Future Circular Collider

PUBLICATION

Cultural Effects at CERN

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Study of the socio-economic impact of CERN HL-LHC and FCC

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REPORT

Cultural Effects at CERN

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TABLE OF CONTENTS

List of Abbreviations

CBA	Cost Benefit Analysis
GDP	Gross Domestic Product
LHC	Large Hadron Collider
MSV	Marginal Social Value
RI	Research Infrastructure
WTP	Willingness to Pay

Executive Summary

This report summarises the results of the impacts of cultural and outreach activities carried out at CERN. This report demonstrates the robustness of findings of previous studies by validating them using additional information and most recently updated data. Specifically, the following communication channels were investigated in details:

- YouTube social media platform for videos,
- CERN, LHC and related experiments' websites,
- Social media for fast one to many communication (e.g. Facebook, Instagram, Twitter),
- Travelling and permanent exhibitions.

For each channel, CERN cultural products relating to the LHC/HL-LHC programme were analysed in detail and their economic values were assessed through quantification of the impacts on the user community. Benefits were estimated by applying the "willingness to pay" method of on-site and "virtual" CERN visitors. Findings from this analysis confirm that cultural activities generate significant amounts of positive impacts for individuals. The single largest impact is achieved via videos, as the results of the YouTube platform reveal. This impact is amplified by cross-linking multimedia material on social media and websites. While web-based impacts are generated through large amounts of consumers, exhibitions generate impact by capturing the attention of visitors for longer time periods.

1. Introduction

Research infrastructures (RIs) perform outreach events and activities to inform the public on advances in science and technology. These activities may entail visits (permanent or temporary exhibitions, open days, guided tours) and "virtual visits" through social media, broadcasting, news and press articles, books and websites. The rates of participation are indicators of the size of the cultural impact produced by the RI.

How is it possible to measure the social value of these communication products? There are standard Cost Benefit Analysis (CBA) approaches to evaluate the impact of tourism to museums and other recreational sites, like natural parks. In line with these approaches, the expected marginal social value of the benefit is the expected visitors' implicit willingness-to-pay (WTP) for an on-site visit to the RI or for consuming other cultural and outreach products (virtual visits). The cumulated intertemporal benefit (CU) of outreach activities can be expressed as the sum of the WTP for each type of activities by type of consumer (e.g. high-school students, retired people, etc.), such as (3):

$$CU = \sum_{x=1}^{X} \sum_{g=1}^{G} \sum_{t=0}^{\mathcal{T}} \frac{1}{(1+SDR)^t} \cdot WTP_{xgt}.$$

where SDR = social discount rate; g = users; t = time; x = type of activities

From an empirical perspective, the approach to estimating the WTP may be different for each of the cultural products. For instance, the travel cost method (TCM) is a well-established approach for evaluating the willingness to pay of people for on-site visits. It consists in estimating the travel cost associated to the visit, including the cost of trips (fuel, train or airplane ticket, etc.), the opportunity cost of time spent during the travel and the visit, the cost of accommodation, food, souvenirs and further, related expenses. Given the number of visitors to the site in a given time period and the marginal economic cost of a trip, the demand curve can be derived and the willingness to pay for a visit can be estimated. The value of other outreach impacts – e.g. trough media like television, websites and communication platforms can be quantified through standard techniques commonly used by marketing specialists. Examples include the number of 'tweets' and followers in Twitter, posts or impressions in Facebook, subscribers of YouTube channels and the number of views, the estimated number of people watching an event on TV, the number of blog conversations, the analysis of web traffic, registrations on the RI website and other performance indicators. In all cases, reliable recording to be able to estimate the average time spent consuming a product is essential As a direct extension of the travel cost method, the marginal cost of accessing and using the media can be used to estimate benefits that an outreach product is likely to generate. Considering that most of the resources are freely accessible, the economic values corresponds best to the opportunity cost of users' time. Similarly, the social value of time spent in reading, listening, and viewing content related to RI outreach in traditional media is a reasonable proxy for the benefits to users net of any price paid by them (the cost of creating the outreach product needs to be accounted in the operation expenditures of the infrastructure Cost Benefit Analysis). Information on the income of users and the time they spend on enjoying outreach activities by the RIs help to come to a reasonable estimation of these benefits, when the explicit WTP is not available through survey data. For the calculation purpose an estimation of the number of distinct virtual visitors, the time spent by each consuming the products and the marginal social value of time are needed.

Previous attempts to measure cultural impacts generated by LHC-related outreach activities have been carried out. Findings and approaches used are briefly presented.

Previous studies [(1), (4)] have already quantitatively and qualitatively reported on the positive effects of CERN's outreach activities. The results are briefly described in Section 3. The objective of this report is to show the robustness of previous findings by providing fresh calculations based on most recent data.

2. Previous evidence

A first attempt of quantifying the cultural impacts generated by CERN was carried out by (4) in 2016 in the framework of a cost-benefit analysis of the Large Hadron Collider (LHC). Specifically, the following groups of beneficiaries were considered: (a) onsite CERN visitors; (b) visitors to CERN travelling exhibitions; (c) people reached by media reporting LHC-related news; (d) visitors to CERN and Collaborations websites; (e) users of LHC-related social media (YouTube; Twitter; Facebook; Google+); (f) participants in two volunteer computing programs.

