LAUDATIO

In honor of **Professor Kenneth J. ARROW**

Joan Kenney Professor of Economics and Professor of Operations Research,
Department of Economics,
Stanford University,
1972 Nobel Memorial Prize Laureate in Economic Sciences

On the ocassion of the award of the Doctor Honoris Causa title of
Alexandru Ioan Cuza University of Iași

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Mentor to a generation of great mathematicians at Göttingen University, including David Hilbert and also the Romanian Alexandru Myller, Doctor Felix Klein wrote in his course of history of mathematics ("Unterrichtsblatter für Mathematik und Naturwissenschften"):

"The mystery of brilliant productivity will always be the posing of new questions, the anticipation of new theorems that make accessible valuable results and connections. Without the creation of new aims, mathematics would soon exhaust itself in their rigor of logical proofs and begin to stagnate as its substance vanishes. Thus, mathematics has been most advanced by those who distinguished themselves by intuition rather than by rigorous proofs." (*Markets, Information and Uncertainty. Essays in Economic Theory in Honor of Kenneth J. Arrow*, Edited by Graciela Chichilnisky, Cambridge University Press, 1999).

And Professor Graciela Chichilnisky wrote: "Few people fit this description. Kenneth J. Arrow is one of them."

Economic theory after World War II was deeply influenced by Professor Arrow's original thinking. Several economic models and analytic instruments used for the study of economic systems in general or of some specific domains (e.g. the financial market, insurance, health services, public decisions, etc.) are the fruit of his brilliant intellectual creativity and bear his name. Today, experts in economics, mathematics, statistics, political sciences, and even law, make use of the general scientific knowledge which includes "*Arrow's Theorem of General Possibility or Impossibility", the Arrow-Debreu model of general competitive economic equilibrium, Arrow-Pratt Index of Risk aversion, "Arrow securities*" etc.

That is why the Colombia-based professor feels entitled to describe her mentor as mastering the "mystery of brilliant scientific creativity" and

fulfilling the "calling of the few" who were able to grow new research domains.

Doctor Kenneth Joseph Arrow is now the Joan Kenney Professor of Economics and Professor of Operations Research, emeritus, at the Department of Economics, Stanford University. In 1972, he was awarded the Nobel Memorial Prize in Economics Sciences for "pioneering contributions to general equilibrium theory and welfare theory," together with British economist John Hicks.

His academic merits are known throughout the world, and his name is mentioned in a multitude of scientific articles, monographic studies, honorary volumes, dictionary and encyclopedia articles about his life and work (e.g. New Palgrave Dictionary of Economics, International Encyclopedia of Social and Behavioral Sciences etc.) to fill a library. Also, the literature which is grounded on the sound theoretical apparatus formulated by him is so vast that even the simple operation of collecting all the references would require a number of specialized committees.

Michael Spence, Professor Arrow's disciple and a Nobel Memorial Prize Laureate in Economic Sciences himself (in 2001) said: "Describing Ken Arrow's contribution to economics in the second half of the 20th century would come quite close to just describing the evolution of economics during that period."

To enumerate the revolutionary scientific achievements of a famous personality without disregarding his personal life and the meaning of his intellectual quest; to present his life and the meaning of his intellectual quest without disregarding his work and creative contribution – this is a dilemma leading to a potential paradox. Namely, Kenneth Arrow's work rigorously explains, in the accuracy of modern logic and mathematics, a

multitude of facts and social processes, from the functioning of the general economic system to the organization of firms and information channels, but does not explain, or at least not in the same analytic and systematic manner, an essential aspect in the evolution of post-war economic thinking, namely the life and work of the eminent economist Kenneth Arrow. This is maybe a different meaning that can be attached to the wording "Arrow's impossibility paradox."

Far from us the idea of a counterpoint to the "Arrow mystery" in Professor Graciela Chichilnisky's apt phrasing. It is only an attempt to escape the "axiomatic constraints" of rational individual choice, of the Pareto efficiency of the system of general competitive equilibrium, of the consistency and transitivity of social choice and, last but not least, of the optimal allocation of risks.

