PROFESSOR GEORGE BERNARD DANTZIG, LIFE AND LEGEND

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ABSTRACT
A biographical sketch of Prof. Dantzig, recently dead, is given. He is considered as one of the founding fathers of Mathematical Programming.

Key words: Linear Programming, Games Theory, Simplex Method.

RESUMEN
Se dan datos biográficos del recientemente fallecido Prof. Dantzig. Este es considerado como uno de los fundadores de la Programación Matemática.

MSC: 90:00

1. GEORGE B. DANTZIG AND HIS RELATIVES

Prof. George Bernard Dantzig passed away at his Stanford home at age 90 on 13 May 2005 in Palo Alto, California, due to complications from diabetes and cardiovascular disease. His death has been divulged by important newspapers and journals, see for example the articles of Scott and Devlin (2005), Holley (2005), Mintz (2005) and Pearce (2005). His wife and sons survive him. The international mathematical community deeply deplores his decease.

His parents were Tobias Dantzig and Anja Ourisson. Tobias was born in Russia, but went to France for studying mathematics in Paris. Being there he received classes from Henry Poincaré. Anja studied mathematics in Paris when they met and got engaged. They emigrated to the United States where Tobias worked as lumberjack, road builder and painter before becoming a lecturer for a Ph.D. in mathematics at the University of Indiana. He made different contributions in mathematics being his most famous work "Number: the language of science". It is a remarkable book. George helped him being a teenager by preparing some of the figures that appeared in the book. This oeuvre has been reprinted several times. His mother obtained a Master's degree in French and worked as linguist at the Library of Congress in Washington D.C.

Tobias and Anja considered that names would influence in the future careers of their sons. Their first one was named "George Bernard" after Shaw because they wanted him to become a writer. George Bernard Dantzig was born the 8th of November 1914 in Portland, Oregon. The second son was named Henry after Poincaré, hoping he would be a mathematician.

The family moved from Oregon to Washington D.C where Dantzig's results in mathematics were, rather poor. Encouraged by his father he began to improve his marks in mathematics and in High School he became fascinated by geometry. His father gave him thousands of geometry problems. The mental capacity required to solve them were considered by George as a gift from is father and that the training obtained by solving these problems during high school days developed his analytic power.

He met and married Anne Shmuner in 1936.

2. SCHOLARSHIP AND JOBS

Dantzig studied mathematics at the University of Maryland where his father was teaching in the Mathematics Faculty. He obtained his Bachelor's degree there in 1936 and a Master's from the University of Michigan in 1937. Then he started his graduate studies there as a Horace Rackham Scholar being a student of T. H. Hildebrandt, R. L. Wilder and G. Y. Rainer.

Unhappy with abstract mathematics, the only courses he enjoyed were those related with statistics. Dantzig moved to Washington and obtained a job as Junior Statistician on a project named "Urban study of consumer purchase" at the U.S. Bureau of Labor Statistics. He was there from 1937 to 1939. Dantzig became interested in mathematical theory after reading some of the basic papers written by Jerzy Neyman and asked him to obtain a teaching assistantship at Berkeley for doing his doctoral studies under his advisory in 1939. He obtained it and restarted his graduate studies

World War II makes him to interrupt his Ph.D. studies. From 1941 to 1946 he was Head of the Combat Analysis Branch, U.S.A.F. Headquarters Statistical Control and was awarded the War Department Exceptional Civilian Service Medal. He was involved with the collection of data about sorties flown, bombs dropped, aircraft lost. He personally helped other divisions of the Air Staff to prepare plans called "programs" where everything was planned in greatest detail.

