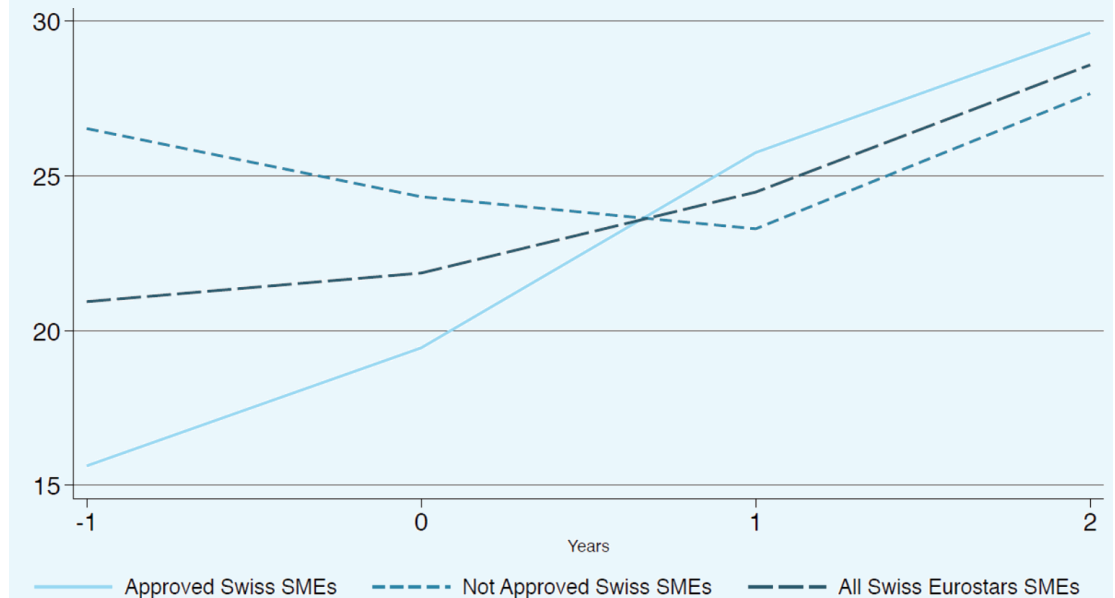
In general, funded Swiss SMEs employ more people than the non-approved Swiss SMEs. Again here, the composition of firms in the respective groups of approved and non-approved firms might have changed over the years. However notably, approved firms are somewhat larger after project start compared to before project start.

Both groups of approved and non-approved Swiss SMEs have seen a slight increases in size from the year before participation to the following years.

Number of observations in subgroups

Number of Observations	Approved Swiss SMEs	Not Approved Swiss SMEs	All Eurostars Swiss SMEs
t=-1	97	92	189
t=0	106	104	210
t=1	91	98	189
t=2	70	78	148

Average employment before and after project start (FTE)



Note: The years before and after the project start are indicated by "Years $t = [-1, 0, 1, 2]$ ". The above figures include all firms that are available in the Swiss firm register data in the given year relative to project start. The number of firms in each group differs from year to year (see page Tab. 1). The light blue solid line shows the average FTE employment for the approved firms available in the Swiss firm data one year before until two years after participation, whereas the dashed lines show the average FTE employment for the non-approved firms, respectively all Swiss Eurostars SMEs available one year before until two years after project start.

Data source: STATENT, BZ (SFSO), Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Turnover in Swiss Eurostars SMEs

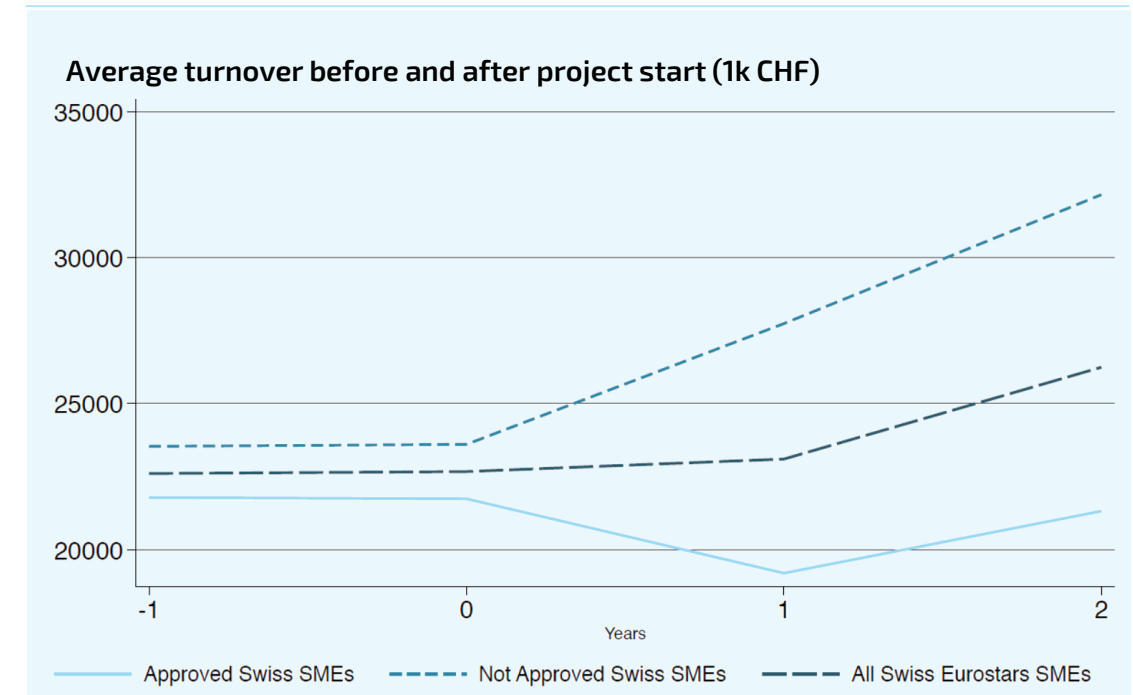
The Eurostars projects are typically not expected to affect turnover of the participating firms during the project or immediately after the conclusion. The new solutions are not expected to be implemented until at least two years after the projects end – or five years after project start.

According to the Figure 1 on the right, **the average turnover for the approved Swiss firms is lower compared to the non-approved Swiss Eurostars SMEs. One year after project start the figure indicates a slight increase in average turnover of approved Swiss SMEs.**

However, the growth rates are affected by the fact that not all firms appear in the Swiss firm data in all years. Increases and decreases can be a result of changing group compositions.

Number of observations in subgroups

Number of Observations	Approved Swiss SMEs	Not Approved Swiss SMEs	All Eurostars Swiss SMEs
t=-1	25	22	47
t=0	25	25	50
t=1	19	16	35
t=2	18	15	33



Note: The years before and after the project start are indicated by "Years t = [-1, 0, 1, 2]". The above figures include all firms that are available in the Swiss firm level data (SF50) in the given year relative to project start. The number of firms in each group differs from year to year (see page Tab. 1). The light blue solid line shows the average total turnover for the approved firms available in the Swiss firm data one year before until two years after participation, whereas the dashed lines show the average total turnover for the non-approved firms, respectively all Swiss Eurostars SMEs available one year before until two years after project start.

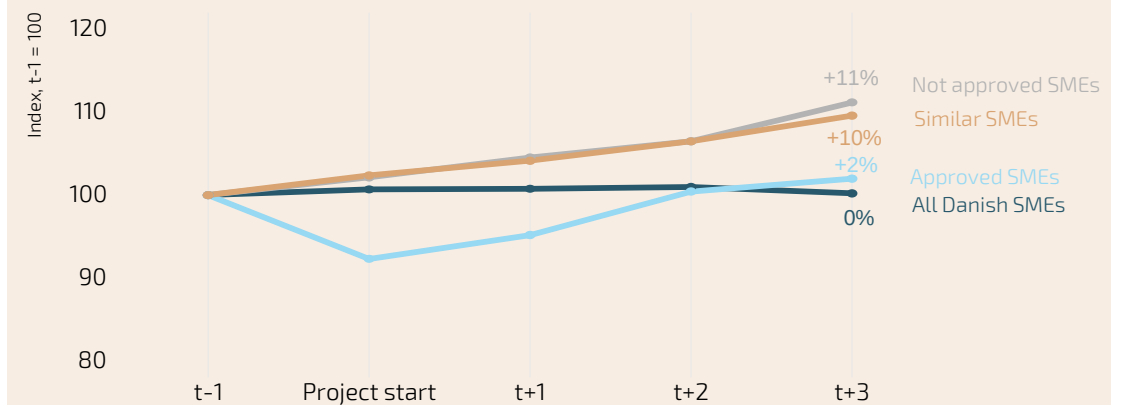
Data source: Value added statistics (SF50), Eureka. Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Employment in Danish Eurostars SMEs

The approved Danish SMEs does not employ more than other SMEs. On contrary, the non-approved SMEs have on average hired more than the approved. So has the similar SMEs, ie. the group of SMEs that resembles the approved SMEs with respect to size and sector.