(a) *Onsite CERN visitors*

Benefits for on-site visitors were estimated by using the revealed preference method (by following (2), with the marginal social value (MSV) of the time spent in traveling for visiting the LHC. Historical data for on-site visitors (from 2004 to 2013) were provided by the CERN education, communication and outreach group and by each LHC Collaboration. Forecasts up to 2025 were extrapolated by a constant yearly value, based on the trend observed in the previous years. An overlap of 80% between visitors to LHC experiment facilities and the permanent CERN exhibitions (Microcosm and Universe of Particles, in the Globe of Science and Innovation) was assumed and only 80% of total number visitors to CERN were attributed to the LHC/HL-LHC programme. For the benefit estimation, the travel cost method was applied. Visitors were divided in three areas of origin with increasing distance from CERN. An average travel cost was calculated for each zone, using the cost benchmarks of seven origin cities and by assuming a transport mode combination and duration of stay[1]. The economic value of the time travellers spend was taken from HEATCO guidelines[2] for each member state and for some non-member states. Based on the distribution of visitors by country and the mode of transportation, an overall distribution of visitors based on a probability density function was derived (4).

(b) *Visitors to travelling exhibitions*

In order to estimate the benefit for the travelling exhibitions, (4) considered the number of past visitors as reported by CERN (between 30,000 and 70,000, for the period 2006-2013) and assumed a constant number of 40,000 visitors per year during from 2014 to 2035. They prudentially assumed a WTP equally to 1 EUR per visitor (assuming local transport).

(c) *people reached by media reporting LHC-related news*

For the estimation of benefits generated by social media, (4) conservatively considered only the spikes in postings and news on September 10, 2008 (LHC start) and July 4, 2012 (announcement of the discovery of the Higgs boson). An analysis of the traffic showed that the average time that a person spent reading those news was about 2 minutes. The economic value of time of the readers was estimated by considering the current GDP per capita in the CERN Member States and the US (for 2013, using International

[1] The three zones and the share of visitors for each zone were based on data provided by the CERN Communication Group (personal communication October 2013); additional costs were estimated, including for accommodation and meals (data extracted from the CERN website).

[2] http://heatco.ier.uni-stuttgart.de/

Monetary Fund data) as well as the number of working days per year (8 hours times 225 working days). The resulting value was treated as a stochastic, triangular distribution, with the minimum equal to EUR 3; maximum EUR 42, and mode and mean equal to EUR 17.

(d) *visitors to CERN and Collaborations websites*

(4) also estimated the number of website visitors on the basis of historical data until 2014 (data were provided by CERN and communication groups in the four main experiment collaborations). They conservatively assumed that the levels of website visits remain constant. The benefit comes from the number of minutes that a user remains on a web page per retrieval. The value is assumed to be a triangular distribution with average and mode equal to 2 minutes, and ranging from 0 to 4 minutes.

(e) *users of LHC-related social media (YouTube; Twitter; Facebook; Google+)*

Further benefits were estimated in relation to social media. For this purpose, the MSV of time of the public was proxied by the hourly value of per capita GDP. Historical data were used until 2014 and for the subsequent years, the last year's data was assumed to be constant. The average time a person reads an entry was assumed to be 0.5 minutes per person across all social media channels.

(f) participants in two volunteer computing programs

Finally, (4) considered the benefit generated by volunteers using LHC programmes for running particle collision simulations. WTP was applied to the time that people spent using these programmes to evaluate the economic value. Specifically, the analysis focused on two programs: SIXTRACK and TEST4THEORY. Users donate machine time and can subsequently access some data and join a social network. The number of volunteers in 2013 and a forecast in the coming years were provided by the CERN experimental physics department. A constant rate of increase from the program start years (2007 and 2001, respectively) was assumed (4). The opportunity cost was the time to download, install, and configure the programs (15 minutes per capita una tantum) and the time spent in forum discussions (15 minutes per month per capita). Again, time was valued relying on per capita GDP.

(4) found that benefits from **LHC outreach activities amount to around EUR 2.1 billion (not discounted, 2013 prices) over the entire CBA observation period from 1993 to 2025, generating benefits worth around 12% of the total cost of the infrastructure**.

An update of the above estimations was carried out by (1) in 2018 in the framework of the cost-benefit analysis of the High Luminosity upgrade of the Large Hadron Collider (HL-LHC), assessing its economic costs and benefits up to 2038. This update mostly relied on the approaches adopted by (4). For onsite visitors, (1) specifically assumed that for the 2026-2038 period there is no increase of visits at CERN. Hence the 2025 benefit value was kept constant until 2038. For the counterfactual scenario (CFS) which entails the switch off and maintenance of the infrastructure, (1) assumed a slight increase of tourists after the accelerator shutdown (5% from 2031 onwards), considering that the underground infrastructure can be visited during this period. Estimation of benefits has been done using the Travel Cost Method. The benefits reported by (1) and their percentage contribution to cultural effects are as follows:

- Onsite CERN visitors and visitors of CERN travelling exhibitions (57%)
- Media reporting on LHC (25%);
- Visitors of CERN and LHC experiment websites (12%)
- Users of LHC-related social media (YouTube; Twitter; Facebook; Google+) (2%);
- Participants in two volunteer computing programs (2%)

- Other media-related benefits such as movies and non-scientific books (2%).

