KNOWLEDGE AS AN INTERGENERATIONAL PUBLIC GOOD: AN EVALUATION FOR CERN[1]

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ABSTRACT

Global and intergenerational public goods have become an important issue for both current and future generations nowadays. In this context, knowledge is of great importance. Especially, basic scientific knowledge and developments, inventions, and technologies based on this kind of knowledge are important for both present and future generations. As a distinguished case, CERN has a special role for producing basic scientific knowledge. Basic scientific knowledge that produced by CERN experiments reaps benefits to both present and future generations. However, CERN's funding system is based on traditional resources generally comes from member states. In this study, it is concluded that for generating more basic science knowledge, CERN must be funded globally through new funding methods.

Keywords: *Public Goods, İntergenerational Public Goods, Knowledge*

JEL Classification: *H41, H87, D80*

NESİLLERARASI KAMUSAL MAL OLARAK BİLGİ: CERN İÇİN BİR DEĞERLENDİRME

ÖZ

Küresel ve nesillerarası kamusal mallar *günümüzde hem bugünkü hem de gelecek nesiller için önemli bir konu haline gelmiştir. Bu bağlamda, bilgi çok önemlidir. Özellikle* temel bilimsel bilgi ve *bu tür bilgiye dayalı gelişmeler, buluşlar ve teknolojiler de hem bugünkü hem de gelecek nesiller için önemlidir. Özel bir örnek olarak CERN temel bilimsel bilgi üretiminde özel bir role sahiptir. CERN deneylerinin ortaya çıkardığı temel bilimsel bilgi hem bugünkü hem de gelecek nesillere fayda sağlar. Ancak CERN'in finansman sistemi genellikle üye devletlerden sağlanan geleneksel kaynaklara dayalıdır. Bu çalışmada daha fazla temel bilimsel bilgi üretimi için CERN'in yeni finansman yöntemleri ile küresel olarak finanse edilmesinin zorunlu olduğu sonucuna varılmaktadır.*

Anahtar Kelimeler: *Kamusal Mallar, Nesillerarası Kamusal Mallar, Bilgi*

JEL Sınıflandırması: *H41, H87, D80*

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1. INTRODUCTION

In today's world, intergenerational effects of externalities and public goods are becoming more prevalent facts. Stemming largely from environmental pollution, negative externalities such as depletion of ozone layer and global warming and also the provision of public goods for decreasing those externalities have been affecting not only present generations but also future generations. Similarly, contagious diseases and the provision of public goods against those diseases are very important for the health of both present and future generations.

Knowledge has also an intergenerational public good character clearly. Especially, basic science knowledge and developments, inventions, and technologies based on this kind of knowledge are also important for both present and future generations. In this context, as a scientific institution that study on advanced nuclear physics, The European Organization for Nuclear Research - widely known as CERN (derived from the acronym for the French "Conseil Européen pour la Recherche Nucléaire") - has a special importance for generating basic science knowledge. Recently, CERN has become more popular due to its experiments such as ATLAS that use The Large Hadron Collider. Basic science knowledge that generated by CERN experiments reaps benefits to both present and future generations. Moreover, it is highly probable that this kind of knowledge would reap more benefits to future generations.

This paper is intended to emphasize the role of CERN in generating basic science knowledge from the perspective of intergenerational public goods. Initially, the concept of intergenerational public goods is explained briefly. Consequently, intergenerational public good character of knowledge is analyzed. Then, some aspects of CERN are investigated. Lastly, conclusive thoughts about these issues are given.

2. THE CONCEPT OF INTERGENERATIONAL PUBLIC GOODS

In theory, a public good is defined as "goods that have the properties of nonrivalry in consumption and nonexcludability" in the strict sense. Nonrivalry in consumption means that an individual's use does not reduce availability to other individuals. Nonexcludability means that individuals cannot be effectively excluded from use (Samuelson, 1954:387). However, public goods are generally classified in a broader sense according to their degree of publicness. In this context, four types of public goods are defined as follow.

