**20 October 1982**

THIS YEAR's PRIZE IN ECONOMICS IS AWARDED FOR RESEARCH ON MARKET PROCESSES AND **THE CAUSES AND EFFECTS OF PUBLIC REGULATION**

[**The Royal Swedish Academy of Sciences**](http://www.nobelprize.org/redirect/links_out/prizeawarder.php?from=/nobel_prizes/economics/laureates/1982/press.html&object=kva&to=http://www.kva.se/en/) has decided to award the 1982 Alfred Nobel Memorial Prize in Economic Science to

**Professor George Stigler, University of Chicago, USA,**
**for his seminal studies of industrial structures, functioning of markets and causes and effects of public regulation.**

**George Stigler's Principal Contribution**Through long and extensive research efforts ***with strong empirical orientation***, **George Stigler** has made fundamental contributions to the study of market processes and the analysis of the structure of industries. As part of this research he has investigated how markets are affected by economic legislation. His studies of the forces which give rise to regulatory legislation have opened up a completely new area of economic research.

Stigler's achievements establish him as a leader in applied research on markets and industrial structure - a field often known as industrial organization. Through particular features of his research, Stigler is also recognized as the founder of "economics of information" and ''economics of regulation", and one of the pioneers of research in the intersection of economics and law.

**Market Processes and Industrial Structure**
Despite strong simplifications, basic economic theory has proved effective in explaining and predicting the dominant features of market events. At the same time, the high level of abstraction has left many individual market phenomena unexplained. This is the premise for Stigler's research work. His underlying ambition has been to seek explanations for the distinctive features and peculiarities of markets and structural developments within the framework of basic theoretical assumptions about firms' and households' optimizing behavior and the interplay between supply and demand.

This is exemplified in Stigler's studies of the role of information in market processes. According to traditional theory, the result of optimization and market processes should be that every commodity, except for transport costs, is sold for one and the same price everywhere. But, in practice, price variation is observed on most markets. Stigler has shown that this can be explained if the costs of searching for, and diffusing information about, goods and prices are incorporated in the model along with production and transport costs. The basic properties of traditional theory do not have to be challenged. It has merely been too schematic by assuming "perfect information", in the same way that fundamental theories in physics simplistically assume the existence of a vacuum.

A market participant's lack of knowledge about goods and prices can, of course, be alleviated by collecting and furnishing information. The amount of information a firm or household acquires is guided by the same comparisons between costs and benefits as the production of any commodity. That is, information is gathered until the expected utility of further search no longer outweighs additional search costs. The information a subject acquires is consciously chosen. Conversely - and more provocatively - even a lack of market information is rationally and deliberately chosen

These, and similar achievements prove an indispensable complement to basic theory. Subsequent research has shown how phenomena such as price rigidity, variations in delivery periods, queuing and unutilized resources, which are essential features of market processes, can be afforded a strict explanation within the framework of basic economic assumpions. They are no longer unnecessary market imperfections which can give rise to government intervention. The results have also contributed to explaining inflation and unemployment. An appreciable amount of the research on these phenomena during the last decade has also followed this line of reasoning. Thus, Stigler is not only the foremost originator of economics of information. He is also among those who have provided the basic postulates for today's research on the theoretical foundations of macroeconomics.

In another important study, Stigler examines the traditional theoretical prediction that differences in rates of return are rapidly erased though movements of capital and from low-yield to high-yield firms - one of the cornerstones of the neoclassical concept of market mechanisms. On the basis of extensive compilation of American earnings and capital data - in itself a pioneering effort in economic statistics - Stigler also finds that differences in rates of return are effectively equalized, even if the process might take as long as a decade. The fact that an industrial sector is profitable, or unprofitable, one year indeed indicates that it can be expected to remain so in the coming 2-3 years. But it says hardly anything whatsoever about the condition of the sector after 7-8 years. Sluggishness can postpone equalization, but it will emerge eventually. Differences in rates of return between firms or sectors may appear to last a long time, but this is often because new, highly-productive firms and sectors rise, while firms and sectors which were profitable fall. There are many indications that these tendencies have recently been reinforced by increased internationalization of the economic system. In principle, these processes appear to be equally prevalent in many countries as they are in the USA.

In another study, Stigler shows that, in practice, clear-cut conclusions about economies of scale and similar phenomena cannot be drawn on the basis of traditional cost data in order to determine optimal firm size in every industrial sector. A firm's vitality and development capacity are only weakly related to cost conditions in production itself, but depend instead on various factors which are difficult to observe. This brought Stigler to the so-called survivor principle which states that, first, those categories of firms which actually exhibit an ability to survive should be determined; then, the properties which yield this ability should be sought. Stigler himself has carried out a study along these lines which has had many successors.

Stigler's contributions to the empirical study of markets and sectoral structure based on economic theory also include a number of further investigations. One of them is a survey of pricing behavior in American industry. Others refer to the significance of monopoly and oligopoly.

**Causes and Effects of Public Regulation**
As early as the 1940s, Stigler studied the effects of some features of regulatory legislation in the USA, particularly rent controls and minimum-wage legislation. He indicated that far-reaching, unintended side-effects could arise alongside the primary desired effects. A later study showed that regulation of electricity rates completely lacked observable effects. As a conceivable explanation, Stigler saw that regulation can be based on erroneous perception of real conditions and thus, in practice, be difficult to implement, and on the fact that the intended effects can be neutralized by external pressures. This work on the consequences of regulatory legislation have set a pattern for numerous similar studies, performed by other researchers in many countries.

In later studies of regulatory legislation, Stigler has emphasized its causes rather than its effects. Preliminary observations led him to the hypothesis that, in practice, some regulations protect firms, organizations and professional and occupational groups - *i.e.*, producer interests - instead of the general public that, according to stated motives, they were intended to protect. Stigler himself found firm empirical support for this hypothesis in a number of studies; it is still too early to assess its ultimate scope. But Stigler's results do show that legislation can also be an outflow of market participants' optimizing behaviour. To the extent that this is so, legislation is no longer an "exogenous" force which affects the economy from outside, but an "endogenous'' part of the economic system itself. This approach constitutes a further step towards extending the sphere of application for the basic assumption of economic theory.

Stigler's studies have opened up a new area of research known as economics of regulation. In many quarters, it has resulted in fundamental testing of the forces, purposes and effects of different aspects of legislation. These achievements have also made Stigler one of the pioneers in another new field of research, law and economics.

**15 October 1991**

[**The Royal Swedish Academy of Sciences**](http://www.nobelprize.org/redirect/links_out/prizeawarder.php?from=/nobel_prizes/economics/laureates/1991/press.html&object=kva&to=http://www.kva.se/en/) has decided to award the Sveriges Riksbank (Bank of Sweden) Prize in Economic Sciences in Memory of Alfred Nobel, 1991, to

Professor **Ronald Coase**, University of Chicago, USA,

**for his discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy.**
**Breakthrough in Understanding the Institutional Structure of the Economy**
Until recently, basic economic analysis concentrated on studying the functioning of the economy in the framework of an institutional structure which was taken as given. Efforts to explain the institutional structure were usually considered unnecessary or futile. For instance, the existence of organizations of the type we call firms seemed almost self-evident. Observed variations in contract forms in the economic sphere were also regarded as a given fact, and the laws and rules of the legal system were perceived as an externally imposed setting for economic activity.

By means of a radical extension of economic micro theory, **Ronald Coase** succeeded in specifying principles for explaining the institutional structure of the economy, thereby also making new contributions to our understanding of the way the economy functions. His achievements have provided legal science, economic history and organization theory with powerful impulses and are therefore also highly significant in an interdisciplinary context. Coase's contributions are the result of methodical research work, where each segment was gradually added to the next over a period of many years. It took a long time for his approach to gain a foothold. When the breakthrough finally occurred during the 1970s and 1980s, it was all the more emphatic. Today Coase's theories are among the most dynamic forces behind research in economic science and jurisprudence.

Coase showed that traditional basic microeconomic theory was incomplete because it only included production and transport costs, whereas it neglected the costs of entering into and executing contracts and managing organizations. Such costs are commonly known as transaction costs and they account for a considerable share of the total use of resources in the economy. Thus, traditional theory had not embodied all of the restrictions which bind the allocations of economic agents. When transaction costs are taken into account, it turns out that the existence of firms, different corporate forms, variations in contract arrangements, the structure of the financial system and even fundamental features of the legal system can be given relatively simple explanations. By incorporating different types of transaction costs, Coase paved the way for a systematic analysis of institutions in the economic system and their significance.

Coase also demonstrated that the power and precision of analysis may be enhanced if it is carried out in terms of rights to use goods and factors of production instead of the goods and factors themselves. These rights, which came to be called "property rights" in economic analysis, may be comprised of full ownership, different kinds of usership rights or specific and limited decision and disposal rights, defined by clauses in contracts or by internal rules in organizations. The definition of property rights and their distribution among individuals by law, contract clauses and other rules determine economic decisions and their outcome. Coase showed that every given distribution of property rights among individuals tends to be reallocated through contracts if it is to the mutual advantage of the parties and not prevented by transaction costs, and that institutional arrangements other than contracts emerge if they imply lower transaction costs. Modifications of legal rules by courts and legislators are also encompassed by these arrangements. Property rights thus constitute a basic component in analyses of the institutional structure of the economy. In perhaps somewhat pretentious terminology, Coase may be said to have identified a new set of "elementary particles" in the economic system. Other researchers, to some extent under the influence of Coase, have also made pioneering contributions to the study of property rights.

**Coase's Contributions: First Stage**
In his first major study entitled, *The Nature of the Firm,* Coase posed two questions which had seldom been the objects of strict economic analysis and, prior to Coase, lacked robust and valid solutions, *i.e. ,* why are there organizations of the type represented by firms and why is each firm of a certain size? A key result in traditional theory was to show the ability of the price system (or the market mechanism) to coordinate the use of resources. The applicability of this theory was diminished by the fact that a large proportion of total use of resources was deliberately withheld from the price mechanism in order to be coordinated administratively within firms.