The approved SMEs have overall experienced a decrease in the number of full-time employees from the year before project start to the project start year. However, after project start and in the project period they have experienced a growth in full-time employment.

Employment before and after project start

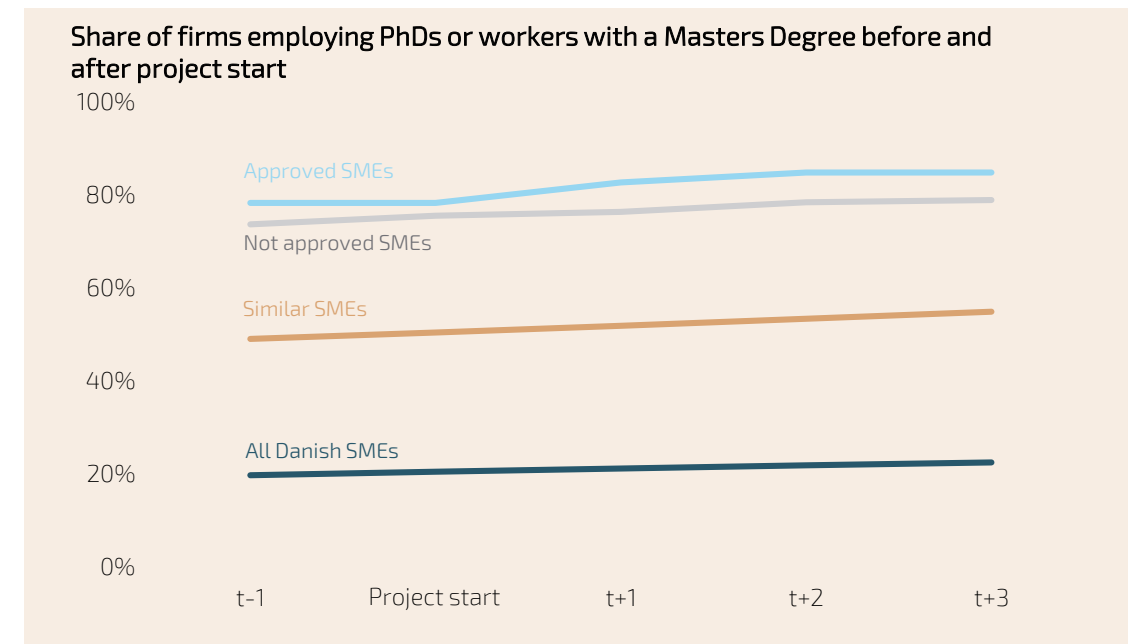
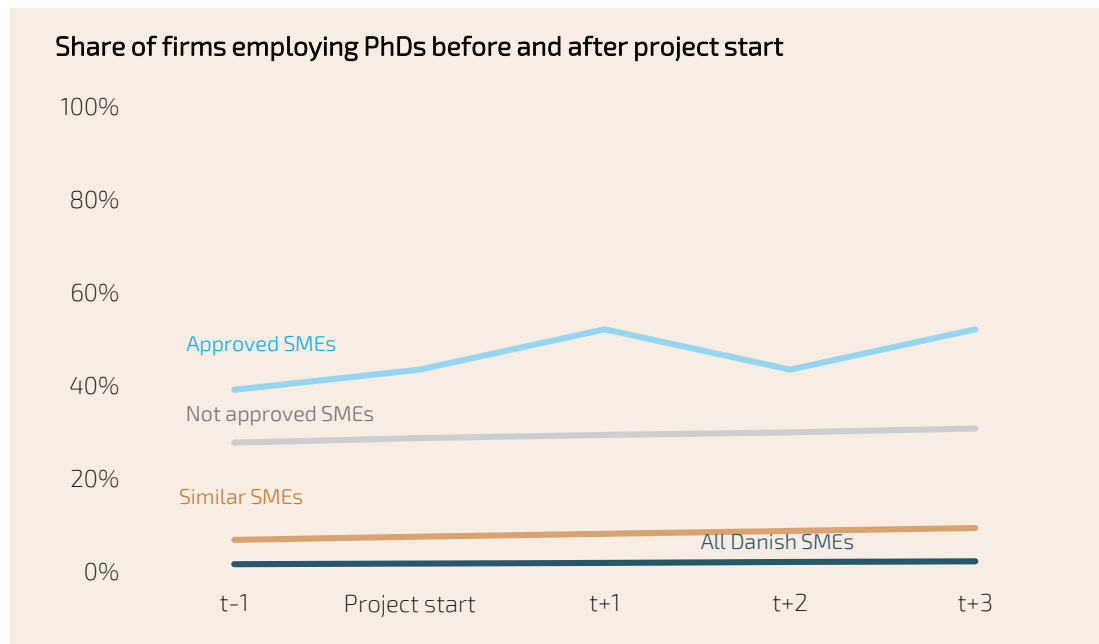


Source: Eureka and Statistics Denmark.

Note: The figure shows the growth in employment for the same group of firms. The light blue line shows the growth in employment for the approved firms available one year before and three years after project start (N = 49).

Education level in Danish Eurostars SMEs

The below figures show the share of firms that employ highly educated workers before and after project start in Denmark. In general, the approved Eurostars firms employ highly educated workers – around 45 percent of the firms employ a PhD and 80 percent employ PhDs or workers with a Masters Degree. The figure to the left indicates that a greater share of the participating SMEs employ PhDs after project start than before compared to the non-approved SMEs, similar SMEs and all Danish SMEs.



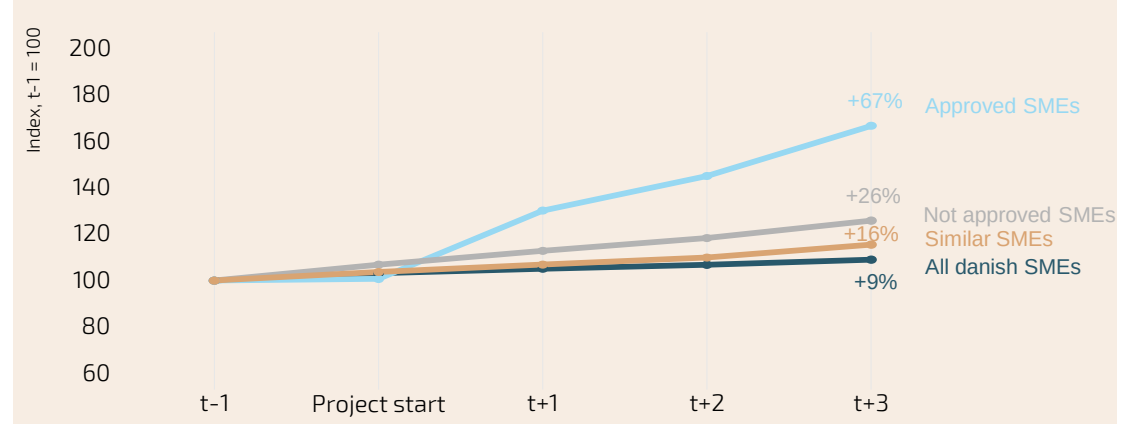
Source: Eureka and Statistics Denmark.

Note: The figure shows the growth in investment intensity for the same group of firms. The light blue line shows the growth in investment intensity for the approved firms available one year before and three years after project start (N = 46).

Turnover in Danish Eurostars SMEs

The total turnover of all the Danish approved SMEs was 665 million EUR in 2016. In general the approved SMEs have experienced a significantly higher growth in turnover after their projects begin compared to the not approved SMEs as well as the group of similar SMEs and all SMEs.