In the case of HL-LHC, benefits stemming from outreach activities represent 13% of total benefits.

3. Evidence from new data

Building on previous studies (1,4), further investigations were carried out with the objective to assess in more detail the benefits generated by cultural goods and outreach activities[3]. Specifically, we focused the following four channels:

1. YouTube
2. Websites
3. Social Media
4. Travelling and permanent exhibitions

We collected new data for each of these channels to estimate the WTP of "on-site and virtual visitors". By adopting the approach described above (see Section 1), the marginal social value of the time spent by these visitors for enjoying CERN cultural good (e.g. news, video, exhibitions, etc.) was used as a proxy of the WTP. Details of data collected and calculation performed are provided in the following sections. We summarise some methodological choices and assumptions adopted for the purpose of our estimation:

a) For each of the above channels, we collected available historical data on the number of visitors (e.g. on site for temporary and permanent exhibition; virtual for all other channels) and the average time spent by these visitors for taking part in the visits or for consuming the virtual cultural products.
b) In order to express the time spent in economic quantities, we considered the social marginal value of the time spent for leisure activities. For this purpose, we relied on the values provided by (8) for the different EU member states. Specifically, we calculated a weighted average social value of time by weighting the value of time for the population of each country. The resulting value is EUR 0.13 per minute and person. See Annex I for details on the calculation.
c) For the calculation of the benefits generated by the different channels, we considered a time span from the first year in which the channel was launched until 2025. This entailed the adoption of different time horizons according to the different channels considered. 2025 was kept as the last year of analysis in compliance with the assumption made by (3).
d) Starting form historical data collected, we estimated data for future years as well as for past years during which the channel was active, but no historical data were available because of the lack of systematic monitoring. Details on this estimation are provided in the following sections.
e) The WTP was calculated as proxy of the benefit generated by cultural goods and activities. Specifically, it was calculated as follows: *Number of visitors * Average minutes per visits (on-site or virtual) * Value of time in monetary terms* (0.13 EUR per minute).
f) The estimation of the WTP relied on a mix of both historical and future data (as described under point c above). We decided to carry out the analysis using the 2017 value since this was the last year for which historical data were available. Therefore, we capitalised past values and discounted future values by taking 2017 as reference year[4]. To this end, we used the social discount factor of

[3] Differently from previous attempts, the perspective was enlarged to CERN as a whole.
[4] Capitalisation formula: Benefit*(1+3%)^year; Discounting formula: Benefit/(1+3%)^year

3% suggested by the "Guide to Cost-benefit Analysis of Investment Project" of the European Commission [9].

g) The estimation reported in this report is in Swiss francs. We used the following conversion factor: 1 EUR = 1.14 CHF.

h) Because of the lack of data, additional channels, such as press cutting and books were only qualitatively analysed.

3.1 YouTube

YouTube is a video-sharing platform launched in February 2005, enabling users to upload, view, rate, share, comment on videos, and subscribe to other users. Available content includes video clips, TV show clips, music videos, short and documentary films, audio recordings, movie trailers, live streams, and other content such as video blogging, short original videos, and educational videos. In 2018, this platform counted around 1,900 Million registered users. The actual number of users is actually much higher, but it is not possible to count the anonymous users.

A wide range of videos related to CERN can be found on YouTube. However, for the purpose of our analysis, we considered only videos about the LHC research programme, its four experiments and directly about CERN. A carefully analysis of all videos available on the platform was carried out, selecting only those that were causally related to the object of our analysis. **We found a total of 616 LHC and CERN specific in videos between 2007 and 2017 with about 39.5 million views in total**. For each video, we considered the number of views provided by YouTube statistics and the duration of the video. Annual data are reported in Table provided in Annex. A significant increase of views is observed in 2008 and 2012, which can be explained by the starting of LHC operation and the discovery of the Higgs Boson, having both events drawn the attention and curiosity of the community. The video recording the highest views was uploaded in August 2008. It is a rap video recorded by an amateur group of CERN enthusiasts, directed by Katherine McAlpine. The video aims at explain what a particle accelerator is in an entertaining fashion. It counts more than 8 Million views.

As explained above, the number of views stands for the number of users which have accessed the video (even if more than one time). This does not mean that they have actually watched it entirely. In order to take into account partial views, a reduction factor was applied for each video as a function of their total length. The reduction factors adopted in our analysis were taken from (7) and are reported in the table below.

Table 1: Reduction factors for partially visualization based on (7).

Video Length	Reduction Factor
< 1 MIN	60%
1-2 MIN	50%
2-3 MIN	45%
3-4 MIN	35%
4-5 MIN	35%
5-10 MIN	35%
10-20 MIN	28%
20-30 MIN	19%
30-45 MIN	15%
45-60 MIN	10%
>60 MIN	9%

In compliance with our methodological approach, the benefits from YouTube were estimated from 2005 (launching year of the platform) until 2025 (last year of our analysis). Missing data were calculated for the past (from 2005 to 2007) and future (until 2025) by applying an average growth rate of views and minutes equal to 0.5%[5]. The annual WTP of YouTube CERN's visitors was then calculated as follows:

*[Number of views (reduced) * duration of video (in minutes) * social value of time (EUR 0.13 per minutes)]*

The **total conservatively estimated discounted benefit generated between 2005 and 2025 by YouTube videos amounts to CHF 1.9 billion** (2017 value) or ca. 95 MCHF per year on average with a tendency to grow.