This is the point at which Coase introduced transaction costs and illustrated their crucial importance. Alongside production costs, there are costs for preparing, entering into and monitoring the execution of all kinds of contracts, as well as costs for implementing allocative measures within firms in a corresponding way. If these circumstances are taken into account, it may be concluded that a firm originates when allocative measures are carried out at lower total production, contract and administrative costs within the firm than by means of purchases and sales on the market. Similarly, a firm expands to the point where an additional allocative measure costs more internally than it would through a contract on markets. If transaction costs were zero, no firms would arise. All allocation would take place through simple contracts between individuals.

An important element in the model is that there are two types of contracts: those which stipulate the parties' total obligations (or, the reverse, rights) and those which are deliberately made incomplete by not specifying all obligations, but intentionally allow a free margin for unilateral decisions by one of the parties. Such "open" agreements may be exemplified by employment contracts, which usually leave room for direction and giving orders. According to Coase's theory, the firm is characterized by the latitude for decision created by a particular cluster of such open contracts. The firm in fact consists of this array of contracts and is related to the rest of the world by other fully specified contracts regarding purchases of inputs, sales of products, and loans under prescribed terms.

Coase's formulation has proved to be exceedingly practicable and has given rise to intensive examination of the contract relations which characterize firms. It is now clear that every type of firm is comprised of a distinctive contract structure and thereby a specific distribution of rights and obligations (property rights). Coase's work on the firm has become the basis for rapidly expanding research on principal-agent relations. It has also influenced vital aspects of financial economics, such as the lively research devoted to explaining the pattern of financial intermediaries.

**Coase's Contributions: Second Stage**In retrospect, it is easy to realize that these examinations of firms' basic characteristics would provide a basis for more general conclusions regarding the institutional structure of the economic system. Coase himself laid the groundwork in a subsequent stage.

In another major study entitled, *The Problem of Social Cost* , Coase introduced the set-up in terms of rights or property rights. He postulated that if a property right is well defined, if it can be transferred, and if the transaction costs in an agreement which transfers the right from one holder to another are zero, then the use of resources does not depend on whether the right was initially allotted to one party or the other (except for the difference which can arise if the distribution of wealth between the two parties is affected). If the initial holding entailed an unfavorable total result, the better result would be brought about spontaneously through a voluntary contract, as it can be executed at no cost and both parties gain from it. In other words, all legislation which deals with granting rights to individuals would be meaningless in terms of the use of resources; parties would "agree themselves around" every given distribution of rights if it is to their mutual advantage. Thus, a large amount of legislation would serve no material purpose if transaction costs are zero. This thesis is a direct parallel to the conclusion in The Nature of the Firm that firms under the same conditions are superfluous. All allocations could be effectuated through simple, uncomplicated agreements without administrative features, *i.e. ,* through frictionless markets.

This led Coase to conclude that it is the fact that transaction costs are never zero which indeed explains the institutional structure of the economy, including variations in contract forms and many kinds of legislation. Or, more exactly, the institutional structure of the economy may be explained by the relative costs of different institutional arrangements, combined with parties' efforts to keep total costs at a minimum. Alongside price formation, the formation of the institutional structure is regarded as an integral step in the process of resource distribution. Hence, economic institutions do not require a "separate" theory. It is sufficient to render existing theory complete and formulate it in terms of the primary components, *i.e.,* property rights.

These conclusions concerning the radical effects of ever prevalent transaction costs are thus the main result of Coase's analysis. Somewhat paradoxically, circumstances have ordained that it is the preceding conclusion about the consequences of overlooking transaction costs which has come to be called the "Coase Theorem". Of course, the situation without transaction costs is only a hypothetical norm of comparison. However, it can facilitate the analysis of real-world conditions. It may also inspire studies of contracting which can actually be observed, in areas where earlier theory prematurely took it for granted that transaction costs are so high that contracts are inconceivable. Further examinations by Coase himself or students and others inspired by him have shown that in some such cases, transaction costs are not so high as to preclude a contract. Such contracts are found to have strong peculiarities, created by the parties in order to alleviate the drawbacks of high transaction costs. These observations are wholly in line with Coase's main conclusion. In cases where transaction costs absolutely prevent a contract, there is - as inferred by the theorem - a tendency for other institutional arrangements to arise, for example a firm or amended legislation. The circle is closed; this is exactly the message conveyed by *The Nature of the Firm*.

As regards legislation, in *The Problem of Social Cost* , Coase developed a hypothesis concerning the behavior of courts in rather frequent cases where two (or more) parties dispute rights and where agreements are impossible or extremely difficult because of high transaction costs. Coase found that courts probably try to distribute the rights among the parties so as to realize the solution which would have been the outcome of an agreement, if such an agreement had been possible. The underlying idea is that this is a natural and rational way for a court to reason if it is more intent on setting a precedent to generate expedient incentives for the future than solving a particular dispute. This means that common pleas courts serve as an extension of the market mechanism to areas where it cannot function due to transaction costs. This hypothesis has become immensely important because, along with the general formulation in terms of rights or property rights, it has become the impetus for developing the new discipline of "law and economics" and, in prolongation, for renewal of many aspects of legal science.

**11 October 1994**

[**The Royal Swedish Academy of Sciences**](http://www.nobelprize.org/redirect/links_out/prizeawarder.php?from=/nobel_prizes/economics/laureates/1994/press.html&object=kva&to=http://www.kva.se/en/) has decided to award the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 1994, jointly to

Professor **John C. Harsanyi**, University of California, Berkeley, CA, USA,
Dr. **John F. Nash**, Princeton University, Princeton, NJ, USA,
Professor Dr. **Reinhard Selten**, Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany,

**for their pioneering analysis of equilibria in the theory of non-cooperative games.**
**Games as the Foundation for Understanding Complex Economic Issues**
Game theory emanates from studies of games such as chess or poker. Everyone knows that in these games, players have to think ahead - devise a strategy based on expected countermoves from the other player(s). Such strategic interaction also characterizes many economic situations, and game theory has therefore proved to be very useful in economic analysis.

The foundations for using game theory in economics were introduced in a monumental study by John von Neumann and Oskar Morgenstern entitled *Theory of Games and Economic Behavior* (1944). Today, 50 years later, game theory has become a dominant tool for analyzing economic issues. In particular, non-cooperative game theory, i.e., the branch of game theory which excludes binding agreements, has had great impact on economic research. The principal aspect of this theory is the concept of equilibrium, which is used to make predictions about the outcome of strategic interaction. John F. Nash, Reinhard Selten and John C. Harsanyi are three researchers who have made eminent contributions to this type of equilibrium analysis.

**John F. Nash** introduced the distinction between cooperative games, in which binding agreements can be made, and non-cooperative games, where binding agreements are not feasible. Nash developed an equilibrium concept for non-cooperative games that later came to be called Nash equilibrium.

**Reinhard Selten** was the first to refine the Nash equilibrium concept for analyzing dynamic strategic interaction. He has also applied these refined concepts to analyses of competition with only a few sellers.

**John C. Harsanyi** showed how games of incomplete information can be analyzed, thereby providing a theoretical foundation for a lively field of research - the economics of information - which focuses on strategic situations where different agents do not know each others' objectives.

**Strategic Interaction**
Game theory is a mathematical method for analyzing *strategic interaction*. Many classical analyses in economics presuppose such a large number of agents that each of them can disregard the others' reactions to their own decision. In many cases, this assumption is a good description of reality, but in other cases it is misleading. When a few firms dominate a market, when countries have to make an agreement on trade policy or environmental policy, when parties on the labor market negotiate about wages, and when a government deregulates a market, privatizes companies or pursues economic policy, each agent in question has to consider other agents' reactions and expectations regarding their own decisions, i.e., strategic interaction.

As far back as the early nineteenth century, beginning with Auguste Cournot in 1838, economists have developed methods for studying strategic interaction. But these methods focused on specific situations and, for a long time, no overall method existed. The game-theoretic approach now offers a general toolbox for analyzing strategic interaction.

**Game Theory**
Whereas mathematical probability theory ensued from the study of pure gambling without strategic interaction, games such as chess, cards, etc. became the basis of game theory. The latter are characterized by strategic interaction in the sense that the players are individuals who think rationally. In the early 1900s, mathematicians such as Zermelo, Borel and von Neumann had already begun to study mathematical formulations of games. It was not until the economist Oskar Morgenstern met the mathematician John von Neumann in 1939 that a plan originated to develop game theory so that it could be used in economic analysis.

The most important ideas set forth by von Neumann and Morgenstern in the present context may be found in their analysis of two-person zero-sum games. In a zero-sum game, the gains of one player are equal to the losses of the other player. As early as 1928, von Neumann introduced the minimax solution for a two-person zero-sum game. According to the minimax solution, each player tries to maximize his gain in the outcome which is most disadvantageous to him (where the worst outcome is determined by his opponent's choice of strategy). By means of such a strategy, each player can guarantee himself a minimum gain. Of course, it is not certain that the players' choices of strategy will be consistent with each other. von Neumann was able to show, however, that there is always a minimax solution, i.e., a consistent solution, if so-called mixed strategies are introduced. A mixed strategy is a probability distribution of a player's available strategies, whereby a player is assumed to choose a certain "pure" strategy with some probability.

**John F. Nash**John Nash arrived at Princeton University in 1948 as a young doctoral student in mathematics. The results of his studies are reported in his doctoral dissertation entitled *Non-cooperative Games* (1950). The thesis gave rise to Equilibrium Points in n-person Games (Proceedings of the National Academy of Sciences of the USA 1950), and to an article entitled Non-cooperative Games, (Annals of Mathematics 1951).