Turnover before and after project start



Source: Eureka and Statistics Denmark.

Note: The figure shows the growth in turnover for the same group of firms. The light blue line shows the growth in turnover for the approved firms available one year before and three years after project start (N = 49).

Exports in Danish Eurostars SMEs

The approved SMEs differ from the average SMEs in several aspects. The approved SMEs are more prone to export. About 60% of the Danish approved SMEs have export compared to 15% among all Danish SMEs, see table 1. The share of firms with export is also markedly higher than other SMEs with similar size and sector affiliations.

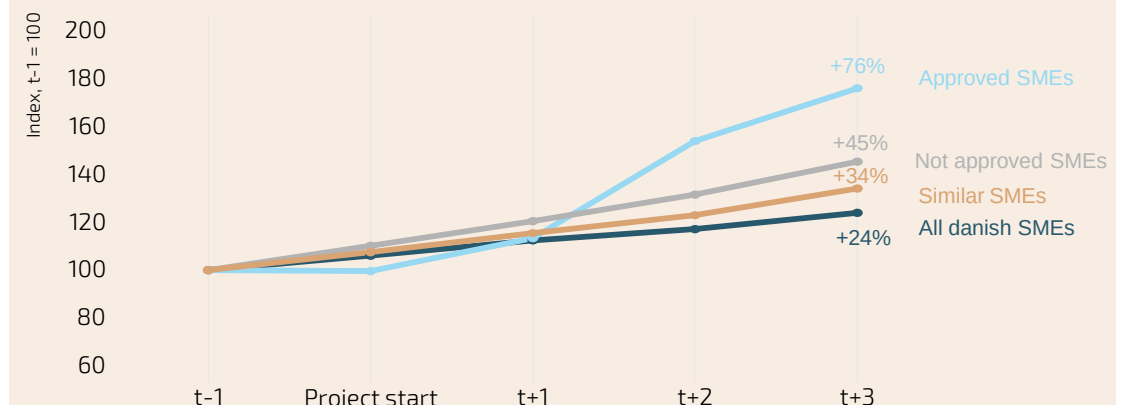
The pattern is quite consistent from 2006 to 2016. This indicates, that Eurostars is particularly relevant for firms with an international perspective.

The approved SMEs appears to increase the export levels after starting Eurostars projects. On average the exports have increased significantly two and three years after project start. At this point the projects have not resulted in new products on the market. Therefore the growth must be due to other factors. The export growth is most likely related to the international dimension in Eurostars, which connects firms and organization across borders allowing them to discover new possibilities in foreign markets.

Table 1: Share of firms with export, 2006-2016

	2006	2008	2010	2012	2014	2016
Approved SMEs	60 %	56 %	55 %	54 %	56 %	61 %
Not-approved SMEs	58 %	55 %	56 %	57 %	56 %	59 %
Similar SMEs	33 %	31 %	33 %	35 %	36 %	34 %
All Danish SMEs	11 %	11 %	12 %	13 %	14 %	15 %

Fig. 1: Exports before and after project start



Source: Eureka and Statistics Denmark.

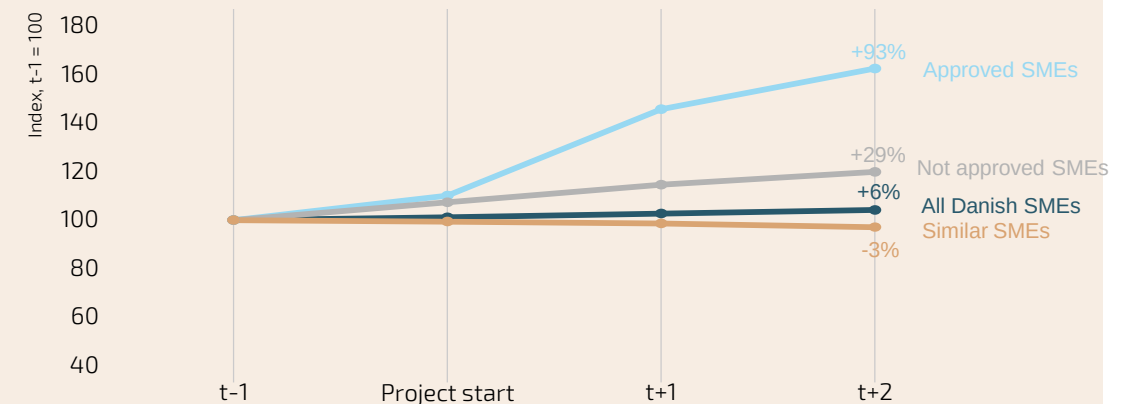
Note: The figure shows the growth in exports the same group of firms. The light blue line shows the growth in exports for the approved firms available one year before and three years after project start (N = 49).

Productivity in Danish Eurostars SMEs

Increasing productivity means creating more value per input – either by increasing output or reducing input. Or both. This benefits the firms and society as a whole measured for example by a higher GDP. One way to increase productivity this is to develop new solutions and technology, that allows more efficient production or new products of high value. Eurostars is designed for this.

The descriptive analysis confirms that the approved SMEs increase their productivity significantly more than the other groups of SMEs we compare with. This happens already 1 and 2 years after the projects start at which point there has not yet been developed and implemented new solutions. This indicates, that the growth in productivity is a result of other factors, for example learning effects and new contacts in foreign countries.

Productivity in the years before and after project start

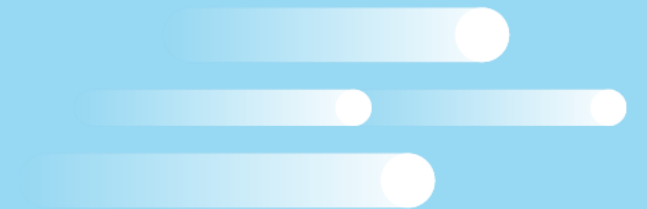


Source: Eureka and Statistics Denmark.

Note: The figure shows the growth in productivity for the same group of firms. The light blue line shows the growth in productivity for the approved firms available one year before and to years after project start (N = 59).

Part 2 – Econometric analysis

5. Impact on firms performance



Introduction to the econometric analysis

In the previous section we presented descriptive indicators for the economic performance of the Eurostars firms. However, comparing the economic outcomes of the different groups over time is not enough to conclude anything about the effect of participating in the Eurostars Programme, as the groups may display dissimilar characteristics and/or trends.

In this section we use econometric methods to identify and estimate the causal impact of Eurostars participation on firms' performance. To do this, we employ the so-called difference-in-difference framework, which is one of the most popular research designs in econometric programme evaluation (e.g. Cerulli, 2015; Makarow et al., 2014). The key ingredient is to construct a control group of SMEs which are similar with respect to their characteristics (size, industry) and their past employment dynamics.

We compare the economic performance of approved SMEs to the performance of SMEs with non-approved projects as well as to all other SMEs in the economy.

To analyse the data on a relative time axis, we randomly assign project start years to non-Eurostars firms. Our assignment mechanism ensures that the relative frequency of project start years is the same as the relative frequency among approved SMEs.

For Switzerland the analysis is restricted to FTE employment as a performance measure due to data limitations. For Denmark we have also estimate the effect on turnover, exports, investments and labor productivity.

Generally, the results suggest that Eurostars participation helped to boost employment for the approved SMEs. The employment effects are observed from the beginning of the project phase and tend to increase over time.

The effect on other performance indicators is unclear.

The estimated effect on other performance indicators is less clear and quite sensitive to even small changes in the analytical setup. As mentioned above, we do not expect to see any substantial effect on indicators such as turnover and labor productivity, since these effects are not expected until a few years after the projects end – where we do not yet have sufficient data to estimate the effect.