He was promoted from the University of California at Berkeley in 1946. They offered him a job but his colleagues at the Pentagon proposed him a better payed work mechanizing the planning process. He became Mathematical Advisor at the Defense Department. In 1947 Dantzig made his most famous contribution to mathematics: the Simplex Method of Optimization. It looked for improving the job of planning using desk calculators in the U.S. Air Force. The name of "programming" grew from a military term, which identified to plan and schedule for training, logistical supply or deployment of men. See McArthur (1990) and Rosser (1982). Dantzig mechanized the planning process by considering that the programs had a linear structure. He pointed out that he was looking for "to more rapidly compute a time-staged deployment, training and logistical supply program". Von Neumann received the visit of Dantzig for exchanging ideas on determining an algorithm for solving the programming problem that he was facing. It was encouraging and Von Neumann determined during this visit the existence a connection between Games Theory and Linear Programming in the Two Persons Zero Sum games. In fact Von Neumann fixed that they were equivalent and elaborated ideas on the maximization of a linear function with linear inequalities constraints which were published in a note. Both mathematicians discussed how to develop a universitary project for studying the underlying mathematical structure of Games Theory and Linear Programming, see Weintraub (1992), Grattan-Guinnes. (1994): Tucker, Khun and Gale were supported to develop the work that resulted in the classic oeuvres Linear Programming and the Theory of Games of Gale, Khun and Tucker (1951). In Linear Programming and Extensions of Dantzig (1963) also made clear the close relationships between Games Theory and Matematical Programming. Kjeldsen (2000) and Lenstra et. al. (1991) discussed at large these facts. Nowadays Games Theory tools are commonly used in Operations Research and its models are the base of the modern theoretical modeling of economic issues. Von Neumann was a Nobel Laureate by his job in this area.

The large-scale "activity analysis" model developed by Dantzig could be described using modern terminology as "...a time-staged dynamic linear program with a staircase matrix structure". Dantzig explained that initially "There was no objective function" in the modeling.

He obtained a job in RAND Corporation in Santa Monica.During his work there he developed the implementation of linear programming on computers. The implementation of methods for linear programming began in 1952 in the laboratories of this corporation where the first-generation of computers were developed. By that time it received the largest support for developing scientific research with military applications. The development of Games Theory had its nest in Santa Monica due to the applicability of it to war. The logistic project gave support to the work of . H. Kuhn, J. Nash, M. Shubik and A. Tucker.

The work there became boring to Dantzig and he took up an appointment as professor at Berkeley in 1960 and was Chairman of the Operations Research Center.

In 1966 he took the job of Professor of Operations Research and Computer Science at Stanford University.

According to the current on-line database, George Dantzig had 52 students and 165 descendants.

3. HIS CONTRIBUTION

Mathematical programming has been blessed by the involvement of at least two exceptionally creative geniuses: George Dantzig and Leonid Kantorovich. They are the indisputable Founding Fathers of Linear Programming and, as a consequence, of the offspring of Mathematical Programming. Kantorovich developed the basic model of Linear Programming looking to optimize the plans of the centralized soviet economy.

Dantzig is universally known as the "mathematician who introduced the simplex algorithm". When Kantorovich received the Nobel Prize for his contribution he expressed his "outrage" of not including Dantzig.

Perhaps soviet mathematicians could develop the Simplex Method because the first proposal and applications of the so-called Linear Programs were due to Kantorovich. Stalinism pervaded scientific development and the method was considered as a way of intruding in the development of the centralized economic plan, which was a task of the politicians. See Kantarovich (1939), Charnes and Cooper (1961), Brentjes (1976), Lorentz (2002), Zdrakovska and Duran (1993) and Siegmund-Schultze (2003) for detailed discussions on the subject: The work of Kantorovich was buried and he continued doing research in pure mathematics. Nowadays it is considered the role that Kantorovich method could have played in the development of the Soviet Army offensive and defensive operations in the II World War. It has been established how some large operations as the Arc of Kursk would not only been less costly but could have achieved far better results in destroying defeated Nazi troops and in liberating larger extensions of the occupied territories.

T. J. Koopmans proposed the term "linear programming" during a visit Dantzig made to the RAND Corporation in 1948. His father Tobias suggested the term Dual during a meeting of his son with other researchers at home while he was a visitor. The term primal was a consequence of the meaning of dual and was determined after accepting the proposal of Tobias.

