X-band technology spread and societal impact

Anastasiya Magazinik

On behalf of Nuria Catalan Lasheras, Joel Sauza Bedolla, Nikolaos Kokkinis Ntrenis

14 December 2021

CLIC Project Meeting #41

Guideline

- Why do we speak about the societal impact?
- What did we learn?
- What did we collect?
- What have we done?
- What have still to be done?

May 2019

Voir en français

In Granada, the European particle physics community prepares decisions for the future of the field

The European particle physics community is meeting this week in Granada, Spain, to discuss the roadmap for the future of the discipline

13 MAY, 2019

- **On the significance to the public and society of implementing the ILC project (revised plan) in Japan**
  As with much other purely academic research, the ILC project arouses the public's intellectual interest in the sense of knowledge exploration. In addition, if it develops into a hub at which advanced researchers, who will later spread out across the world, develop in an environment where top-class scientists from around the world are working hard and competing, then the project's significance is substantial.
  On the other hand, with regard to the technical and economic ripple effects other than its pure academic significance, the effects of the ILC are unclear at the moment and are considered to be limited. More in-depth dialogue with the general public, and residents in the vicinity of the potential site in particular, is needed to communicate not only the scientific significance of the ILC project but also its potential merits, advertised in the context of regional development, and potential environmental impacts from civil construction and the production of radioactive material, based on accurate information provided by the scientific community.

NEWSLINE
THE NEWSLETTER OF THE LINEAR COLLIDER COMMUNITY

CURRENT ISSUE
10 MAY 2019

A common scientific, technical and strategic vision

Download the current issue as a full .pdf

PREPRINTS

ARXIV PREPRINTS

1905.00220
Complementarity between ILC250 and ILC-GigaZ

1904.10156
Gauge-Higgs unification at e+e− linear colliders

1904.07407
Minimal Dirac Neutrino Mass Models from U(1)R Gauge Symmetry and Left-Right Asymmetry at Collider

1903.12327

FEATURE

Executive Summary of the Science Council of Japan's Report

21 December 2018

This is the executive summary of the Science Council of Japan (SCJ)'s report on the International Linear Collider, released on 19 December 2018. This is an unofficial translation by KEK from the original Japanese.

BACKGROUND

The International Linear Collider (ILC) is an international project in the field of elementary particle physics to construct a straight accelerator (linear accelerator) to perform high-energy electron-positron collision experiments, and thereby advance research on the Higgs particle.

In response to the receipt of "Regarding Deliberations on International Linear Collider (Requests)" by the President of the Science Council of Japan from the Ministry of Education, Culture, Sports, Science and Technology on July 20, 2018, the "Review Committee on the Revised Version of the International Linear Collider Project" and "Technical Verification Subcommittee" were established. Since the ILC is a major international project requiring huge long-term investment and international cooperation, the committees deliberated on the project itself, including its academic status of systems at oad, and for

on of the ILC

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MEXT outreach SCRF SLAC TDR
Technical Design Report United

On the other hand, with regard to the technical and economic ripple effects other than its pure academic significance,
the effects of the ILC are unclear at the moment and are considered to be limited. More in-depth dialogue with the

Use SOCIETY, SOCIETAL 4 times

European Strategy Update

June 2020

To highlight the impacts of particle physics

the recommendations highlight the scientific impact of particle physics, as well as its technological, societal and human capital.

To invest in strong cooperative programmes

between CERN and other research institutes

“These collaborations are key to sustained scientific and technological progress and bring many societal benefits.”

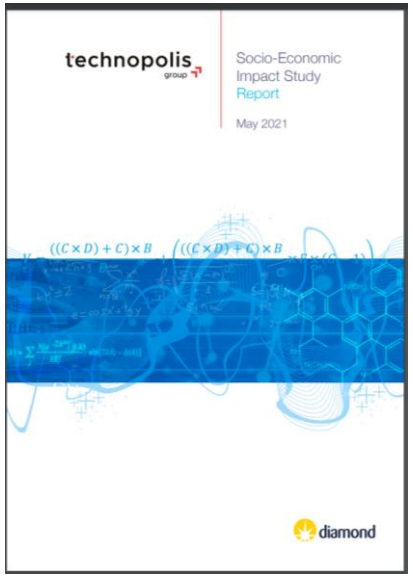
To ramp up focused and transformational R&D

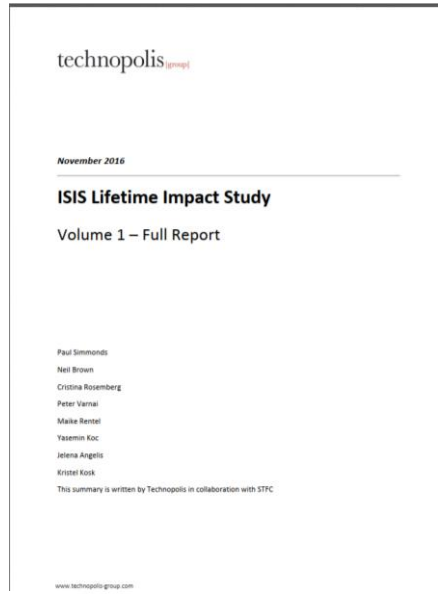
Delivering the near and long-term future research programme envisaged in this Strategy update requires both focused and transformational R&D, which also has many potential benefits to society.

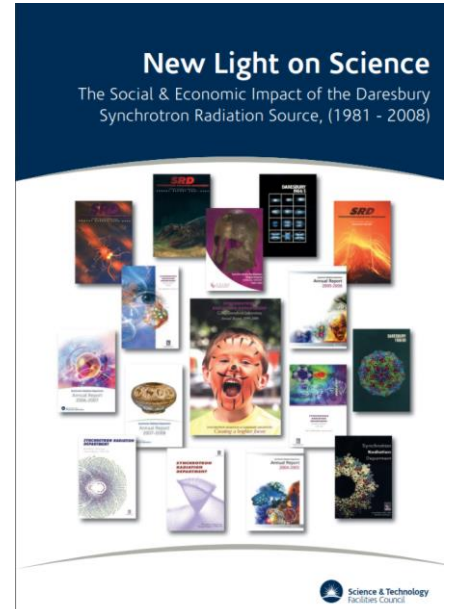
Beyond the immediate scientific return, major research infrastructures such as CERN have vast societal impact, thanks to their technological, economic and human capital.

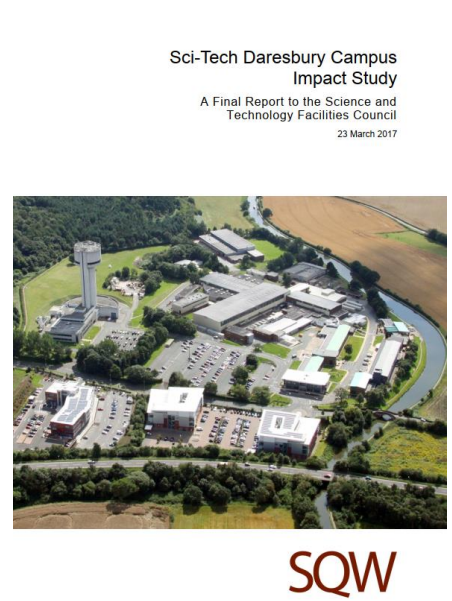
Partnerships with large RI help drive innovation in industry

Partnerships with large research infrastructures help drive innovation in industry.





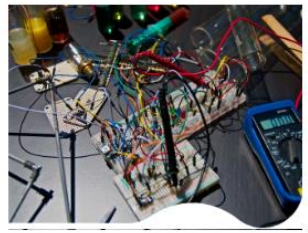




Interactive Toolkit on Socio-Economic Impact Assessment of Research Infrastructures

Over the last decade, the EFIS Centre team has built up an in-depth experience on the topic of socio-economic impact assessment of research infrastructures. Our staff have participated in numerous [...]

1 year, 1 month ago



New Open-Access publication: The Social Cost-Benefit of large Research Infrastructures

Massimo Florio and Chiara Pancotti, from CSIL and the University of Milan, authored a new paper published on Oxford Research Encyclopedia of Physics. The full-length article is freely available online. [...]

1 year, 5 months ago

RI-PATHS Webinar "Spotlight on impact pathway insights: what RIs have learned about their impact and impact study requirements?"

The RI-PATHS project team was pleased to invite research infrastructures, funding agencies, policy makers, impact analysts and other potential user communities to three dedicated online webinars tackling the theme "A [...]

1 year, 5 months ago

https://ri-paths.eu/

arXiv:1507.05638v1 [physics.soc-ph] 20 Jul 2015

TIF-UNIMI-2015-9

Cost-Benefit Analysis of the Large Hadron Collider to 2025 and beyond

Massimo Florio[1], Stefano Forte[2], and Emanuela Sirtori[3]

[1] *Dipartimento di Economia, Management e Metodi Quantitativi, Università di Milano , via Conservatorio 7, I-20122 Milano, Italy*
[2] *TIF Lab, Dipartimento di Fisica, Università di Milano and INFN, Sezione di Milano, Via Celoria 16, I-20133 Milano, Italy*
[5] *CSIL, Centre for Industrial Studies Corso Monforte 15, I-20122 Milano, Italy*

Abstract

Social cost-benefit analysis (CBA) of projects has been successfully applied in different fields such as transport, energy, health, education, and environment, including climate change. It is often argued that it is impossible to extend the CBA approach to the evaluation of the social impact of research infrastructures, because the final benefit to society of scientific discovery is generally unpredictable. Here, we propose a quantitative approach to this problem, we use it to design an empirically testable CBA model, and we apply it to the the Large Hadron Collider (LHC), the highest-energy accelerator in the world, currently operating at CERN. We show that the evaluation of benefits can be made quantitative by determining their value to users (scientists, early-stage researchers, firms, visitors) and non-users (the general public). Four classes of contributions to users are identified: knowledge output, human capital development, technological spillovers, and cultural effects. Benefits for non-users can be estimated, in analogy to public goods with no practical use (such as environment preservation), using willingness to pay. We determine the probability distribution of cost and benefits for the LHC since 1993 until planned decommissioning in 2025, and we find there is a 92% probability that benefits exceed its costs, with an expected net present value (NPV) of about 3 billion €, not including the unpredictable economic value of discovery of any new physics. We argue that the evaluation approach proposed here can be replicated for any large-scale research infrastructure, thus helping the decision-making on competing projects, with a socio-economic appraisal complementary to other evaluation criteria.

CERN-ACC-2018-0014

Future Circular Collider

PUBLICATION

Social Cost Benefit Analysis of HL-LHC

Bastianin, Andrea (Università degli Studi e INFN Milano (IT))
et al.

22 May 2018

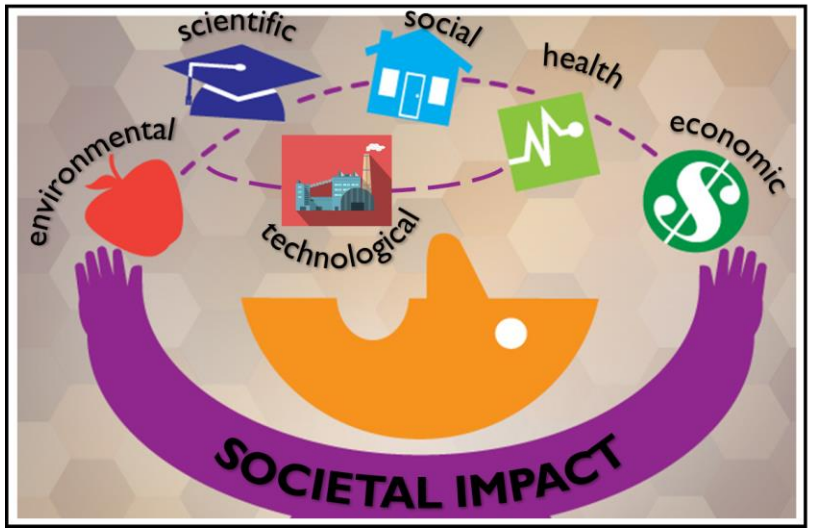
The research leading to this document is part of the Future Circular Collider Study

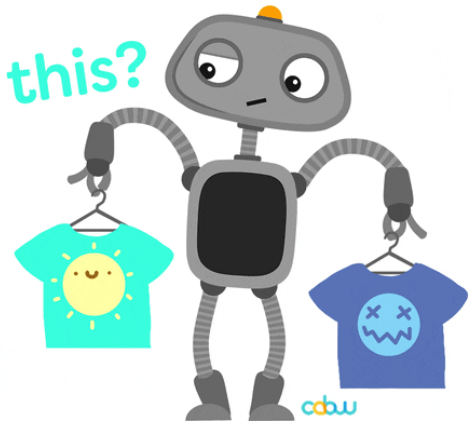
The electronic version of this FCC Publication is available on the CERN Document Server at the following URL : <http://cds.cern.ch/record/2319300>

CERN-ACC-2018-0014

SIA Highlights

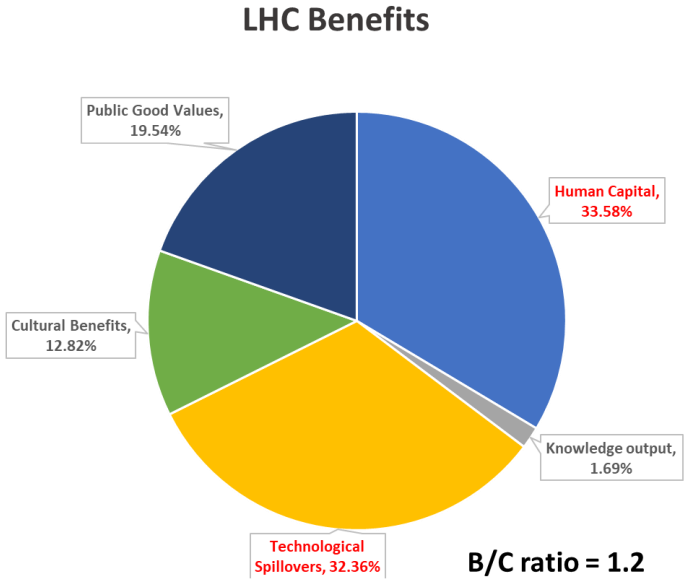
- The source of economic value generation is public investment in fundamental research.
- How to assess that society **will be better with a project** or worse?
- It is important to identify **which values for society and economy** is created, how it can be measured and where it comes.



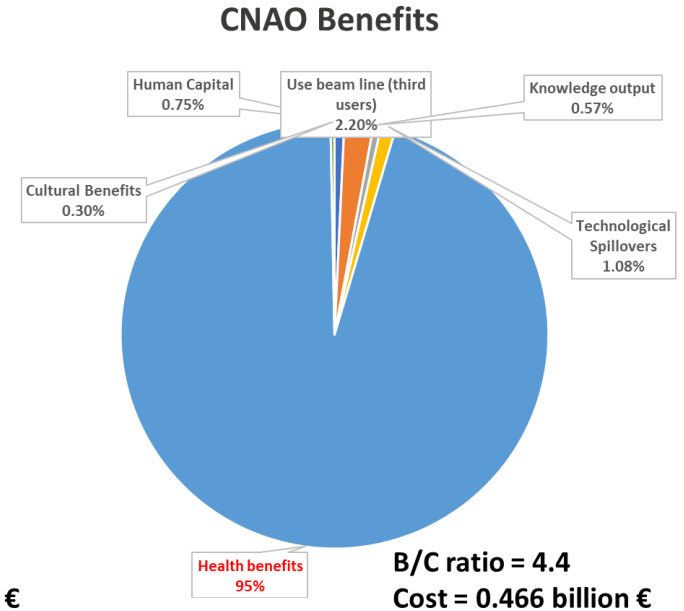


What did we learn?

- The topic of Societal Impact Assessment (SIA) is contemporary;
- There is no still existing common mechanism to calculate the societal impact;
- LHC, HL-LHC, FCC and few other examples for Socio Cost-Benefit Analysis from CSIL from Milano with Massimo Florio;
- The community of SIA of research infrastructures is growing, many institutes, laboratories are involved around the World.