- Pure public goods: goods that meet both nonrivalry in consumption and nonexcludability such as national defense and lighthouses.
- Impure public goods: goods that meet either nonrivalry in consumption or nonexcludability such as health services and education.
- Club goods: goods that are special cases of impure public goods, which possess partially rival benefits that can be excluded such as golf clubs and cable TV broadcasting.

- Joint products: products that simultaneously produce two or more outputs that may vary in their degree of publicness such as medical aid and flood control. Public, private and non-governmental actors produce joint products.

An intergenerational public good is defined as 'a public good that benefits not only to current generation but also future generations as well'. On the other hand, if a public good that benefits only to current generation, it is named as 'intragenerational public good' (Tosunoğlu, 2004:20). Both kinds of public goods may have different characteristics. In this regard, Sandler (1999:24-25) classifies these goods by degree of publicness and by geographical range of spillovers, as given in Table 1. This classification may help for deciding on which kind of authority (national governments, regional institutions or international organizations) should provide which kinds of intergenerational public goods.

Table 1. Classification of Intergenerational Public Goods based on Good's Characteristics

Categories	**Geographical range**	**Pure public**	**Impure public**	**Club**	**Joint products**
Intra-generational	**Regional**	Forest fire suppression Groundwater pollution cleanup Animal disease control Flood control	Waterways Rivers Highways Local parks	Common markets Crisis management forces Electric grid Information networks	Peacekeeping Military forces Medical aid Technical assistance
	Global	Ocean pollution cleanup Weather forecasts Monitoring stations World Court	Electromagnetic spectrum allocation Satellite transmissions Postal service Disease control	Canals Air corridors Internet Shipping lanes	Foreign aid Disaster relief Drug interdiction
		Wetland preservation Lake	Acid rain reduction Fisheries	National parks Irrigation	Peacekeeping Flood control

Inter-generational	**Regional**	cleansing Toxic waste cleanup Lead emissions reduction	protection Hunting grounds protection VOC emissions reduction	systems Lakes Cities	North Atlantic Treaty Organization (NATO) Cultural norms
	Global	Ozone layer protection Global warming prevention Disease eradication *Knowledge creation*	Overuse of antibiotics Oceans fisheries Antarctica protection Revolution making	Transnational parks Geostationary orbits Polar orbits Barrier reefs	Tropical forest preservation Space colonies United Nations (UN) Poverty alleviation

Source: Sandler (1999:24-25)

Markets do not produce many goods that have intergenerational positive externality due to the uncertainty of the future. Hence, it is asserted that public sector must provide some of these goods although it does not ensure future and long-term provision because of multi-actor process of decision making that is inherent in its structure. Consequently, governments do not attach importance to the long-term results of public goods and hence the provision of some intergenerational public goods become inadequate or does not realized (Tosunoğlu, 2004:24-25).

3. KNOWLEDGE AS AN INTERGENERATIONAL PUBLIC GOOD

Knowledge creation is accepted as an intergenerational, global and pure public good (Sandler, 1999:24). One can use knowledge without reducing its availability for other individuals and one cannot be effectively excluded from using knowledge if it is released. In this regard, math and geometry theorems, physics and chemistry laws are definitely intergenerational, global and pure public goods. These examples can be expanded as Einstein's Theory of Relativity, molecular structure of DNA, technical specifications of electronic parts etc. (Stiglitz, 1999:310; Henry, 2006:138).

On the other hand, in practice, some types of knowledge can lose their nonexcludability property easily and be private goods or impure public goods through intellectual property rights. As a result of intellectual property methods, knowledge creation and usage in most industries (e.g. chemistry, electronics, medicine, etc.) have been subjected to restriction. In microeconomic theory restriction of knowledge and technology production and usage through intellectual property rights is already accepted as rational, profit seeking behavior of creator or developer. Even the restriction of knowledge is accepted as the main factor for development of science and technology (See Stiglitz, 1999:310-314; Henry, 2006:138-142). However, Boldrin and Levine (2010:23) assert that there is no evidence for intellectual property rights to enhance innovation and creativity (thus, the development of science and technology) at least for about two hundred years. Hence, this kind of ideas against intellectual property rights put the case clearly that the traditional understanding, which accepts intellectual property restrictions as the main source of development in science and innovation, is controversial.