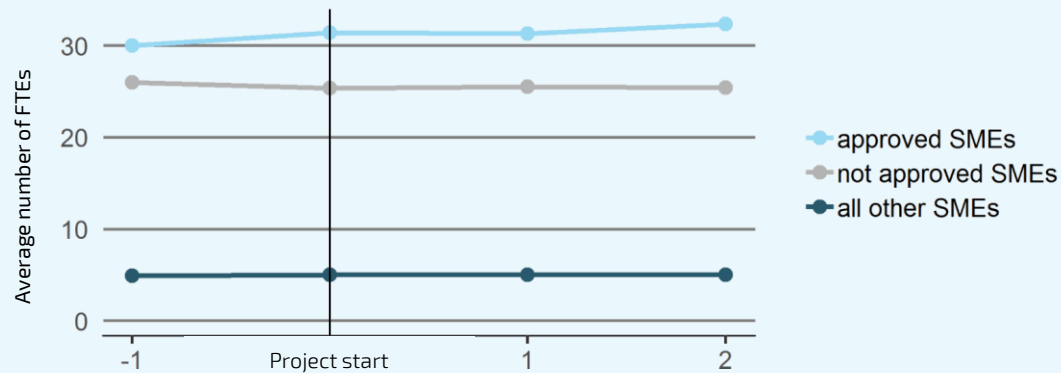
Validity of the estimated effects

It is fair to ask whether the estimated effects accurately measure the true causal impact that Eurostars participation had on employment in these approved SMEs ("internal validity"). The answer hinges most critically on the **unobserved trend assumption**: this assumption states that our constructed control group accurately captures the employment trend that we would have observed among approved SMEs if they had not received Eurostars funding. To address this, we condition on firm size, past employment dynamics and industry composition. The belief is that firms within the same industries, with the same size and the same employment growth in the past make this assumption likely to hold. However, it is possible that the comparability of the control group may not be sufficient due to unobserved factors. For example, it is possible that approved SMEs are more likely to be exporters, register more patents or employ more specialized workers than control group SMEs. If these characteristics affected future employment growth (beyond similar employment growth in the past), we would tend to over-estimate the effect of Eurostars participation.

Employment in Swiss Eurostars firms

Below, we consider firms that can be observed between one year before and two years after the project start year (approved SMEs: N=71). We see that approved Eurostars SMEs have an average of 30 full-time equivalent employees (FTE) prior to project start. They are slightly larger than non-approved firms. The average Swiss SME is considerably smaller.

Fig. 1: Employment (FTEs) before and after project start

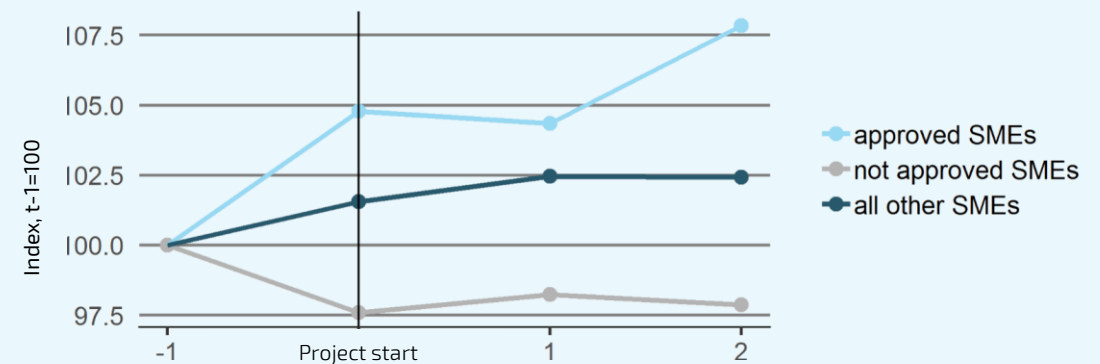


Source: Eureka; BZ, STATENT (SFSO). Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung

Note: The project start year is marked with «0». The figure shows the growth in employment for firms observed between t=-1 and t=2. Sample sizes are: 71 approved SMEs, 96 not approved SMEs, 272'981 other SMEs.

The figure below shows the relative change in average employment (FTEs) over time. Approved SMEs grew by about 7.5 percent during the first three years of the project phase. This growth in employment was more pronounced compared to other Swiss SMEs. At the same time, not approved SMEs experienced a slight decline in employment.

Fig. 2: Employment before and after project start (Index, year t-1 = 100)



Source: Eureka; BZ, STATENT (SFSO). Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung

Note: The project start year is marked with «0». The figure shows the relative growth in average employment for firms observed between t=-1 and t=2. Sample sizes are: 71 approved SMEs, 96 not approved SMEs, 272'981 other SMEs.

Econometric treatment analysis of employment effects

The previous analysis has demonstrated that approved SMEs have grown more strongly in terms of FTE employment than other groups of SMEs. However, this result is purely descriptive, only for the observable SMEs from t-1 until t+2, and suggestive regarding the potential impact of the Eurostars funding on employment growth. After all, we do not know how the approved SMEs would have evolved in the absence of the funding – they might have grown faster in any case.

To estimate the causal effect of Eurostars participation on firms' performance, we conduct an econometric treatment analysis using the so-called **difference-in-difference method**. Due to data limitations, however, the analysis only considers employment as the outcome variable.

To proceed, we construct a "control group" out of all other Swiss SMEs that is as similar as possible to the Eurostars participants:

- To effectively capture employment dynamics prior to Eurostars participation, we only consider SMEs that are observed at least four years prior and three years after the project start year (in total, eight years). This leaves **38 Eurostars participants and 117'000 SMEs in the control group**.
- Firms from industries, where no approved SME can be found, are excluded. This ensures overlap between Eurostars SMEs and the control group with respect to the detailed industry classification (4-digit-level). This step **reduces the size of the control group further to 12'000 Swiss SMEs**.
- Using a so-called **propensity score method**, the control group is "re-weighted" such that the average employment level, log employment level and employment growth prior to the project start year and the industry composition (almost) exactly matches those of the approved SMEs. The numbers are shown in the table on the right.

Tab. 1: Average characteristics of re-weighted control group SMEs and approved SMEs

		control group SMEs	approved SMEs
Variables			
Employment level	t-4	39.1	39.2
	t-3	40.9	41.0
	t-2	42.1	42.2
	t-1	42.6	42.7
Employment growth from previous year	t-3	-0.5%	-0.4%
	t-2	5.1%	5.1%
	t-1	5.9%	5.9%
Ma. of chemicals and chemical prod.	two-digit industry classification	5.3%	5.3%
Ma. of computer and electronic prod.		28.9%	28.9%
Ma. of machinery and equipment n.e.c.		10.5%	10.5%
Computer progr., consult. and rel. act.		10.6%	10.5%
Architectural and engineering act.		5.3%	5.3%
Scientific research and development		7.9%	7.9%
Oth. prof., scientific and technical act.		7.9%	7.9%
number of SMEs		12'170	38

Source: Eureka; BZ, STATENT (SFSO). Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S.

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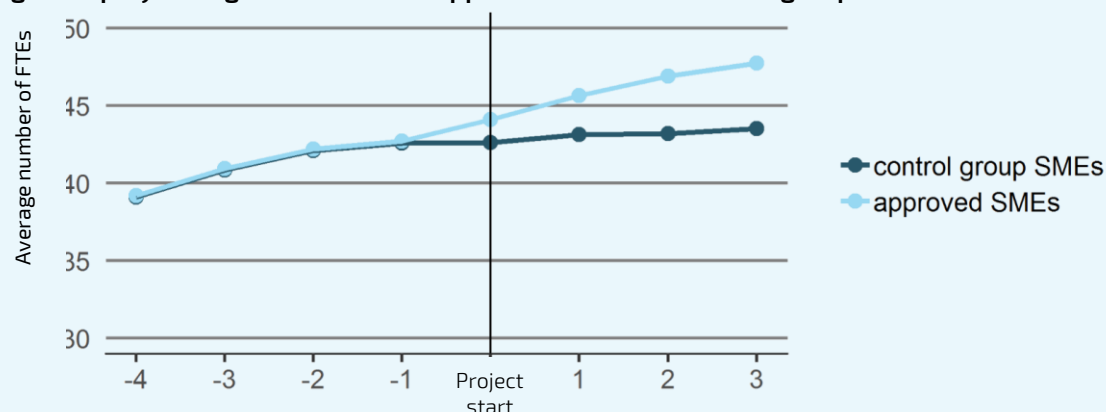
Note: The table shows the average characteristics across the re-weighted control group SMEs and the approved SMEs. Industry codes with only a single approved SMEs are omitted for ease of exposition.

Econometric analysis of employment effects in Switzerland

The figure below shows the evolution of average employment across a period of eight years: four years prior to three years after the project start year. Due to the econometric re-weighting, past employment dynamics between approved SMEs and control group SMEs match almost exactly.