B/C ratio = 1.2
Cost = 13.5 billion €
NPV=3.1 billion €



B/C ratio = 4.4
Cost = 0.466 billion €
NPV=1.65 billion €

What did society already receive from CLIC?

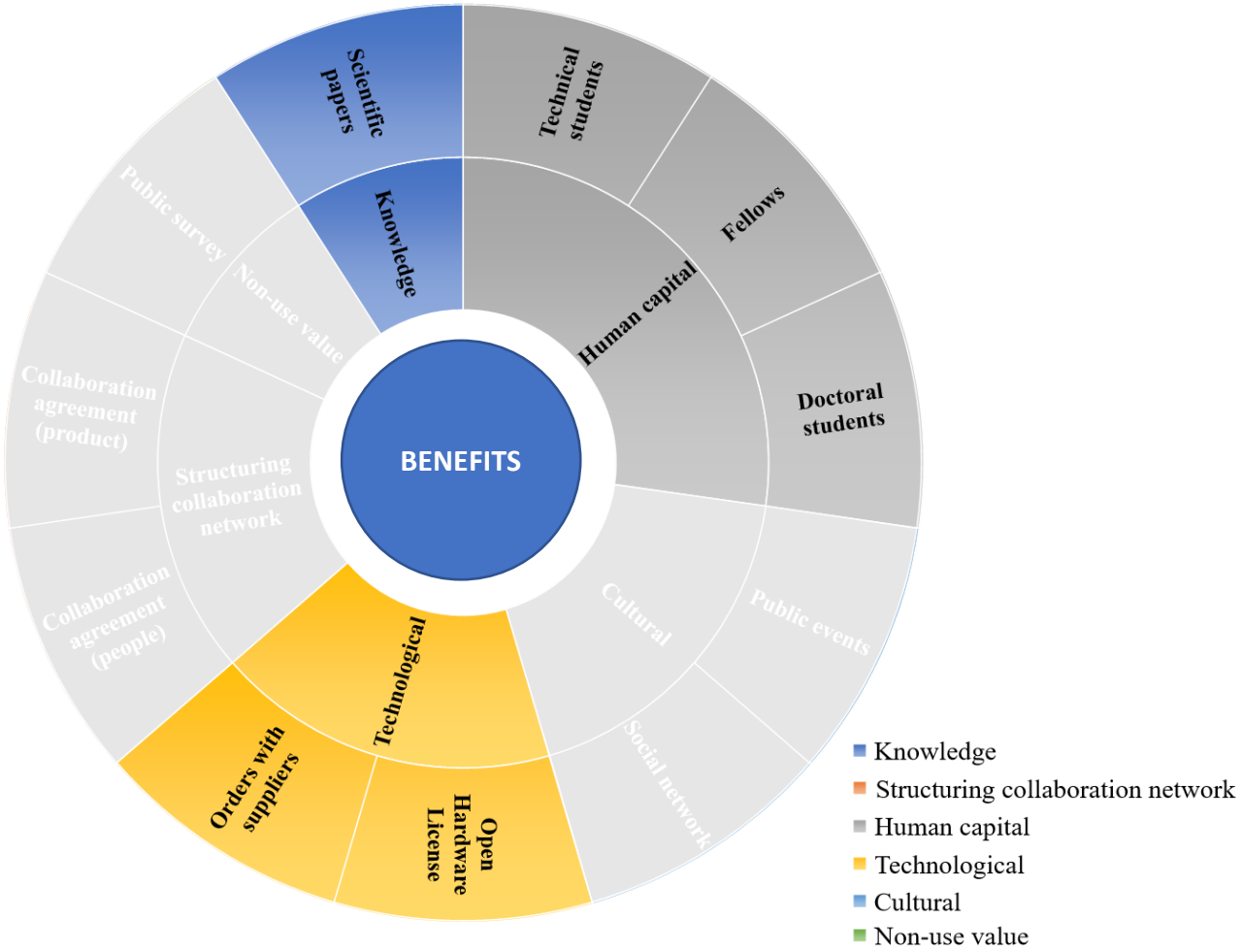
Society represents by industries, scientific community and public

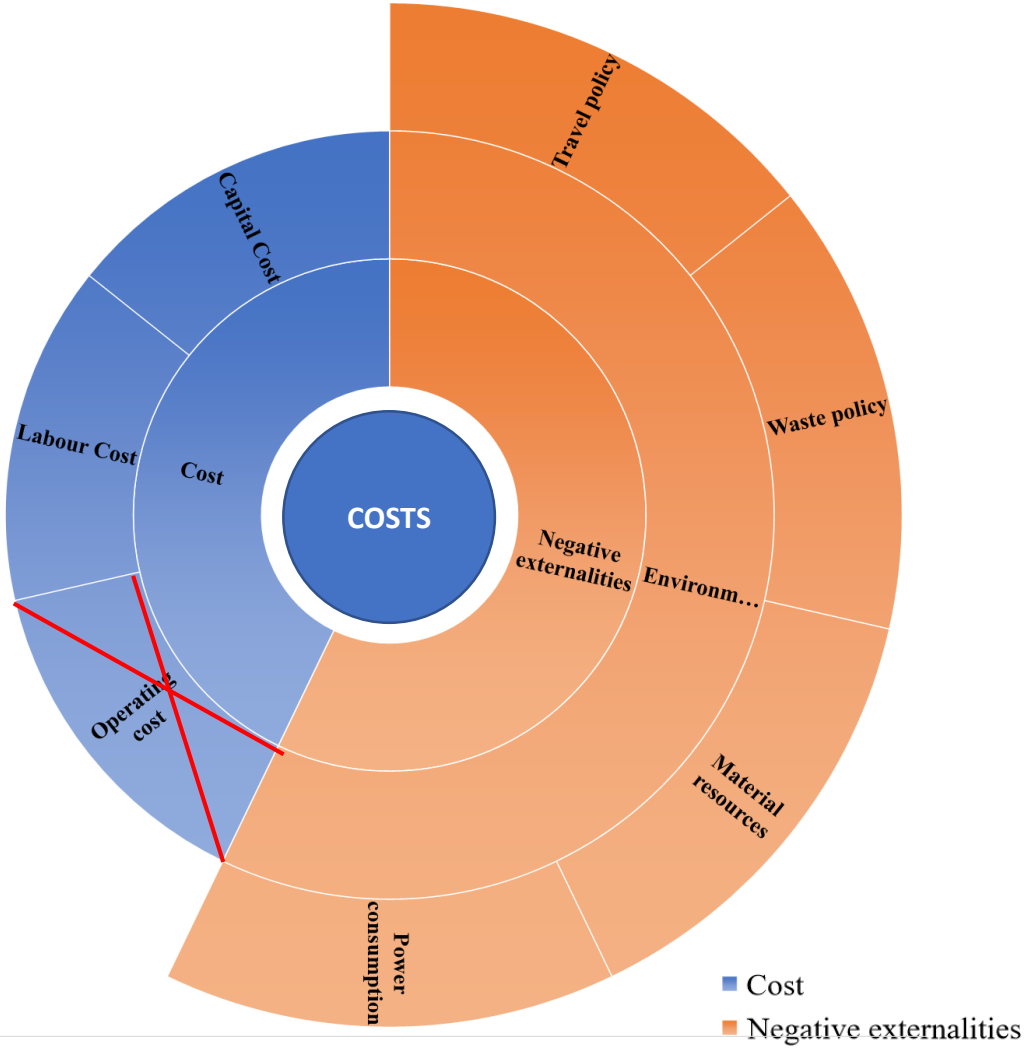
- Experienced specialists
- Knowledge as publications
- Technological feedbacks

Conceptual model for CLIC

Our focus was…

C. S. Waaijer, “EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE CERN-GS Department GUIDELINES AND CRITERIA FOR AN ENVIRONMENTAL IMPACT ASSESSMENT FOR A LINEAR COLLIDER PROJECT,” 2011.





CLIC Societal Impact (what did we collect?)

DATA MODEL

CLIC accelerator

Data from 2009 to 2019

What have we done?

Collect data

Calculated the impact:

From CERN perspective

- Human capital (see CLIC Project Meeting #39, link)
- Technological impact
- Knowledge benefits

From Perspective from Industry

TECHNOLOGICAL IMPACT

- use existing CERN developments,
- Reduce the production price

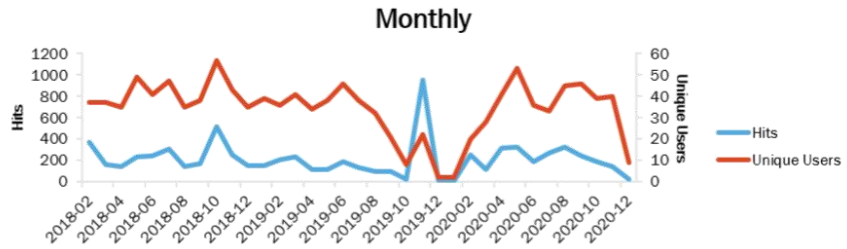
Economic Benefits = Incremental Turnover + Cost Saving [1]

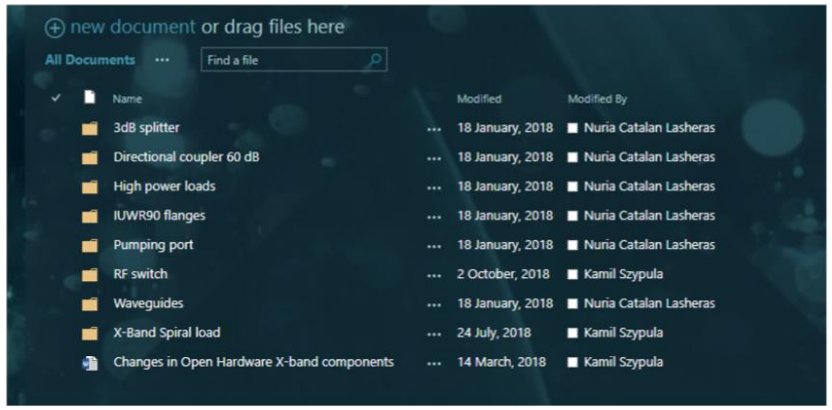
Utility/sales ratio = 3 [1]

Incremental Turnover = EBITDA×Sales×3 [2]

Sales = Sum of CERN orders,
Utility = Sales×3
Incremental turnover = Utility×EBITDA

EBITDA margin measures a company's Earnings Before Interest, Taxes, Depreciation, and Amortization as a percentage of the company's total revenue.
The EBITDA is extracted from ORBIS.com for 2009-2020





N. Catalan Lasheras,
CLIC project meeting 38,
10.12.2020

[1] Bianchi-Streit, M. et al. (1984) 'Economic utility resulting from CERN contracts (second study)'. CERN. doi: 10.5170/CERN-1984-014.
[2] M. Florio, S. Forte, and E. Sirtori, "Cost-Benefit Analysis of the Large Hadron Collider to 2025 and beyond," *Technol. Forecast. Soc. Change*, vol. 112, pp. 38–53, 2015.

Benefits to firms

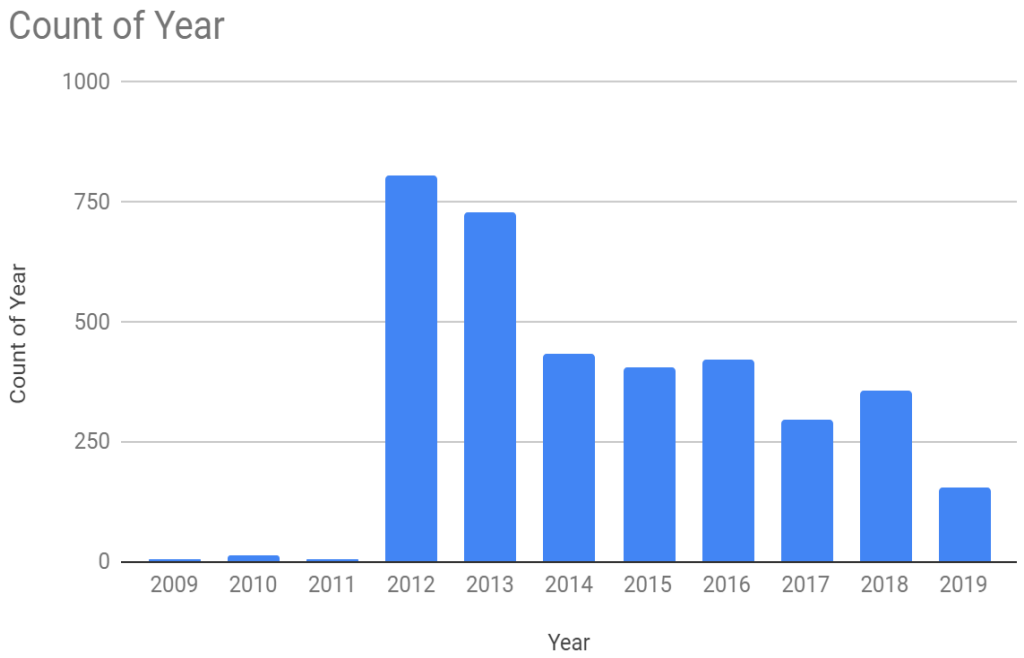
Method	Margin	Sample	Source	Benefit Value
1	EBITDA	CLIC suppliers	Orbis.com	10.4%
2	EBITDA	Suppliers matched with activity codes [1]	Orbis.com	13.1%
3	Increase in clients (self-estimation from the industrial survey)	CLIC suppliers	Industrial Survey	11.1%

[1] M. Florio, S. Forte, and E. Sirtori, "Cost-Benefit Analysis of the Large Hadron Collider to 2025 and beyond," *Technol. Forecast. Soc. Change*, vol. 112, pp. 38–53, 2015.

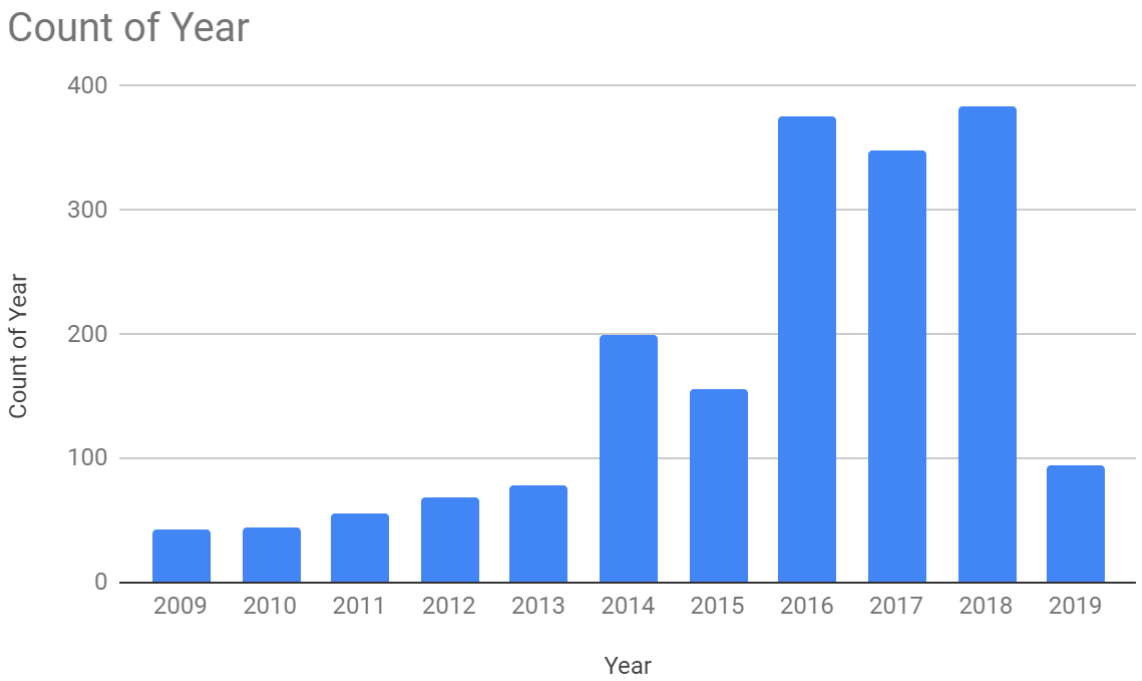
Open Hardware Xband components

Users	Development time	Salary rate	Development price	Cost Saving just for the development
39	12 -24 weeks	51 CHF/hour	24480-48960	954 720 CHF -1 909 440 CHF

(1) The calculated cost does not include the prove of the concept by producing and testing prototypes.
(2) The calculation is done based on the assumption of downloading a single component only, whilst the OHL users are usually interested in the design of multiple components.