In a seminal book dedicated to a few exceptional economists, "*Roads to Wisdom. Conversations with ten Nobel Laureates in Economics*", (Edward Elgar Publishing, 2009), author Karen Ilse Horn wonders if the factors which determine crucial scientific contributions can be accurately predetermined. Her answer is quite interesting: "The evolution of economic reality, the progress of economic theory and the personal growth of scholars are simultaneous processes that draw on each other at all times. Most of the time, these interactions between major influences come about by coincidence and behave in "unruly, unpredictable ways." (p.9)

With the permission of our distinguished guest, our presentation of his life and work does not observe the conditions of the optimal allocation of risks, or the reasonable axioms of social choice.

Professor Kenneth J. Arrow was born in New York on August 23rd, 1921. His family (parents Lillian and Harry and, sister Anita) were doing well in the 1920s, but were badly hit by the Great Depression. So, when he graduated from high school, he had to go to City College of New York, where classes were free of charge. In a recent essay, "*Some Developments in Economic Theory Since 1940: An Eyewitness Account*" (Annual Reviews Economics, 2009, 1-16), Professor Arrow said: "I had a variety of intellectual interests: mathematics, history and logic. I found the first dominant and majored on it, at the College of the City of New York, but I took quite a few courses in other subjects, even economics." (p.2)

While he was still an undergraduate, he met A. Tarski, a reputed mathematician, philosopher and logician, whose book "*Introduction to Logic*" he read with promising mathematical rigor. At least one of Tarski's concepts – *transitivity* – would later become a pillar of "*Arrow's Impossibility Theorem.*" A self-taught scholar, he also studied Bertrand Russell, R. A. Fisher, E. S. Pearson, and J. Neyman. Once awarded the degree of *Bachelor's of Science in Social Science, major in Mathematics*, his intention was to become a teacher of mathematics. But, as there were no high school vacancies, he considered the possibility of becoming a statistician or an expert in actuary. He passed his actuary exams, which supplied him with other two important concepts in his later research: *moral hazard* and *adverse selection.*

In 1940, he applied for graduate school to study mathematics and statistics at Columbia University. Here he would meet Harold Hotteling and Abraham Wald. As Professor Arrow would say: "an incredible stroke of

good fortune." In 1941 he was holding a *Master degree in Mathematics*. But it was not possible for him to continue his education in statistics at that time because Columbia did not have a *Department of Statistics*, and the existing *Department of Mathematics* was not too interested in statistics. Harold Hotteling, an outstanding statistician and economist, advised him to begin a PhD in Economics. This is how Professor Arrow evokes his Columbia years: "The statistics courses given by Hotelling and Wald were superb. We were at the frontiers very quickly, to which indeed they were major contributors."

But for most of the time he had to teach himself economic theory and economic mathematics.

Even though it seems very unlikely today, back then, the Economics department did not have theoretical courses, but a sort of empirical approaches inspired from the vision of American institutionalists – according to which an accumulation of historical data might eventually generate enough patterns or causal relationships to constitute a theory. To Wesley Mitchell and his assistant Arthur Burns, the main economic issue to research was the business cycle. Their statistical methodology did not go by the principles of mathematical statistics and scientific investigation which our young student had taken up. And yet, years later, Professor Arrow would evoke his meeting with the future head of the Federal Reserve Systems saying: "I found him one of the most brilliant and knowledgeable economist I have ever met."

The Second World War and military service cut short this passionate young man's education. During the war, he was an officer in *Weather Division in the U.S. Army Air Corps* and worked for the *Long Range Forecasting Group*, where he was made captain.

Those years, and his preoccupation for optimizing the planning of military aircraft, were the starting point for his first scientific paper – "*On the use of winds in flight planning*" – published in *Journal of Meteorology* no. 6 of 1949. Arrow had found a way to avoid serious losses in aircraft and military materials on bad weather. It seems that experts in aerodynamics were to regret the "loss" of a promising talent to economics.

In 1946 he resumed his studies at Columbia, but Harold Hotelling had already gone to University of North Carolina.

He was considering a non-academic career "as a life insurance actuary." But a meeting with the famous econometrist Tjalling Koopmans proved yet another providential turning point, as the latter advised him to choose better. In Koopmans' simple words, "There is no music in it."

As Ross M. Star, Professor Arrow's student, would note years later, "Fortunately for economic science, Arrow followed this advice and decided to continue a research career."