Basic science knowledge is very crucial for humanity. First of all, basic science knowledge makes contributions to culture of humanity. Knowledge of solar system, the Universe, the genetic code, emergence of life, etc. has all enrich lives of human being. Basic science knowledge also increases the possibility of discoveries that have enormous economic and practical importance. Additionally, basic science produces spin-offs and stimulates industry, e.g. medical imaging techniques, the world wide web (www), cancer therapy techniques have all been produced by particle physics research as spin-offs. Finally, research in basic science provides a perfect training opportunity for individuals who continue to work in applied research or development in an industry (Smith, 1997:4-10).

As noted by Stiglitz (1999:314), the patentability (hence, the privatization) of basic science knowledge is quite costly due to its widespread and diffuse benefits and due to attempts to appropriate its returns may notably slow the speed of innovation. Hence, basic science knowledge is an intergenerational, global, and pure public good.

4. CERN AS A GENERATOR OF BASIC SCIENCE KNOWLEDGE

4.1. About CERN

CERN, namely The European Organization for Nuclear Research, was established in 1954 in Geneva, Switzerland by 12 European states include Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom and Yugoslavia with the mandate of establishing an eminent fundamental physics research organization in Europe. At that time, pure physics research focused on understanding the interior of the atom, hence the word “nuclear” was used in its name. Today, scientists’ understanding of matter goes beyond the nucleus, and CERN’s mission has evolved as providing the particle accelerators and other infrastructure required for high-energy particle physics research (CERN, (a)). As the world’s largest particle physics laboratory, CERN is also known for inventing the World Wide Web.

Today CERN has reached 21 member states with the accession of Austria, Bulgaria, Czech Republic, Finland, Hungary, Israel, Poland, Portugal, Slovakia, and Spain (excepting Yugoslavia). These states have special duties and privileges. They make a contribution to the capital and operating costs of CERN’s programmes, and are represented in the council, responsible for all of important decisions about the organization and its activities. Romania is a candidate to become a member state and Serbia is in the pre-stage to membership. Also, there are 7 observers include European Commission, India, Japan, Russian Federation, Turkey, UNESCO and USA. Membership is either not possible or not yet feasible for observers but they take part CERN programmes. Additionally, there are tens of non-member states that have co-operation agreements and scientific contacts with CERN (CERN, (b)).

4.2. The Role of CERN in Generating Basic Science Knowledge

CERN is the world's leading institution that produces basic science knowledge effectively in many years. At CERN, the generation process of (basic) science knowledge is very closely tied to the process of carrying out the research and development (R&D) for new accelerator and detector components (Liyanage *et al*.: 2007:70). Accelerators boost beams of particles to high energies before the beams are made to collide with each other or with stationary targets. Detectors observe and record the results of these collisions (CERN, (a)).

CERN has five current accelerators: The Antiproton Decelerator, The Large Hadron Collider (The LHC), The Proton Synchrotron, The Super Proton Synchrotron, CERN Neutrinos to Gran Sasso. In the past, CERN also had five accelerators: Linear Accelerator 1, The Intersecting Storage Rings, The Large Electron-Positron Collider, The Low Energy Antiproton Ring, The Synchrocyclotron (CERN, (c)).