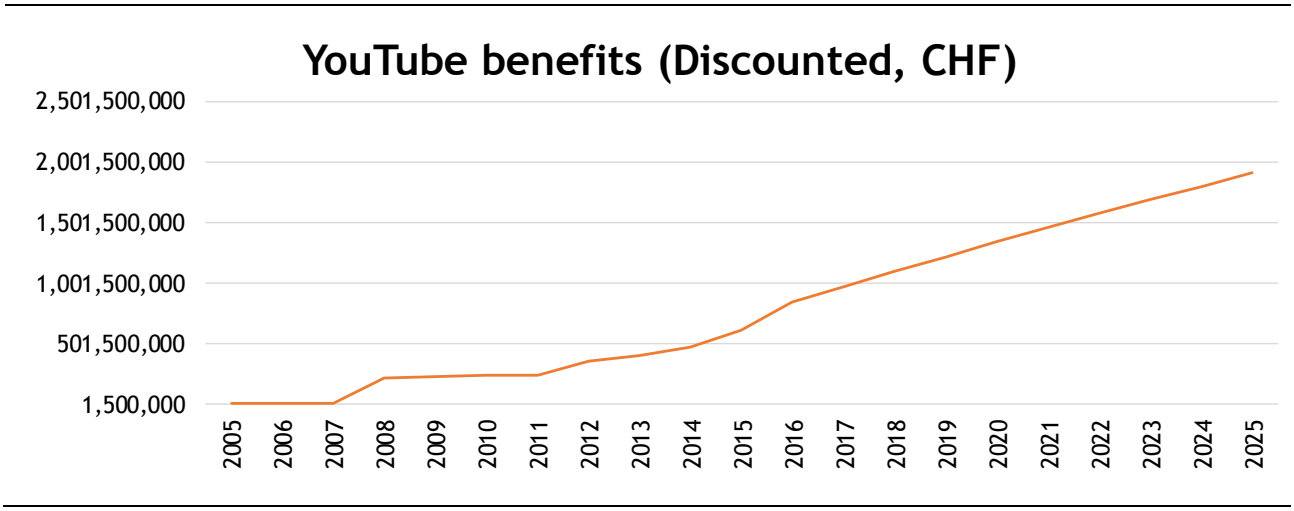

Figure 1: Total discounted benefit in CHF generated by YouTube videos between 2005 and 2025.

3.2 Social Networks

Social networks - such as Facebook, Twitter and Instagram – have become widely used communication channels for the society. This is also confirmed by CERN outreach activities, which have significantly increased over last years due to the use of social media channels. Any discovery or new information that is generated at CERN, including at the LHC, becomes a topic of global interest in a few minutes due to dissemination through social networks.

For the purpose of our analysis, we considered information from the different social networks in which CERN or the LHC is specifically mentioned. Historical data about the number of mentions through Facebook, Twitter and Instagram – from 2014 to 2017 - were provided by the media and press relations office at CERN (see Figure below).

[5] This rate was calculated by considering the R-squared value on chart number of videos per year (data between the years 2007-2017).

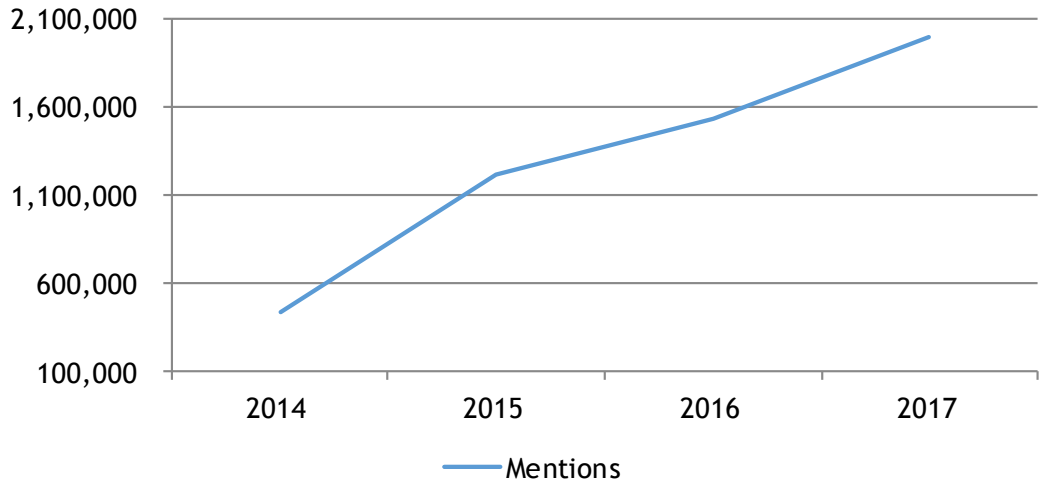

Figure 2: Number of mentions of CERN or LHC on social media between 2014 and 2017.