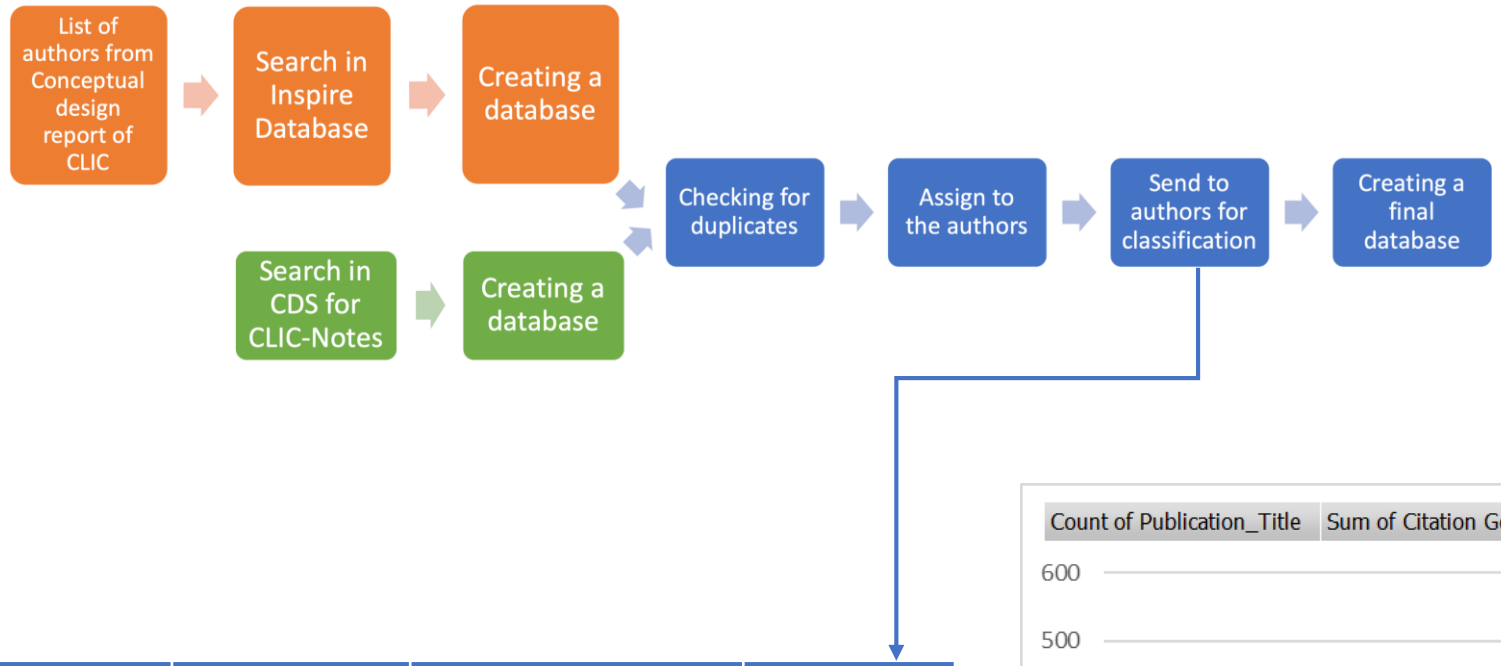


Procurement orders



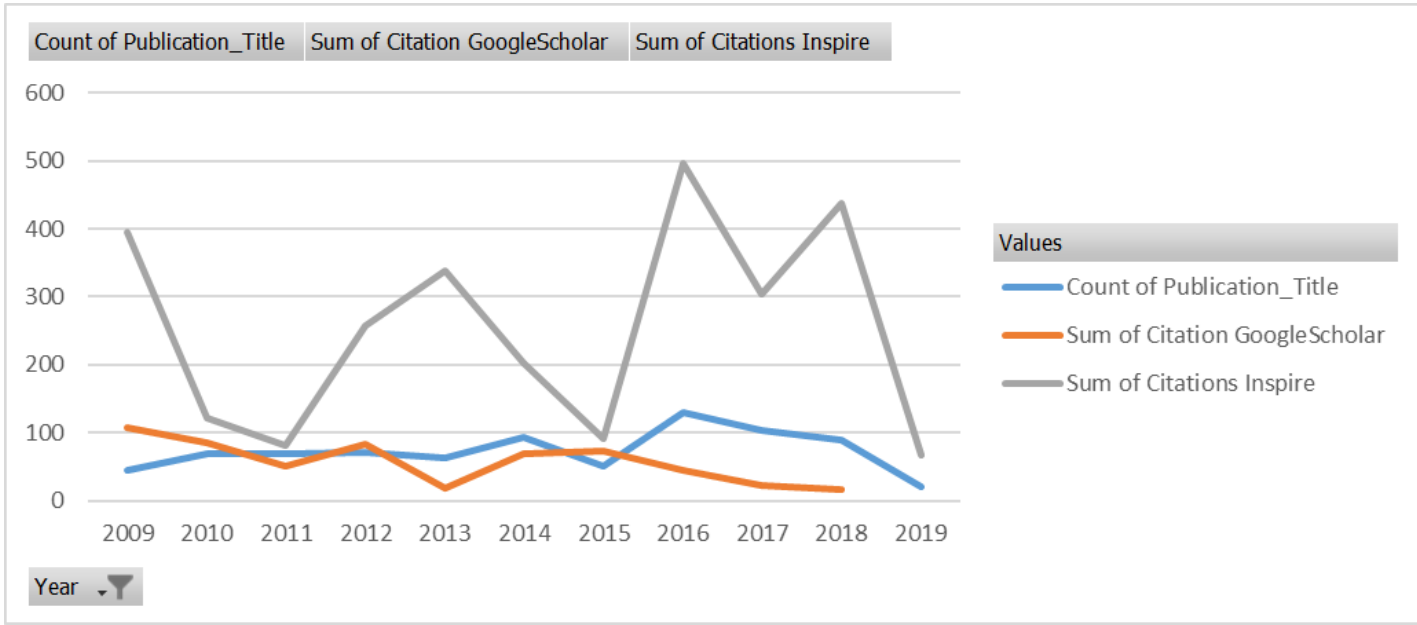
Publications

Publications

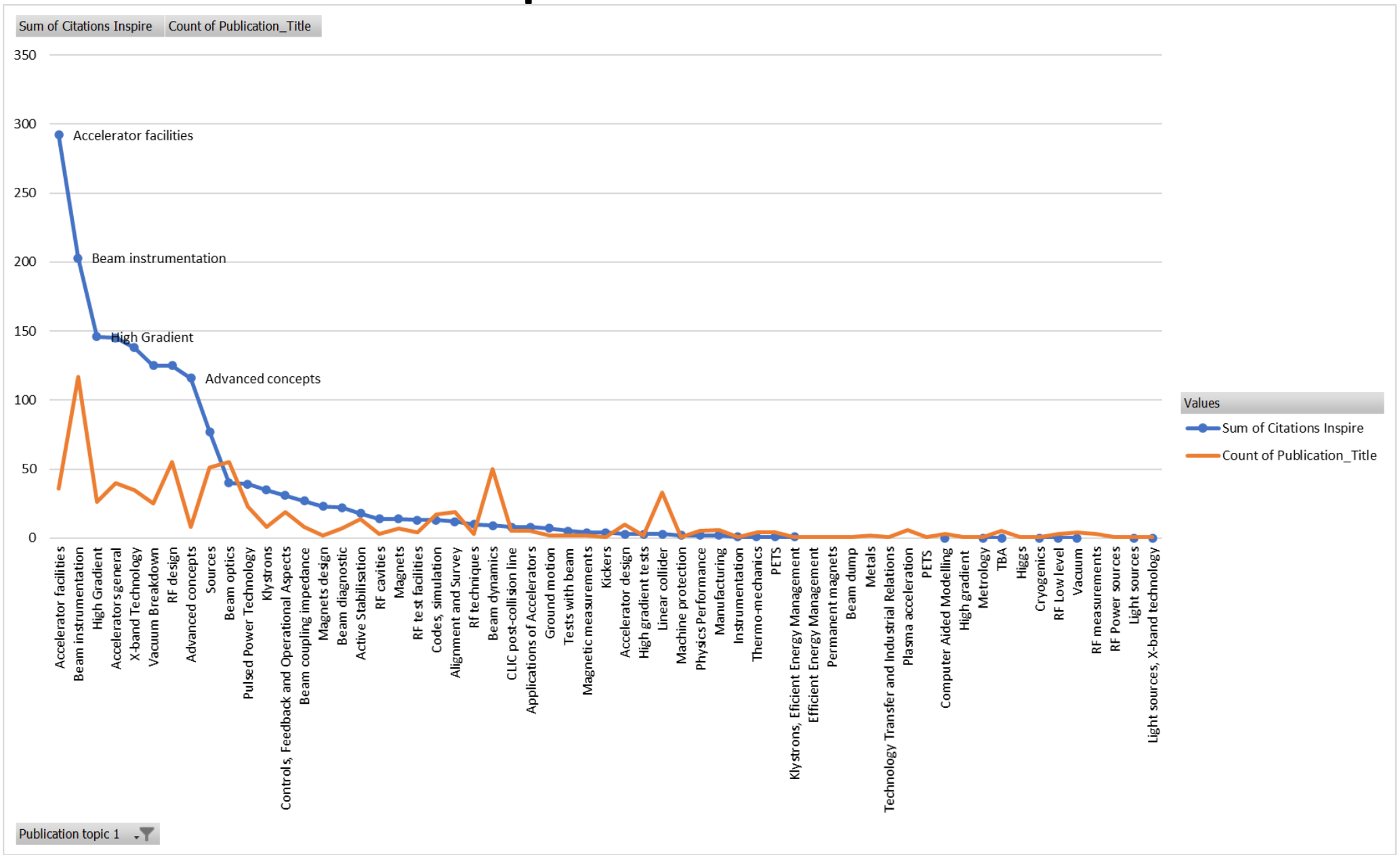


1. Collection of CLIC publications: CDS and Inspire database;
2. Gathering citations in Google Scholar and Inspire.

	Publications	Received	From total
Sent	1635	1400 (+8% of new)	93%
Classified	1299	79%	74%
Total	1767	108%	



Descriptive statistics



Publications as knowledge benefit

The cost of the paper – **X**

(1) The cost of the paper depends on the distribution of authors (fellows, PhD students, stuffs) since itis directly connected to the time spent for the research and for writing the paper.

BENEFITS = value per citation*nr of citation

Value per citation = X/references

Ratio Benefit/Cost = nr of citation / references

Ratio 73 - 196

Parameters	
Yearly productivity per an author	2
Share time for research	60%
Average references [3] benchmarking	30
Average references [4] benchmarking	14.4 +2.2L=37.8
Average references (our sample)	14.122
Average citation	3.469
Average number of authors per paper	5.9
Salary of a researcher	X
Nr of papers cited	798
Global nr of citations	2768
Value per citation	X/Av_ref
Benefits	X/Av_ref*2768
Ratio Benefits/Costs	2768/Av_ref

[3] "THE SOCIO-ECONOMIC IMPACT OF THE NATIONAL HADRONTHERAPY CENTRE FOR CANCER TREATMENT (CNAO): APPLYING A CBA ANALYTICAL FRAMEWORK CHIARA PANCOTTI GIUSEPPE BATTISTONI MARIO GENCO MARIA VITTORIA LIVRAGA PAOLA MELLA SANDRO ROSSI SILVIA VIGNETTI The C Chiara."

[4] H. A. Abt and E. Garfield, "Is the relationship between numbers of references and paper lengths the same for all sciences?," *J. Am. Soc. Inf. Sci. Technol.*, vol. 53, no. 13, pp. 1106–1112, Nov. 2002.

From perspective from Industry

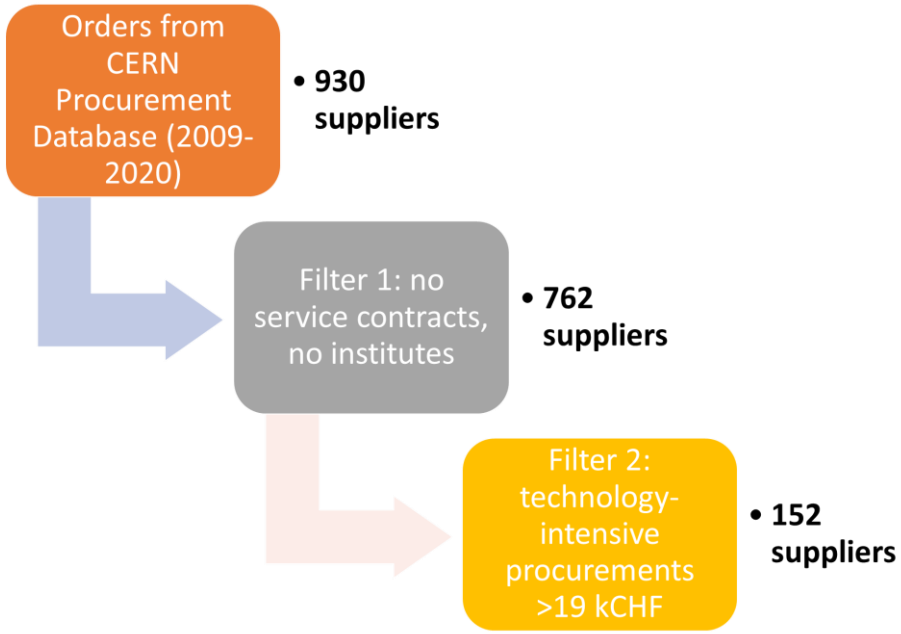
DATA from CERN PD (2009 – beginning 2020), the industrial survey

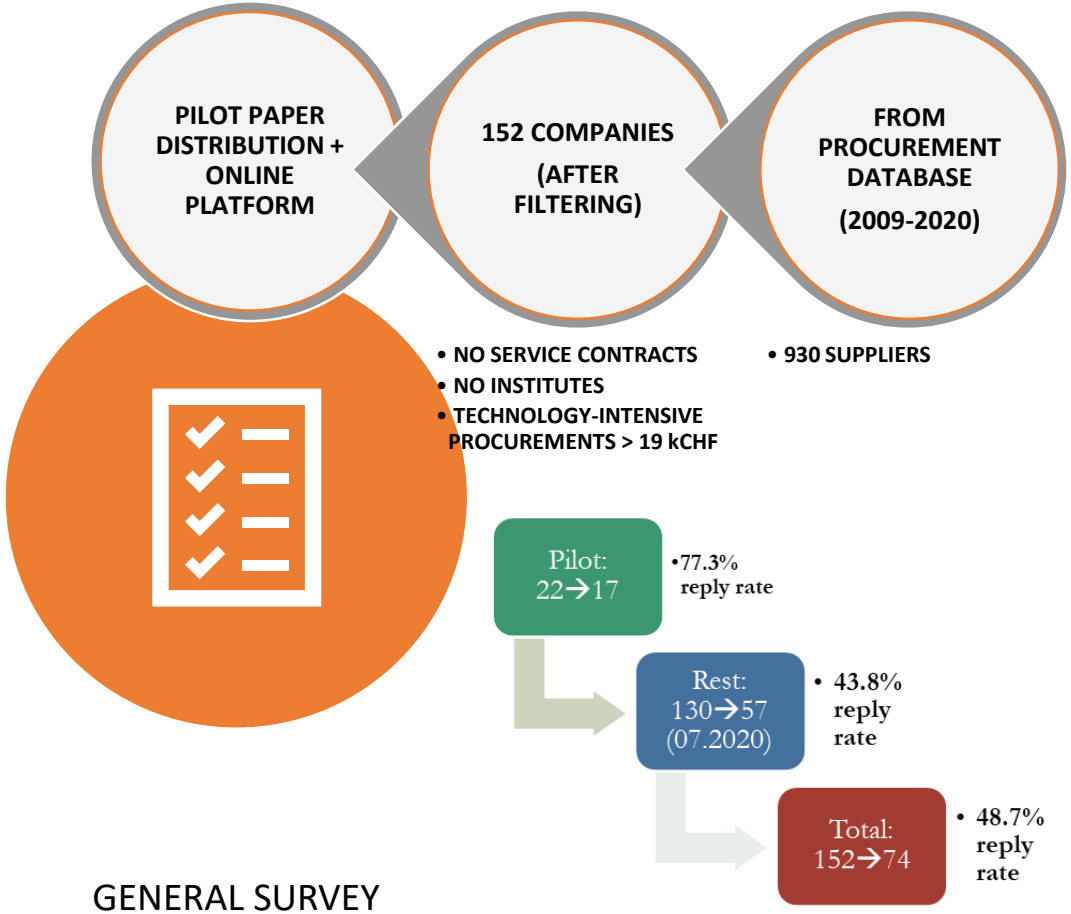
1. Benefits associated with procurement activities

Regression analysis on the possible benefits: marketing image, expansion, learning outcome, R&D, innovation, economic.