In his dissertation, Nash introduced the distinction between cooperative and non-cooperative games. His most important contribution to the theory of non-cooperative games was to formulate a universal solution concept with an arbitrary number of players and arbitrary preferences, i.e., not solely for two-person zero-sum games. This solution concept later came to be called Nash equilibrium. In a Nash equilibrium, all of the players' expectations are fulfilled and their chosen strategies are optimal. Nash proposed two interpretations of the equilibrium concept: one based on rationality and the other on statistical populations. According to the rationalistic interpretation, the players are perceived as rational and they have complete information about the structure of the game, including all of the players' preferences regarding possible outcomes, where this information is common knowledge. Since all players have complete information about each others' strategic alternatives and preferences, they can also compute each others' optimal choice of strategy for each set of expectations. If all of the players expect the same Nash equilibrium, then there are no incentives for anyone to change his strategy. Nash's second interpretation - in terms of statistical populations - is useful in so-called evolutionary games. This type of game has also been developed in biology in order to understand how the principles of natural selection operate in strategic interaction within and among species. Moreover, Nash showed that for every game with a finite number of players, there exists an equilibrium in mixed strategies.

Many interesting economic issues, such as the analysis of oligopoly, originate in non-cooperative games. In general, firms cannot enter into binding contracts regarding restrictive trade practices because such agreements are contrary to trade legislation. Correspondingly, the interaction among a government, special interest groups and the general public concerning, for instance, the design of tax policy is regarded as a non-cooperative game. Nash equilibrium has become a standard tool in almost all areas of economic theory. The most obvious is perhaps the study of competition between firms in the theory of industrial organization. But the concept has also been used in macroeconomic theory for economic policy, environmental and resource economics, foreign trade theory, the economics of information, etc. in order to improve our understanding of complex strategic interactions. Non-cooperative game theory has also generated new research areas. For example, in combination with the theory of repeated games, non-cooperative equilibrium concepts have been used successfully to explain the development of institutions and social norms. Despite its usefulness, there are problems associated with the concept of Nash equilibrium. If a game has several Nash equilibria, the equilibrium criterion cannot be used immediately to predict the outcome of the game. This has brought about the development of so-called refinements of the Nash equilibrium concept. Another problem is that when interpreted in terms of rationality, the equilibrium concept presupposes that each player has complete information about the other players' situation. It was precisely these two problems that Selten and Harsanyi undertook to solve in their contributions.

**Reinhard Selten**The problem of numerous non-cooperative equilibria has generated a research program aimed at eliminating "uninteresting" Nash equilibria. The principal idea has been to use stronger conditions not only to reduce the number of possible equilibria, but also to avoid equilibria which are unreasonable in economic terms. By introducing the concept of subgame perfection, Selten provided the foundation for a systematic endeavor in *Spieltheoretische Behandlung eines Oligopolmodells* *mit Nachfrageträgheit*, (Zeitschrift für die Gesamte Staatswissenschaft 121, 301-24 and 667-89, 1965).

An example might help to explain this concept. Imagine a monopoly market where a potential competitor is deterred by threats of a price war. This may well be a Nash equilibrium - if the competitor takes the threat seriously, then it is optimal to stay out of the market - and the threat is of no cost to the monopolist because it is not carried out. But the threat is not credible if the monopolist faces high costs in a price war. A potential competitor who realizes this will establish himself on the market and the monopolist, confronted with *fait accompli*, will not start a price war. This is also a Nash equilibrium. In addition, however, it fulfills Selten's requirement of subgame perfection, which thus implies systematic formalization of the requirement that only credible threats should be taken into account.

Selten's subgame perfection has direct significance in discussions of credibility in economic policy, the analysis of oligopoly, the economics of information, etc. It is the most fundamental refinement of Nash equilibrium. Nevertheless, there are situations where not even the requirement of subgame perfection is sufficient. This prompted Selten to introduce a further refinement, usually called the "trembling-hand" equilibrium, in *Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games* (International Journal of Game Theory 4, 25-55, 1975). The analysis assumes that each player presupposes a small probability that a mistake will occur, that someone's hand will tremble. A Nash equilibrium in a game is "trembling-hand perfect" if it is robust with respect to small probabilities of such mistakes. This and closely related concepts, such as sequential equilibrium (Kreps and Wilson, 1982), have turned out to be very fruitful in several areas, including the theory of industrial organization and macroeconomic theory for economic policy.

**John C. Harsanyi**In games with complete information, all of the players know the other players' preferences, whereas they wholly or partially lack this knowledge in games with incomplete information. Since the rationalistic interpretation of Nash equilibrium is based on the assumption that the players know each others' preferences, no methods had been available for analyzing games with incomplete information, despite the fact that such games best reflect many strategic interactions in the real world.

This situation changed radically in 1967-68 when John Harsanyi published three articles entitled *Games with Incomplete Information Played by Bayesian Players*, (Management Science 14, 159-82, 320-34 and 486-502). Harsanyi's approach to games with incomplete information may be viewed as the foundation for nearly all economic analysis involving information, regardless of whether it is asymmetric, completely private or public.

Harsanyi postulated that every player is one of several "types", where each type corresponds to a set of possible preferences for the player and a (subjective) probability distribution over the other players' types. Every player in a game with incomplete information chooses a strategy for each of his types. Under a consistency requirement on the players' probability distributions, Harsanyi showed that for every game with incomplete information, there is an equivalent game with complete information. In the jargon of game theory, he thereby transformed games with incomplete information into games with imperfect information. Such games can be handled with standard methods.

An example of a situation with incomplete information is when private firms and financial markets do not exactly know the preferences of the central bank regarding the tradeoff between inflation and unemployment. The central bank's policy for future interest rates is therefore unknown. The interactions between the formation of expectations and the policy of the central bank can be analyzed using the technique introduced by Harsanyi. In the most simple case, the central bank can be of two types, with adherent probabilities: Either it is oriented towards fighting inflation and thus prepared to pursue a restrictive policy with high rates, or it will try to combat unemployment by means of lower rates. Another example where similar methods can be applied is regulation of a monopoly firm. What regulatory or contractual solution will produce a desirable outcome when the regulator does not have perfect knowledge about the firm's costs?

**Other Contributions of the Laureates**
In addition to his contributions to non-cooperative game theory, John Nash has developed a basic solution for cooperative games, usually referred to as Nash's bargaining solution, which has been applied extensively in different branches of economic theory. He also initiated a project that subsequently came to be called the Nash program, a research program designed to base cooperative game theory on results from non-cooperative game theory. In addition to his prizewinning achievements, Reinhard Selten has contributed powerful new insights regarding evolutionary games and experimental game theory. John Harsanyi has also made significant contributions to the foundations of welfare economics and to the area on the boundary between economics and moral philosophy. Harsanyi and Selten have worked closely together for more than 20 years, sometimes in direct collaboration.

Through their contributions to equilibrium analysis in non-cooperative game theory, the three laureates constitute a natural combination: **Nash** provided the foundations for the analysis, while **Selten** developed it with respect to dynamics, and **Harsanyi** with respect to incomplete information.

**8 October 1996**

[The Royal Swedish Academy of Sciences](http://www.nobelprize.org/redirect/links_out/prizeawarder.php?from=/nobel_prizes/economics/laureates/1996/press.html&object=kva&to=http://www.kva.se/) has decided to award the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 1996, to

Professor **James A. Mirrlees**, University of Cambridge, U.K. and

Professor **William Vickrey**, Columbia University, New York, USA,
(deceased October 10, 1996)

*for their fundamental contributions to the economic theory of incentives under asymmetric information.*

**Information and Incentives**One of the most important and liveliest areas of economic research in recent years addresses situations where decision-makers have different information. Such *informational asymmetries* occur in a great many contexts. For example, a bank does not have complete information about borrowers' future income; the owners of a firm may not have the same detailed information about costs and competitive conditions as the managing director; an insurance company cannot fully observe policyholders' responsibility for insured property and external events which affect the risk of damage; an auctioneer does not have complete information about the willingness to pay of potential buyers; the government has to devise an income tax system without much knowledge about the productivity of individual citizens; etc.

Incomplete and asymmetrically distributed information has fundamental consequences, particularly in the sense that an informational advantage can often be exploited strategically. Research on the economics of information has therefore focused on the question of how contracts and institutions can be designed to handle different incentive and control problems. This has generated a better understanding of insurance markets, credit markets, auctions, the internal organization of firms, wage forms, tax systems, social insurance, competitive conditions, political institutions, etc.

This year's laureates have laid the foundation for examining these seemingly quite disparate areas through their analytical work on issues where informational asymmetries are a key component. An essential part of **William Vickrey's** research has concerned the properties of different types of *auctions*, and how they can best be designed so as to generate economic efficiency. His endeavors have provided the basis for a lively field of research which, more recently, has also been extended to practical applications such as auctions of treasury bonds and band spectrum licenses. In the late 1940s, Vickrey also formulated a model indicating how income taxation can be designed to attain a balance between efficiency and equity. A quarter of a century later, interest in this model was renewed when **James Mirrlees** found a more thorough solution to the problems associated with *optimal income taxes*. Mirrlees soon realized that his method could also be applied to many other similar problems. It has become a principal constituent of the modern analysis of complex information and incentive problems. Mirrlees's approach has become particularly valuable in situations where it is impossible to observe another agent's actions, so-called *moral hazard*.

**Income Taxation**
Philosophers, economists and political scientists have studied the principles of income taxation for a long time. Different principles of justice have governed the structure of taxation. In a classical essay published in 1897, Oxford professor Francis Y. Edgeworth adopted a utilitarian welfare perspective; he concluded that all differences in income should be neutralized, which requires strongly progressive tax rates. Vickrey's analysis, in the mid-1940s, emphasized that a progressive tax schedule would affect individuals' incentives to exert themselves. He therefore reformulated the problem with respect to both incentive problems - that each individual takes the tax schedule into account when choosing his work effort - and asymmetric information - that, in practice, the productivity of individuals is not known to the government. He formulated a solution to the problem in principle, but did not succeed in mastering its mathematical complications.