The results suggest that Eurostars participation boosted employment in the first three years after the project start. If we take the figure at face value, the **increase in employment appears to be around 5 FTEs**.

Fig. 1: Employment growth between approved SMEs and control group SMEs



Source: Eureka; BZ, STATENT (SFSO). Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S.

Volkswirtschaftliche Beratung

Note: The figure shows average employment for the re-weighted control group SMEs (N=12'170) and the approved SMEs (38). Only firms that are observed over a period of eight years (t=-4 to t=3) are included.

Employing an econometric model, the **estimated effect of Eurostars participation on employment is roughly 12 percent in the project start year and about 17 – 19 percent in the first three years after project start**. These effects are statistically significant. In other words, Eurostars funding appears to have increased employment growth among approved SMEs quite substantially.

Note that the relative effects from the econometric model do not directly compare to the relative effect in the figure: The econometric estimates accounts for differences in firm-specific employment levels (so-called fixed effects) and are therefore more robust estimates.

Tab. 1: Estimated effect of Eurostars participation on (log) employment

period	coefficient	st. error	p-value
t=-3	0.000	0.019	0.986
t=-2	0.000	0.018	0.979
t=0	0.125 ***	0.045	0.005
t=1	0.167 ***	0.049	0.001
t=2	0.193 ***	0.068	0.005
t=3	0.169 *	0.094	0.071
number of observations			97'664
number of firms			12'208
adjusted R-squared			0.963

Source: Eureka; BZ, STATENT (SFSO). Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S.

Volkswirtschaftliche Beratung

Note: The table shows estimated effects of Eurostars participation on log employment. The model includes firm-level fixed effects. Standard errors are clustered at the firm level. The sample consists of approved and control group SMEs observed between t=-4 and t=3 (balanced panel).

Economic impact of Eurostars in Switzerland

Policy makers are often interested in the socio-economic impact of a support programme. In order to evaluate the socio-economic impact of Eurostars, a "back-of-the-envelope" calculation can be derived from the econometric treatment effects analysis (e.g. Makarow et al., 2014). Our treatments effects estimates measure the effect of funding (for a individual firm) compared to a counterfactual situation (for an identical firm) of not having received the funding. Hence our treatment estimates can be used to causally analyse a total programme effect.

Interpretations of this exercise should be undertaken with care, as it relies on a subset of crucial assumptions which we cannot verify:

- (1) In the sample for the treatment effects regressions we have 38 treated firms. We assume that these 38 observations are representative of the 256 treated firm observations that are approved for funding in Switzerland.
- (2) The initial firm size before funding amounts to 42.6 FTEs in in our regression sample. We assume that the firm size effects are representative of the 256 treated firm observations.
- (3) For firms in our sample, we observe the employment development over a period of 6 years. In the following calculations, we assume that employment effects are similar in those treated firms which are outside of our sample. Overall, we assume that the treatment effects are stable over the period of observation, explicitly, they are independent on the time they start and are not affected differently by varying economic conditions.

In accordance with Makarow et al., (2014), we calculate the number of created jobs by the initial employment level multiplied by the treatment factor four years after project start. Multiplying this number by the 256 treated firm observations in Switzerland, that received a grant, we obtain the total employment creation of the programme.

Total employment creation after four years after project start can be written as :

$$\text{Employment Creation (CH)} = ((42.6 * (1 + 0.169) - 42.6) * 256 = 42.6 * (0.169) * 256 = 1'843$$

which means that **approximately 1'843 FTEs are created through the programme.**

By all means, this number is a rough estimation and should be treated with care. To illustrate how sensitive this number reacts to variation in the sample, we provide the calculations using the 95% confidence interval for the treatment coefficients. The point estimates presented in the Table on slide 50, show that the treatment coefficients are statistically significant different from zero. However, rather than using precise point estimates, we can also allow that with 95% confidence the true parameters of the population lie between a lower and upper bound. Taking account these lower and upper bounds for the size of coefficients, we can re-calculate the number of created jobs.

Extrapolating the treatment effects for the total population of treated firms, we find that the employment effect ranges between -109 FTEs for the lower bound, and 3'817 created FTEs using the upper bound of the effect size.

Regardless the sensitivity of the size of the treatment effect for creating new jobs in the funded firms compared to a situation of absence of funding, we can state that the programme has a substantial and robust multiplier effect. This means, the amount of funding invested in this programme creates socio-economic outcomes that range substantially above the amount of invested taxpayers money.

Impact on Danish firms – results of econometric analysis

These tables show the results of the econometric analysis of Eurostars' impact on Danish firms. The results should be used with caution. Even though several of the results are statistically significant using standard significance levels, they are not robust. The results are highly sensitive to even small changes in the model and the results are based on a relatively small number of treated observations.

The one exception is the results related to the employment, which are relatively robust. The approved firms employ more people than comparable firms.

The first table shows the regression results using non-approved firms as control group, whereas the second table shows the regression results using all Danish firms as control group.

The results are different across the two control groups. The estimates are typically lower when using the non-approved firms as control group. This may indicate that there are some general differences between the approved firms and all Danish firms, which is not not accounted for in the model.

To increase the population size as much as possible, we have only analysed the effect from participating in the Eurostars Programme two years from project start.

Not-approved SMEs as control group

period	coefficients (in levels)				
	employment	turnover (million DKK)	exports (million DKK)	investments (million DKK)	labor productivity (million DKK)
t=0	11.3*** (2.2)	-14.3*** (2.6)	16.0*** (2.8)	-0.1 (0.2)	0.1*** (0.0)
t=1	1.5 (1.4)	11.7*** (1.2)	-19.3*** (1.9)	0.6** (0.3)	0.0 (0.0)
t=2	4.3*** (1.4)	-3.4** (1.7)	5.75** (2.2)	1.4*** (0.4)	0.0 (0.0)
number of observations	628	628	628	604	528
number of firms	157	157	157	151	132

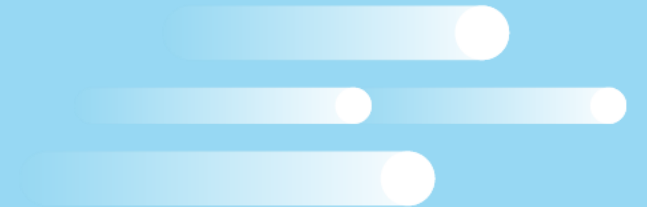
All Danish firms as control group

period	coefficients (in levels)				
	employment	turnover (million DKK)	exports (million DKK)	investments (million DKK)	labor productivity (million DKK)
t=0	26.9*** (2.0)	-32.7*** (4.1)	-30.3*** (0.4)	-1.44 (0.8)	5.3*** (0.3)
t=1	60.1*** (4.4)	-49.9*** (5.2)	-74.8*** (3.1)	-14.7*** (0.7)	3.4*** (0.1)
t=2	76.9*** (5.4)	-208.5*** (11.7)	151.5*** (5.3)	-2.5** (1.0)	1.4*** (0.3)
number of observations	716,988	716,988	716,988	577,188	285,596
number of firms	179,247	179,247	179,247	144,297	71,399

Source: Eureka and Statistics Denmark.

Notes: Clustered standard errors are reported in parantheses. *<0.10, **p<0.05, ***p<0.01.

6. Recommendations for future impact analysis



Conclusions from the econometric analysis for future studies

The evaluation is limited by lack of data in the years after the projects end. This makes it difficult to identify the full impact of Eurostars on the participating firms' economic performance. In order to identify the effects of a programme like Eurostars, a sufficient amount of firm observations is needed for a period before and after the participation.

We have data to evaluate the firm performance in the project period (we follow them one year before and two years after project start), but limited data to evaluate the performance in the years after the projects end. We do not expect to see an increase in turnover, export or productivity in the project period, because the technology has not been introduced to the market at this time. Because of these data issues, we are only partially – with respect to overall employment– able to identify the impact of the Eurostars Programme in Switzerland and Denmark. As in the case of Switzerland, **we are able to observe (positive) employment effects** – the are good reasons to interpret those as lower bound of the effects.

There are several reasons why we cannot track a sufficient number of firms at the moment:

- A major reason is that a **systematic monitoring of Eurostars applicant firms** integrated in a representative innovation survey panel (such as the KOF Innovation Survey) is not in place.
- Several projects have only been finalized recently and data from the statistical offices (e.g. SFSO, Statistics Denmark) are available with a significant time lag.