Key influence: size, age, scientific events, relationship with CERN, CLIC and other RI, CHF per order.

Industrial survey



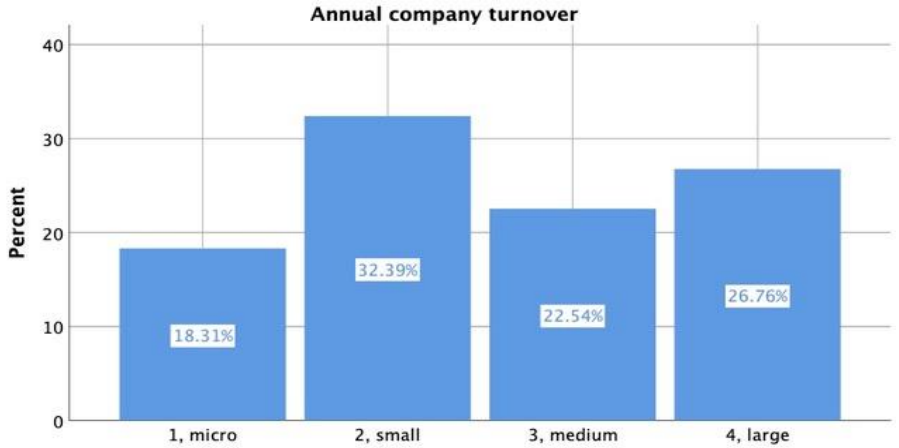


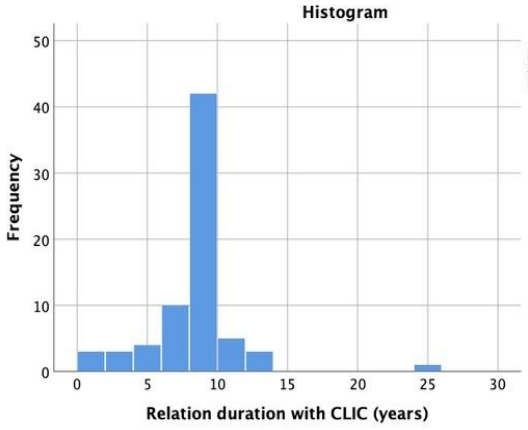
GENERAL SURVEY

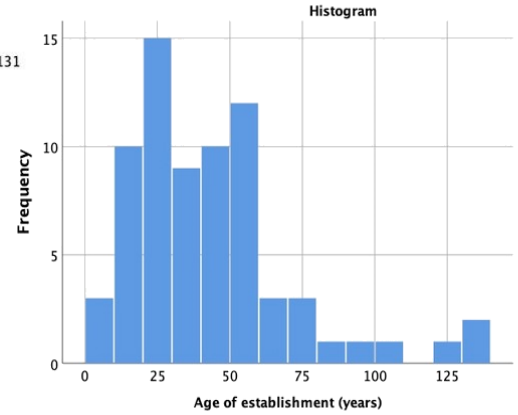
- TECHNOLOGICAL SPILLOVERS ASSESSMENT

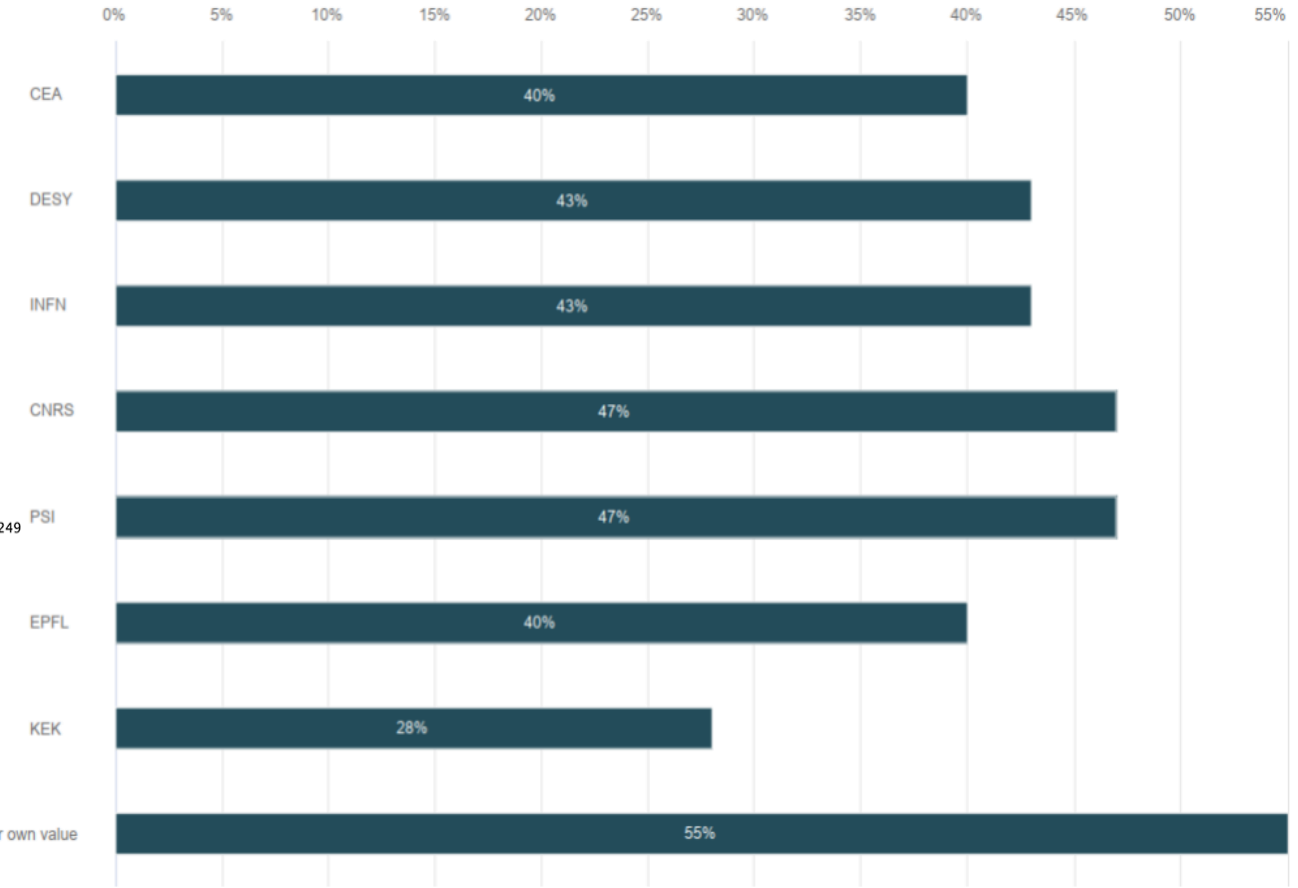
Who are our suppliers?

- Age: 42.75 ±28.25
- Size
- Country
- With whom they are working
- Relationship duration with CLIC: 7.72 ±3.13









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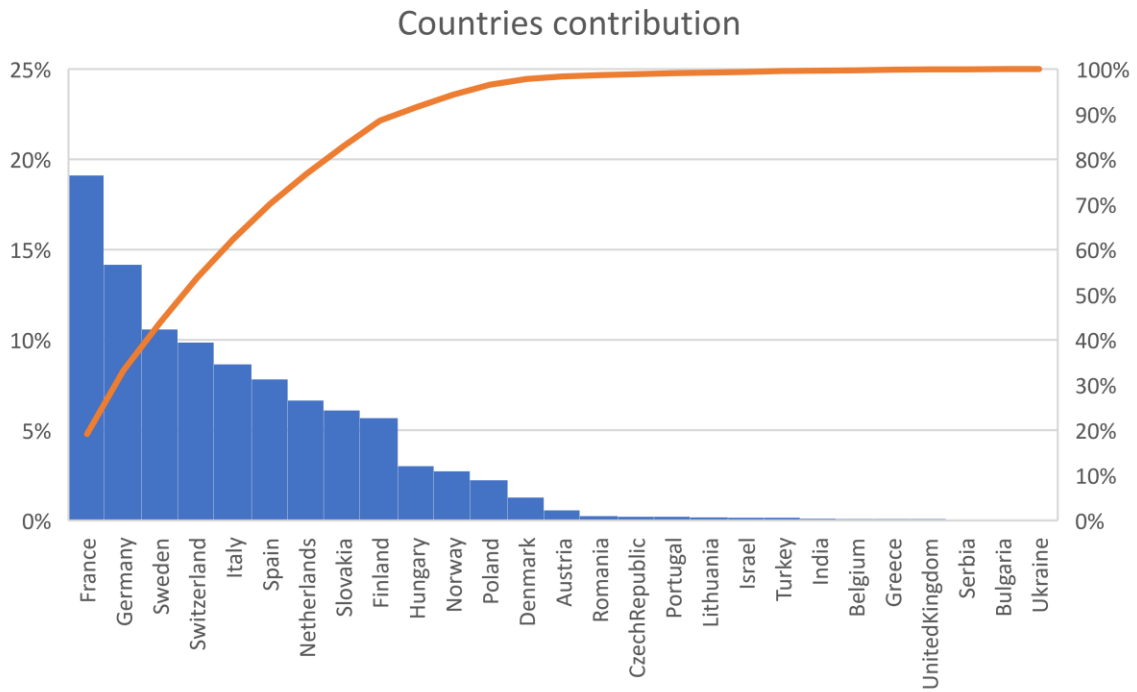