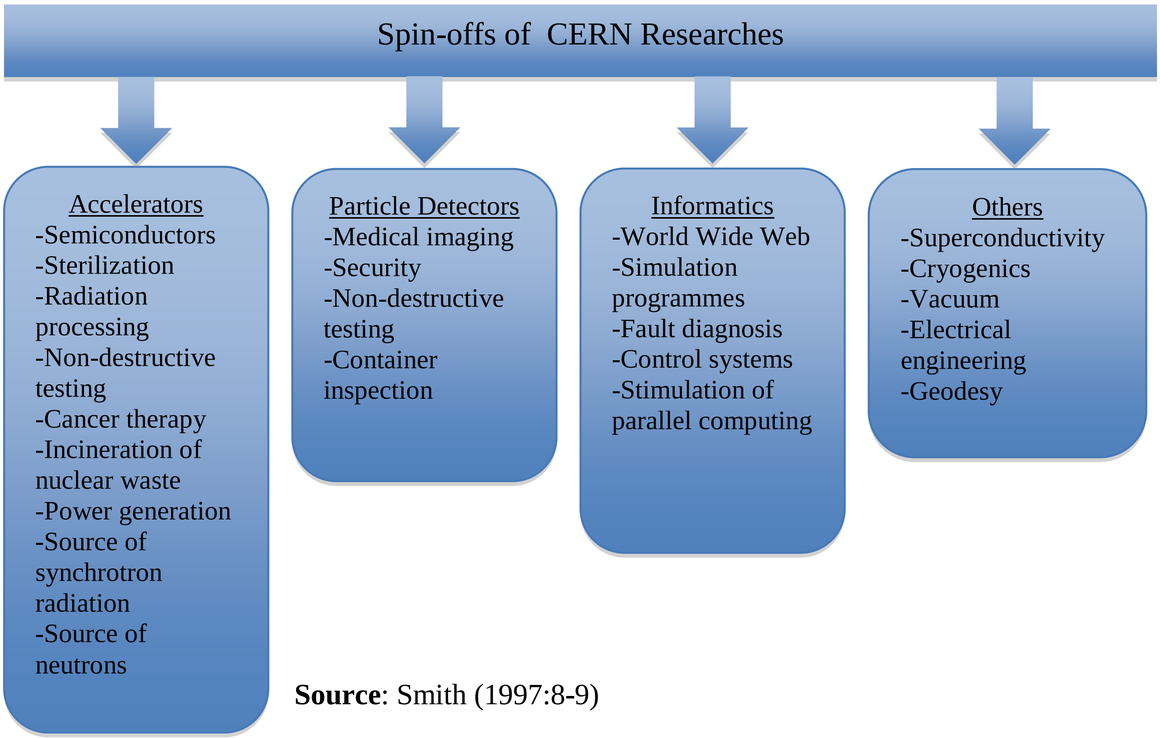
At CERN, there are 26 experiments that use detectors for investigating physics from cosmic rays to supersymmetry: ACE, AEGIS, ALICE, ALPHA, AMS, ASACUSA, ATLAS, ATRAP, AWAKE, BASE, CAST, CLOUD, CMS, COMPASS, DIRAC, ISOLDE, LHCb, LHCf, MOEDAL, NA61/SHINE, NA62, NA63, nTOF, OSQAR, TOTEM, UA9. These experiments are run by collaborations of scientists from institutes all over the world. Each experiment is different, and characterized by its detectors. In the past, there were 5 experiments at CERN: ALEPH, DELPHI, Gargamelle, L3, OPAL, UA1, UA2 (CERN, (d)).

The LHC is the world's largest and most powerful particle accelerator. The LHC consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way (CERN, (e)). Seven experiments at the LHC use detectors to analyze the myriad of particles that produced by collisions in the accelerator. ATLAS and CMS are the two biggest of these experiments and use general-purpose detectors to investigate the largest range of physics possible. The existence of two independently designed detectors is vital for cross-confirmation of any new discoveries made (CERN, (d)).

As the most popular experiment of CERN, ATLAS is focused on making new particle discoveries based on diverse theoretical assumptions (Liyanage *et al*.: 2007:71). In this regard, basic science knowledge derived from ATLAS experiment is explicitly an intergenerational public good because of its long-term and public character. A quotation from Gökhan Ünel, a physicist from University of California emphasizes the very generational aspect of the search for Higgs boson through ATLAS experiment: "Although we can't benefit from Higgs boson, I am absolutely positive that the technology which is developed for this purpose will provide a better life for our grandchildren" (Ntvmsnbc News Online).