The later point will automatically improve, as many more projects will be completed and are traceable in the official statistics. For instance, in the case of Switzerland, **by August 2021**, we are able to track 85 (more than the double as compared to now) of the treated Eurostars firms over a period of 8 years, and 156 treated firms for a period of 4 years with the data from the Statistical Office. At this point there may be enough firm observation to **substantially extend the econometric impact evaluation**.

It may be worth re-examining the possibilities at that time with the possibility to build upon the already developed and established impact approach. However, it will take an additional couple of years before there is data for the projects that started in 2015 or later – which makes up the bulk of the projects. These projects will reach the market in 2020 (or even later).

That highlights the importance to track Eurostars applicant firms for many years even after the project end in a systemic and integrative monitoring as mentioned before. This allows to compare Eurostars firms to similar firms (control groups) and evaluate the performance on established firm performance indicators. Hence, having more firm observations after project end, we would probably be able to **improve the econometric impact analysis on a broader lens of economic input (R&D investments & employment) and output indicators (turnover, etc).**

Re-examining the impact of Eurostars on a richer firm data will also allow to improve and extend the evaluation of the different policy instruments of innovation support such as Eurostars. For instance, including the **collaboration behaviour** of Eurostars participants can be an additionally policy feature to evaluate for future studies. Finding answers to the question **which firms benefit most** from funding will provide additional insights for improving the design of innovation policies. Generally, overcoming the actual lack of data availability will extend the possibilities of the evaluation approach, and hence will contribute to design effective future innovation policies.

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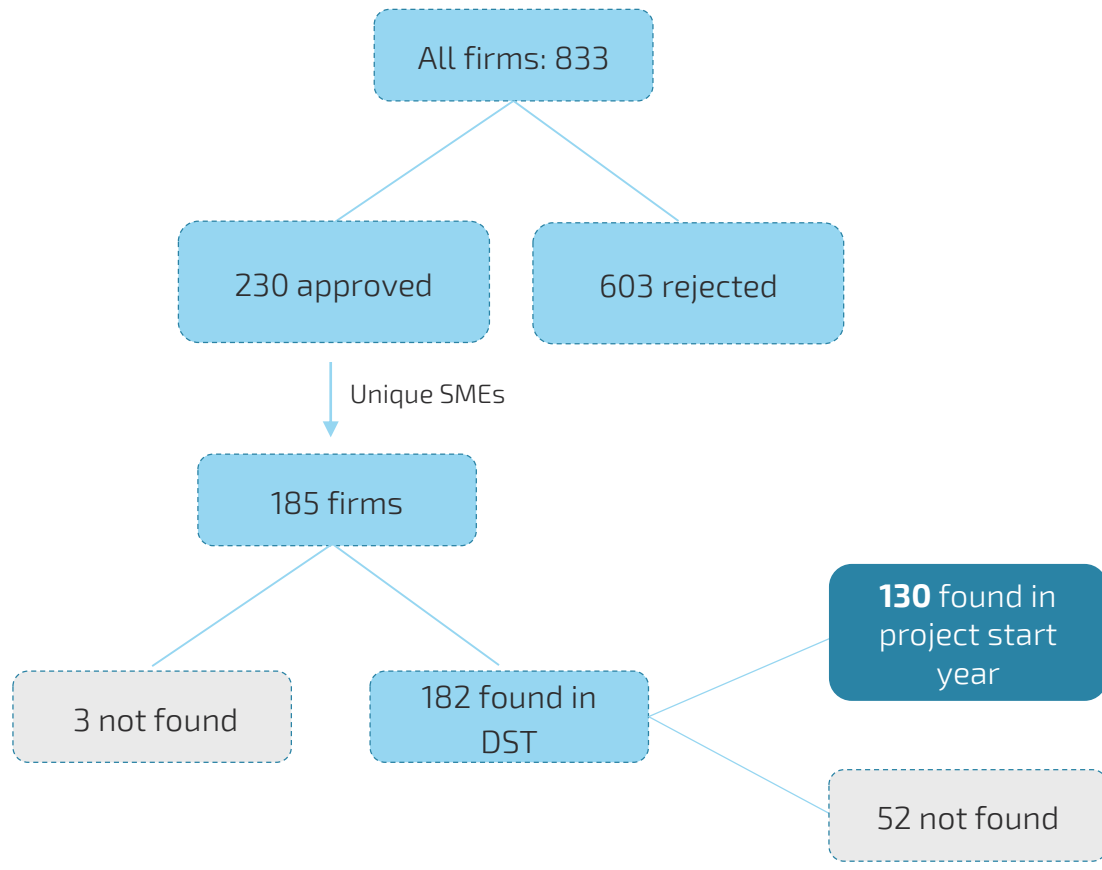
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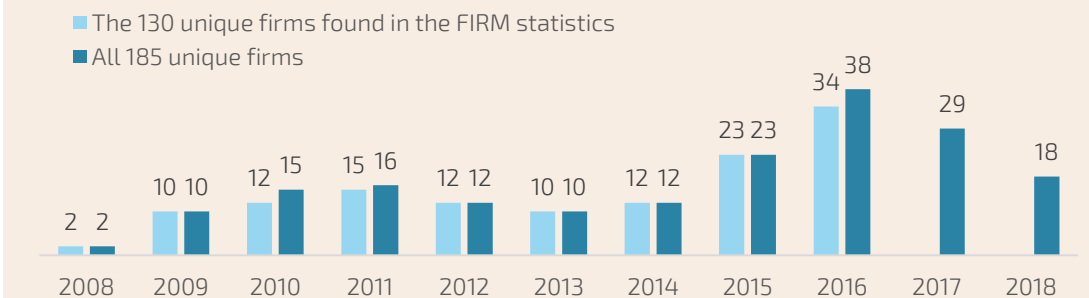
8. Annex

Not all participants are represented in data - Denmark



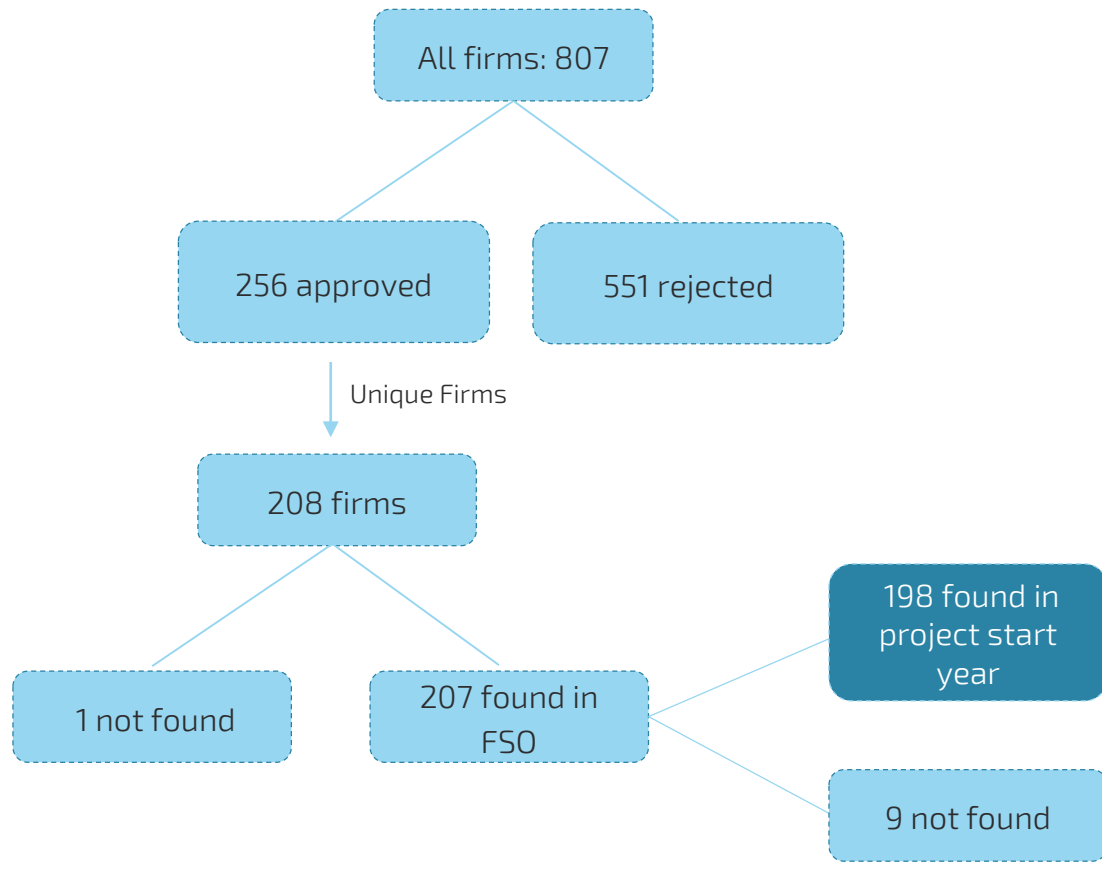
- We received a full list of 833 firms with project applications for the Eurostars Programme - 230 were approved and 603 were rejected.
- Of the 230 approved projects 185 are from unique firms (meaning that some firms have participated in several Eurostars projects in the period 2008-2018)
- We are able to match 182 of the approved firms in any given year with data from Statistics Denmark.
- However, we can only find 130 of the firms in the year their projects begin.
- This is because many Eurostars projects started in 2017 and 2018, and Danish firm data covers the period 2006-2016. The figure below shows this point.