Dantzig used the discovered algorithm in the solution of the problem of eating adequately at minimum cost. It is described in his book (Dantzig, 1963) and is utilized with some small variations in the majority of the specialized books for introducing the model. It is identified as the determination of an adequate diet that was of least cost. The motivation is that after the war there were food shortages and a serious practical problem was to establish "minimum-priced, optimal diet" for the U.S. population. The solution should allow providing the government ideas for estimulating the production of certain crops and animals. The method was tested by Jack Laderman in the Mathematical Tables Project of the National Bureau of Standards. It was the first large-scale computation in this field. The problems consisted of a system of nine equations with seventy-seven unknowns. The solution was obtained in a record time. It is interesting to quote that the solved problem was studied earlier by George Stigler. He proposed a solution based on the substitution of certain foods by others, which gave more nutrition per dollar. He examined some ways to combine the selected foods. He did not considered it as the cheapest solution but argued that it was reasonable to consider that the yearly cost could not be reduced seriously by any other solution. He was a Nobel Laureate.

Linear programming is catalogued as one of the most striking developments because it provides of the means to state general objectives and to find, using the simplex method, optimal policy decisions for a broad class of practical decision problems of great complexity. Dantzig said that: "The tremendous power of the simplex method is a constant surprise to me". The modesty of his words speaks in favor of him because today it is considered that the most used mathematical problem is Linear Programming. It is used to allocate resources, plan production, schedule workers, plan investment portfolios and formulate marketing (and military) strategies. The versatility and economic impact of linear programming is awesome. A whole new discipline has been founded having Linear Programming as its touchstone. It is Operations Research and has his origins in the work of the British Army during Word War II, see McArthur (1990). The Operations Research groups were multidisciplinary and their task was to suggest how to optimize the common military operations and strategies. Following Rau (2000), the U.S. started to develop such groups as a result of the cooperation in the struggle against the Nazis in 1943.

In addition to his founding of the simplex method and furthering linear programming as easy computational tool for solving Linear Programs, Dantzig also advanced the fields of decomposition theory, sensitivity analysis, complementary pivot methods, large-scale optimization, nonlinear programming, and programming under uncertainty. He worked in the foundation of a wide range of topics related to optimization and operations research that over the years has been of major importance.

Linear programming and its offspring (such as nonlinear constrained optimization, Stochastic Programming and Integer Programming) are commonly used in everyday practice. See a detailed discussion in Kjeldsen, T. (2000): They have proved to be useful tools in the economic practice of organizations and management. That is, Dantzig's inventions have revolutionized planning, scheduling, network design and other complex functions that are yielded by modern-day business, industry and government.

Dantzig's work is also one of the most impacting results in computer development and use because many variables must be juggled to get optimal results. The further development of optimization modeling and computer have motivated the existence of a set of new methods as interior point methods but the simplex method, due to the authorship of Dantzig performs remarkably well in terms of efficiency and speed. It is regarded, both by theoreticians and applied operations researchers, as a pre-eminent tool for almost all applications of linear programming. Professor Dantzig's seminal work has laid the foundation for much of the field of systems engineering and is widely used in network design and component design in computer, mechanical, and electrical engineering.

In 1991, Dantzig quoted that: -"... it is interesting to note that the original problem that started my research is still outstanding - namely the problem of planning or scheduling dynamically over time, particularly planning dynamically under uncertainty. If such a problem could be successfully solved it could eventually through better planning contribute to the well-being and stability of the world."

4. THE LEGEND

Dantzig's story motivated different variations of the development of a genius. He became the origin of one of the most famous urban legends. Teachers and professors use the fact that while being a graduate student of one of the fathers of modern statistics, Jerzy Neyman, he accidentally solved two problems that the professor gave to the students as an example of open questions in statistics.

The legend, see O'Connor **et al**. (1986), goes more or less as follows:

Being late for class, Dantzig thought that the problems written in the blackboard were merely a homework assignment. Not knowing they were examples of statistics qualified as open problems. He made is homework and worked out their proofs. Later, Neyman notified him that he had prepared one of his two "homework" proofs for publication, and Dantzig was given co-author credit on another paper several years later when another mathematician independently. Abraham Wald, a token of Decision Theory development, worked out independently the same solution to the second problem.