Besides searching for Higgs boson and generating basic science knowledge, the accelerators and particle detectors at CERN generate spin-offs for both current and future generations. By spin-offs, it is meant devices and techniques developed to do basic researches, which turn out to have other uses (Smith, 1997:7).

Figure 1: Spin-offs of CERN Researches



Source: Smith (1997:8-9)

4.3. Funding of CERN

Funding of basic science is important for a society as a whole, but not in the interest of any individual actor. Because those who make fundamental discoveries generally do not reap the benefits - the laws of nature cannot be protected; the applications are too long-term and unpredictable, and the cultural and educational benefits do not generate direct profits (Smith, 1997:11). Consequently, people or organizations that have no commercial aims, e.g. governments, fund most basic research.

In economics, basic science knowledge is an intergenerational public good that must be supported by governments and international organizations on the basis of the benefits of directly acquired knowledge, the spin-offs and the training opportunities, as well as cultural base. Despite its global and intergenerational public good character, CERN's funding mechanism is grounded on traditional resources generally comes from member states. Funding mechanism of CERN is depicted in CERN Financial Rules, Section 3 - Financing, Articles 10, 11, 12, 14, as given below (CERN, CERN Financial Rules, 2013:7-8):

Article 10: Financial contributions of the Member States

CERN's activities shall be financed by the annual contributions of the Member States. The Council shall adopt the scale of the annual contributions of the Member States, which shall be drawn up in accordance with the method specified in Article VII of the Convention. After consulting the Director-General, the Finance Committee shall determine the arrangements for the payment of contributions in such a way as to ensure the regular financing of CERN (Article 4 (5) (a) of the Protocol).

The Director-General shall notify the Member States of the amounts of their contributions and of the dates on which payments are due (Article 4 (5) (b) of the Protocol).

In the event that the budget is not adopted before the beginning of the financial year, CERN shall call up contributions from the Member States in accordance with the schedule defined in the Implementing Regulations.

CERN shall be authorized to charge interest on contribution arrears.

Article 11: Additional revenues

CERN may receive additional revenues, consisting in particular of other contributions from the Member States, contributions from non-Member States and the European Union on the basis of agreements concluded with CERN, as well as revenues generated by CERN itself and donations.

The Director-General may accept donations in accordance with the provisions of Article VII.6 of the Convention.

Article 12: Loans

After consulting the Finance Committee, the Council may authorize CERN to have recourse to long-term loans if they are required for the funding of approved investments.

…

Article 14: Sale of CERN property

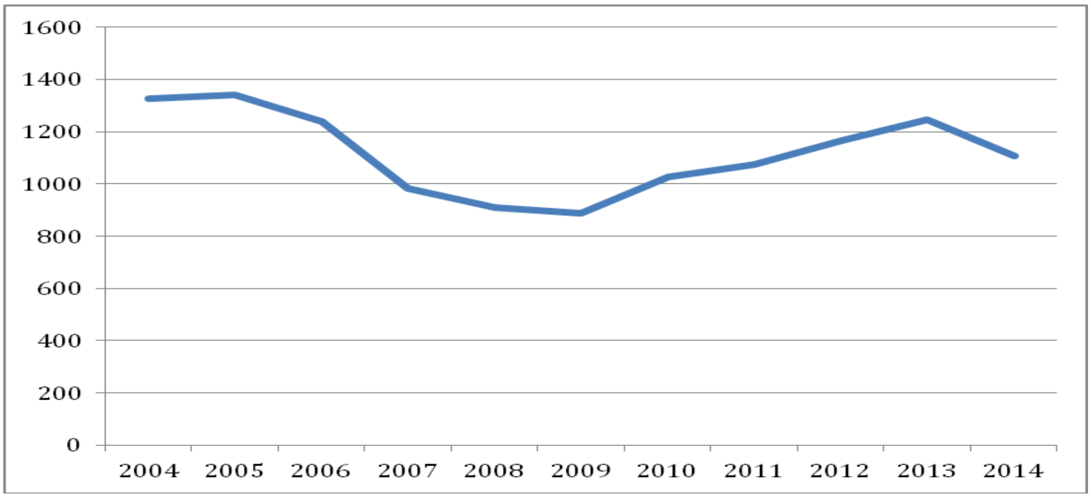
CERN may sell its property that is of no further use for the accomplishment of its mission or may, if such property is of negligible market value, dispose of it as a gift.