It was not until 25 years later that the problem was reconsidered by James Mirrlees, who solved it in a way which has established a paradigm for analyzing a broad spectrum of economic issues where asymmetric information is a prime component. Mirrlees identified a critical condition (known as *single crossing*) which drastically simplifies the problem and enables a solution. His analysis also proved to contain the germ of a general principle: the *revelation principle*. According to this principle, the solution to incentive problems under incomplete information belongs to the relatively limited class of so-called allocation mechanisms which induce all individuals to reveal their privat information truthfully, in a way which does not conflict with their self-interest. By applying this principle, it becomes much easier to design optimal contracts and other solutions to incentive problems. It has therefore had a large bearing on the treatment of many issues of economic theory.

**Moral Hazard**
For a long time, a well-known problem in connection with insurance is that damage to insured objects depends not only on external factors such as weather and attempted theft, but also on the care taken by the policyholder, which is costly for an insurance company to monitor. Corresponding problems also arise regarding different kinds of social insurance, such as health and disability insurance. Generous insurance coverage can exaggerate risktaking and affect the way individuals care for themselves and their property. Many other two-party relations involve an outcome that is observable to both parties, where the outcome depends on one party's (the agent's) actions, which cannot be observed by the other party (the principal), as well as on a random variable. In the relation between the owner and the management of a firm, for instance, the action would be the executive's work effort, the outcome would be the firm's profit and the random variable could be the firm's market or production conditions. The owners of both the insurance company and the firm want to choose terms of compensation, a "contract", which gives the agent incentives to act in accordance with the principal's interests, for example, by maximizing the owner's expected profits.

The technical difficulties encountered in analyzing these so-called *moral hazard* problems are similar to the income tax problems emphasized by Vickrey and solved by Mirrlees. In the mid-1970s, by means of an apparently simple reformulation of the problem, Mirrlees paved the way for an increasingly powerful analysis. He noted that an agent's actions indirectly imply a choice of the probabilities that different outcomes will occur. The conditions for the optimal terms of compensation thus provide "probability information" about the agent's choice and the extent to which insurance protection has to be restricted in order to provide the agent with suitable incentives. In designing an incentive scheme, the principal has to take into account the costs of giving the agent incentives to act in accordance with the principal's interests. The higher the agent's sensitivity to punishment and the larger the amount of information about the agent's choice contained in the outcome, the lower these costs. This is stipulated in a contract; the agent bears part of the cost of undesirable outcomes or receives part of the profits from favorable outcomes. The policyholder takes care of the insured object almost as if it were uninsured, and the executive manages the firm almost as if it were his own.

**Auctions**
Asymmetric information is also an essential component of auctions, where potential buyers have limited knowledge about the value of the asset or rights up for sale. Vickrey analyzed the properties of different kinds of auctions in two papers in 1961 and 1962. He attached particular importance to the second-price auction or, as it is now often called, the Vickrey auction. In such an auction, an object is auctioned off in sealed bidding, where the highest bidder gets to buy the item, but only pays the next highest price offered. This is an example of a mechanism which elicits an individual's true willingness to pay. By bidding above his own willingness to pay, an individual runs the risk that someone else will bid likewise, and he is forced to buy the object at a loss. And vice versa, if an individual bids below his own willingness to pay, he runs the risk of someone else buying the item at a lower price than the amount he himself is willing to pay. Therefore, in this kind of auction, it is in the individual's best interest to state a truthful bid. The auction is also socially efficient. The object goes to the person with the highest willingness to pay, and the person in question pays the social opportunity cost which is the second highest bid. Other researchers have later developed analogous principles, for example in order to elicit the true willingness to pay for public projects. Thus, Vickrey's analysis has not only been momentous for the theory of auctions; it has also conveyed fundamental insights into the design of resource allocation mechanisms aimed at providing socially desirable incentives.

**Other Contributions**
In addition, both James Mirrlees and William Vickrey have made noteworthy contributions to other areas of economics. In collaboration with the U.S. economist [**Peter Diamond**](http://www.nobelprize.org/nobel_prizes/economics/laureates/2010/), Mirrlees analyzed the structure of consumption taxes in a world where tax wedges give rise to social inefficiency. They arrived at an unambiguous and highly universal result by showing that under relatively general conditions, it is worthwhile to maintain full production efficiency. In concrete terms, this means that small open economies should not impose tariffs on foreign trade and that taxes on factors of production such as labor and capital should not be levied on the production side, but at the consumption stage. The latter result has had important consequences for project appraisal and economic policy in developing countries. In work with the British economist Ian Little and based on his research with Diamond, Mirrlees himself has set up criteria for evaluating development projects.

Efficient pricing of public services permeates Vickrey's scientific production. He has not only made significant theoretical contributions, but - unlike most excellent theorists - he has also followed up on his proposals all the way to their practical application. An example is Vickrey's famous study of the New York subway fare system in the 1950s. His proposal was an early attempt at efficient pricing of public services, under the restriction that the authorities should receive full cost coverage. His study represents more than an improvement on the basic pricing principle (so-called Ramsey pricing); it is also fascinating in its wealth of detail.

**James A. Mirrlees** was born in 1936 in Minnigaff, Scotland. He received his M.S. in Mathematics in Edinburgh in 1957, and his Ph.D. from the University of Cambridge in 1963. He was Edgeworth Professor of Economics at Oxford University between 1969 and 1995, and currently holds a professorship in Economics at the University of Cambridge.

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**William Vickrey** was born in 1914 in Victoria, British Columbia, Canada. He received his B.S. from Yale University in 1935. He then began postgraduate studies at Columbia University, New York, where he received his Master's degree in 1937 and his Ph.D. in 1947. He has been affiliated with the faculty of Columbia University since 1946, and also served as a tax advisor between 1937 and 1947. He was Professor Emeritus at Columbia University.

## Markets with Asymmetric Information - 2001

**George Akerlof**,  **Michael Spence** and  **Joseph Stiglitz**.

For more than two decades, the theory of markets with asymmetric information has been a vital and lively field of economic research. Today, models with imperfect information are indispensable instruments in the researcher's toolbox. Countless applications extend from traditional agricultural markets in developing countries to modern financial markets in developed economies. The foundations for this theory were established in the 1970s by three researchers:  They receive the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 2001, ***"for their analyses of markets with asymmetric information"***.

Why are interest rates often excessively high on local lending markets in Third World countries? Why do people who want to buy a good used car turn to a dealer rather than a private seller? Why does a firm pay dividends even if they are taxed more heavily than capital gains? Why is it advantageous for insurance companies to offer clients a menu of contracts where higher deductibles can be exchanged for lower premiums? Why do rich landowners not bear the entire harvest risk in contracts with poor tenants? These questions exemplify familiar – but seemingly different – phenomena, each of which has posed a challenge to economic theory. This year's Laureates proposed a common explanation and extended the theory when they augmented the theory with the realistic assumption of asymmetric information: agents on one side of the market have much better information than those on the other side. Borrowers know more than the lender about their repayment prospects; the seller knows more than buyers about the quality of his car; the CEO and the board know more than the shareholders about the profitability of the firm; policyholders know more than the insurance company about their accident risk; and tenants know more than the landowner about their work effort and harvesting conditions.

More specifically, Akerlof showed that informational asymmetries can give rise to *adverse selection* on markets. Due to imperfect information on the part of lenders or prospective car buyers, borrowers with weak repayment prospects or sellers of low-quality cars crowd out everyone else from the market. Spence demonstrated that under certain conditions, well-informed agents can improve their market outcome by *signaling* their private information to poorly informed agents. The management of a firm can thus incur the additional tax cost of dividends to signal high profitability. Stiglitz showed that an uninformed agent can sometimes capture the information of a better-informed agent through*screening,* for example by providing choices from a menu of contracts for a particular transaction. Insurance companies are thus able to divide their clients into risk classes by offering different policies, where lower premiums can be exchanged for a higher deductible.

#### George Akerlof

Akerlof's 1970 essay, "The Market for Lemons" is the single most important study in the literature on economics of information. It has the typical features of a truly seminal contribution – it addresses a simple but profound and universal idea, with numerous implications and widespread applications.

Here Akerlof introduces the first formal analysis of markets with the informational problem known as *adverse selection.* He analyses a market for a good where the seller has more information than the buyer regarding the quality of the product. This is exemplified by the market for used cars; "a lemon" – a colloquialism for a defective old car – is now a well-known metaphor in economists' theoretical vocabulary. Akerlof shows that hypothetically, the information problem can either cause an entire market to collapse or contract it into an adverse selection of low-quality products.

Akerlof also pointed to the prevalence and importance of similar information asymmetries, especially in developing economies. One of his illustrative examples of adverse selection is drawn from credit markets in India in the 1960s, where local lenders charged interest rates that were twice as high as the rates in large cities. However, a middleman who borrows money in town and then lends it in the countryside, but does not know the borrowers' creditworthiness, risks attracting borrowers with poor repayment prospects, thereby becoming liable to heavy losses. Other examples in Akerlof's article include difficulties for the elderly to acquire individual health insurance and discrimination of minorities on the labor market.

A key insight in his "lemons paper" is that economic agents may have strong incentives to offset the adverse effects of information problems on market efficiency. Akerlof argues that many market institutions may be regarded as emerging from attempts to resolve problems due to asymmetric information. One such example is guarantees from car dealers; others include brands, chain stores, franchising and different types of contracts.

A timely example might further illustrate the idea that asymmetric information can generate adverse selection. At first, firms in a new sector – such as today's IT sector – might seem identical to an uninformed bystander, while some "insiders" may have better information about the future profitability of such firms. Firms with lower than average profitability will therefore be overvalued and more inclined to finance new projects by issuing their own shares than high-profitability firms which are undervalued by the market. As a result, low-profitability firms tend to grow more rapidly and the stock market will initially be dominated by "lemons". When uninformed investors eventually discover their mistake, share prices fall – the IT bubble bursts.