Mentions refer to the comments provided by "visitors" of social media, citing CERN or LHC. In compliance with our approach (see above), we considered data from the first year of launch of the social networks. However, since these channels have been launched in different years, we considered 2008 as starting year of our analysis. Missing data before 2014 and from 2018 onwards were estimated by assuming an annual average growth rate equal to that recorded between 2015 and 2017 (we excluded 2014 since during this year, social network has significantly boomed). For the purpose of calculation, we assumed that each visitor has spent about 0.5 minutes for writing the mention.

The annual WTP of CERN Social Media 'visitors' was then calculated as follows:

*[Number of mentions * time spent to draft the mention (0.5minutes) * social value of time (EUR 0.13 per minutes)]*

The **total discount benefit amounts to CHF 2.7 million** (2017 value) in the time period between 2008 and 2023. However significant growth is observed from 2014 only and therefore forecasts need to consider the lower social media channel use between 2008 and 2013. Results are shown in the figure below.

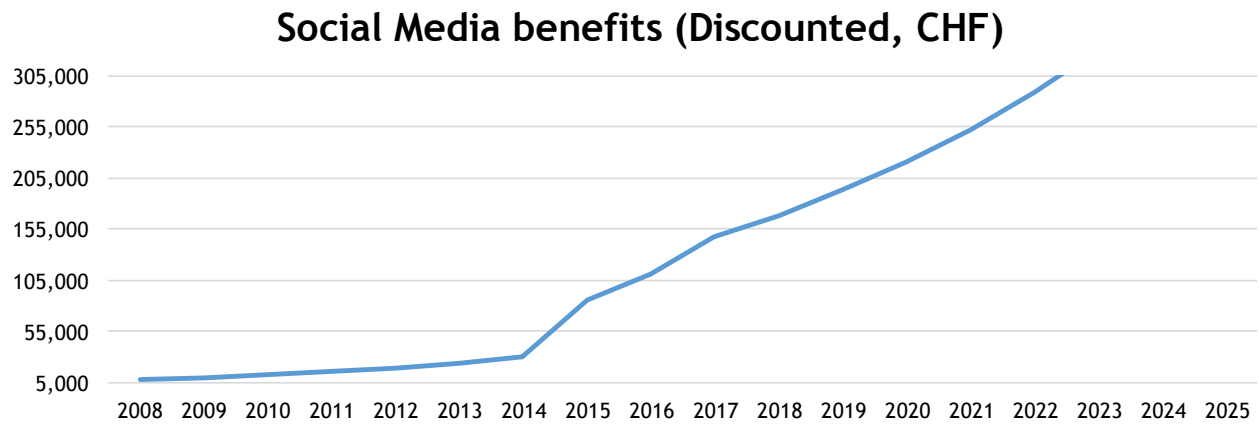

Figure 3: Benefits generated by social network usage in CHF between 2008 and 2023.

It is worth noting that social networks and YouTube are strongly related, since videos available on YouTube are often disseminated through social networks. This activity is, however, not recorded in our

analysis, due to the lack of systematic monitoring of this information. For a proper analysis, the social media entries including videos for viewing as anonymous visitor would need to be adjusted and the effective time spent on consuming such entries would have to be corrected to larger values. Hence, today's benefit estimates should be considered as highly conservative.

3.3 Websites

The objective of our analysis was to consider of the benefits generated by information provided on CERN and experiment collaboration web pages. To this end, we considered the following sites:

- CERN main site
- Main LHC experiments sites (ATLAS, ALICE, CMS and LHCB)
- IPPOG and CIEMAT, which are two national laboratories which have been added for the purpose of comparison. These two sites were the only ones with detailed statistical information about the site visitors available to us.

Historical data on the number of visits to the webpages and average time of the visit were collected from web statistics at CERN (see Figure below). For each webpage, we considered a different starting year (e.g. according to the different launch of experiment). For the sake of prudency, we assumed that number of visits and average time spent for each visit remains constant from 2018 onwards.

Table 2: Number of visits by website.

	2013	2014	2015	2016	2017
ALICE			40,470	144,943	156,430
ATLAS			2,296	393,125	559,324
CERN	4,667,659	6,366,057	8,633,143	6,142,340	6,592,573
LHCb	75,424	88,959	131,108	90,237	169,572
CMS	207,975	322,744	322,736	324,688	207,975
IPPOG	36,462	38,631	28,311	27,617	56,186
CIEMAT	513,327	484,887	475,449	518,292	445,423

Source: Web Statistics at CERN, accessed on May 2018

The annual WTP of "visitors" was then calculated as follows:

*[Number of visits * average time spent for the visit (in minutes)* social value of time (EUR 0.13 per minutes)]*

The **total discounted benefit of the outreach activities through website amounts to CHF 429.9 million** (2017 value) **during the time period 2000 to 2025. Since websites were launched at different times ranging from 2000 to 2008, the average yearly benefit is about 22.5 MCHF.** Details are provided in the table below.

Table 3: Discounted benefits generated by Websites (CHF).

Total discounted benefit	
ALICE	173,401.29
ATLAS	3,828,166.99
CERN	422,046,607.55
CMS	898,102.76
LHCb	97,230.40
TOTAL BENEFIT	427,043,508.99

3.4 Exhibitions

Among the outreach activities, there are also permanent and temporary exhibitions. For the purpose of our analysis, we considered the number of visitors and the average time spent during the visits.