His own description is the following:

"It happened because during my first year at Berkeley I arrived late one day at one of [Jerzy] Neyman's classes. On the blackboard there were two problems that I assumed had been assigned for homework. I copied them down. A few days later I apologized to Neyman for taking so long to do the homework — the problems seemed to be a little harder than usual. I asked him if he still wanted it. He told me to throw it on his desk. I did so reluctantly because his desk was covered with such a heap of papers that I feared my homework would be lost there forever. About six weeks later, one Sunday morning about eight o'clock, [my wife] Anne and I were awakened by someone banging on our front door. It was Neyman. He rushed in with papers in hand, all excited: "I've just written an introduction to one of your papers. Read it so I can send it out right away for publication." For a minute I had no idea what he was talking about. To make a long story short the problems on the blackboard that I had solved thinking they were homework were in fact two famous unsolved problems in statistics. That was the first inkling I had that there was anything special about them.

A year later, when I began to worry about a thesis topic, Neyman just shrugged and told me to wrap the two problems in a binder and he would accept them as my thesis.

The second of the two problems, however, was not published until after World War II. It happened this way. Around 1950 I received a letter from Abraham Wald enclosing the final galley proofs of a paper of his about to go to press in the Annals of Mathematical Statistics. Someone had just pointed out to him that the main result in his paper was the same as the second "homework" problem solved in my thesis. I wrote back suggesting we publish jointly. He simply inserted my name as co-author into the galley proof. "

The legend started when the Lutheran minister the Reverend Schuler of the Crystal Cathedral in Los Angeles used a conversation with Dantzig on thinking positively. He told Schuler the story about the homework problems and his thesis. It was included in his book on the power of positive thinking. Dantzig pointed out that though Schuler's published version was a bit garbled and exaggerated it was essentially correct. The moral of the legend was that, if he had known that the problem were not a homework, but two famous unsolved problems in statistics only a positively thinking would led him to tackle them.

This legend was used in Hollywood as the setup of the plot Good Will Hunting, produced in 1997, and in one of the motivating scenes of Rushmore a film released in 1999. The fairy tale is that a daydreamer may be able to solve unsolvable problems and to win the recognition from his detractors.

There is not Nobel Prize in Mathematics. Dantzig did not it as Stigler, Kantorovich and Von Neumann did. Their work were in some way or another directly connected with Linear Programming, Even the work of John Nash is related to Linear Programming through Games Theory, and he also was laureated with a Nobel Prize in Economics. The importance of Dantzig's results to economy is huge and at least comparable with those of Nash who was a contemporary collaborator with the group working in Game Theory under RAND's umbrella and Von Neuman's leadership and the advisory of Khun.

He received different awards. The President of the USA Gerald Ford awarded him the National Medal of Science in 1975. But more significant is that a Prize with his name was created by the Mathematical Programming community. He was honored with many honors including the Von Neumann Theory Prize in Operational Research in 1975. Other awards were:

- Award in Applied Mathematics and Numerical Analysis in 1977.

- Harvey Prize in Science and Technology from Technion, Israel, in 1985.

- Silver Medal from the Operational Research Society of Britain in 1986.

- Adolph Coors American Ingenuity Award Certificate of Recognition from the State of Virginia in 1989.

- Special Recognition Award from the Mathematical Programming Society in 1994.

As mentioned early, the Mathematical Programming Society honored him and created the Dantzig Award. It is assigned every three years, since 1982, on one or two people who have made a significant impact in the field of mathematical programming. It was awarded for the first time to Michael Powell and R. T. Rockafellar. Some other recipients have been Ellis Johnson and Manfred Padberg (1985), Michael J. Todd (1988), Martin Grotschel and Arkady S. Nemirovsky (1991), Claude Lemarechal and Roger J. B. Wets (1994).

The first issue of the SIAM Journal on Optimization in 1991 was dedicated to him.

He was Member of the National Academy of Engineering, the American Academy of Arts and Sciences, Recipient of the National Medal of Science and of 8t honorary degrees.

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