In 1947, he joined the *Cowles Commission for Research in Economics*, then based at University of Chicago. The commission wanted to develop social research, economic research in particular, on a more serious scientific ground. Mathematics, statistics, and econometrics provided enough instruments to generate a theoretic framework for economic analysis and empirical research. Numerous economic models now currently used in the profession were elaborated by the research group of the Cowles Commission. The list of people who worked under Tjalling Koopmans and then Iacob Marschak shows an unmatched intellectual community.

Keats calls artists as "God's Spies on Earth." The poet's metaphor easily applies to those who, between 1940 and 1950, worked for the *Cowles*

Commission: Kenneth Arrow, Gerard Debreu, James Tobin, Franco Modigliani, Herbert A. Simon, Lawrence Kein, Trygve Haavelmo, Leonid Hurwicz, and Harry Markowitz. Most of them were to be awarded the *Nobel Memorial Prize in Economic Sciences* from the 1970s onwards. In his turn, their mentor, Tjalling Koopmans, became the 1975 Nobel Laureate.

In the Foreword to "*Reflecions of Eminent Economists"*, eds. Michael Szenberg and Lall Ramrattan (Edward Elgar, 2004), Professor Arrow wrote: "Many, perhaps most, put great emphasis on the presence of some outstanding teacher or teachers. Indeed, not only in these volumes, but in the history of economic thought, we have narratives based on some great original scholar who inspired and teaches disciples." Of course, intellectual emulation in an exceptional community, the possibility of a ceaseless activity of the mind under the guidance of an inspired teacher is a great chance for any young scholar. It surely was for an exceptionally endowed young man such as Arrow. But, as Louis Pasteur once insightfully remarked: "Chance favors only the prepared mind."

Kenneth Arrow was prepared to solve challenging problems in economic analysis, and to propose challenging theories too. During a RAND Corporation internship, where another group of researchers was famous for the game theory and operational research, he took part in an informal discussion on the game theory. A logician put forth the following problem: "Game theory supposes rational strategic behavior among optimizing agents. The maximand of an individual may be well-defined, perhaps as a utility function, but what is the maximand of a country?" (R. M. Starr, *Arrow, Kenneth Joseph*, New Palgrave Dictionary of Economics, vol. I, p.236). Arrow replied: "a Bergson social welfare function should represent a country maximand." That reply opened the way to one of the

most important theoretical contribution to social sciences, "*Arrow's Impossibility Theorem.*" He investigated a wide variety of mechanisms in the elaboration of group decisions. Generally speaking, all activities involving groups, communities, or populations, from the political poll to the distribution of resources, require public decisions or social choices. The difficulty in making a social choice is adopting a decision which should take into account all expressed individual preferences, or all the rankings of individual preferences, so that the result should satisfy the demands of all individuals. The issue of social choice was long overdue. All the previous attempts had failed, the best-known of which was Condorcet's paradox regarding the majority's vote. The simplest illustration is as follows: Be it a community of three members who try to decide, by majority vote, between three possibilities: A, B, and C. Each member has rational or transitive preference. Member 1 prefers A to B and B to C. Member 2 prefers B to C and C to A. Member 3 prefers C to A and A to B. There is a majority who prefers A to B (members 1 and 3) and a majority who prefers B to C (members 1 and 2). If the decision taken in the community is rational, then they should prefer A to C. But the exact opposite happens: there is a majority who prefers C to A (members 2 and 3). Despite the transitivity of individual preferences, the group preference between pairs of alternatives, expressed in a majority vote, is intransitive, or irrational. Arrow gave a mathematic formulation for the conditions of group decisions based on some reasonable axioms: (1) *non-restricted domain* (all individual preferences or logically possible choices must be taken into account); (2) *the Pareto principle* (if any member prefers an alternative, the group decision should reflect the same alternative); (3) *independence of irrelevant alternatives* (in making a choice between two alternatives, the group

decision should only take into account individual preferences for those alternatives; the preferences for a third alternative do not count in the enunciated choice); (4) *the non-dictatorial regime* (there is no one single person whose preferences determine a public decision).