About 425,000 visitors have been recorded for two permanent exhibitions (Microcosm and Universe of Particles) from 2012 to 2017 at CERN. The first permanent exhibition was set up in 2012. A high number of visitors was recorded in 2013, because of the open days event launched by CERN.

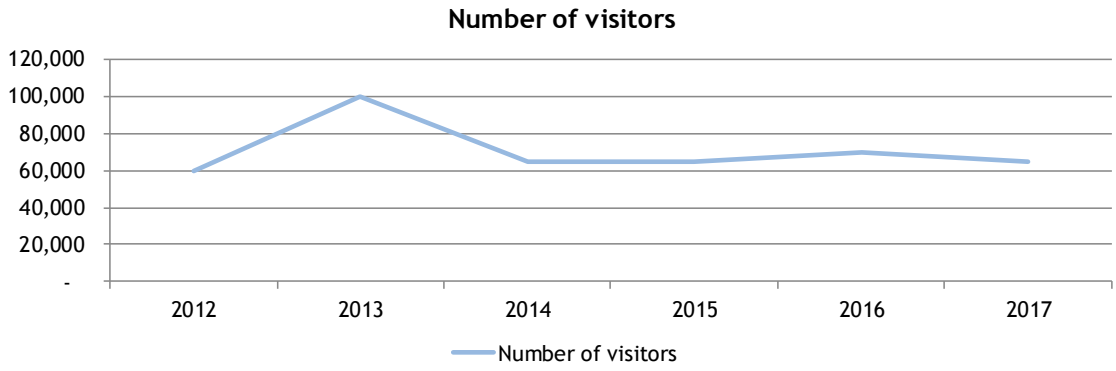

Figure 4: Yearly number of visitors at CERN permanent exhibitions.

For these exhibitions, we assumed an average, conservative duration of visit of about 30 minutes. From 2018 onwards, we assumed that visitors will increase with an annual average growth rate of 2%.

The benefit generated by permanent exhibitions has been calculated as follows:

*[Number of visitors to permanent exhibitions * average time spent for the visit (30 minutes)* social value of time (EUR 0.13 per minutes)]*

The total discounted benefit over the entire observation period including the forecast amounts to CHF 3.9 million. Details by year are provided in the figure below.

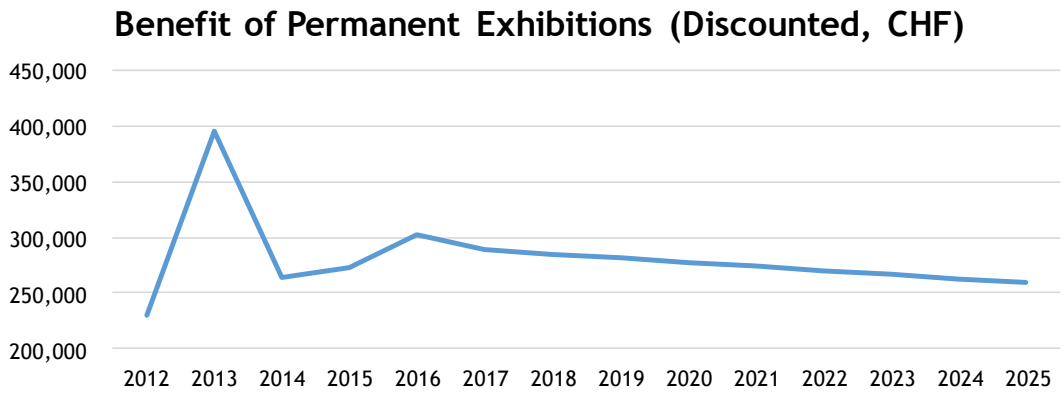

Figure 5: Yearly discounted benefits generated by permanent exhibitions in CHF.

Temporary exhibitions welcome people from all over the world who are not able to visit CERN. For the purpose of our analysis, we focused on the following travelling exhibitions:

- Accelerating Science,
- LHC Interactive Tunnel,
- CERN Images,
- Other Exhibitions.

The first travelling exhibition (Accelerating Science) was launched in 1997 and was active until 2002. It was re-launched in 2009. Similarly, also shown in the Figure below, other travelling exhibitions have been launched in different years and then temporarily stopped.