Apart from his research on asymmetric information, Akerlof has developed economic theory with insights from sociology and social anthropology. His most noteworthy contributions in this genre concern efficiency on labor markets. Akerlof points out that emotions such as reciprocity towards an employer or fairness towards colleagues can prompt wages to be set so high as to induce unemployment. He has also examined how social conventions such as the caste system may have unfavorable effects on economic efficiency. As a result of these studies, Akerlof's research is also well known and influential in other social sciences.

#### Michael Spence

Spence asked how better informed individuals on a market can credibly transmit, "signal", their information to less informed individuals, so as to avoid some of the problems associated with adverse selection. Signaling requires economic agents to take observable and costly measures to convince other agents of their ability or, more generally, of the value or quality of their products. Spence's contribution was to develop and formalize this idea as well as to demonstrate and analyze its implications.

Spence's pioneering essay from 1973 (based on his PhD thesis) deals with education as a signal of productivity on the labor market. A fundamental insight is that signaling cannot succeed unless the signaling cost differs sufficiently among the "senders", i.e., job applicants. An employer cannot distinguish the more productive applicants from those who are less productive unless the former find it sufficiently less costly to acquire an education that the latter choose a lower level of education. Spence also pointed to the possibility of different "expectations-based" equilibria for education and wages, where e. g. men and white receive a higher wage than women and black with the same productivity.

Subsequent research contains numerous applications which extend this theory and confirm the importance of signaling on different markets. This covers phenomena such as costly advertising or far-reaching guarantees as signals of productivity, aggressive price cuts as signals of market strength, delaying tactics in wage offers as a signal of bargaining power, financing by debt rather than by issuing new shares as a signal of profitability, and recession-generating monetary policy as a signal of uncompromising commitment to reduce stubbornly high inflation.

An early example in the literature concerns dividends. Why do firms pay dividends to their shareholders, knowing full well that they are subject to higher taxes (through double taxation) than capital gains? Retaining the profits within the firm would appear as a cheaper way to favor the shareholders through the capital gains of a higher share price. One possible answer is that dividends can act as a signal for favorable prospects. Firms with "insider information" about high profitability pay dividends because the market interprets this as good news and therefore pays a higher price for the share. The higher share price compensates shareholders for the extra tax they pay on the dividends.

In addition to his research on signaling, Spence was a forerunner in applying the results and insights of the 1996 economics laureates, Vickrey and Mirrlees, to the analysis of insurance markets. During the period 1975-1985, he was one of the pioneers in the wave of game-theory inspired work that clarified many aspects of strategic market behavior within the so-called new theory of industrial organization.

#### Joseph Stiglitz

One of Stiglitz's classical papers, coauthored with Michael Rothschild, formally demonstrated how information problems can be dealt with on insurance markets where the companies do not have information on the risk situation of individual clients. This work is an obvious complement to Akerlof's and Spence's analyses by examining what actions uninformed agents can take on a market with asymmetric information. Rothschild and Stiglitz show that the insurance company (the uninformed party) can give its clients (the informed party) effective incentives to "reveal" information on their risk situation through so-called *screening.* In an equilibrium with screening, insurance companies distinguish between different risk classes among their policyholders by offering them to choose from a menu of alternative contracts where lower premiums can be exchanged for higher deductibles.

Stiglitz and his numerous coauthors have time and again substantiated that economic models may be quite misleading if they disregard informational asymmetries. Their common message has been that in the perspective of asymmetric information, many markets take on a completely different guise, as do the conclusions regarding appropriate forms of public-sector regulation. Stiglitz has analyzed the implications of asymmetric information in many different contexts, varying from unemployment to the design of an optimal tax system. Several of his essays have become important stepping stones for further research.

One example is Stiglitz's work with Andrew Weiss on credit markets with asymmetric information. Stiglitz and Weiss show that in order to reduce losses from bad loans, it may be optimal for bankers to ration the volume of loans instead of raising the lending rate. Since credit rationing is so common, these insights were important steps towards a more realistic theory of credit markets. They have also had a substantial impact in the domains of corporate finance, monetary theory and macroeconomics.

In collaboration with Sanford Grossman, Stiglitz analyzed efficiency on financial markets. Their key result is known as the Grossman-Stiglitz paradox: if a market were informationally efficient, i.e., all relevant information is reflected in market prices, then no single agent would have sufficient incentive to acquire the information on which prices are based.

Stiglitz is also one of the founders of modern development economics. He has shown that asymmetric information and economic incentives are not merely academic abstractions, but highly concrete phenomena with far-reaching explanatory value in the analysis of institutions and market conditions in developing economies. One of his first studies of information problems dealt with sharecropping, an ancient, though still common, form of contracting.

A sharecropping contract stipulates that the harvest should be divided between a landowner and his tenant in fixed shares (usually half each). Since the landowner is usually richer than the tenant, it would seem advantageous to both parties to let the landowner bear the entire risk. But such a contract would not give the tenant strong enough incentives to cultivate the land efficiently. Considering the landowner's inferior information about harvest conditions and the tenant's work effort, sharecropping is in fact the optimal solution for both parties.

Joseph Stiglitz's many contributions have transformed the way economists think about the working of markets. Together with the fundamental contributions by George Akerlof and Michael Spence, they make up the core of the modern economics of information.

## The Prize in Economic Sciences 2005

1 0 o c t 2 0 0 5

 **Robert Aumann** and **Thomas Schelling** have contributed to enhancing our understanding of conflict and cooperation. They have achieved this by extending and applying game theory – a method used to analyze strategic interaction among different agents. Their work has transformed the social sciences far beyond the boundaries of economics. Aumann’s and Schelling’s research continues to shape the debate on the formation of social institutions.

***Conflict and cooperation through the lens of game theory***

In human interaction, a single individual can seldom determine what will happen; everyone can to some extent affect the outcome. For example, if someone in a two-party relation can choose between two alternative courses of action and the other party has three options, there are a total of 2 x 3 = 6 possible outcomes. The two parties usually have different evaluations of these outcomes and act on the basis of which alternative they think the other party will choose. Many interactions involve several steps over time and it is not unusual for them to be associated with asymmetric information, i.e., some parties know something which others do not. The analysis of strategic interaction – of all kinds – is the essence of game theory. The term itself brings to mind games in everyday life. But, as this year’s Laureates have shown, the most important applications of game theory are to be found in such vital issues as security and disarmament policies, price formation on markets, as well as economic and political negotiations.

**Negotiations in the Shadow of the Cold War**

 In the mid-1950s, Thomas Schelling began to apply game-theory methods to one of the era’s most vital issues – global security and the arms race. As Schelling himself noted, considerable progress can be achieved simply by drawing a diagram which describes the alternatives available to the opponent and to one’s own country, followed by systematic consideration of the outcome in the different cases. Such a process also serves as a reminder that the other party in a conflict faces a similar decision-making problem. Schelling was particularly intrigued by the ways in which the parties’ negotiating strength could be affected by different factors, such as the initial alternatives at their disposal and their potential to influence their own and each others’ alternatives during the process. He clarified why it could be advantageous to limit one’s own alternatives or worsen one’s own options – literally to burn one’s bridges. He was also interested in the process of establishing a climate of confidence, whereby long-term cooperation could be built up over a period of time, and in the long-run gains a party could achieve by making short-run concessions. The results of Schelling’s work were published in his book, The Strategy of Conflict (1960), which became a classic and has influenced generations of strategic thinkers. Other researchers have extended several of the concepts in Schelling’s book. His ideas regarding credible threats and limitations on one’s own alternatives were later formalized by Reinhard Selten, an Economics Laureate in 1994. Schelling’s formulation of the prerequisites for cooperation has elicited extensive research on the origins and development of cooperation over time between parties who initially lacked confidence in one another. Schelling was also concerned with the ability of individuals to coordinate their behavior in situations without any strong conflict of interest, but where unsuccessful coordination would give rise to high costs for all parties. In his research, including classroom experiments with his students, Schelling found that coordinative solutions – which he called focal points – could be arrived at more often than predicted by theory. The ability to coordinate appears to be related to the parties’ common frames of reference. Social conventions and norms are integral parts of this common ground. Schelling’s work in this area inspired the philosopher David Lewis to specify the idea that language originated as a means of coordination. Why Does Segregation Arise? A recurring theme in Thomas Schelling’s research is: what happens when individual plans and patterns of behavior are confronted in the social arena? The title of one of his most widely read books, **Micromotives and Macrobehavior** (1978), reveals the overall theme. The book addresses different everyday phenomena such as professional ice-hockey players’ use of helmets, audiences’ choice of seats in an auditorium, and racial and sexual discrimination. Segregation is usually associated with oppression. Historically, this has been an important part of the explanation, but segregation is also a stable phenomenon in developed societies, where considerable effort is devoted to counteracting it. Schelling formulated a simple model where he assumed that all individuals are tolerant in the sense that they willingly live in the proximity of people with a different culture, religion or skin color, but that they want to have at least a few neighbors that share their own characteristics. If not, then they move to a neighborhood where they can find more people like themselves. Schelling showed that even rather weak preferences regarding the share of like persons in a neighborhood can result in strongly segregated living patterns. In other words, no extreme preferences on the part of individuals are required in order for a social problem to arise. Long-run Cooperation While Tomas Schelling’s strength lies largely in his ability to introduce original ideas and concepts with a minimum of mathematical technique, Robert Aumann’s primary contributions consist of using the tools of mathematical analysis to develop concepts and hypotheses, provide them with concise formulations and draw precise conclusions. He once likened his research to artistic creativity – as “expressing through a difficult or resistive medium” Aumann shared Schelling’s early interest in interaction where the parties interact many times over a long period, so-called repeated games. He showed that peaceful cooperation is often an equilibrium solution in a repeated game, even between parties with strong short run conflicts of interest. Aumann and other researchers have extended and generalized his results in different directions, for example regarding credibility in “threats of punishment” for deviating from cooperation. Aumann, in joint work with Michael Maschler, also established the theory of repeated games with asymmetric (or, more generally, incomplete) information, i.e., situations where one party knows more than another about certain aspects of the repeated game, for example concerning the real costs of a competitor or the military strength of another country. The theory of repeated games is now the common framework for analysis of long-run cooperation in the social sciences. Applications extend from competing firms which collude to maintain a high price level, and farmers who share pastures or irrigation systems, to countries which enter into environmental agreements or are involved in territorial disputes.