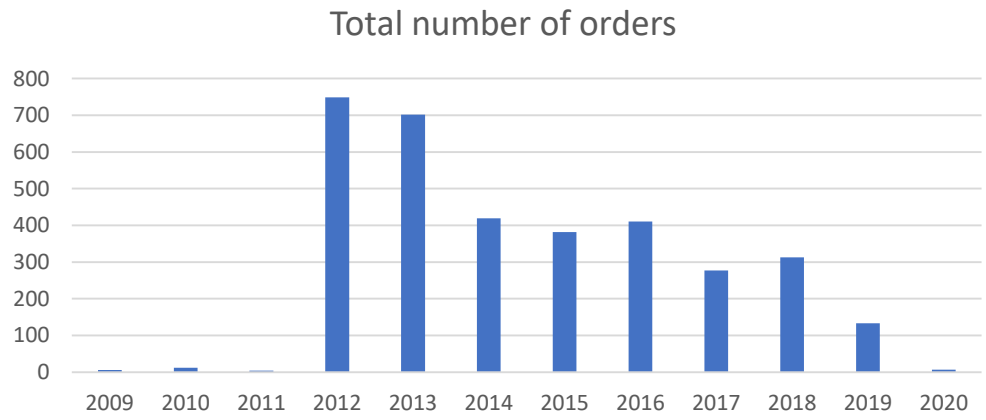

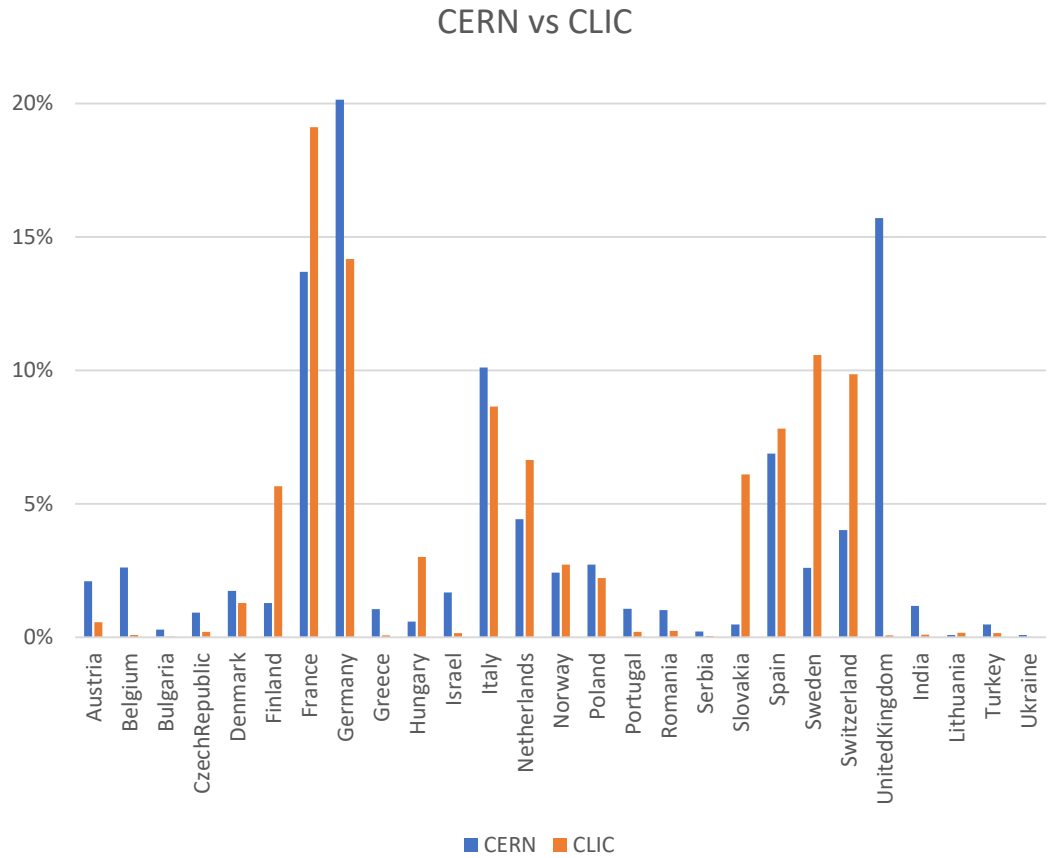

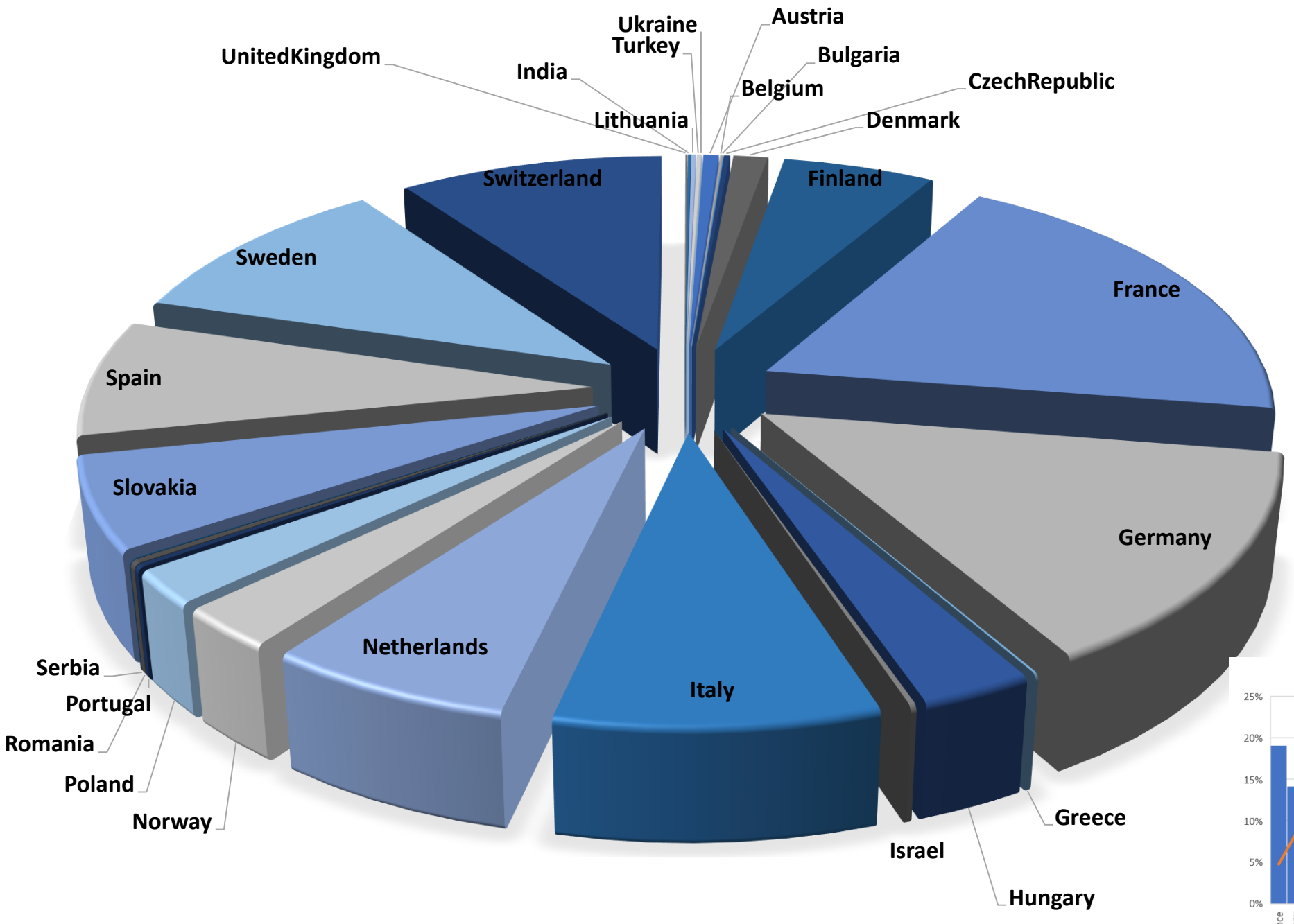
Ukraine
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Austria
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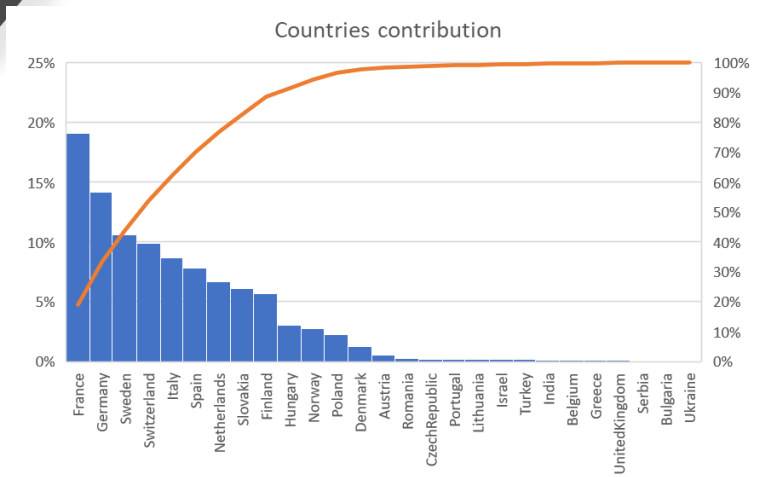
Romania
Italy
Poland
Norway
Greece
Israel
Hungary

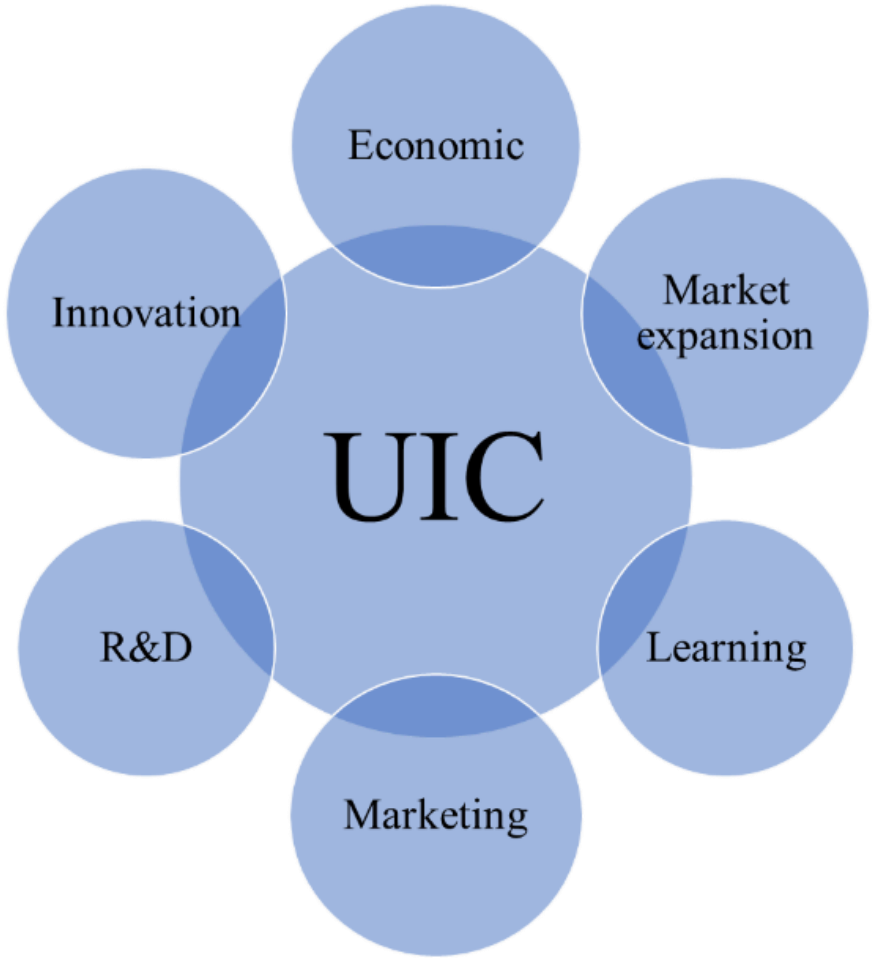

Countries contribution
25%
20%
15%
10%
5%
0%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
France
Germany
Sweden
Switzerland
Italy
Spain
Netherlands
Slovakia
Finland
Hungary
Norway
Poland
Denmark
Austria
Romania
CzechRepublic
Portugal
Lithuania
Israel
Turkey
India
Belgium
Greece
UnitedKingdom
Serbia
Bulgaria
Ukraine

What has the industry received from CLIC?

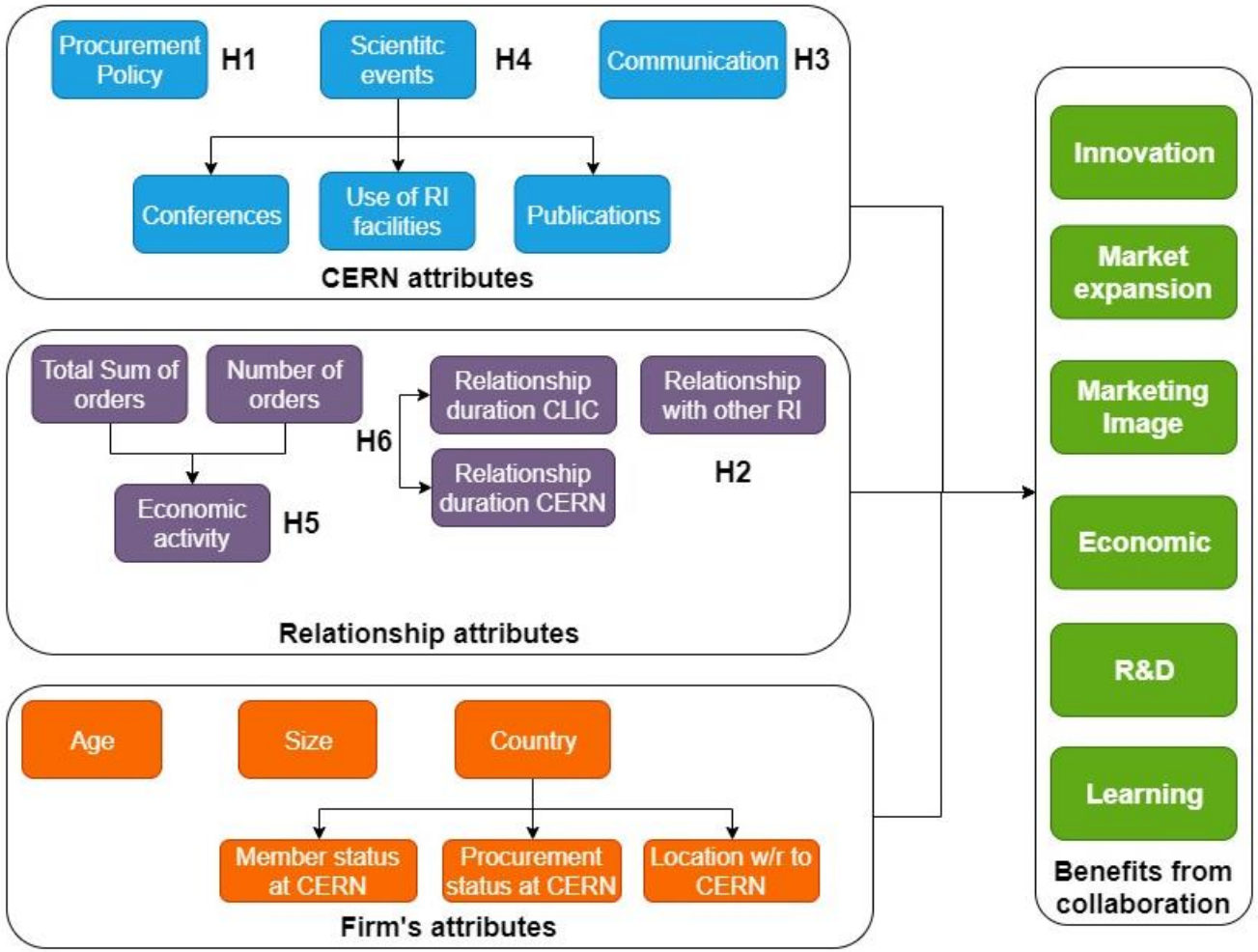
- Economic – orders, based on the health competitive process;
- Knowledge – they learn from us and with us;
- Market expansion - New clients – we share the list of suppliers;
- Marketing image – how many companies catalogues hav an image of our X-band components?!
- Quality improvement – can be used and promoted for other clients (Bodycote – new assembly room, which they are using now for other projects);
- R&D improvement at house.

Benefits (statistical analysis)

We distinguish the following outcomes for industries from CLIC collaboration



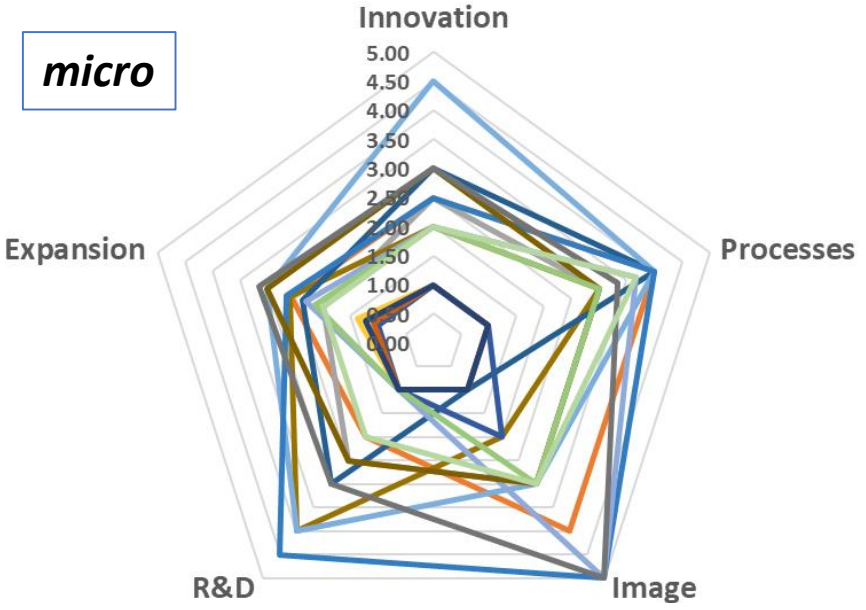
We distinguish the key influencing factors, grouped by three sets

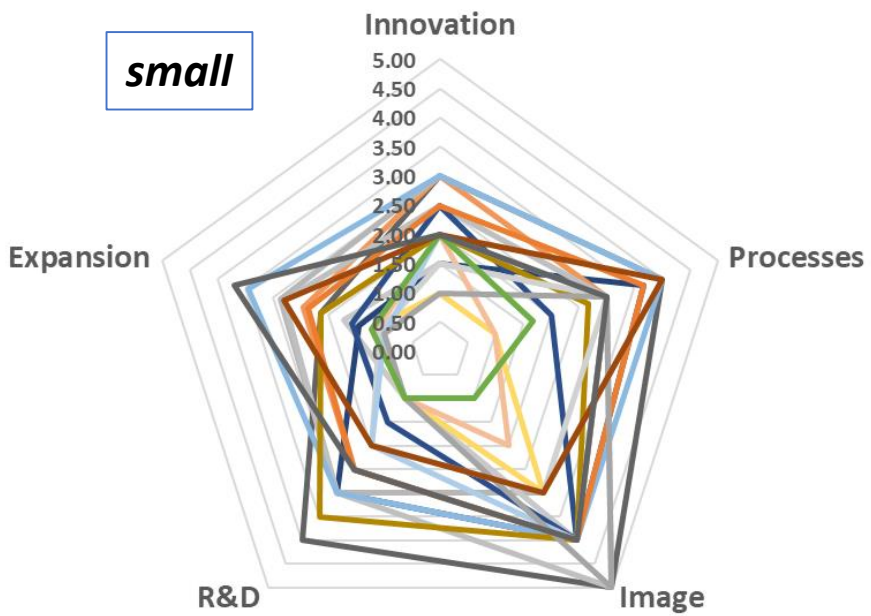


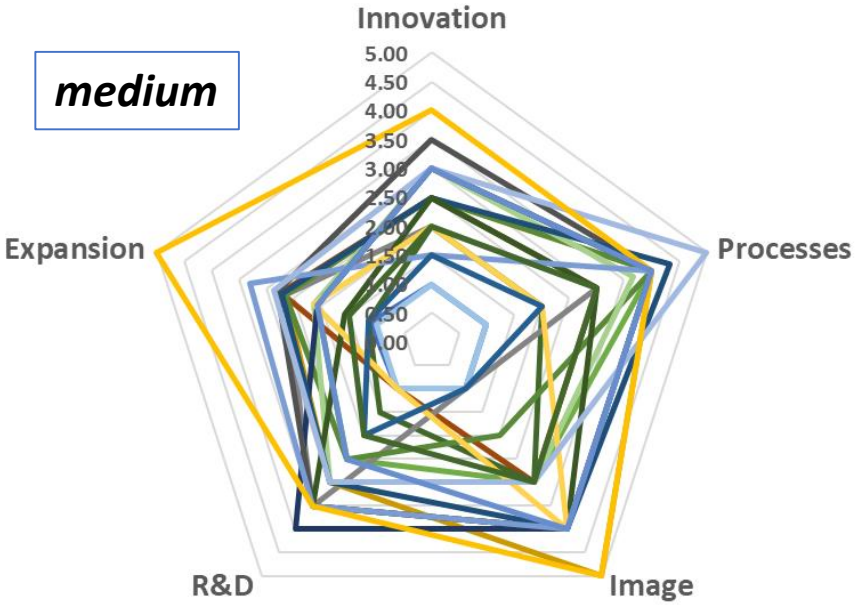
Radar graphs (different firm sizes)

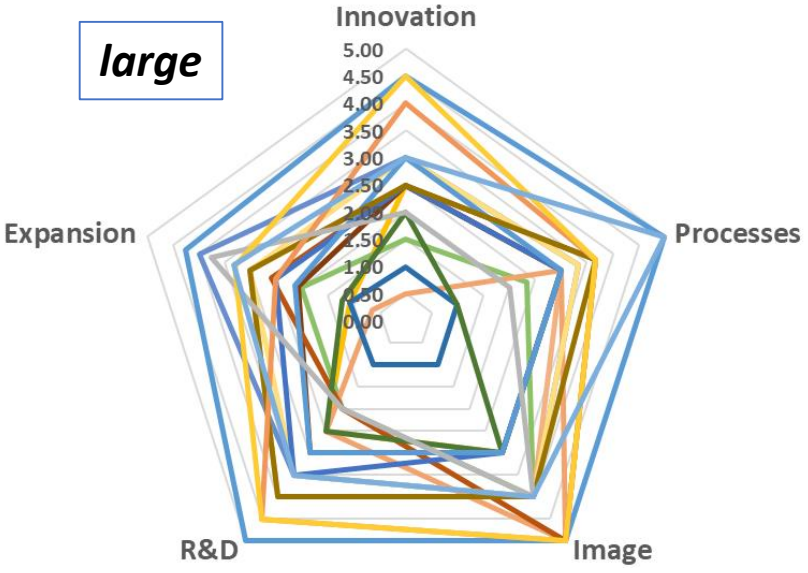
The bias to one of the benefits depending on the company sizes:

- micro, and small size companies show a bias to **image lifting** because of the collaboration with RI,
- medium size companies additionally signalise benefits towards **the learning in terms of the improving the process, product and logistic,**
- large size companies distribute more homogeneously benefits between all five outcome fields.

