» INTERVIEW

LHC: COST-BENEFIT ECONOMIC ANALYSIS TO 2025 AND BEYOND

Interview with the economist Massimo Florio, professor at the University of Milan

In April, CERN of Geneva and INFN organised the FCC Week, an international conference which brought together around the table in Rome 450 scientists from around the world to discuss the Future Circular Collider (FCC) concept. The conference was attended by the economist Massimo Florio, Professor at the University of Milan, who worked on the first study on the impact of a scientific research infrastructure. The Cost-benefit analysis of the Large Hadron Collider to 2025 and beyond was concluded in July 2015, with the benefits outweighing the costs.

Professor Florio, what is the context underpinning your study on the impact of a major research infrastructure such as the LHC?

Three years ago, a call was issued by the European Investment Bank, which has its own grant programme dedicated to Universities on issues of interest to the EIB. So we formed a team of experts, twenty or so people, from the departments of economics and physics of the University of Milan, and from the Centre for Industrial Studies (CSIL), including economists, statisticians, physicists and professionals with analysis experience of traditional infrastructures, such as bridges, motorways or railways, who had collaborated on the implementation of the guidelines of the European Commission on the subject, since 1994, the year of their first edition. The European guidelines, however, did not previously include specific chapters dedicated to methodologies on the cost-benefit analysis of research infrastructures. So the analysis work carried out on the LHC was the first study on this type of major infrastructures.
In our study we decided to propose two case studies: we examined two similar machines, i.e. two hadron accelerators, one used for basic research, the Large Hadron Collider at CERN, and one used for applications, in particular in the medical field, the National Oncology Hadrontherapy Centre (CNAO) in Pavia, where the accelerator is used to treat patients suffering from tumours which cannot be

» INTERVIEW

treated with conventional radiotherapy. We therefore tried to apply a methodological approach for two different cases but which envisage the use of the same type of machine, even if of course on a different scale and with different objectives. As already mentioned, we were aware that since the existing guidelines did not include a specific chapter on these infrastructures, we would have had to develop a new methodology. So, we started from a conceptual model that we developed during the first year of our work, while the next two years were dedicated to analysing these two case studies in detail. The EIB was interested in our study because in recent years it has started receiving numerous requests for funding for the construction of research infrastructures, hence the need for tools enabling it to make its own impact analyses, as it does for other large infrastructure projects.

What considerations did you make to identify the methodologies to be used for the impact assessment?

What we did in our study was to apply to research infrastructures a number of methodologies already known but which had never been combined together in this specific way. In particular, we analysed the costs, or more precisely the aggregation of costs incurred by the different entities. In the case of the LHC, the system is extremely complex: it is necessary to consider, for example, the accelerator construction costs, those for the experiments and supplies in kind. The cost study was, therefore, very challenging, despite the significant collaboration of CERN in putting all the necessary information at our disposal.

Subsequently, we assessed the benefits. Here we distinguished between user benefits and non-user benefits, i.e. between the benefits of the direct users of the machine and the benefits to civil society.

We therefore considered the main system of measurement of scientific output, i.e. publications in specialised journals, the long-term benefits for students and post-docs, i.e. for young researchers, and the benefits deriving from what we call "scientific tourism", i.e. visitors to CERN, approx. 100,000 per year, considering the infrastructure as a cultural centre, a museum or an archaeological site, or rather a 'science city'. For each of these components we used economic analysis methodologies.

What first of all is the impact of the benefits on the direct users of the infrastructure?

As regards publications and scientific output, the impact is relatively small compared to other benefits because, although involving large international collaborations, when compared with other research areas, the number of users is nevertheless limited.