**Common Knowledge and Correlated Equilibria**

 Another of Aumann’s fundamental contributions concerns the cognitive foundations of game theory, i.e., the implications of the parties’ knowledge about the various aspects of the game, including “knowledge about each others’ knowledge”. In the early days of game theory, analysis was often simplified by assuming that the parties know everything about all aspects of the game, in analogy, e.g., to physics, where friction or air resistance are sometimes disregarded. Knowledge that another party is rational can affect one’s own behavior, as will knowledge about someone else’s knowledge about one’s own rationality, and so on. Aumann’s formalization of the concept of common knowledge allowed for systematic analysis of the relation between the knowledge of the parties and the outcome of the game. Aumann also introduced a new equilibrium concept, correlated equilibrium, which is weaker than Nash equilibrium, the solution concept developed by John Nash, an economics laureate in 1994. Correlated equilibrium can explain why it may be advantageous for negotiating parties to allow an impartial mediator to speak to the parties either jointly or separately, and in some instances give them different information.

**The Limits of Rationality**

As scholars, Robert Aumann and Thomas Schelling have distinctive profiles, but throughout their research they have shared a common trait: an interest in considering aspects neglected by established theory and in developing new concepts and analytical tools, thereby extending the scope of analysis. A consequence of these endeavors is that the concept of rationality now has a wider interpretation; behavior which used to be classified as irrational has become understandable and rational. Their work has contributed significantly to bridging the gap between economics and other behavioral and social sciences.

## The Prize in Economic Sciences 2007  was awarded jointly to Leonid Hurwicz, Eric S. Maskin and Roger B. Myerson *"for having laid the foundations of mechanism design theory"*.

**12 October 2007**

## The design of economic institutions

Adam Smith's classical metaphor of the invisible hand refers to how the market, under ideal conditions, ensures an efficient allocation of scarce resources. But in practice conditions are usually not ideal; for example, competition is not completely free, consumers are not perfectly informed and privately desirable production and consumption may generate social costs and benefits. Furthermore, many transactions do not take place in open markets but within firms, in bargaining between individuals or interest groups and under a host of other institutional arrangements. How well do different such institutions, or allocation mechanisms, perform? What is the optimal mechanism to reach a certain goal, such as social welfare or private profit? Is government regulation called for, and if so, how is it best designed?

These questions are difficult, particularly since information about individual preferences and available production technologies is usually dispersed among many actors who may use their private information to further their own interests. Mechanism design theory, initiated by Leonid Hurwicz and further developed by Eric Maskin and Roger Myerson, has greatly enhanced our understanding of the properties of optimal allocation mechanisms in such situations, accounting for individuals' incentives and private information. The theory allows us to distinguish situations in which markets work well from those in which they do not. It has helped economists identify efficient trading mechanisms, regulation schemes and voting procedures. Today, mechanism design theory plays a central role in many areas of economics and parts of political science.

Buyers and sellers sometimes haggle too hard and therefore fail to trade. Desirable joint projects are sometimes not undertaken because the projects’ beneficiaries fail to agree how the costs should be shared. Sickness insurance, for example, is typically criticized either for offering too little coverage or for inviting misuse. In either case, the basic problem is that people have an incentive to economize with their private information: some insurancy-policy sellers claim that their costs are high in order to increase the price; some beneficiaries of joint projects such as insurance-policy holders claim that their benefits are low in order to reduce their own contributions to the project; some well-insured workers claim that they are sick, in order to reduce their workload. Asymmetric information and economic institutions An important goal of economic theory is to understand what institutions, or allocation mechanisms, are best suited to minimize the economic losses generated by private information. What trading mechanisms will realize the largest gains from trade, and what mechanisms will maximize the seller’s expected revenue? What collective decision-making procedures will succeed in implementing desirable joint projects while denying funds for undesirable projects? What insurance schemes will provide the best coverage without inviting misuse? Mechanism design theory, initiated by Leonid Hurwicz and refined and applied by Eric Maskin and Roger Myerson, provides tools for analyzing and answering and these questions and many others like them. For example, mechanism design theory shows why an auction is typically the most efficient institution for the allocation of private goods1 among a given set of potential buyers, and it frequently also specifies what auction format will give the largest expected revenue for the seller. Likewise, mechanism design theory explains why there is often no good market solution to the problem of providing public goods.2 Indeed, the theory demonstrates why the efficient provision of public goods may require substantial departures from the principles of unanimous decision-making. Before the advent of mechanism design, microeconomic analysis of resource allocation mechanisms was very largely a theory of markets. A central question was: When will a market mechanism suffice to allocate resources efficiently? It could be shown that the market implements fully efficient outcomes under very stringent (unrealistic) conditions such as perfect competition, freely available information, private goods, and the absence of any environmental effects of production and consumption. Mechanism design theory asks a much more general question: What resource allocation mechanism produces the best attainable outcome under more general conditions? One part of the answer is that markets, even if they do not attain full efficiency, perform at least as well as any other mechanism under conditions that are considerably less stringent than the conditions for full efficiency. For example, so-called double auctions – where buyers as well as sellers submit bids – are frequently unbeaten mechanisms for trading private goods. Another part of the answer is that markets can be ill suited for providing public goods. The funding of such joint projects may require another institutional framework, admitting for example, taxation of potential users.

While it has long been understood that markets could still be desirable even when they are not perfect, and that public goods may sometimes justify funding through taxation, mechanism design theory made these intuitions much more precise. It provides a tool for characterizing the optimal institution for any given set of conditions, thereby enabling a much deeper scientific analysis of the merits of alternative institutions. Applications of mechanism design theory have thus led to major breakthroughs in many areas of economics, including regulation theory, corporate finance, the theory of taxation, and voting procedures. Key concepts and results The development of mechanism design theory originated with the work of Leonid Hurwicz (1960). He defined a mechanism as a game in which the participants send messages to each other and/or to a “message center”, and where a pre-specified rule assigns an outcome (such as an allocation of goods and services) to every collection of received messages. For given assumptions about participants’ preferences and beliefs, each rule induces one or more predicted outcomes – or equilibria. Within this framework, the predicted outcomes associated with markets and market-like institutions can be compared with the predicted outcomes of a vast array of alternative trading institutions. Hurwicz (1972) also introduced the key notion of incentive compatibility, which proved central to later developments. In the 1970s, the formulation of the so-called revelation principle and the development of implementation theory led to great advances in the theory of mechanism design. The revelation principle is an insight that greatly simplifies the analysis of mechanism design problems. It states that the researcher, when searching for the best possible mechanism to solve a given problem, can restrict attention to a small subclass of mechanisms, namely those so-called direct mechanisms that satisfy Hurwicz’s condition of incentive compatibility. While direct mechanisms are not intended as descriptions of real-world institutions, their mathematical structure makes them amenable to analysis. Finding the best of all direct mechanisms for a given problem is often straightforward, and once the best direct mechanism has been found, the researcher can “translate back” that mechanism into a more realistic mechanism. By this seemingly roundabout method, researchers have been able to solve problems of institutional design that would otherwise have been effectively intractable. The first version of the revelation principle was formulated by Gibbard (1973). Several researchers – including Dasgupta, Hammond and Maskin (1979) and Myerson (1979) – independently extended it to the standard notion of Bayesian Nash equilibrium, which has proved particularly fruitful for subsequent research. Myerson (1979, 1982, 1986) developed the principle in its greatest generality and pioneered its application to specific economic problems such as auctions and regulation. The revelation principle has transformed the analysis of economic mechanisms. One problem remains, however. In many cases, one mechanism admits several different equilibria.3 Even if the best outcome is achieved in one equilibrium, other, inferior equilibria may also exist. For example, conventional double auctions tend to have many equilibria, some of which are associated with very low volumes of trade. Can a mechanism be designed such that all its equilibria are optimal? The first general solution to this problem was given by Eric Maskin (1977). The resulting theory, known as implementation theory, is a key part of modern mechanism design.

