BBVA Foundation Frontiers of Knowledge Award in Basic Sciences

The BBVA Foundation distinguishes David Cox and Bradley Efron for revolutionizing statistics and making it into an indispensable tool for other sciences

- The jury singles out "the pioneering and hugely influential contributions" of the two mathematicians to both the theory and practice of statistics, emphasizing their "enormous impact in all the sciences which rely on the analysis of data"
- Cox, at Oxford, and Efron, at Stanford, devised models that have furthered the advancement of knowledge across a vast range of research fields, from medicine and epidemiology to economics, psychology or sociology
- Their work has contributed, for instance, to assess the effectiveness in clinical trials of cancer or AIDS therapies, to analyze the data from human genome sequencing, and even to test the resistance and durability of industrial products

Madrid, January 24, 2017.-The BBVA Foundation Frontiers of Knowledge Award in the Basic Sciences category goes, in this ninth edition, to mathematicians David Cox and Bradley Efron, for the development of "pioneering and hugely influential" statistical methods that have proved indispensable for obtaining reliable results in a vast spectrum of disciplines from medicine to astrophysics, genomics or particle physics.

"Cox and Efron's techniques are used on a daily basis in the practice of statistical science, and have made an enormous impact in all the sciences which rely on the analysis of data," in the words of the jury's citation. For jury member Trevor Hastie, "they are the two most influential statisticians alive today, and true revolutionaries in their field."

Cox's contribution, known in honor of its creator as "the Cox regression," is a powerful tool to explain the duration of a time interval between two events of interest, which depends on identifiable factors rather than mere chance (for instance, the mortality of a group of individuals due to a particular disease or a risk factor like environmental pollution). It finds use in such varied fields as cancer research, epidemiology, economics, psychology or sociology, and even in the

testing of the resistance and durability of industrial products. The jury illustrates the technique's application in the medical field by citing the conclusion that even a year of smoking cessation contributes to reduce mortality.

Efron, meantime, is the inventor of the bootstrap, a "deceptively simple" technique, as the jury terms it, to estimate the margin of error of a given outcome; a must-know in science without which results are worthless.

Both contributions date from decades ago and both laureates found it hard to pick just one out of the multiple applications found since then. David Cox (Birmingham, United Kingdom, 1924), of the University of Oxford, declared himself "enormously surprised and gratified" by the sheer range of scientific problems his method has helped address. For example: "It is used in the study of cancer patients, to determine what aspects of the treatment are determining their progress. There are many factors at work in an individual's survival, including their social background, sex and age. Which are the most relevant?" This is the kind of issue that can be broached with his technique, published in 1972 in what is now the second most cited statistics paper in modern scientific literature.

"We are talking about hundreds of thousands of studies," says Bradley Efron (Minnesota, United States, 1938), Professor of Statistics at Stanford University, who devised the bootstrap in 1979. He admits that statistics' role in science is "less fun" than the research that throws up the data to be analyzed, but is also clear about its importance: "Scientists collect data, we analyze them. Take, for example, the search for the Higgs boson. What you do is gather a bucketful of data which ultimately boils down to a bump in the chart. But, how can we be sure that the bump is real and not an artifact? The bootstrap will tell you."

Cox's move into statistics was motivated by the military imperatives of the aeronautics industry at the time of the Second World War. He defines himself as a theoretical researcher. He was already a world leader in the field when he crossed paths with Efron in London in 1972, then on a sabbatical year in the UK. The American, who had been nudged towards statistics by his father's love of mathematics and sport – "Even today, I still adore sports statistics" – reveals that part of what led him to the bootstrap technique was a conversation he had with Cox at the time about another statistical analysis method.

Efron chose to entrust the data analysis to computers, at that time still in their infancy. Until then, margins of error had been worked out using mathematical approximations "which could be very complex and not always right," he explains. "With the bootstrap, you delegate the hard 'thinking' part to the computer; not that they think, of course, but just obey the algorithm you've designed." The technique was so simple in appearance that it initially met with distrust from the statistical community: "It seemed like cheating to leave the hard work to an algorithm, and it wasn't obvious that it would work," Efron recalls. Shortly after it was published, thousands of papers appeared evaluating its utility.

"The bootstrap," he elaborates, "harnesses the calculation power of computers to check the accuracy or precision of a statistical analysis. In any analysis, the main role goes to the algorithm, whose job is to answer the question that the researcher is posing. The support role consists of determining how accurate that answer is. So the bootstrap may almost never be the star, but it has become the best secondary actor in statistics."