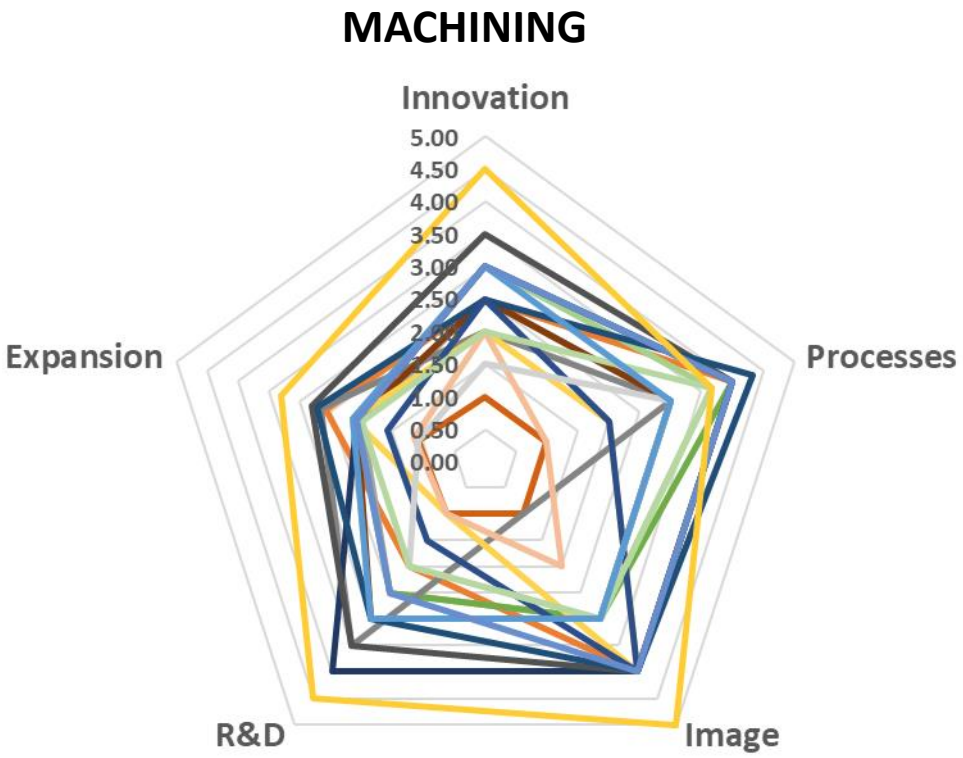


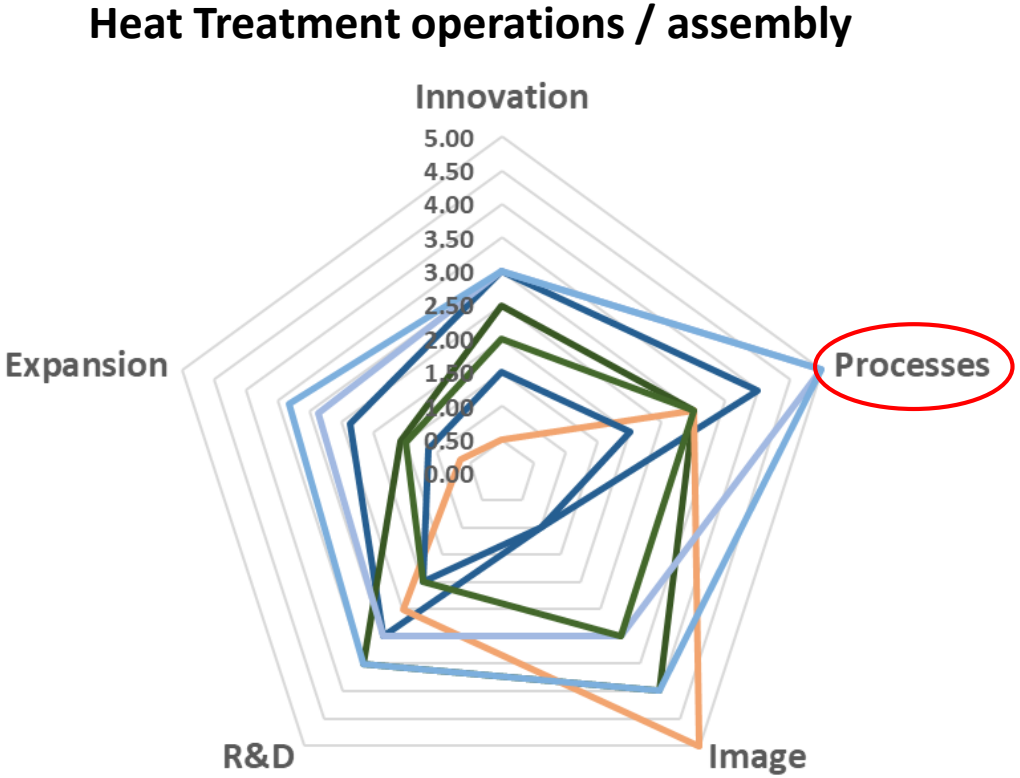






Radar graphs (technology)



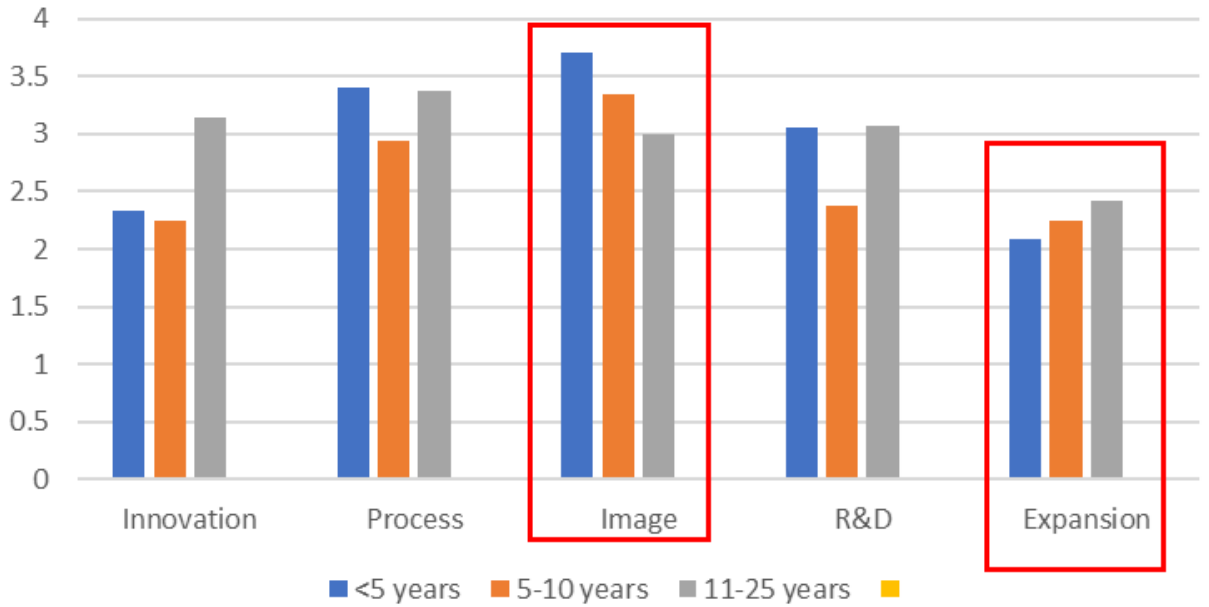


Process improvement, because of TT to companies (visits, procedures, present expert at site during operations and assembling prototypes)

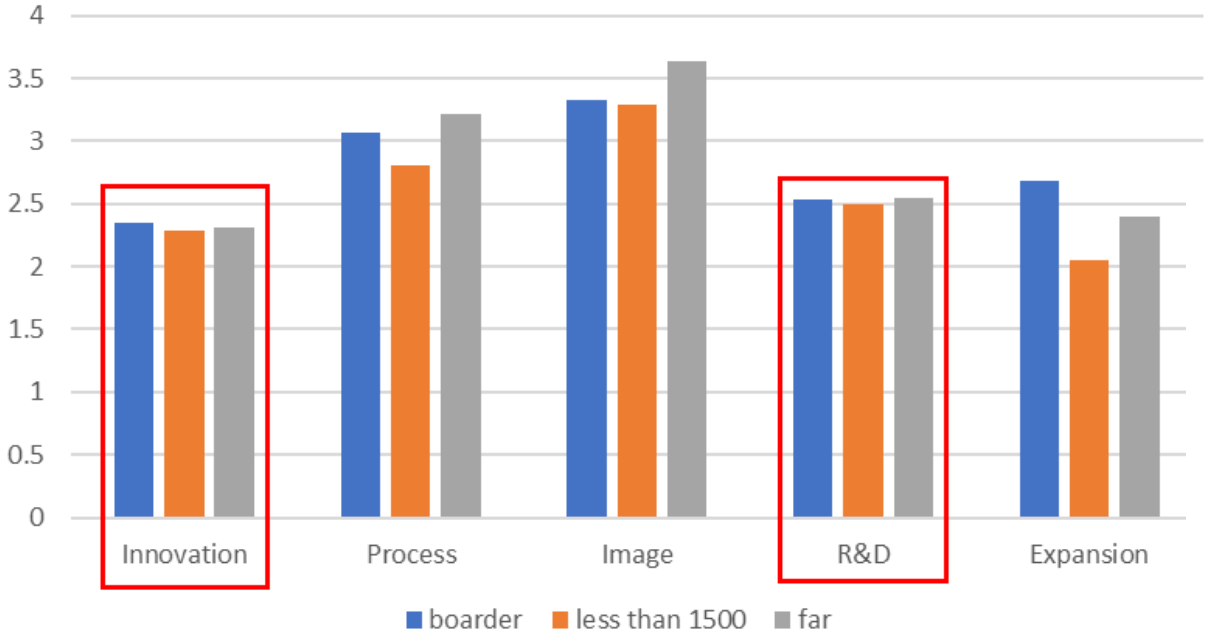
Other observations

- Benefits can change among the relationship time,
- Marketing image benefit is higher in the beginning of relationship and expansion higher for longer relationship,
- Location does not affect innovation and R&D benefits.

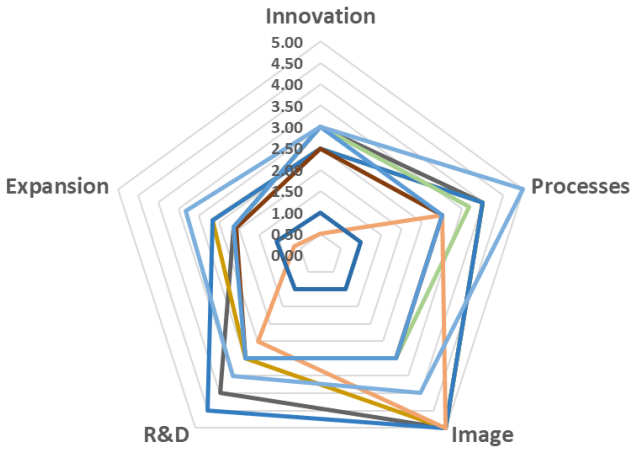
Relationship duration vs benefits



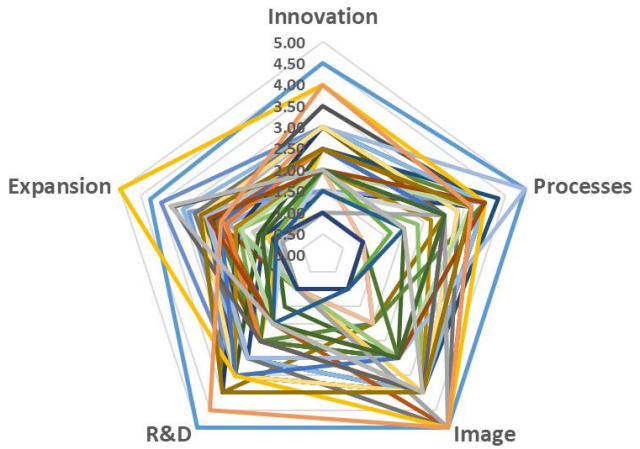
Geographical location and benefits



Less than 5 years



5-10 years



Benefits (statistical analysis)

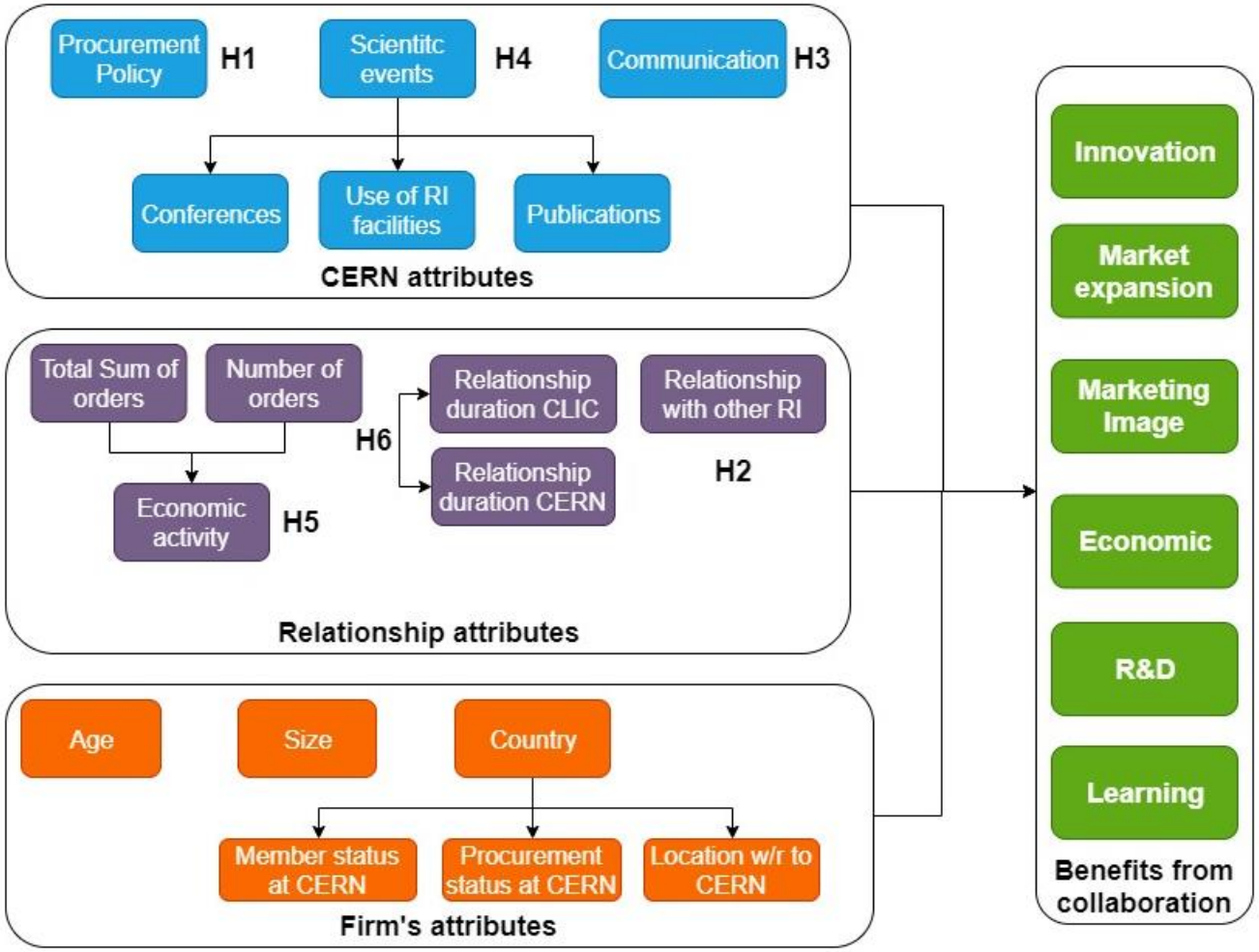
1. We distinguish the following outcomes for industries from CLIC collaboration (dependent variables):

- Innovation,
- Learning: internal process, logistics, service,
- Marketing image,
- Market expansion,
- R&D improvement,
- Economic.

