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News

2007 Nobel Prizes won by mathematicians

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Even though there is no Nobel Prize for mathematics, mathematicians still often win it in other categories.

The 2007 Nobel Prize for Economics has been won by Leonid Hurwicz from the University of Minnesota, Eric Maskin from the Institute for Advanced Study, Princeton, and Roger Myerson, from the University of Chicago, for their work spanning 50 years in a branch of game theory called *Mechanism Design Theory*. Hurwicz, at 90, is the oldest person to receive the Nobel Prize.

Mechanism design theory, initiated by Hurwicz and refined and applied by Maskin and Myerson, has greatly developed our understanding of optimal funding mechanisms in financial markets. It is a classical assumption in financial maths that under ideal conditions resources will be allocated efficiently. But in practice, conditions are never ideal. For example, competition is never completely free, consumers are not perfectly informed and many transactions do not take place in open markets but within firms. It is also difficult to predict market behaviour when actors within the system have their own private information that they can use for their own gain.

Under these conditions, what is the best way to provide social welfare or maximise private profit? Perhaps government regulation is called for, but how should it be designed?

Within financial markets, sellers want to sell for the highest price they can, whilst buyers want to buy for the smallest amount they can. Both parties have their own information regarding the transaction and what they think the real price should be, and so the final outcome may not be efficient for the economy as a whole. Mechanism design theory attempts to find occasions in which this happens and sets up a structure so that the actors behave in a manner beneficial to the economy − or at least, meet the goals for that particular part of the market or system.

The seminal work of Leonid Hurwicz from 1960−1972 marks the birth of the theory, and in his initial formulation, a mechanism is a communication system in which participants exchange messages with each other that may contain private information, such as how much an individual is willing to pay for a public good this may be truthful or false information. The mechanism is like a machine that processes the received messages, aggregating the private information provided and setting up a framework in which the transactions can take place. Each agent strives to maximise his or her expected payoff within this framework.

Mechanism design theory is the science of structuring these frameworks in an optimal manner. It is an application of game theory which uses mathematics to evaluate sets of strategies in game like situations. An interesting illustration of mechanism design is the *stable marriage problem.*

Given n men and n women, where each person has ranked all members of the opposite sex with a unique number between 1 and n in order of preference, marry the men and women off such that there are no two people of opposite sex who would both rather have each other than their current partners. If there are no such people, all the marriages are "stable".

This is a nice example of a situation in which mechanisms need to be created such that an overall desire is satisfied that is, everyone is happy in their marriage. In 1962, David Gale and Lloyd Shapley proved that, for any equal number of men and women, it is always possible to solve the problem and make all marriages stable.

The Gale−Shapley algorithm uses a number of iterations in which each unengaged man "proposes" to the most preferred woman to whom he has not yet proposed, and she accepts or rejects him based on whether she is already engaged to someone she prefers. If she is unengaged, or engaged to a man lower down her preference list than her new suitor, she accepts the proposal (and in the latter case, the other man becomes unengaged again). Only women can switch partners to increase their happiness.

In financial markets, mechanism design is used, for example, to stop a monopoly from overcharging, or in situations where goods are sold whose value is difficult to determine, such as art. An auction house will set up a framework so that the value of the art can be found in a transparent manner. In 2000, the UK government sold 3G mobile phone licenses that raised Â£22 billion in revenue. The structure of the auction was designed so that potential buyers made bids based on what they saw as the true worth of the licences, and prevented them colluding to pay lower prices.

The 2007 prize follows the 2001 prize given to George A. Akerlof, A. Michael Spence and Joseph E. Stiglitz for their work in the related field of understanding markets with asymmetric information.

Physics

The 2007 Nobel Prize for Physics went to Albert Fert and Peter GrÃ¼nberg for their groundbreaking work in technology that is being used to read data on hard disks. This technology has led to the radically reduced size of modern hard disks that allow for portable computing.

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Magnetoresistance, a phenomenon in which magnetic fields cause very small changes in the electrical properties of metals, was first observed 150 years ago by William Thomson and is the principle upon which reading computer memories is based.

Fert and GrÃ¼nberg both independently discovered *Giant Magnetoresistance (GMR)* in 1988. In GMR systems, very weak magnetic changes give rise to major differences in electrical resistance. Working with specially constructed stacks made from alternating layers of very thinly spread iron and chromium, Fert and GrÃ¼nberg discovered that magnetic fields can cause greater increases in electrical resistance than was previously thought possible.

GMR is a quantum mechanical effect depending upon electron spin. Electrons can have upward or downward spin, and as they are spinning, they have magnetic properties. Using a magnetic field to force electrons from alternate metal layers to adopt opposite spins results in a reduction in the passage of electric current. When

magnetic fields are used to align the electron spins in different layers, more current can pass.

This discovery has dramatically improved information storage capacity in many devices, allowing for radically smaller and portable gadgets. A hard disk stores information in the form of microscopically small areas magnetised in different directions. The information is retrieved by a read−out head that scans the disk and registers the magnetic changes. The smaller the hard disk, the weaker the individual magnetic areas. More sensitive read−out heads are therefore required if information is to be packed more densely on a hard disk. A read−out head based on the GMR effect can convert very small magnetic changes into large differences in electrical resistance and therefore into changes in the current emitted by the read−out head.

GMR is also a pioneering field in applications of nanotechnology. The materials used have layers that are only a few atoms thick. The principles GMR are also now being used to tackle problems in wider fields such as in the selective separation of genetic material.

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