The name bootstrap comes from the 18th century tales of Baron von Munchhausen, a favorite of Efron's, and refers to the mechanics of the technique. In one of the stories, the Baron is drowning in a lake and saves himself by "pulling himself up by the strap of his boots," explains Efron. The technique involves randomly resampling the data from the study sample time and time again, so it is these same data, with no additional inputs, that provide the margin of error.

The two laureates concur that their own methods, and statistical tools in general, will become increasingly necessary in the practice of science, more reliant by day on the analysis of massive data sets. Big Data itself will undoubtedly, in Cox's view, run into "statistical problems."

Efron, in turn, singles out genomics; for instance, the study of the role of a rare mutation in a particular disease or the response to a given pharmacological treatment – statistics, of course, being one of the principal motors of personalized medicine. "Centuries ago, science tackled concrete problems, like the movement of the planets. But now any problem entails working with far more data, which causes a lot more noise. Humans are much noisier than atoms. Now we have situations where we need to eliminate a lot of noise, and statistics is the means to do that."

Bio notes: David Cox

David Cox (United Kingdom, 1924) studied mathematics at St John's College (University of Cambridge), and obtained his PhD from the University of Leeds in 1949. At the start of his career, he was employed at the Royal Aircraft Establishment (1944-1946), the Wool Industries Research Association (1946-1950), and the Statistical Laboratory at the University of Cambridge (1950-1955). He then moved to the University of London, where he was Reader and then Professor of Statistics at Birkbeck College (1956-1966) and Professor of Statistics at Imperial College of Science and Technology (1966-1988), for a time heading its Department of Mathematics (1969-1973). In 1988, he was appointed Warden at Nuffield College, Oxford, and joined the University's Department of Statistics. He continues to work at Oxford despite formally retiring in 1994.

His scientific paper "The Regression Analysis of Life Tables" (1972) revolutionized the theory and practice of statistical methods for medical research and is the second most cited in the statistics area, with some 30,000 Web of Science citations and 42,000 in Google Scholar. This same article won him the Kettering

Prize and Gold Medal for Cancer Research in 1990, the only time this honor has gone to a mathematician. In 2014, *Nature* placed it 16th in its list of the top 100 scientific papers of all time in any discipline. The influence it has exerted was also recognized in the bestowal on its author of the first International Prize in Statistics in 2016.

Cox is an honorary member of more than forty universities and learned societies, among them the Royal Society of London, which granted him its Copley Medal in 2010, the British Academy and the U.S. National Academy of Sciences. He also holds the Guy Medal of the UK's Royal Statistical Society (Silver in 1961 and Gold in 1973), the Weldon Memorial Prize from the University of Oxford (1984) and the Max Planck Forschungspreise (1992), and was President of the International Statistical Institute from 1995 to 1997. He received a knighthood for his achievements in 1985.

Bio notes: Bradley Efron

Bradley Efron (United States, 1938) is Professor of Statistics and Biomedical Data Science at Stanford University. He studied mathematics at California Institute of Technology (Caltech) before completing an MS in statistics at Stanford University in 1962. That same year, he began his doctoral studies in statistics under the supervision of Rupert Miller and Herb Solomon, and after earning his PhD (1964), joined the faculty at Stanford, where he has pursued the remainder of his teaching and research career. Since 1988, he has held the Max H. Stein Professorship in the School of Sciences and Humanities.

Bradley Efron has made numerous contributions to statistical science, but his best known paper – "Bootstrap Methods: Another Look at the Jackknife" – was published in *The Annals of Statistics* in 1979. This initially controversial method is now considered a triumph of applied mathematics in conjunction with numerical analysis, and has had a profound impact upon statistical practice, finding wide application in science and medicine.

Bradley Efron has published extensively in leading journals like *Biometrika*, *The Annals of Statistics* or *Journal of the American Statistics Association*. He has been honored with a MacArthur Prize Fellowship and is a Fellow of the U.S. National Academy of Sciences, the American Academy of Arts and Sciences, the Institute of Mathematical Statistics and the American Statistical Association. His many awards include the Lester R. Ford Award, the Wilks Medal, the Rao Prize and the National Medal of Science.

About the BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation has as its core objectives the promotion of scientific knowledge, the transmission to society of scientific and technological culture, and the recognition of talent and excellence across a broad spectrum of disciplines, from science to the arts and humanities.

The **BBVA Foundation Frontiers of Knowledge Awards** were established in 2008 to recognize outstanding contributions in a range of scientific, technological and artistic areas, along with knowledge-based responses to the central challenges of our times. The areas covered by the Frontiers Awards are congruent with the knowledge map of the 21st century, in terms of the disciplines they address and their assertion of the value of cross-disciplinary interaction.