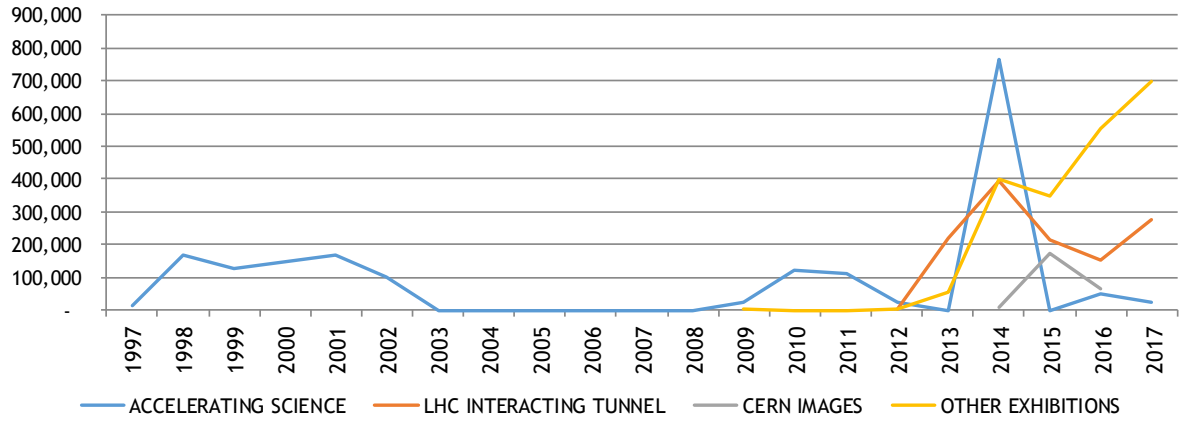

Figure 6: Yearly number of visitors of CERN-related travelling exhibitions.

All the traveling exhibitions that took place until 2017 welcomed 5.4 million visitors in 107 exhibitions[6]. We assumed an average visit duration of about 30 minutes. From 2018 onwards, we assumed that visitors will increase with an annual average growth rate of 2%, as for permanent exhibitions and we assumed they are carried out regularly every year. The benefit generated by permanent exhibitions has been calculated as follows:

*[Number of visitors to travelling exhibitions * average time spent for the visit (30 minutes)* social value of time (EUR 0.13 per minutes)]*

[6] Data provided by Rolf Landua, CERN exhibition and global engagement.

The total discounted benefit amounts to CHF 48 million. Details for each travelling exhibitions are provided in the table below.

Table 4: Discounted benefit of Travelling Exhibitions (CHF).

Travelling Exhibition	Benefits 1997* - 2025 (CHF)
Accelerating Science	7,509,910.65
LHC Interacting Tunnel	17,601,995.50
CERN Images	3,914,944.67
Other Exhibitions	19,077,664.62
Total	**48,104,515.43**

*Starting year different for different exhibitions.

3.5 Press Cuttings

Press cuttings are paragraphs or short articles clipped from a newspaper or magazine. Since the majority of newspapers and magazines are nowadays online, the definition has been also applied for online press cuttings.

According to data provided by CERN media and press relations office, approximately 70% of the total CERN press cuttings are online. Overall 422,687 press cuttings have been recorded between 2014 and 2017 (details by years are provided in Annex). However, due to the lack of data about the readers of press cuttings, it was not possible to assess the benefit in economic terms. The methodology for the calculation of this benefit would require the following, additional information:

- Number of readers by press-cuttings,
- A reduction factor to considering that persons do not read articles up to the end,
- Average time spent to read the press cuttings,
- Economic value of the time spent for reading in EUR.

Further investigations would be needed for the estimation of this benefit.

3.6 Books

Assessing the benefit deriving from reading books is challenging for a number of reasons:

- The book may not be specific to CERN and the LHC, but may deal with fundamental physics in general. This fact calls for applying a reduction factor to be applied on the time spent for reading the book, focusing on those chapters that deal specifically with CERN and the LHC.
- The number of copies sold may not correspond to the number of readers since one single book can be read by several people (e.g. borrowing from a library or a friend).

From a very preliminary research, we found about 25 books mentioning CERN in different languages. A total of 39,311,305 copies were sold.

This item remains to be explored in a future cost benefit analysis.

4. Conclusions

Cultural activities attract a significant number of visitors. The rate of participation of both in-person and virtual visitors are indicators of the size of the cultural impacts. Previous studies have found that the positive effects of LHC programme related activities amounts to about EUR 2.1 billion between 1993 and 2025. The cost benefit analysis of the LHC/HL-LHC combined programme reports an estimated value of cultural goods from 1993 to 2038 of EUR 3.3 billion. Our analysis confirms the positive impacts found in these previous studies. In addition, revised baselines have been created to estimate the impacts of websites, social media and media-rich contents such as videos. The table below shows the total discounted benefits generated by LHC/HL-LHC-related cultural goods generated by four different communication channels.

Table 5 Overview of benefits related to CERN, LHC and HL-LHC generated by different media channels over the recent years (from 2000 until 2025 based on a forecast simulation).

Cultural channel	Discounted Benefit (CHF)
YouTube	1,907,771,970.07
Social media	2,724,419.03
Permanent exhibitions	3,929,352.19
Websites	427,043,508.99
Travelling exhibitions	48,104,515.43
Total benefit	2,389,573,765.71

These findings should be considered as conservative. There are many other communication channels – such as for instance TED and CERN events, which have not been included in this analysis. Further investigations are needed to quantify their impacts. YouTube platform turns out to be the channel with the highest single media-related impact. Its benefits may still be underestimated if considering, that we only focused on the views of the videos by registered users. However, a video can also be disseminated also trough other channels, such as social media and websites.

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5. References

1.**Bastianin, A., Florio M.** *Social Cost Benefit Analysis of HL-LHC. CERN-ACC-2018-0014, http://cds.cern.ch/record/2319300*

2. **Clawson, M. and J.L. Knetsch, J.L.**.. *Economics of outdoor recreation. Baltimore.* Johns Hopkins Press, 1966.