Arrow's General Possibility Theorem, also known as *Arrow's Possibility Theorem,* or *Arrow's Impossibility Theorem,* shows that there are no mechanisms in group or public decision-making which can fulfill all the four axioms, which, in other words, can result in rational or transitive social choices based on transitive individual preferences. With rigor and mathematical precision, Arrow demonstrates that *Condorcet's paradox* is not an anomaly, but a given flaw in the mechanism of collective decisions.

His PhD thesis, "*Social choice and Individual Values" (1950)*, was ahead of his time and of the general view in the Economics Department.

Th. Anderson, an econometrist, considered it to be "a sound subject in economics." Kokaro Suzumura believes that "*Social choice and Individual Values"* was special because of "its innovative nature" and had a revolutionary influence "on the whole field of social choice theory". Since its publication, the domain of "social choice theory" has developed a huge literature. Recently, an expert in the field has counted the titles of scientific papers on social choice, and the list runs over more than 300 pages!

It is a singular achievement to create an entire research domain or a new academic subject by a PhD thesis. In economics, this record may only have been matched by Paul Samuelson and Gerard Debreu.

In 1949, Arrow was appointed *Acting Assistant Professor of Economics and Statistics* at Stanford University, and then Associate Professor shortly after. In 1953 he became *Professor of Economics and Statistics* and *Professor of Operations Research*. At Stanford University,

Professor Arrow worked assiduously with the "*Institute for Mathematical Studies in the Social Sciences.*" Later on, he would recall those first years: "Economic theory backed by serious mathematical reasoning was just beginning to be recognized. Our group of faculty and students in economic theory (...) felt ourselves a community. Not an oppressed minority, but rather a vanguard. We were taking over!"

It is interesting that the economists of Stanford and Berkeley had organized a society of "*Mathematical Economics*" which held meetings every other week. Apart from Professor Arrow, the Stanford group included Herbert Scarf (famous for his contribution to the model of general computational equilibrium) and Hirofumi Uzawa (who wrote on the theory of stability of general equilibrium, among others).

The Berkeley group included: Gerard Debreu, Peter Diamond, Dan McFadder (all future Nobel Laureates), and Roy Radner.

At first, Professor Arrow and Gerard Debreu worked independently on the model of general equilibrium and the two theorems of welfare, and then they joined forces. Unlike the previous attempts on the model of general equilibrium (Walras – the founder of the general equilibrium theory, Marshall – the father of the term "economics" and rather a theoretician of partial equilibrium, Cassel – who took an interest in the currency issue in general equilibrium, John Hicks – who amended Walras' theory using the efficiency criterion, etc.), the Arrow-Debreu model mathematically demonstrated (using fixed-point theorems) the existence, uniqueness, and optimality of competitive general equilibrium. The result of their analysis was published in 1954 under the title "*Existence of equilibrium for a competitive economy.*"

The general equilibrium theory was long considered the crux of

economic analysis and the „philosopher's stone" in economics.

Professor Arrow wrote in 1973: "From the time of Adam Smith's Wealth of Nations in 1776, one recurrent theme of economic analysis has been the remarkable degrees of coherence among the vast numbers of individuals and seemingly separate decisions about the buying and selling of commodities. In everyday, normal experience, there is something of a balance between the amount of goods and services that some individuals want to supply and the amount that other, different individuals, want to sell." (apud *"General Equilibrium Analysis. A century after Walras"*, edited by Pascal Bridel, Routledge, 2011, p.35.)

The Arrow-Debreu model surpasses all the previous theories not just by the complexity and completeness of its theorem of existence, but also by its dynamic character, because it incorporates uncertainty in the form of "*contingent commodities"*. Professor Arrow would later remark: "To only look at situations where the Invisible Hand has finished its work cannot lead to real understanding of how that work is accomplished." (Idem, p.36)

In the late 1950s, Arrow worked with Leonid Hurwicz in order to find a solution to the problem of stability of general equilibrium, and published texts which explain this matter. We will only mention their paper, "*On the stability of competitive equilibrium",* (I), in *Econometrica* (1958), no. 26, pp.522-52, and (II) in *Econometrica* (1959), no. 27, pp.82-109.

In the 1960s, Professor Arrow did research at Cambridge, where he worked with the reputed economist Frank Hahn. Their work, "*General Competitive Analysis"* (1971), gives a complete view on the theory of general competitive equilibrium.