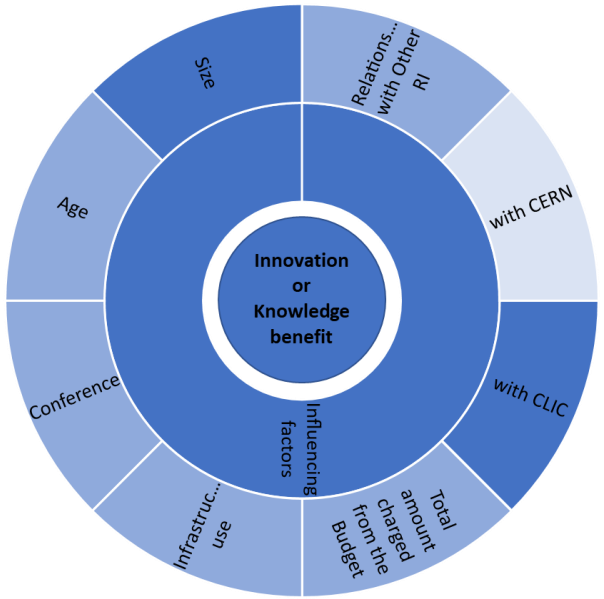
2. We distinguish the key influencing factors, grouped by (independent variables):

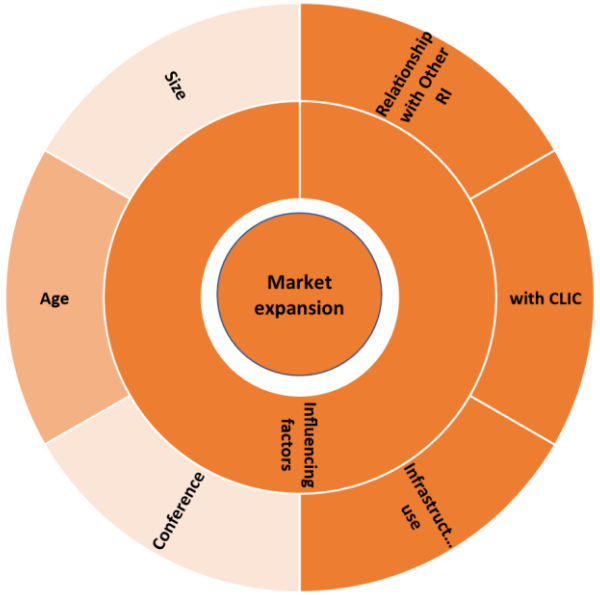
- CERN attributes,
- Relationship attributes,
- Firm's attributes (control variables).

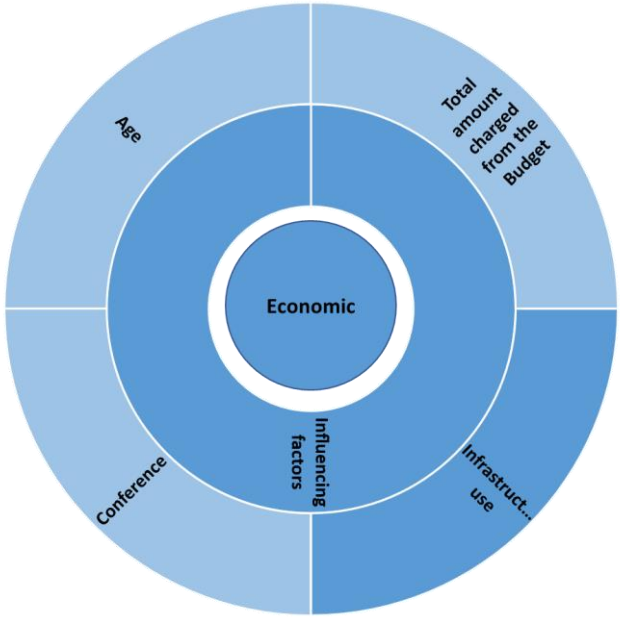
3. Repeat the regression analysis for each outcome (see next slide).



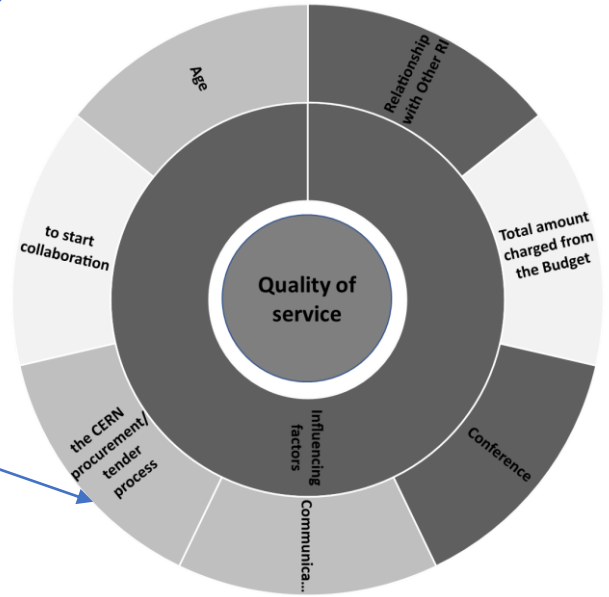
Findings from regression

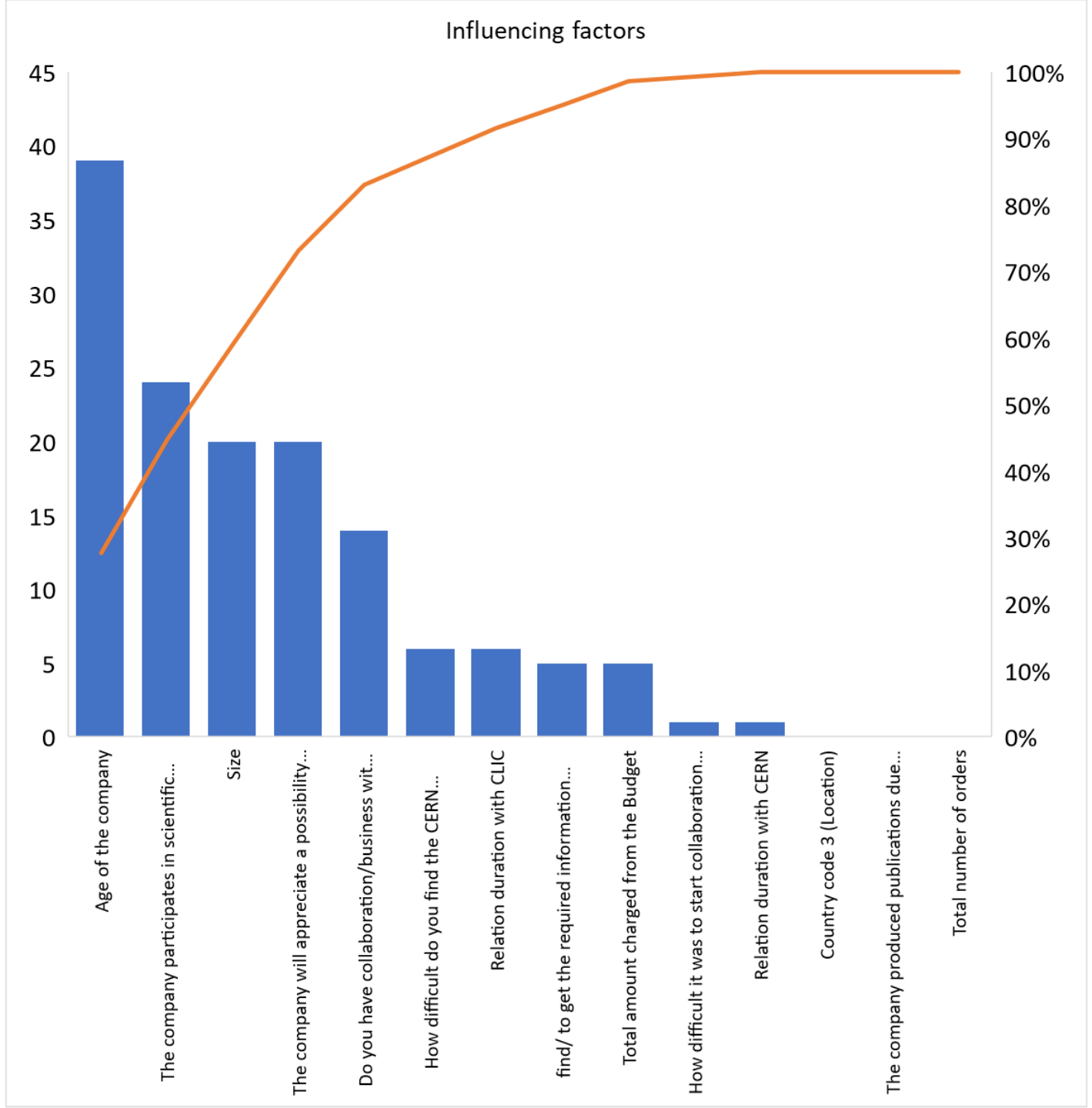




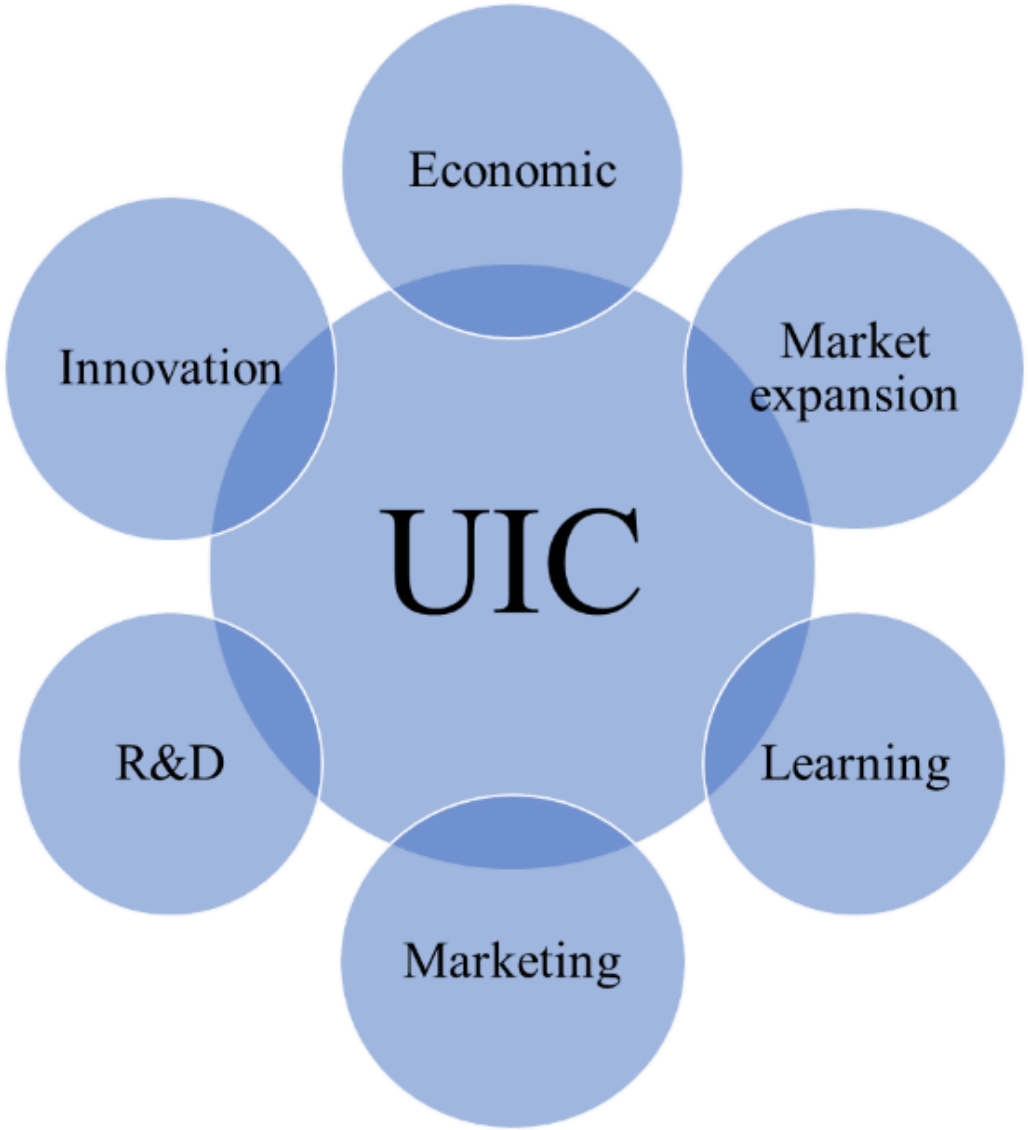


Learning




Influencing factors
45
40
35
30
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Age of the company
The company participates in scientific...
Size
The company will appreciate a possibility...
Do you have collaboration/business wit...
How difficult do you find the CERN...
Relation duration with CLIC
find/ to get the required information...
Total amount charged from the Budget
How difficult it was to start collaboration...
Relation duration with CERN
Country code 3 (Location)
The company produced publications due...
Total number of orders