A detailed example: bilateral trade Mechanism design theory offers many powerful results that may seem quite abstract. In order to illustrate the underlying principles in an accessible way, we present a detailed (albeit still incomplete) analysis of a simple example. Suppose that Erika owns an indivisible object, for instance a piano. She is considering selling the piano to a prospective buyer, we can call him Peter. Erika and Peter each value the piano. Suppose that the piano is worth x to Erika and y to Peter. (That is, Erika would be happy to sell it at any price above x but would prefer to keep it if the price is below x, and conversely for Peter.) They may be able to agree on a price so that both of them gain from the transaction, but only if the piano is of more value to Peter than to Erika (that is, only if y>x). For each of them, the utility gain from a transaction equals the difference between the agreed price and the value each of them ascribes to the piano. If the agreed price is p, then Erika’s utility gain is p-x and Peter’s gain is y-p. The total gain from trade is thus p-x+y-p=y-x. If no trade occurs, then no party obtains any utility gain, so we are looking for a mechanism in which trade will always occur if and only if Peter’s evaluation of the piano is higher than Erika’s. Now suppose that neither Peter nor Erika knows how the other values the piano, so they each have private information about their own valuation. What kind of mechanism could they use to trade with each other? One possibility is that Erika makes a take-it-or-leave-it offer to Peter. Another possibility is that Peter makes such an offer to Erika. A third possibility would be a so-called double auction, a mechanism in which both parties simultaneously announce a price at which they are willing to trade, and, if Peter’s offer exceeds Erika’s, they trade at the price half way between the two proposed prices (or according to some other pre-specified splitting rule). However, none of these three mechanisms has the property that trade always occurs if the buyer’s evaluation is higher than that of the seller. For example, if Erika makes a take-it-orleave-it offer, then it is in her interest to set the price above the actual value she ascribes to the piano. If she sets a price exactly equal to her own valuation, she does not care whether Peter buys or not. If she sets a slightly higher price, she does better – gaining something if Peter buys, and losing nothing if he does not. Peter will of course accept her offer only if the proposed price is equal to or less than the value he ascribes to the piano. So, even if Erika values the piano less than Peter, she may end up proposing a price that is higher than Peter is prepared to pay. The argument is of course analogous if it is instead Peter who makes an offer. The double auction would realize all gains of trade if traders were to bid according to their private valuation, that is, if Erika announced the bid p=x and Peter the bid p´=y, since then trade would occur if and only if y exceeds x. However, Erika and Peter will not bid according to their valuations, because Erica benefits from bidding above her valuation (in order to obtain a higher price) and Peter benefits from bidding below his valuation (in order to obtain the object at a lower price). To see why, consider Erika’s problem. By bidding slightly above her valuation, Erika knows that she forgoes the opportunity to trade in case her valuation is just about the same as Peter’s bid. But Erika loses virtually nothing from the forgone trade, because (i) the loss in trading probability is small, and (ii) the price is almost the same as Erika’s valuation. On the other hand, whenever Peter’s bid substantially exceeds Erika’s, Erika’s higher bid remains below Peter’s. In these cases, there is still trade, and Erika receives a higher price than if she were to bid truthfully. This (first-order) gain outweighs the (second-order) loss from forgone trade. The outcome is illustrated in the diagram, where Erika’s valuation, x, is plotted on the horizontal axis and Peter’s valuation, y, on the vertical axis. Ideally, trade should occur whenever y>x, that is, for all valuation pairs in the large triangle above the diagonal. In equilibrium, however, trade will occur only in a subset of this triangle. For instance, if we think of Erika and Peter as randomly drawn from a population in which the valuations of pianos are uniformly distributed between zero and one, and if Erika and Peter use linear bidding strategies (that is, their bidding prices are linear functions of their valuations), then the best possible equilibrium outcome is that trade occurs in the shaded area – the smaller, upper triangle.4 In other words, there is trade if and only if Peter’s valuation y exceeds Erika’s valuation x by a certain positive amount. (In the example, there is trade if and only if Peter’s valuation exceeds Erika’s valuation by 1/4.) The double auction described above is formally identical with a direct mechanism; namely the mechanism whereby each agent is asked to report his or her valuation of the object at hand to a “center,” and where the object changes hands if and only if the seller’s valuation exceeds that of the buyer, at a price that lies half way (or at any other pre-specified point) between the announced valuations. This direct mechanism would realize all gains of trade, and hence be Pareto efficient 5 , if the agents announced their valuations truthfully. However, for the reasons given above for the double auction, this particular outcome is not incentive compatible: the seller will have an incentive to inflate her valuation and the buyer will have an incentive to deflate his. Truthful reporting of private information is incompatible with equilibrium. This situation is quite general. Impossibility results established by Laffont and Maskin (1979) and Myerson and Satterthwaite (1983) show that no incentive compatible direct mechanism which satisfies voluntary participation has the property that trade occurs if and only if there are gains from trade, that is, if and only if x<y in our example. By the revelation principle, we can then infer that no mechanism whatsoever can realize all gains from trade. In other words, classical Pareto efficiency is incompatible with voluntary participation and free trade in this example. The remarkable power of mechanism design theory is that it does not stop here. It allows a characterization of the best mechanism of all conceivable mechanisms. Specifically, Myerson and Satterthwaite (1983) established a precise upper limit for the expected gains from trade that are realizable in any trading mechanism in bilateral situations like this. Moreover, they showed that this upper limit can be realized by way of a double auction. That is, no mechanism can ensure a better outcome than the double auction equilibrium outcome described above.6

Concluding remarks

 The example shows why markets in general, and auctions in particular, can be efficient institutions for the allocation of private goods. However, efficiency does not imply that an institution will be chosen by those who have the power to select it. Instead, we may expect the choice of institution to reflect the interests of the designer. Fortunately, mechanism design theory can equally well be used to analyze such situations and explain what mechanisms (menus of price offers, bundling of products, auctions etc.) that sellers and buyers prefer, thus providing a theory of which market institutions will emerge. Myerson (1981) and Maskin and Riley (1984) are two leading examples of work in this direction. Whereas the study of optimal trading institutions is one important application, mechanism design theory has a much broader scope, and it has been used to sharpen the analysis of many other issues in economics and political science. For example, the theory admits a sophisticated analysis of institutions for the provision of public goods, of optimal forms of regulation, and of voting schemes. For a discussion of these and other applications, we refer to our scientific background article.

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The Prize in Economic Sciences 2009

**12 October 2009**

## Economic governance: the organization of cooperation

**The Royal Swedish Academy of Sciences has decided to award The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel for 2009**

#### Elinor Ostrom

**Indiana University, Bloomington, IN, USA,**

**"for her analysis of economic governance, especially the commons"**

**Elinor Ostrom has demonstrated how common property can be successfully managed by user associations.**

**and**

#### Oliver E. Williamson

**University of California, Berkeley, CA, USA,**

**"for his analysis of economic governance, especially the boundaries of the firm"**

**Oliver Williamson** has developed a theory where business firms serve as structures for conflict resolution. Over the last three decades these seminal contributions have advanced economic governance research from the fringe to the forefront of scientific attention.