The major benefit, on the other hand, regards the careers of young researchers. We needed a time horizon, so we took 2025 as the reference date, when the High Luminosity LHC project (see interview with Lucio Rossi in Newsletter14, August 2015, ed.).will be launched. In this perspective, if we consider the plethora of PhD students and post-docs, we arrive at approx. 36,000 young researchers. Since we can assume that the effects will last for approx. 35 years, then the fact

» INTERVIEW

of being able to include this experience in one's CV produces a considerable overall impact. We conducted interviews with 400 people, including current and former students, asking them on a given scale in which range they positioned the "LHC effect" on their careers; a significant positive effect emerged which was convergent for both current and former students.
As for companies, on the other hand, we calculated the incremental profits from potential incremental sales of technologies developed for LHC, i.e. the impact of being included in the supply chain of advanced technologies. In this case, we also had previous surveys conducted by CERN at our disposal, based on which we were able to conclude that for every euro of high-tech supplies to CERN there were 3 euros of additional sales to other customers. We considered the years from 1991 to 2013, considering more than one thousand companies. For a total of 333 CERN suppliers, we were able to examine the history of the financial statements before and after the supply event. Here we found a discrepancy between hi-tech and traditional companies, as expected: in the case of hi-tech companies, we measured a statistically significant and positive effect on profits. Among other things, we also considered the significant social impact on computing, thanks to the availability of advanced software for free to thousands of users, also in industry and in hospitals.
Finally, as regards the effects that we could call "cultural", we used a method that is used in the US for natural parks: the so-called travel cost method, which we could summarise by reflecting on the fact that, when a visitor goes to visit a cultural site, such as a museum, its impact is not given so much by the cost of the ticket to enter the site, but by everything the visitor does before, during and after his visit. In the analysis we also considered the wide-ranging effects, for example, itinerant exhibitions implemented by CERN, visits to web sites and the media impact.

The impact of the benefits on civil society is also part of your assessment.
The benefits for those not directly using the infrastructure, the non-user benefits, are conceptually of two types. The first concerns the potential for scientific discovery: i.e. what it brings in terms of future uses. But asking ourselves today what we could do tomorrow with the Higgs boson creates confusion and rhetoric. It is the scientists themselves who tell us that this factor can not be evaluated, it is not possible to make its cost-benefit analysis. So we decided to assign it the value 0, which means that we consider its impact unpredictable for the time being, but certainly not negative.
The second concerns the willingness to pay, even by those who have no interest in using the infrastructure. Let me make a familiar example: the panda. There are people willing to pay to see it but there are also those who are willing to pay just to know that it exists, to preserve it from extinction: this is called *non-user willingness-to-pay, existence value*. In this case we made an experiment with one thousand students (including non-scientific courses) of four European universities, two in large cities (Milan and Paris) and two in smaller cities (Exeter and A Coruna in Spain), on their willingness to pay for the existence, in this case, of a major research project, the LHC to be precise.

» INTERVIEW

In conclusion, overall in our study we extracted the average and distribution of the discounted difference of costs and benefits (net present value), using for the calculation of the probability distribution the Monte Carlo methods, also known in the physics world, and we obtained a 90% probability of the benefits outweighing the costs.

Did you identify any weaknesses in major research infrastructure projects?
For large infrastructures, from transport to energy and the environment, governments adopt coded social cost-benefit analysis procedures. For research infrastructures, the decision-making process is fragmented, based on intrinsic ad hoc criteria, such as the scientific reasons, so it is difficult to carry out a systematic analysis. But, since civil society pays the bill through taxes, a commitment to make the decision-making process more transparent and to conduct a social impact assessment is also necessary. A criterion complementary to the scientific criterion, but necessary, also because there is competition between different projects.

Do you think that the approach used in this study can also be applied to other cases?
Yes, we believe that this methodology can also be used for new infrastructures, so much so that the ESFRI (European Strategy Forum on Research Infrastructures) in its latest report (Strategy Report 2016) mentions us, underlining that in the area in question there is progress and it is open to the study of these cost-benefit analysis methodologies. In addition, the 2014 edition of the Guide to Cost-Benefit Analysis of the European Commission now has a chapter that we wrote on this subject.

You will be appointed by CERN to make a similar assessment for the FCC project.
We are thinking about this appointment. Our idea is to apply what we have learned in conducting the LHC study, although in this new case, of course, specific criteria and expedients will need to be adopted since it is a totally ex-ante assessment, with a variety of possible scenarios, given that the scientific community is still in the discussion stage of the project concept. Also this time we will work with a team of economists and physicists, with a coordination group comprising representatives of CERN, the University of Milan and CSIL, within the broader framework of the FCC Study, also considering the prospects of the High Luminosity LHC. The interdisciplinary approach is very stimulating and fruitful. ■