In 1968-1979, Mr. Arrow taught Economics at Harvard University, and in 1979 returned to Stanford to join the Department of Economics as *Joan Kenney Professor of Economics and Professor of Operations Research* until 1991 when he became a Professor Emeritus.

Professor Arrow's erudition, his passion for theory, new intellectual challenges, his interest in economic and social issues which he tackles with a unique depth and inspiration, nurture his very active scientific life when he has reached an age of glowing wisdom.

*   *   *

Professor Kenneth Arrow's work is so rich, important, and influential in post-war social research, that only to enumerate his main topics and directions of research would take up a whole monographic book. Unfortunately, our presentation can only cover a part of it. Our consolation is that his academic merits, as well as his exceptional contributions, are given due recognition in the pantheon of "*Great human accomplishments.*" Also, we hope that someone in our midst, with a passion for contemporary economic thinking, will one day take up the task of writing a complete study about his work.

Professor Arrow's research over six decades comprises an impressive diversity of topics, with a matching set of results and crucial contributions to the economic science.

As the literature and a certain number of his works suggest, Professor Arrow's research addresses the following domains and theories: *social choice theory* (in fact an entire domain of social sciences founded by Professor Arrow), *economics of information and uncertainty, economics of*

medical care or *economics of health care* by its current name*, economics of organization, environmental economics* (his more recent interest), *extensions of the fundamental theorems of welfare economics, general equilibrium theory, optimal programming, mathematical statistics, economics of racial discrimination and CES production function* (constant elasticity of substitution).

All these domains and theories have been developed, improved or rebuilt based on modern mathematics and mathematical statistics. But apart from the works pertaining to economic mathematics and statistics, in all the other works, the formal analysis is accompanied by empirical analysis and tests. As Alfred Marshall would say, once the hypotheses are formulated and demonstrated, an economic analysis requires explanations "in plain English."

In the 1950s, Professor Arrow had already got an exceptional reputation, both in the American and international academia. His contribution to the development of the "*social choice theory,*" "*welfare economics,*" and "*general competitive equilibrium theory*" has brought him a well-deserved "John Bates Clark" medal in 1957, an honor reserved for economists aged under 40 with achievements essential for the progress of science. This honor comes second only after the Nobel Memorial Prize in Economic Sciences and almost half of the "John Bates Clark" medal holders have also been awarded the Nobel Prize.

After that, Professor Arrow continued to look into general equilibrium and social choice. But gradually, his interest shifted towards decision-making in conditions of uncertainty, organization and use of information, as well as many other topics of scientific investigation included in the theories already mentioned.

It is important to say that his interest in the complete analysis of the markets and of the role of information in the market compelled him to formulate some new theories in economics, which mark the developments of economic thinking.

Thus, in 1962, he published "*The economic implications of learning by doing"* (Review of Economic Studies 29, 155 – 73) where, for the first time in economic research, he dealt with the role of learning from experience, a topic previously held as an exclusive tenet of pedagogy. At that time it was a known fact for the RAND that, "the direct labor requirement to build an airframe seems quite regularly to fall as a function of cumulative output, with an elasticity of about (minus) one third. This regularity was called a «learning curve» by practitioners. So, the idea is to build a model embodying the hypothesis that the experience of production carries with it, as, a by–product, an automatic improvement in productivity, what we might as well think of as technological progress." (Robert Solow, "*Learning from «learning by doing»: Lessons for Economic Growth"*, Stanford University Press, 1997). Professor Arrow chose the "gross investment as the vehicle through which learning occurs." He showed that knowledge accumulated through successive investments in equipment for the labor force raises productivity. In other words, technological change caused in the process of "learning by doing" is endogenous to the economic system, and not exogenous, as previously thought.

Robert Solow, a 1987 Nobel Laureate in Economic Sciences, noticed in a 1997 series of lectures that, "Arrow's 1962 paper is explicitly motivated by the wish to convert the level of technology into an endogenous element in the theory of economic growth. ... It is always cited as an

ancestor in the founding works of the "new" or "endogenous" growth theory. It is, in fact, a little more than just an ancestor. One of the points I intend to make in this lecture is that Arrow's paper comes very close to anticipating "*New Growth Theory*" (Op. cit, p.8).