Approved firms by project start year



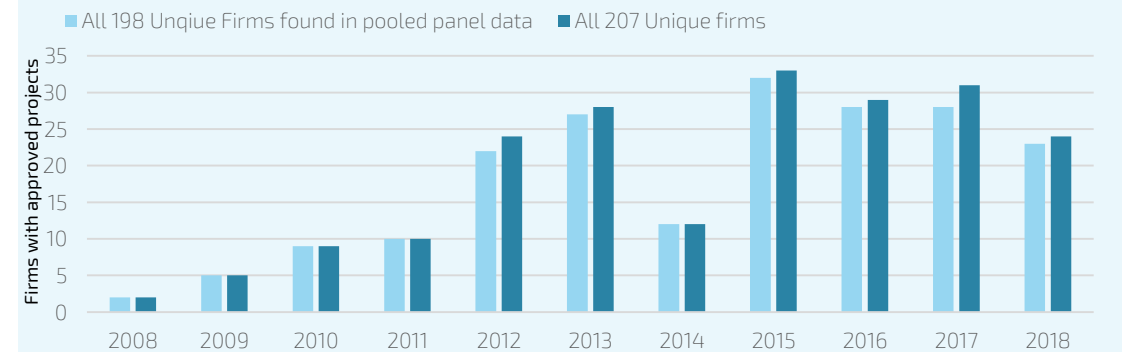
Source: Eureka and Statistics Denmark.

Not all participants are available for the analysis - Switzerland



- We received a full list of 807 firms with project applications for the Eurostars Programme – 256 were approved and 551 were rejected.
- Of the 256 approved projects 208 are from unique firms (meaning that some firms have participated in several Eurostars projects in the period 2008-2018)
- We are able to match 207 of the approved firms in any given year with data from the Swiss Statistical Office.
- However, we can only find 198 of the firms in the year their projects begin.
- This is because many Eurostars projects started in 2016, 2017 and 2018, and Swiss enterprise level data does not cover the full period until 2018, yet. The figure below shows this point.

Approved firms by project start year



Data Source: Eureka; Swiss Federal Statistical Office (SF50)

Calculations: ETH Zurich, Swiss Economic Institute (KOF); B,S,S. Volkswirtschaftliche Beratung.

Lack of data for performance tracking - Switzerland

The number of approved firms that can be observed in the SF50 data increases over time. In 2006, only 61 out of the 207 approved Swiss firms are observed in the data. In 2016, we observe 130 approved firms.

In the year of the project start, data for 138 Swiss firms are available. Firms that started their Eurostars projects in 2017 or 2018 are missing because the SF50 data only covers the period up to 2016. Moreover, many of these firms cannot be tracked far beyond project start: Three years later, only 64 firms (46 percent) of these firms still appear in the Swiss firm data.

These figures show that there are obvious limits as to how long we can track the firms' performance before and after their participation in Eurostars. The reasons are manifold:

- Projects starting after 2016 lie completely outside the coverage of the SF50 data.
- Likewise, participants who started their projects in 2015 can only be observed for one additional year; participants who started their projects in 2014 can only be followed for at most two years after project start.
- Not all of the Swiss Eurostars participants appear in all years. Some firms have closed at some point in time and others are very young (start-ups) so that they cannot be traced far before Eurostars participation. Finally, some firms may be missing in the data for other reasons (e.g. lack of a valid identification number).

The limited sample size obviously induces a degree of uncertainty in the statistical results that needs to be kept in mind when interpreting the results.

Fig. 1: Approved firms available in the Swiss firm data in a given year

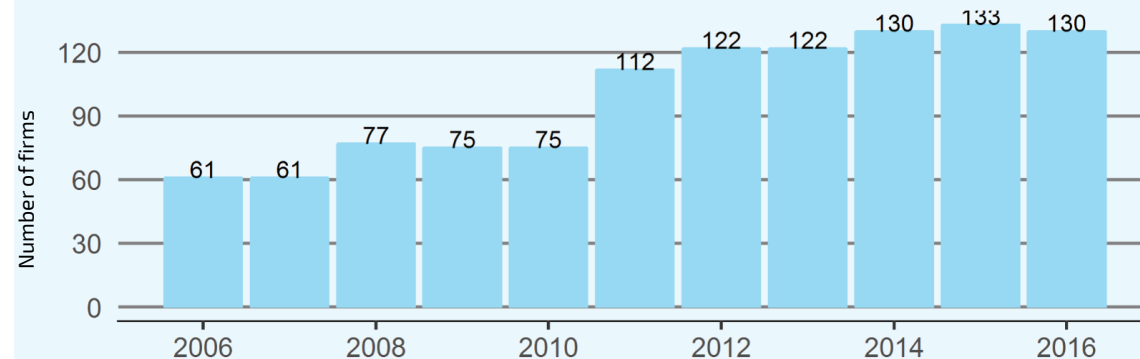
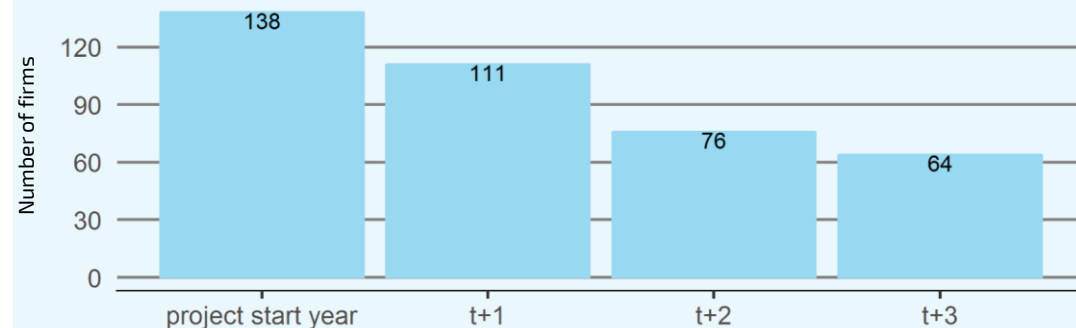


Fig. 2: Approved firms that can be followed for up to three years after project start



Lack of data for performance tracking - Denmark

The number of firms with available data increases over time. In 2006 only 82 out of the 185 approved firms are available in the Danish firm data. In 2016 almost all approved firms are available.

This means that there is a limit to how long we can track the financial performance of the firm before and after participation in Eurostars. One year after project start, we have information on the economic indicators for less than 75 percent of the participants. After two years 52 percent of participants have available data, and after three years only about 40 percent of the participants appear in the Danish firm data.