Traditionally, economic theory has by and large been a theory of markets or, more precisely, about market prices. However, there are at least two reasons why economic science should extend beyond price theory. First, markets do not function properly unless suitable contracts can be formulated and enforced. Hence, we need to understand the institutions that support markets. Second, considerable economic activity takes place outside of markets – within households, firms, associations, agencies, and other organizations. Hence, we need theories to explain why these entities exist and how they work. This year’s Laureates have been instrumental in establishing economic governance as a field of research. Elinor Ostrom has provided evidence on the rules and enforcement mechanisms that govern the exploitation of common pools by associations of users. Oliver Williamson has proposed a theory to clarify why some transactions take place inside firms and not in markets. Both scholars have greatly enhanced our understanding of non-market institutions. Governing the commons Many natural resources, such as fish stocks, pastures, woods, lakes, and groundwater basins are managed as common property. That is, many users have access to the resource in question. If we want to halt the degradation of our natural environment and prevent a repetition of the many collapses of natural-resource stocks experienced in the past, we should learn from the successes and failures of common-property regimes. Ostrom’s work teaches us novel lessons about the deep mechanisms that sustain cooperation in human societies. It has frequently been suggested that common ownership entails excessive resource utilization, and that it is advisable to reduce utilization either by imposing government regulations, such as taxes or quotas, or by privatizing the resource. The theoretical argument is simple: each user weighs private benefits against private costs, thereby neglecting the negative impact on others. However, based on numerous empirical studies of natural-resource management, Elinor Ostrom has concluded that common property is often surprisingly well managed. Thus, the standard theoretical argument against common property is overly simplistic. It neglects the fact that users themselves can both create and enforce rules that mitigate overexploitation. The standard argument also neglects the practical difficulties associated with privatization and government regulation. Failed collectivization and privatization As an example of Ostrom’s concerns, consider the management of grasslands in the interior of Asia. Scientists have studied satellite images of Mongolia and neighboring areas in China and Russia, where livestock has been feeding on large grassland areas for centuries. Histori- 2(5) THE PRIZE IN ECONOMIC SCIENCES 2009 ↔ THE ROYAL SWEDISH ACADEMY OF SCIENCES ↔ HTTP://KVA.SE cally, the region was dominated by nomads, who moved their herds on a seasonal basis. In Mongolia, these traditions were largely intact in the mid-1990s, while neighboring areas in China and Russia – with closely similar initial conditions – had been exposed to radically different governance regimes. There, central government imposed state-owned agricultural collectives, where most users settled permanently. As a result, the land was heavily degraded in both China and Russia. In the early 1980s, in an attempt to reverse the degradation, China dissolved the People’s Communes and privatized much of the grassland of Inner Mongolia. Individual households gained ownership of specific plots of land. Again, as in the case of the collectives, this policy encouraged permanent settlement rather than pastoral wandering, with further land degradation as a result. As satellite images clearly reveal, both socialism and privatization are associated with worse long-term outcomes than those observed in traditional group-based governance. Failed modernization There are many other examples which indicate that user-management of local resources has been more successful than management by outsiders. A striking case is that of irrigation systems in Nepal, where locally managed irrigation systems have successfully allocated water between users for a long time. However, the dams – built from stone, mud and trees – have often been primitive and small. In several places, the Nepalese government, with assistance from foreign donors, has therefore built modern dams of concrete and steel. Despite flawless engineering, many of these projects have ended in failure. The reason is that the presence of durable dams has severed the ties between head-end and tail-end users. Since the dams are durable, there is little need for cooperation among users in maintaining the dams. Therefore, head-end users can extract a disproportionate share of the water without fearing the loss of tail-end maintenance labor. Ultimately, the total crop yield is frequently higher around the primitive dams than around the modern dams. Both of the above-mentioned failures refer to economically poor regions of the world. However, the lessons are much more far-reaching. Ostrom’s first study concerned the management of groundwater in parts of California and also highlighted the role of users in creating workable institutions. Active participation is the key While Ostrom has carried out some field work herself, her main accomplishment has been to collect relevant information from a diverse set of sources about the governance – successful and failed – of a large number of resource pools throughout the world and to draw insightful conclusions based on systematic comparisons. The lesson is not that user-management is always preferable to all other solutions. There are many cases in which privatization or public regulation yield better outcomes than user management. For example, in the 1930s, failure to privatize oil pools in Texas and Oklahoma caused massive waste. Rather, the main lesson is that common property is often managed on the basis of rules and procedures that have evolved over long periods of time. As a result they are more adequate and subtle than outsiders – both politicians and social scientists – have tended to realize. Beyond showing that self-governance can be feasible and successful, Ostrom also elucidates the key features of successful governance. One instance is that active participation of users in creating and enforcing rules appears to be essential. Rules that are imposed from the outside or unilaterally dictated by powerful insiders have less legitimacy and are more likely to be violated. Likewise, monitoring and enforcement work better when conducted by insiders than by outsiders. These principles are in stark contrast to the common view that monitoring and sanctioning are the responsibility of the state and should be conducted by public employees. An intriguing outcome of these field studies concerns the willingness of individual users to engage in monitoring and sanctioning, despite only modest rewards for doing so. In order to ascertain more about individuals’ motivations for taking part in the enforcement of rules, Ostrom has conducted innovative laboratory experiments on cooperation in groups. A major finding is that many people are willing to incur private costs in order to sanction free-riders. Markets versus hierarchies Nowadays, a large fraction of economic activity takes place within firms. Oliver Williamson has facilitated our understanding of why this is so. More broadly, he has taught us to regard markets, firms, associations, agencies, and even households from the perspective of their contribution to the resolution of conflict. Why are there large firms? Couldn’t we all be self-employed, trading our goods and services in the market? A general answer to this question was proposed more than seventy years ago by Ronald Coase, who received the 1991 Prize in Economic Sciences. According to Coase, firms tend to emerge whenever transaction costs, i.e., the costs of exchanging goods, services, and money, are lower inside a firm than in the corresponding market. But what exactly are those transaction costs that may tip the balance between markets and hierarchies? While Coase offered tentative suggestions, the question remained elusive. An appropriate answer should explain why some firms grow by integrating many stages of production, whereas other firms in the same industry focus on only one or a few production stages, thereby leaving other stages to suppliers or customers. As an example, take the energy sector, where some companies operate both coal mines and coal-burning power plants, whereas other similar mines and plants are operated as separate firms. Efficient conflict resolution In the early 1970s, Oliver Williamson argued that hierarchical organizations sometimes dominate markets because they provide a cheaper way to resolve conflicts. If two employees quarrel about the allocation of tasks or the distribution of revenues, a chief executive is entitled to decide. In a market, on the other hand, negotiations have to continue until both parties agree. Haggling costs can be substantial, and there is no guarantee that the final agreement will be either immediate or efficient. This argument may seem to suggest that all transactions should take place in a single giant firm. But this is clearly not an accurate description of the world as we know it. The last decade has witnessed just the opposite. Considerable outsourcing has taken place, sometimes by merely selling part of a company, while activities continue in all units much as before. That is, outsourcing creates a market transaction replacing an internal transaction. In order for 4(5) THE PRIZE IN ECONOMIC SCIENCES 2009 ↔ THE ROYAL SWEDISH ACADEMY OF SCIENCES ↔ HTTP://KVA.SE this kind of outsourcing to make any sense, there must be drawbacks associated with hierarchical organization too. A common view had been that hierarchical organization is costly because it entails administrative costs. Williamson realized that this view was unsatisfactory, because it is eminently possible to move the boundaries of firms without changing administrative routines. Instead, Williamson argued that the primary reason why hierarchies are problematic is that executive authority can be abused – for example by extracting surplus from subordinates in unproductive ways. Mutual dependence behind hierarchical organizations How can these rather broad assertions be transformed into a theory of governance that yields nontrivial and falsifiable implications? Williamson’s key insight is that the value of conflict resolution depends on two main factors. First, there is no point in being able to resolve conflicts that never arise. If it is easy and cheap to regulate future transactions through a contract, there is little need for a firm. Thus, there will not arise firms unless there are limitations to contracting. Second, there is no reason to be able to resolve conflicts if disagreement is costless. If both the seller and the buyer can easily find other suitable trading partners, the firm is again superfluous. In other words, Williamson expects hierarchical organizations to emerge when transactions are complex or non-standard, and when parties are mutually dependent. Perhaps the most typical case of mutual dependence is that parties have assets, either physical assets or knowledge, which are only valuable inside a relationship. Let us see whether this theory can explain the boundaries of firms in the energy market described above. The value of a coal mine in case the owner cannot agree on the terms of trade with a nearby power plant depends on the distance to the second-nearest buyer of coal, which is usually another power plant. Likewise, the value of a coal-burning power plant in case it cannot trade with the nearby coal mine depends on the distance to the second nearest mine. The larger the distances, the greater is the mutual dependence, and – according to the theory – the more likely the mine and the plant are vertically integrated. This is precisely what is observed. When there are other nearby mines and power plants, firms are typically incorporated separately and trade under relatively short and simple contracts. As the distance to alternative trading partners increases, contract duration and complexity also increase. According to one of the studies, a coal-burning power plant that is located next to a coal mine is about six times more likely to be fully integrated than is any other coal-burning power plant. Policy implications Williamson’s theory of the firm has been tested extensively in many other industries too, and the empirical support is strong. Activities are more likely to be organized inside firms when transactions are complex and assets are relationship-specific. Moreover, Williamson’s general framework has proven productive in analyzing all sorts of incomplete contracts, ranging from implicit contracts between household members to financial contracts between entrepreneurs and investors. According to Williamson’s theory, large private corporations exist primarily because they are efficient. They are established because they make owners, workers, suppliers, and customers better off than they would be under alternative institutional arrangements. When corporations fail to deliver efficiency gains, their existence will be called in question. Large corporations may of course abuse their power. They may for instance participate in undesirable political lobbying and exhibit anticompetitive behavior. However, according to Williamson’s analysis, it is advisable to regulate such behavior directly rather than through policies that limit the size of corporations.

## The Prize in Economic Sciences 2014

**13 October 20 14**

The Royal Swedish Academy of Sciences has decided to award The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel for 2014 to

**Jean Tirole**

***Toulouse 1 Capitole University, France***

**“for his analysis of market power and regulation".**

 **The science of taming powerful firms**

Jean Tirole is one of the most influential economists of our time. He has made important theoretical research contributions in a number of areas, but most of all he has clarified how to understand and regulate industries with a few powerful firms.

Many industries are dominated by a small number of large firms or a single monopoly. Left unregulated, such markets often produce socially undesirable results – prices higher than those motivated by costs, or unproductive firms that survive by blocking the entry of new and more productive ones.

From the mid-1980s and onwards, Jean Tirole has breathed new life into research on such market failures. His analysis of firms with market power provides a unified theory with a strong bearing on central policy questions: how should the government deal with mergers or cartels, and how should it regulate monopolies?

Before Tirole, researchers and policymakers sought general principles for all industries. They advocated simple policy rules, such as capping prices for monopolists and prohibiting cooperation between competitors, while permitting cooperation between firms with different positions in the value chain. Tirole showed theoretically that such rules may work well in certain conditions, but do more harm than good in others. Price caps can provide dominant firms with strong motives to reduce costs – a good thing for society – but may also permit excessive profits – a bad thing for society. Cooperation on price setting within a market is usually harmful, but cooperation regarding patent pools can benefit everyone. The merger of a firm and its supplier may encourage innovation, but may also distort competition.

The best regulation or competition policy should therefore be carefully adapted to every industry's specific conditions. In a series of articles and books, Jean Tirole has presented a general framework for designing such policies and applied it to a number of industries, ranging from telecommunications to banking. Drawing on these new insights, governments can better encourage powerful firms to become more productive and, at the same time, prevent them from harming competitors and customers.

## The Prize in Economic Sciences 2016

**10 October 2016**

**The Royal Swedish Academy of Sciences** has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2016 to

**Oliver Hart**
Harvard University, Cambridge, MA, USA

and

**Bengt Holmström**
Massachusetts Institute of Technology, Cambridge, MA, USA

“for their contributions to contract theory”

## The long and the short of contracts

Modern economies are held together by innumerable contracts. The new theoretical tools created by **Hart** and **Holmström** are valuable to the understanding of real-life contracts and institutions, as well as potential pitfalls in contract design.

Society’s many contractual relationships include those between shareholders and top executive management, an insurance company and car owners, or a public authority and its suppliers. As such relationships typically entail conflicts of interest, contracts must be properly designed to ensure that the parties take mutually beneficial decisions. This year’s laureates have developed contract theory, a comprehensive framework for analysing many diverse issues in contractual design, like performance-based pay for top executives, deductibles and co-pays in insurance, and the privatisation of public-sector activities.

In the late 1970s, Bengt Holmström demonstrated how a principal (e.g., a company’s shareholders) should design an optimal contract for an agent (the company’s CEO), whose action is partly unobserved by the principal. Holmström’s informativeness principle stated precisely how this contract should link the agent’s pay to performance-relevant information. Using the basic principal-agent model, he showed how the optimal contract carefully weighs risks against incentives. In later work, Holmström generalised these results to more realistic settings, namely: when employees are not only rewarded with pay, but also with potential promotion; when agents expend effort on many tasks, while principals observe only some dimensions of performance; and when individual members of a team can free-ride on the efforts of others.

In the mid-1980s, Oliver Hart made fundamental contributions to a new branch of contract theory that deals with the important case of incomplete contracts. Because it is impossible for a contract to specify every eventuality, this branch of the theory spells out optimal allocations of control rights: which party to the contract should be entitled to make decisions in which circumstances? Hart’s findings on incomplete contracts have shed new light on the ownership and control of businesses and have had a vast impact on several fields of economics, as well as political science and law. His research provides us with new theoretical tools for studying questions such as which kinds of companies should merge, the proper mix of debt and equity financing, and when institutions such as schools or prisons ought to be privately or publicly owned.

Through their initial contributions, Hart and Holmström launched contract theory as a fertile field of basic research. Over the last few decades, they have also explored many of its applications. Their analysis of optimal contractual arrangements lays an intellectual foundation for designing policies and institutions in many areas, from bankruptcy legislation to political constitutions.

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