Professor Arrow's paper on "learning by doing" paves the way for the theory of endogenous economic growth. Paul Romer, the author of this theory, pointed out that, "I followed Arrow's (1962) treatment of knowledge spillovers from capital investment and assume that each unit of capital investment not only increases the stock of physical capital, but also increases the level of technology for all firms in the economy through knowledge spillovers." ("The Origins of Endogenous Growth", *Journal of Economic Perspectives*, Volume 8, Number 1 – Winter 1994, p.7).

Fifty years ago, Professor Arrow started a new domain of research which is essential for the analysis and assessment of health systems – *economics of medical care.* The characteristics of health services – unpredictability, the market barriers, the importance of the doctor-patient confidence, and asymmetrical information – makes the market of these services a special case, different from the markets of ordinary goods and services.

In his paper "*Uncertainty and the Welfare Economics of Medical Care"* (American Economic Review (1963) 53, pp. 941 – 73), Professor Arrow "argued that a free market for health care leads to unjust and suboptimal outcomes."

Not long ago, William Savedoff from World Health Organization, considered that, "In many ways, it is remarkable that "*Uncertainty and the Welfare Economics of Medical Care"* has stood the test of time ..." *("Kenneth Arrow and the birth of health economics"*, Bulletin of the World Health

Organization, February 2002, Vol. 82, no. 2.)

Not only did this paper open a new domain of economic research, but it also created a few new directions for other domains and subjects such as sociology, education, law, etc. Moreover, it contains the genesis of an extremely important theory for the analysis of business organizations, systems of corporate governance, and financial markets – the "*principal - agent theory*".

In 1972, Professor Arrow was awarded (together with John Hicks) the *Nobel Memorial Prize in Economic Sciences*. He was 51. So far, he is the youngest Nobel Laureate in Economics. Paul Samuelson declared at the time that "it was no surprise, it was to be expected." But, with a modesty, generosity, and elegance that are his mark as much as his brilliant intellect, Professor Arrow said in an interview for the Romanian newspaper *România Liberă* of 1 November 2010: "It was unexpectedly soon. I must say there were many other people – alive at that time – who fully deserved this prize and never got it. I would not have given myself the Nobel Prize then."

Shortly after the eminent economist received his Nobel Prize, Anghel Rugină, professor at *Northeastern University* in Boston at the time, dedicated him a praising article in "*International Journal of Social – Economics*" (No.2, 1974). The Romanian economist was himself fascinated by the theory of general equilibrium and for many years tried to formulate a model designed to work also for the transition from central planning to the free market.

In the decades following the Nobel Prize, Professor Arrow continued to contribute important works in economics. And he taught his students with the same intellectual passion and creative energy. He taught and trained many outstanding economists, who have carried on his ideas and

theories. Out of his former PhD students, John Harsanyi, Eric Maskin, and Robert Myerson have been awarded the *Nobel Memorial Prize in Economic Sciences*. In a brief portrait, we could say that Professor Arrow not only founded new academic fields, but created a great school of economic analysis.

Sir Hans Krebs, a Nobel Laureate in chemistry, remarked in "*The Making of a Scientist*" (1942) "that a distinguished teacher transmits attitudes to students, among the most important being humility, because it nurtures a self – critical mind."

The same illustrious scholar ended his essay with the following phrase: "*Distinction breeds distinction.*"

Professor Arrow shared his exceptional knowledge to his disciples, along with moral values and courage. Walter P. Heller, Ross M. Starr, and David A. Starrett, all former PhD students of Professor Arrow, concluded the Foreword to "*Essays in Honor of Kenneth J. Arrow*", Volume 1 – *Social choice and public decision making* (Cambridge University Press, 1986) with a warm statement: "Those of us who have had chance to know him well are particularly fortunate. We are far richer for the experience".

We have not had the chance to know Professor Kenneth J. Arrow, but make up for the loss now, as we meet him in person.

Today, "Alexandru Ioan Cuza University" of Iaşi is exceptionally honored to offer a token of its appreciation and gratitude – the title of Doctor Honoris Causa – to a "great scholar and remarkable gentleman", to one of the few personalities of our age who marked for ages to come the meaning of the words "knowledge" and "wisdom".

The Laudatio Committee

o Professor **Vasile IŞAN**, Rector of "Alexandru Ioan Cuza" University of Iaşi

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Iaşi, October 29th 2013