The award of any contract for the sale of property for an amount exceeding 750 000 Swiss francs, or exceeding 200 000 Swiss francs in the case of a contract without competitive tendering, shall be subject to prior approval by the Finance Committee.

Property may be disposed of as a gift exclusively to scientific research and educational establishments, museums and public institutions in the Member States, or in non-Member States provided that there has been no indication of interest in the Member States.

As seen in Figure 2 below, CERN budgets have always been at the range of 850 -1350 million Swiss franc (CHF) since 2004. CERN budgets continually fell down between 2005-2009 period, then continually increased between 2010-2013 period. As of 2014, CERN budget was 1108.5 million CHF (approximately 1110.8 million US dollar).

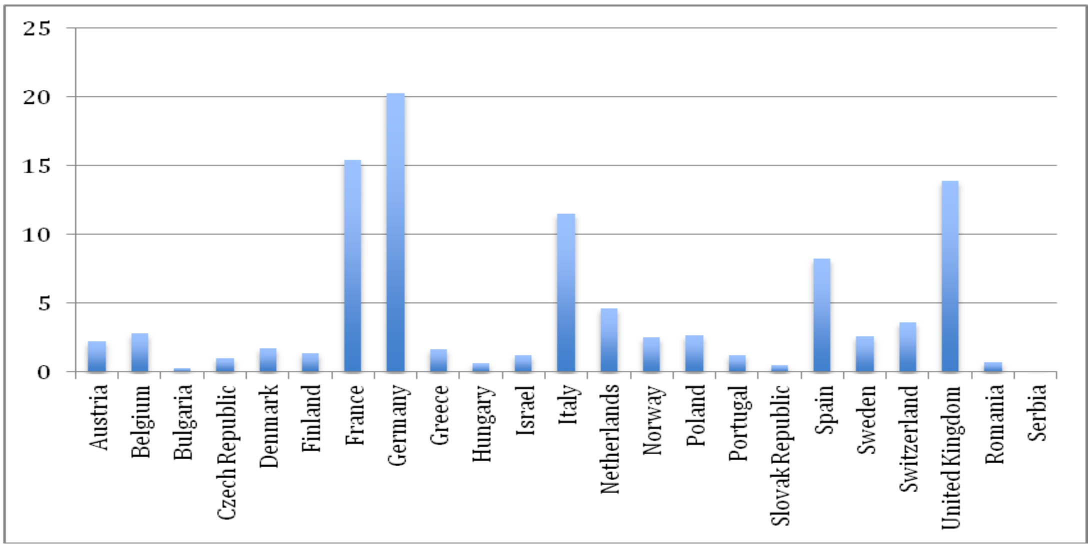
Figure 2: CERN Budget, million CHF



Source: CERN Press Office (a).

CERN budget consists solely of financial contributions of member states. In Figure 3 member states contributions shown. As of 2014 contributions, Germany, France, United Kingdom and Italy are main funding states of CERN budget at total budget shares of 20%, 15%, 13%, and 11% respectively. Bulgaria, Slovak Republic, Hungary and Czech Republic made the least contributions to CERN budget at total budget shares of 0.28%, 0.50%, 0.65%, and 1.03% respectively.

Figure 3: Contributions (% total budget) in 2014



Source: CERN Press Office (b).

In some sense, the success of CERN experiments, for example LHC, gives an impression that adequate funding of CERN is provided or fairly provided. However, as a distinguished global generator of basic science, CERN must be funded globally and hence generate much more basic science knowledge both for current and future generations. In addition to member states contributions to CERN budget, global innovative financing mechanisms must be found.