3.**Florio, M. and Sirtori, E. (2016)**, *Social benefits and costs of large scale research infrastructures.* Technological Forecasting and Social Change, 112, pp.65-78

4. **Florio, M., Forte S., and Sirtori E.** Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond. *Technological Forecasting and Social Change* 112: 38-53, 2016.

5. **We Are Social and Hoosuite.** *Digital in 2017: Global Overview*

6. **CERN.** *the European Organization for Nuclear Research*7. **Wardman, M. & Lyons, G. (2016).** *The digital revolution and worthwhile use of travel time: Implications for appraisal and forecasting.*

7. **Ruedlinger, B.,** (2012), *Does video length matter?*. Wistia Agency, https://wistia.com/learn/marketing/does-length-matter-it-does-for-video-2k12-edition

8. **Wardman, M, Chintakayala, VPK and De Jong, GC** (2016) Values of travel time in Europe: Review and meta-analysis. Transportation Research Part A: Policy and Practice, 94. pp. 93-111. ISSN 0965-8564, https://doi.org/10.1016/j.tra.2016.08.019

9. European Commission (2014), Guide to Cost-Benefit Analysis of Investment Projects, adopted by DG Regio, https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

ANNEX

1. Value of time in monetary terms

The table below shows the values used for the estimation of the average social value of time. Values of time are derived from (8) and data on total populations were taken from Eurostat:

Countries	(€/min, 2010 prices)	Total population	€/min * Total population
Austria	0.15	8,363,400	1,251,257.57
Belgium	0.14	10,895,590	1,529,014.46
Bulgaria	0.05	7,395,600	364,027.87
Czech Rep	0.09	10,474,410	963,645.72
Denmark	0.15	5,547,680	833,076.61
Finland	0.14	5,363,350	727,925.78
France	0.13	65,027,510	8,218,754.74
Germany	0.14	81,776,930	11,389,709.08
Greece	0.10	11,121,340	1,159,090.77
Hungary	0.07	10,000,020	740,001.48
Italy	0.12	59,277,420	6,978,269.61
Netherlands	0.16	16,615,390	2,627,077.77
Norway	0.22	4,889,250	1,067,486.25
Poland	0.07	38,042,790	2,722,172.97
Portugal	0.09	10,573,100	980,361.33
Slovakia	0.08	5,391,430	454,677.26
Spain	0.12	46,576,900	5,483,136.17
Sweden	0.15	9,378,130	1,377,543.10
Switzerland	0.17	7,824,910	1,368,055.10
UK	0.13	62,766,360	8,320,029.72
Total		**477,301,510**	**58,555,313.36**

Value of time €/min = 58,555,313.36 / 477,301,510 = 0.1226 ~ 0.13[7]

It is worth pointing out that countries such as USA, Brazil, Russia, Japan and India, which have the highest number of YouTube users[8] are not included in this calculation, because of lack of data. However, these are countries with extreme high and low per person income ranges, which also would need to be balanced when included in an estimation.

[7] To obtain the value of time in monetary terms, we have focused only on the CERN member countries, since in this way a more precise value is obtained due to income differences.

[8] http://www.businessofapps.com/data/youtube-statistics/#1

2. LHC and CERN related videos and their viewers between 2007 and 2017 in YouTube.

Year	Number of videos	Number of views	Duration of the video in minutes
2007	18	1,173,467	84.07
2008	48	12,551,069	396.38
2009	60	1,065,962	328.07
2010	35	2,426,585	154.55
2011	39	327,446	450.37
2012	54	8,441,822	593.12
2013	42	1,355,750	705.65
2014	77	1,992,482	914.93
2015	103	3,773,252	862.77
2016	66	4,603,369	992.32
2017	74	1,770,141	1,657.75
Total 2007-2018	**616**	39,481,346	7,139.97

Source: Data gathered directly from YouTube platform accessed in June 2018.

3. Press Cuttings

In the following table, the number of press cuttings by year is provided.

Item	2014		2015		2016		2017	
Online, consumer	58.3%	30,705	49.6%	87,987	50.6%	66,321	59.5%	78,773
Online, trade/industry	22%	11,587	26.5%	47,009	24.4%	31,981	21.9%	28,994
Online, news and business	12%	6,320	11.6%	20,578	12%	15,728	9.9%	13,107
Blog, consumer	1.6%	843	2%	3,548	2.5%	3,277	6%	7,943
Online, technical/scientific/academic	1.3%	685	1.4%	2,484	0.70%	917	0.7%	927
Microblog	-	-	-	-	-	-	0.4%	530
Newspaper	1.2%	632	0.5%	887	-	-	-	-
News/release distribution service	1.2%	632	1%	1,774	0.8%	1,049	0.5%	662
Wire service (press agency subscription)	0.8%	42	-	-	-	-	-	-
Newspaper, community	0.4%	211	-	-	-	-	-	-
Television station	-	-	0.5%	887	0.7%	917	-	-
Social network	-	-	-	-	-	-	0.4%	530
Blog, trade/industry	-	-	-	-	-	-	0.2%	265
Radio station	-	-	4.8%	8,515	6.2%	8,126	-	-
Radio network	-	-	-	-	0.4%	524	-	-
Other	1.2%	632	2.1%	3,725	1.7%	2,228	0.5%	662
TOTAL		**52,667**		**177,394**		**131,069**		**132,391**