Benefits

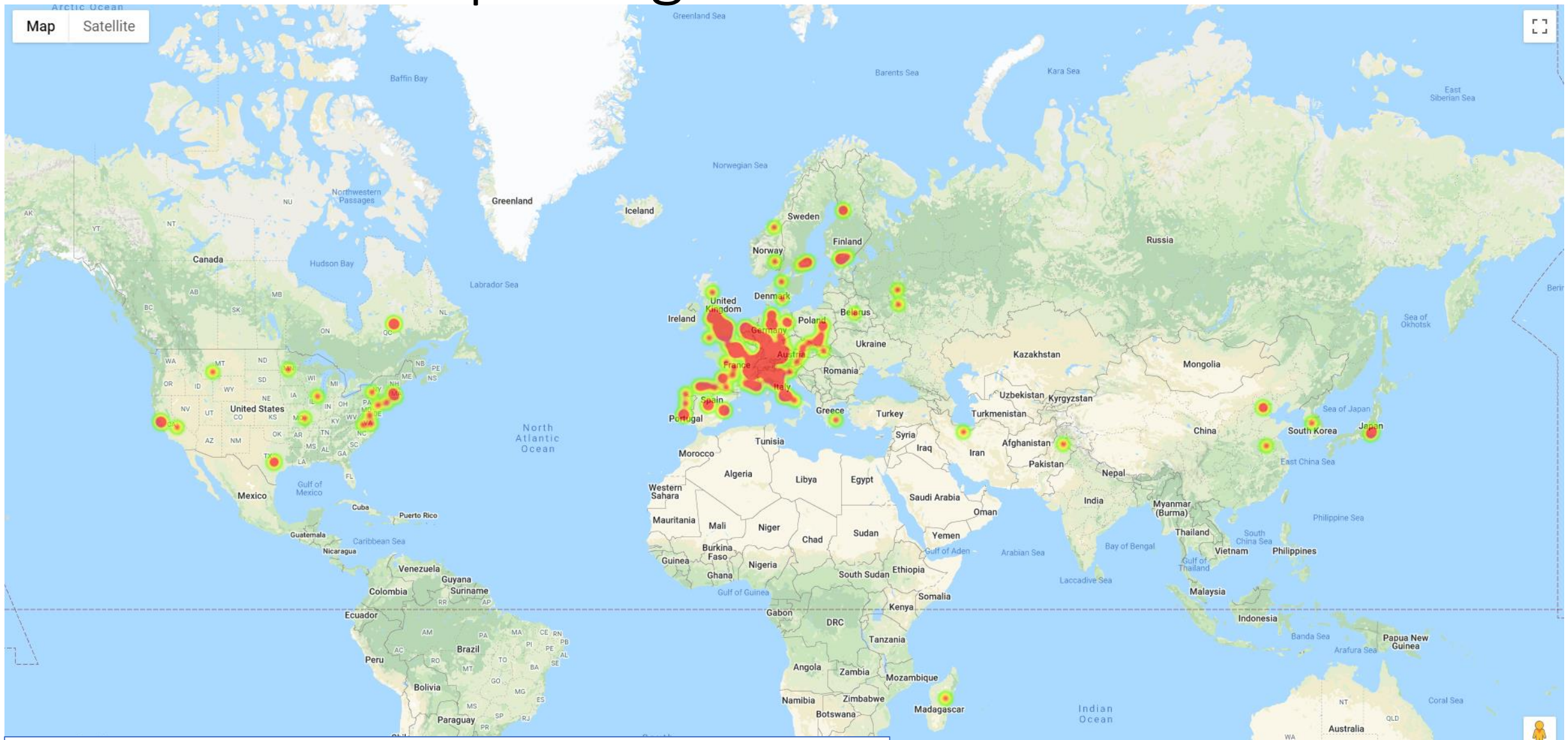

Economic
Innovation
Market expansion
UIC
R&D
Learning
Marketing


Benefits from collaboration
Learning
Learning service
Learning process
Learning logistics
Knowledge
Market expansion
R&D
Economic
Marketing Image
Age
Relationship with Other RI
Total amount charged from the Budget
Conference
Communication
the CERN procurement/ tender process
to start collaboration
Use CERN infrastructure
Conference
the CERN procurement/ tender process
Age
Relationship with Other RI
with CERN
with CLIC
Total amount charged from the...
Infrastructure use
Conference
Age
Size
Relationship with Other RI
with CLIC
Infrastructure use
Conference
Age
Size
Relationship with Other RI
Infrastructure use
Conference
the CERN procurement...
Size
Total amount charged from the...
Infrastructure use
Conference
Age
Relationship with Other RI
Communication

Findings from regression

- Companies benefit from collaboration already at the early stage of an international study,
- Correlation between suppliers' benefits and taking place scientific events (participation in conferences, workshops, having a possibility to use RI facilities by industries).
- Moreover, the findings present significant effect of having collaboration with other RI coming along with the CLIC – supplier relationship duration. It is important for companies to understand this effect which is explained by sharing a list of qualified companies between collaborative institutes.
- CERN procurement policy does not influence on getting benefits by companies in innovation, market expansion, but influence benefits for marketing image, R&D and learning.

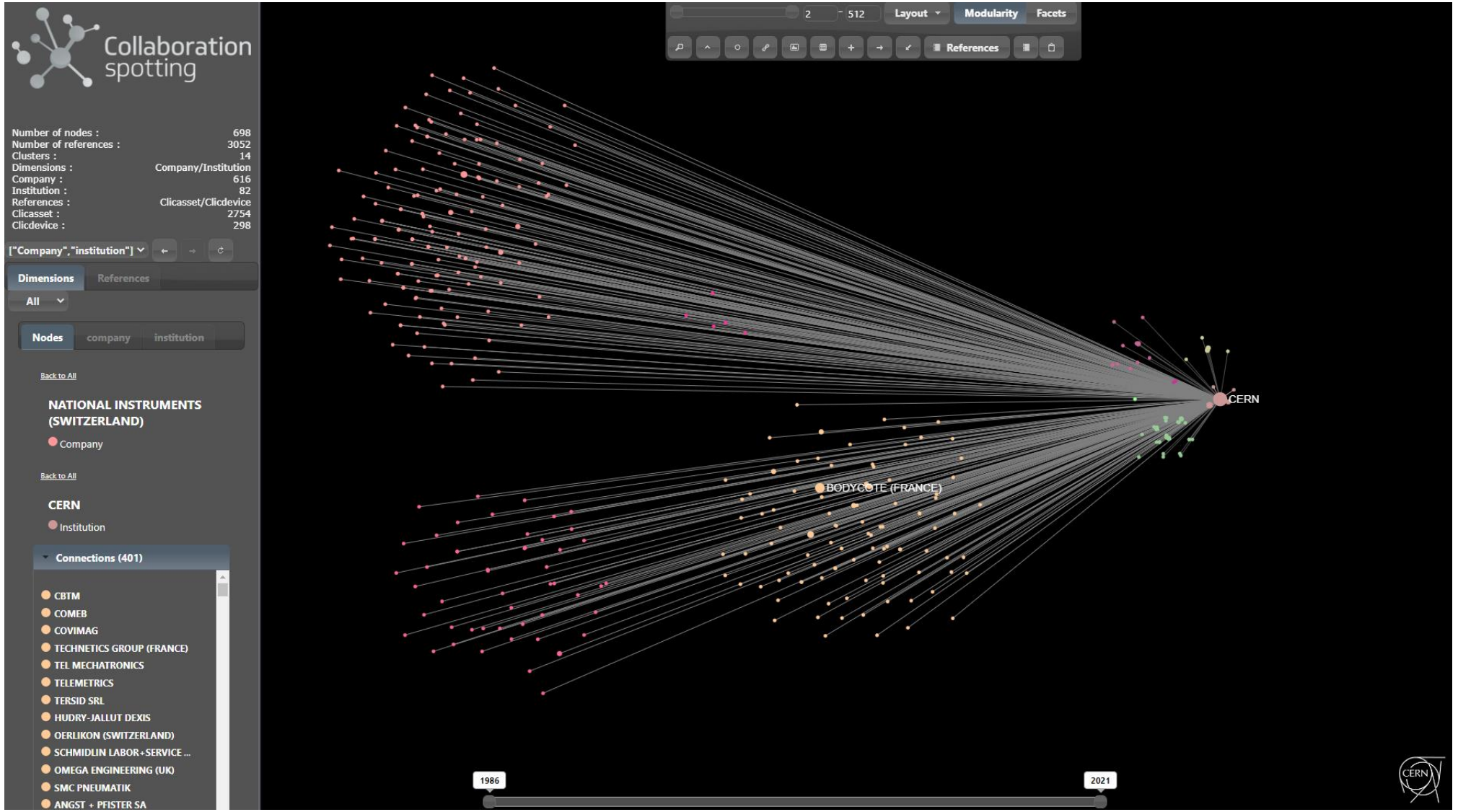
Collaboration spotting



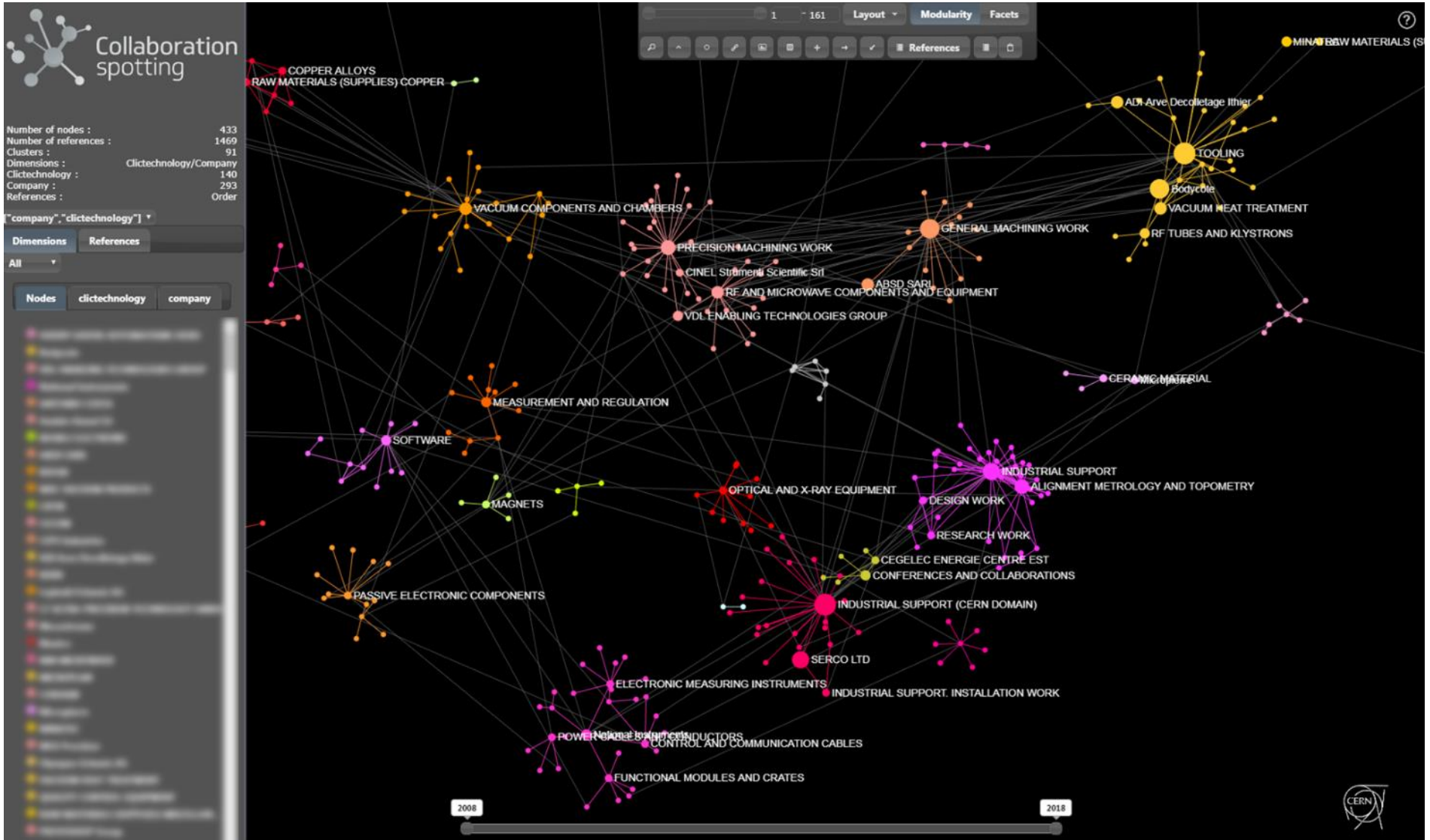
Software developed at CERN

“Collaboration Spotting (CS) is a graph-based interactive visualisation tool for multi-dimensional data networks“.

Collaboration spotting



Collaboration spotting



What have still to be done?

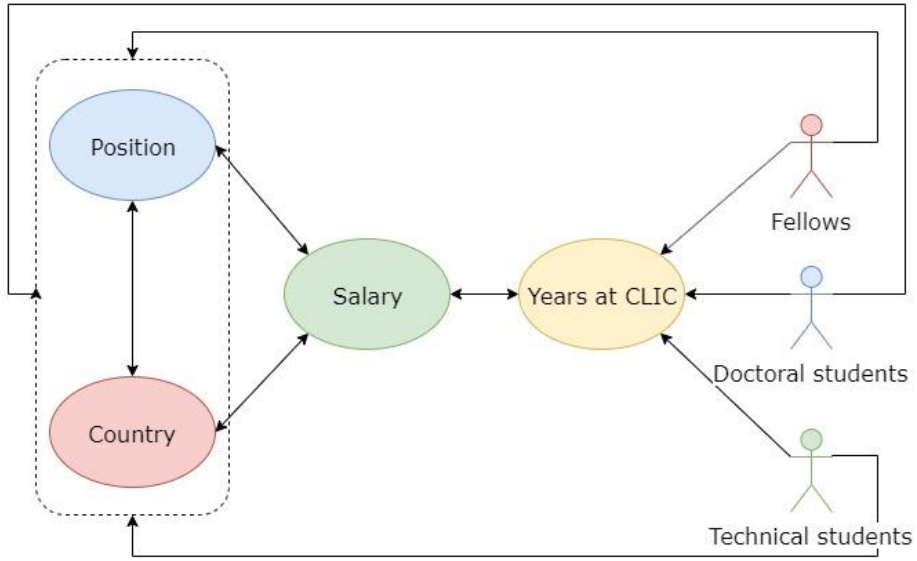
- Evaluation of other impact fields;
- Put pieces of the puzzle together.

Thank you!

EXTRA

Students

- Four categories of early-career researchers (ECR): technical, doctoral student and fellows;
- DATA from: CERN PD, EDMS, Research gate, LinkedIn, CDS.
- Check their carriers
- About incremental salary based on the statistical information:
  - Glaasdoor.com
  - Payscale.com
  - CERN.ch



Benefits

- Three different sources:
  - $\Delta\ salary_i$ from payscale.com (using skilled and average salaries per profession: engineers, researchers and managers).
  - $\Delta\ salary_i$ from glassdoor.com (using an average salary per a company)
  - Percentage premium from LHC study – 11.8%.
- We calculated NPV (Net Present Value), taking into account the discount rate 3%, recommended by *EU (2014) Guide to Cost-benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020, Publications Office of the European Union. DOI: 10.2776/97516.*

$$\sum \binom{Number\ of\ students}{N_i} \times \binom{Incremental\ salary}{Salary_i} \times \frac{Discounting\ effect}{over\ 40\ years} = \frac{Social\ value\ of\ human}{capital\ formation}$$

$$\Delta = Salary_{skilled\ specialist} - Salary_{ECR}$$

Florio, M. et al. (2016) 'Exploring Cost-Benefit Analysis of Research, Development and Innovation Infrastructures : an Evaluation Framework', pp. 1–86. doi: 10.1080/1354570022000077962.

Salary premium *(per person)*

Category	Source	Not discounted CERN salary premium (CHF)	Discounted salary CERN premium (CHF)	Cost/Benefit ratio
Technical students	Payscale.com	Over 40 years: 245975 Per year: 6149	Over 40 years:142141 Per year: 3554	6.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	10
Doctoral students	Payscale.com	Over 40 years: 386292 Per year: 9657	Over 40 years: 223227 Per year: 5580	4.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	4.3
Fellows	Payscale.com	Over 40 years: 308353 Per year: 7709	Over 40 years: 178187 Per year: 4455	1
	Glassdoor.com	Over 40 years: 919366 Per year: 22984	Over 40 years: 531274 Per year: 13282	2.3
	11.8% *	Over 40 years: 388706 Per year: 9718	Over 40 years: 224621 Per year: 5615	1.2

* Florio, M., Forte, S. and Sirtori, E. (2016) 'Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond', *Technological Forecasting and Social Change*, 112, pp. 38–53. doi: 10.1016/j.techfore.2016.03.007.