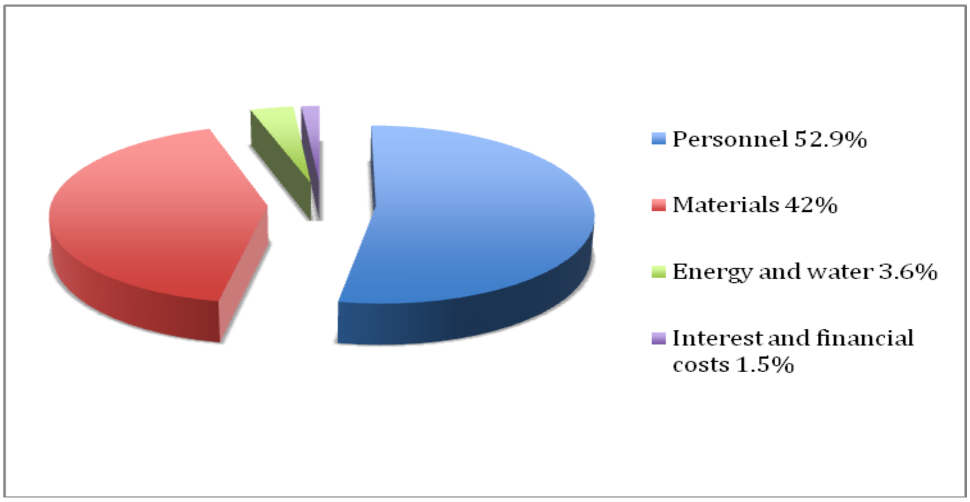
A way of funding CERN globally may be an increase in number of CERN member states. Of course, this solution raises financial contributions of member states and enhances overall budget of CERN. But this way may also increase some CERN expenditures due to the demand for membership advantages and privileges. Hence, an increase in funding of CERN through new members may not be directed to undertake more basic science research and generate basic science knowledge.

Another way of funding CERN globally may be using some revenues of global taxes, e.g. a global financial transaction tax (Tobin tax) and a global carbon tax that are already proposed for funding international development. Global tax proposals seem as a reliable and sound option for funding global public goods and UN's Millennium Development Goals. Also, it is an appropriate tool for achieving an innovative understanding of taxation and public goods (Arslan, 2008:57). However, international politics and the pressure come from international finance do not allow global tax proposals to come into effect.

4.4. CERN Expenditures

As shown in Figure 4, the classification of CERN expenditures by 2013 shows that the share of personnel expenditure is more than half of the total expenditure. Material expenditures including goods, consumable, supplies and other material expenses are second large category of CERN expenditures.

Figure 4: The Classification of CERN Expenditures by 2013



Source: CERN (2014:44)

The long-term and one of the largest expenditure items at CERN is LHC. According to Alex Knapp from Forbes magazine, LHC experiments have run an additional $5 billion in funding and the total cost of finding the Higgs boson ran about $13.25 billion. However, $13.25 billion may be evaluated as very moderate cost when regarding the potential for advancing computer technology, medical imaging, and scientific breakthroughs. Especially when it is considered the fact that on top of all of that, the Large Hadron Collider and its associated experiments are bringing humanity that much closer to understanding the mysteries of the universe (Knapp, 2012).

5. CONCLUSION

Basic science knowledge and developments, inventions, and technologies based on this kind of knowledge are important for both present and future generations. Hence, basic science knowledge can easily be characterized as an intergenerational public good. In this context, the generation of basic science knowledge at CERN through big experiments has also an intergenerational public good character.

CERN was established in 1954 in Geneva, Switzerland by 12 European states and now has reached 21 member states. At CERN, the generation process of basic science knowledge is very closely tied to the process of carrying out the R&D for new accelerator and detector components. CERN has five accelerators and 26 experiment projects. Among them, the LHC is the world's largest and most powerful particle accelerator that produces basic science knowledge on how the matter and universe emerged. Besides generating basic science knowledge, the accelerators and particle detectors at CERN generate many spin-offs for both current and future generations.