Their **eight categories** include classical areas like Basic Sciences and Biomedicine, and other, more recent areas characteristic of our time, ranging from Information and Communication Technologies, Ecology and Conservation Biology, Climate Change and Economics, Finance and Management to Development Cooperation and the innovative artistic realm that is Contemporary Music.

The BBVA Foundation is aided in the organization of the awards by the **Spanish National Research Council (CSIC)**, the country's premier public research agency. As well as designating each jury chair, the CSIC is responsible for appointing the technical evaluation committees that undertake an initial assessment of the candidates put forward by numerous institutions across the world, and draw up a reasoned shortlist for the consideration of the juries.

Basic Sciences jury and technical committee

The jury in this category was chaired by **Theodor Hänsch,** Director of the Division of Laser Spectroscopy at the Max Planck Institute of Quantum Optics (Germany), professor in the Faculty of Physics at the Ludwig Maximilian University of Munich and the 2005 Nobel Laureate in Physics. The secretary was **Francisco Guinea**, a Research Professor at the IMDEA Nanoscience Institute (Spain). Remaining members were **Trevor Hastie**, John A. Overdeck Professor of Mathematical Sciences, Professor of Statistics and Professor of Biomedical Data Science at Stanford University (United States), **Nigel Hitchin**, Emeritus Savilian Professor of Geometry at the University of Oxford (United Kingdom), **Zakya H. Kafafi**, Adjunct Professor of Electrical and Computer Engineering at Lehigh University (United States), **Carmen Menoni**, University Distinguished Professor in Electrical and Computer Engineering at Colorado State University (United States), **Martin Quack**, Head of the Molecular Kinetics and Spectroscopy Group at ETH Zurich (Switzerland), **Sandip Tiwari**, Charles N. Mellowes Professor in Engineering at Cornell University (United States), and **Xueming Yang**, a distinguished research fellow at the Dalian Institute of Chemical Physics, Chinese Academy of Sciences, and also a professor and chairman of the Department of Chemical Physics at the University of Science and Technology of China.

The **CSIC technical committee** was coordinated by **Ana Guerrero**, the Council's Deputy Vice President for Scientific and Technical Areas, and formed by: Miguel **Ángel Bañares**, Research Professor at the Institute of Catalysis and Petrochemistry (ICP); **Alberto Casas**, Research Professor at the Institute for Theoretical Physics (IFIC); **Oscar García**, Research Professor at the Institute of Mathematical Sciences (ICMAT); **Agustín Rodríguez**, Research

Professor in the Institute of Materials Science (ICMS); **Francisco Javier Rojo,** Coordinator of the Chemical Sciences and Technology Area and Research Scientist at the Institute for Chemical Research (IIQ); and **Alfonso Saiz**, Research Scientist in the Institute of Physical Chemistry "Rocasolano" (IQFR).

CALENDAR OF UPCOMING AWARD ANNOUNCEMENTS

Biomedicine	Tuesday, January 31, 2017
Ecology and Conservation Biology	Tuesday, February 7, 2017
Contemporary Music	Tuesday, February 14, 2017
Economics, Finance and Management	Tuesday, February 21, 2017
Development Cooperation	Tuesday, February 28, 2017

Previous awardee in this category

The **Basic Sciences** award in last year's edition was shared by physicists **Stephen Hawking and Viatcheslav Mukhanov**, for discovering independently, with one year's difference, that the galaxies were formed from quantum fluctuations in the Universe's earliest days.

Five of the 79 winners in earlier editions of the BBVA Foundation Frontiers of Knowledge Awards have gone on to win the Nobel Prize. Shinya Yamanaka, the 2010 Biomedicine laureate, won the Nobel Prize in Medicine in 2012; **Robert J. Lefkowitz**, awardee in the same Frontiers category in 2009, won the Chemistry Nobel in 2012. In Economics, Finance and Management, three Frontiers laureates were later honored with the Nobel: **Lars Peter Hansen**, winner of the Frontiers Award in 2010 and the Nobel Prize in 2013; **Jean Tirole**, Frontiers laureate in 2008 and Nobel laureate in 2014; and **Angus Deaton**, 2011 Frontiers laureate and Nobel laureate in 2015.

LAUREATE'S FIRST DECLARATIONS AND IMAGES

A video recording of the new laureate's first interview on receiving news of the award is available from the Atlas FTP with the following coordinates:

Server: **213.0.38.61**

Username: **AgenciaAtlas4**

Password: **premios**

The name of the video is:

"PREMIO CIENCIAS BÁSICAS"

In the event of connection difficulties, please contact Alejandro Martín at Atlas:

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Fundación BBVA

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