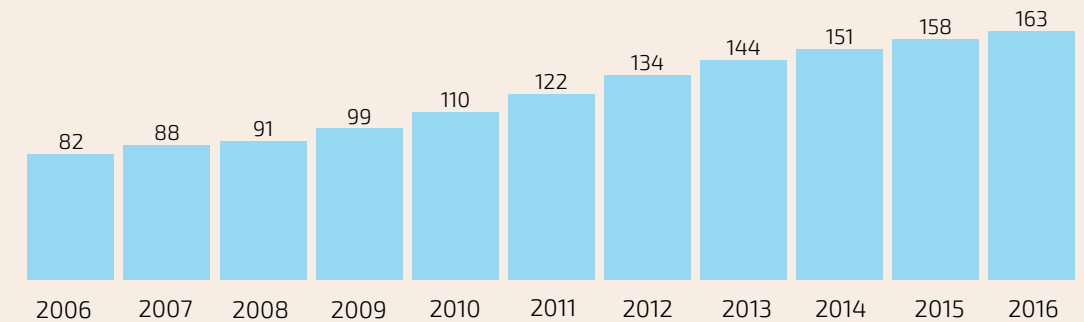
There are three reasons for this:

- A lot of projects started in the year 2016, and as the Danish firm data only covers 2006-2016, we cannot follow these participants forward in time. Likewise, we can only follow the participants starting in 2015 one year ahead.
- Not all participants appear in the Danish firm data in all years – either because they have closed, or because they are not reported by Statistics Denmark due to apparent inactivity.
- A number of the firms are quite young, and cannot be traced very far back historically.

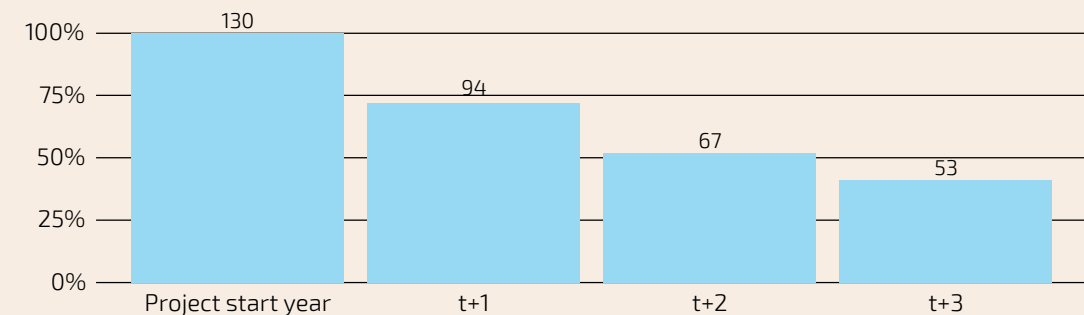
According to the previous page, we are able to find **130 Eurostars participants** in the year their projects begin. This means that we have information on the employment level, turnover and export for these 130 participants in their project start year. However, we only have information on the value added and investment levels for 127 participants. The reason for this is, that there are some missing values in the Danish firm register.

The limited sample size results in some uncertainty in the statistical results in the analysis below.

Approved firms available in the Danish firm data in the given year



Approved firms that can be followed 1, 2 and three years after project start



Source: Eureka and Statistics Denmark.

Note: If we condition on the fact that the firms also should exist in the year before project start (t-1), the population gets even smaller.

Econometric method

Notation. We consider a balanced panel of firms $i = \{1, 2, \dots, N\}$ which is observed between $t = -4$ and $t = 3$. The number of firms in the treated group (Eurostars participants) and control group are N_1 and N_0 , respectively. y_{it} is the observed outcome, D_i is the indicator for treatment. Firms with $D_i = 1$ have received funding from Eurostars (treatment group) and firms with $D_i = 0$ have not received any funding (control group). X_{it} is a vector of exogenous control variables (covariates).

Event time. We employ the notion of “event time” instead of calendar time. For each firm, $t = 0$ denotes the calendar year of the project start, and therefore, the beginning of the “treatment”. The years prior to the project start are $t < 0$. Event time for control units is defined as follows: draw a bootstrap sample of the project start year variable in the treatment group of size N_0 and apply it to the control group. As a result, both groups have the same distribution regarding the calendar year of the project start.

Treatment Effects. We employ the potential outcomes notation to establish a causal framework. The outcome of firm i in year t under treatment is $y_{it}(1)$ and the outcome in the absence of any treatment is $y_{it}(0)$. The observed outcome may be written as:

$$y_{it} = y_{it}(0) + I(t \geq 0)D_i[y_{it}(1) - y_{it}(0)]$$

where the function $I(\cdot)$ equals one if the statement in parentheses is true and zero otherwise.

The treatment effect on the treated (ATT) – or causal effect – in year $t=s$ is:

$$\Delta_{t=s} = E[y_{i,t=s}(1) - y_{i,t=s}(0) | D_i = 1]$$

Identification and Estimation. The ATT can be identified and estimated by applying a difference-in-difference framework. The key assumptions for identification are:

- No anticipation effects, i.e., no effect of Eurostars in $t < 0$.
- Parallel trends in average outcomes in both groups in the absence of treatment

Covariate balancing propensity score weighting. The unobserved trends assumption becomes more credible if firms in the treatment and control group have similar characteristics and display similar trends in outcomes in the pre-treatment period. We employ reweighting based on the covariate balancing propensity score (CBPS) proposed by Imai & Ratovic (2014). Denote the CBPS weight by w_i . The CBPS weight has the exact balancing property, i.e., the average values of the covariates are the same when reweighting the control group. We refer to the appendix on page 64 for more details on the weighting approach.

Control variables. We use the following control variables in the propensity score model: past employment levels ($y_{i,-1}$ to $y_{i,-4}$), past log employment ($\ln y_{i,-1}$ to $\ln y_{i,-4}$), past employment growth ($\Delta \ln y_{i,-1}$ to $\Delta \ln y_{i,-4}$) and industry dummies (two-digit level).

Regression model. In a second step, we can estimate standard (fixed effects) regression models using the weights w_i :

$$y_{it} = \sum_{s=\{-3,-2,0,1,2,3,4\}} \tau_s D_i I(t=s) + \mu_i + \theta_t + \varepsilon_{it},$$

where τ_s captures the treatment effect in year s . The “treatment effects” in $t=-3$ and $t=-2$ should be (very close to) zero and help to test the validity of the design. This is called the “event study specification”. μ_i are firm-specific fixed effects and θ_t are aggregate time effects. Standard errors are clustered at the firm level to account for within-firm serial correlation.

Estimating treatment effects by re-weighting

In the programme evaluation literature, **Propensity Score Re-Weighting** is an attractive strategy to estimate the average treatment effects on the treated (ATT), see for example Imbens & Wooldridge (2009) or Imbens & Rubin (2015).

In what follows, we briefly explain the mechanism behind this estimation strategy. We start by defining the **propensity score**, which is the probability of being treated conditional on the covariates:

$$P(D_i = 1|X_i),$$

where we typically assume that $P(D_i = 1|X_i) < 1$, that is, for all treated firms, we can find similar control firms.

The propensity score weights for the ATT are defined as:

$$w_i = \frac{P(D_i = 1|X_i)}{1 - P(D_i = 1|X_i)}$$

To obtain the weights, the propensity score must be estimated first. To do this, we assume the model:

$$P(D_i = 1|X_i) = \frac{1}{1 + \exp(-X_i\beta)}.$$

Typically, this model is estimated with a simple logistic regression. A more attractive approach, however, is the Covariate Balancing Propensity Score by Imai & Ratkovic (2014) because it has better balancing properties than the logistic regression.

Based on the data, we estimate β using a specific set of moment conditions with Generalized Methods of Moments (GMM), see Imai & Ratkovic (2014) for details. The estimated coefficients $\hat{\beta}$ can then be used to construct the propensity score weights $\hat{w}_i$. That is, for each control firm, we obtain a value of the weight.

The important property associated with the CBPS weights is that the average covariate in the treated group (left-hand side) *exactly* correspond to the average weighted covariates in the control group (right-hand side):

$$\frac{1}{n_1} \sum_{i:D_i=1} X_i = \frac{1}{\sum_{i:D_i=0} w_i} \sum_{i:D_i=0} w_i X_i$$

This is the sense in which propensity score re-weighting makes the control group "comparable" to the treated group in terms of the covariates X_i .

Given the formula for w_i above, the intuition behind the weighting is simple: If a control firm has characteristics that are common among treated firms, it has better comparability and a large value of $P(D_i = 1|X_i)$. Consequently, it obtains a larger weight. On the other hand, if a control firm has characteristics that are almost never found among the treated, it is a "bad match" and has a low value of $P(D_i = 1|X_i)$. As a result, its weight will be close to zero.

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