Despite its global and intergenerational public good character, CERN's funding system is based on traditional resources generally comes from member states. These resources are financial contributions of the member states, additional revenues, loans and sale of CERN property. CERN's budget consists solely of financial contributions of member states and was about 1.11 billion US dollar for 2014.

As a distinguished global generator of basic science, CERN must be funded globally and hence generate much more basic science knowledge both for current and future generations. To this aim, global innovative financing methods must be found such as increasing the number of CERN member states and applying global taxes although these methods have some difficulties.

REFERENCES

Arslan, M. O. (2008). "Global taxation: An idea between taboo and urgency", İktisat İşletme ve Finans, 23 (271): 46-60.

Boldrin, M. and Levine, D. K. (2010). "Entelektüel Tekele Karşı" [Against Intellectual Monopoly], İstanbul: Sel Yayıncılık.

CERN (a). "About CERN", http://home.web.cern.ch/about (13.12.2014).

CERN (b). "Member states", http://home.web.cern.ch/about/member-states (13.12.2014).

CERN (c). "The accelerator complex", http://home.web.cern.ch/about/accelerators (13.12.2014).

CERN (d). "Experiments", http://home.web.cern.ch/about/experiments (16.12.2014).

CERN (e). "The Large Hadron Collider", http://home.web.cern.ch/topics/large-hadron-collider (17.12.2014).

CERN Press Office (a). "Budget overview", http://press.web.cern.ch/facts-and-figures/budget-overview (19.12.2014).

CERN Press Office (b). "Factsheet 2014", http://press.web.cern.ch/facts-and-figures/factsheet-2014 (19.12.2014).

CERN (2013). "CERN Financial Rules", http://council.web.cern.ch/council/en/FC/CERN-e-FinancialRules.pdf (13.12.2014).

CERN (2014). "Annual Report 2013", Geneva: CERN. http://cds.cern.ch/record/1710503/files/AnnualReport.pdf (13.12.2014).

Henry, C. (2006). "Knowledge as a global public good: production conditions and preconditions", Touffut, J-P. (ed.), Advancing Public Goods, Cheltenham: Edward Elgar.

Knapp, A. (2012). "How Much Does It Cost To Find A Higgs Boson?", Forbes Online, July 5. http://www.forbes.com/sites/alexknapp/2015/02/12/virgin-galactic-unveils-manufacturing-facility-for-its-satellite-launcher/ (18.02.2015).

Liyanage, S., Wink, R. and Nordberg, M. (2007). "Managing Path-Breaking Innovations: CERN-ATLAS, Airbus, and Stem Cell Research", Westport, Connecticut: Praeger.

Ntvmsnbc News Online (2011). "Higgs bozonu torunlarımıza yarayacak", http://www.ntv.com.tr/arsiv/id/25307899/ (12.10.2014).

Samuelson, P. A. (1954). "The Pure Theory of Public Expenditure", The Review of Economics and Statistics, 36 (4): 387-389.

Sandler, T. (1999). “Intergenerational Public Goods: Strategies, Efficiency and Institutions”, Kaul, I., Grunberg, I. and Stern, M. A. (eds), Global Public Goods: International Cooperation in the 21st Century, New York: Oxford University Press.

Smith, C. H. L. (1997). “What’s the Use of Basic Science”, Unpublished Draft Discussion Paper, Office of the Director General, CERN, Geneva. http://cdsweb.cern.ch/record/388110/files/open-99-011.pdf (10.10.2014).

Stiglitz, J. E. (1999). “Knowledge as a Global Public Good”, Kaul, I., Grunberg, I. and Stern, M. A. (eds), Global Public Goods: International Cooperation in the 21st Century, New York: Oxford University Press.

Tosunoğlu, Ş. (2004). Nesillerarası Kamusal Mal Olarak Yaşlılık Sigortası ve Türkiye Uygulaması, Unpublished Doctoral Dissertation, Anadolu Üniversitesi Sosyal Bilimler Enstitüsü, Eskişehir.