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The 2007 Nobel Prize in Economics: Mechanism Design Theory*

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Abstract
The 2007 Nobel Prize in Economics has been awarded to Leonid Hurwicz, Eric Maskin, and Roger Myerson, for their contributions to mechanism design theory. The article discusses the importance of mechanism design theory for modern economics, focusing on some of its implications for economic policy making.

1. Introduction[1]

An important feature of settings in which collective decisions are made is that individuals' preferences are not publicly observable. As a result, individuals must be relied upon to reveal this information. How the information can be elicited, and the extent to which the information revelation problem constrains the ways in which collective decisions can respond to individual preferences, is known as the mechanism design problem. The part of economic theory that studies the mechanism design problem is called, unsurprisingly, mechanism design theory.

The Royal Swedish Academy of Sciences has recognized the importance of mechanism design theory by awarding the 2007 Nobel Prize in economic sciences to three economists who provided major contributions to the development of this theory: Leonid Hurwicz, Eric Maskin, and Roger Myerson.

Mechanism design theory may seem to be a very arcane area of economics. Indeed, most basic economics textbooks include little if any reference to this part of economic theory.[2] Newspaper articles trying to explain this theory after the Nobel Prize announcement struggled to come up with easy-to-understand illustrations, noting in one case, for example, that 'Maskin monotonicity' might not be "the sort of thing to mention at parties" (Economist, 2007). Nonetheless, the theory has important contributions both for modern economics and for real life.

Mechanism design theory goes to the heart of one of the biggest challenges in economics: how to arrange economic interactions so that, when everybody behaves in a self-interested manner, the result is something acceptable to all. The word "mechanism" refers to the institutions and the rules of the game that govern economic activities, which can range from a planning commission in a command economy to trading in a market.

The remainder of this text provides an overview of the major developments in mechanism design theory, including its key concepts and results. It also provides

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[1] More information about the 2007 Nobel prizes, including a scientific background article, is to be found at the Royal Swedish Academy of Sciences website: www.kva.se, and at: http://nobelprize.org.

[2] Advanced textbooks do have sections or chapters on the subject. For a graduate textbook-style introduction to mechanism design theory, see (Mas-Collel, Whinston, Green, 1995).

a discussion of the theory's various applications, focusing on those relating to economic policy.

2. Key Concepts and Results

The development of mechanism design theory originated with the work of Leonid Hurwicz (1960). At the time, there was still a very active debate about the pros and cons of central planning and the market mechanism. Hurwicz agreed with Friedrich von Hayek (1945) and others who argued that the dispersion of information among numerous economic agents was at the heart of the failure of central planning. However, he pointed out that the problem went even deeper than information dispersion. He observed that there was a lack of incentives for economic agents to share their information truthfully with others (and in particular with the government). Moreover, Hurwitz showed that although the market mechanism was far less afflicted than central planning by such incentive problems, it was by no means immune from them.

Hurwitz (1972) introduced this idea to economics by coining the term of "incentive compatibility". The intuition behind incentive compatibility is that to get as close as possible to the most efficient economic outcome, there needs to be a mechanism in which everybody does best for themselves by sharing truthfully whatever private information they have. Hurwicz showed that even such a mechanism cannot guarantee an optimal outcome, because even if everyone's incentives are compatible, the mere existence of private (asymmetric) information precludes Pareto efficiency (i.e., a situation where no one can be made better off without someone becoming worse off). But such a mechanism will get closer to Pareto efficiency than if incentives are incompatible (i.e., if some people can do better by not sharing information or by lying). Mechanism design strives to achieve "incentive efficiency": given compatible incentives, no one can do better without someone doing worse.

Roger Myerson's main contribution to mechanism design theory is his work on the "revelation principle", a mathematical method that simplifies the calculation of the most efficient rules of the game for getting people to reveal their private information truthfully. The revelation principle is an insight that greatly simplifies the analysis of mechanism design problems. It states that when searching for the best possible mechanism to solve a given problem, it is possible to look only at a small subclass of mechanisms, namely, so-called direct mechanisms, which 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.

Gibbard (1973) formulated the first version of the revelation principle. Several researchers, including Dasgupta, Hammond, and Maskin (1979) and Myerson (1979), independently extended it to the standard notion of Bayesian Nash equilibrium, which proved an important stepping stone for subsequent research. Myerson (1979, 1982, 1986) developed the revelation principle in its greatest generality.

Eric Maskin's key contribution was implementation theory, which clarified when mechanisms can be designed that only produce incentive-efficient equilibria. The work on the revelation principle by Myerson and others transformed the analysis of economic mechanisms, but an important problem remained. In many cases, a mechanism admits several different equilibria. Even if the best outcome is achieved in one equilibrium, inferior equilibria may also exist. For instance, standard double auctions usually have multiple equilibria, some of them associated with very low trade volumes. It would therefore be very useful if a mechanism could be designed such that all its equilibria are optimal. Maskin (1977) provided the first general solution to this problem. The resulting theory, known as implementation theory, has become a key part of modern mechanism design.

The work of the 2007 Nobel Prize winners is closely related to that of several earlier laureates. These include, in particular, John Harsanyi, John Nash, and Reinhard Selten (the 1994 winners, for non-cooperative game theory), and James Mirrlees and William Vickrey (the 1996 winners, for the theory of incentives under asymmetric information).

3. Range of Applications

Mechanism design theory has a wide and growing range of applications throughout modern economics and in real life. In awarding the prize, the Royal Swedish Academy of Sciences specifically noted the theory's applications to trading mechanisms, regulation schemes, and voting procedures. Real-world applications include topics ranging from utility regulation and auctions to structuring the pay of company executives and the design of elections. The theoretical work has led to more effective regulatory concepts, such as the design of optimal auctions (Myerson, 1981) that give the participants an incentive to reveal their private information, enabling everyone to benefit.

The following example is an illustration of how trade can break down if information held by buyers or sellers is private. For instance, a company might say it is only willing to sell a product for EUR 30 when in fact it would make a profit even if the product was sold it for EUR 20. Another company might say it is only willing to buy the product at EUR 15 when it would really pay up to EUR 25. In this case, trade is possible in the range from EUR 20 to EUR 25, but the transaction might not occur because both the buyer and the seller have an incentive to misrepresent their true positions. The incentives to hide private costs are high in regulated industries.

Since the 1980s, rapid growth in mechanism design theory's applications has been enabled by the boom in computing power, which has allowed mechanism design to be taken to a new level of sophistication and complexity. The theory has increasingly been put to work on tasks ranging from how to auction a radio spectrum to devising a better way of paying contractors than cost-plus contracts (which give contractors incentives to be inefficient) or fixed-price contracts (which often lead to overpaying). Myerson (1979, 1982, 1986) was the first to apply mechanism design theory (and in particular the revelation principle) to economic problems such as auctions and regulation.

Another application of the theory that has attracted a substantial amount of interest recently is the design of environmental policies. It is an area in which Eric Maskin has been active in recent years. For example, Baliga and Maskin (2003) argue that when externalities such as pollution are nonexcludable, agents must be compelled to participate in a "mechanism" to ensure a Pareto-efficient outcome.

4. International Economic Policy Coordination

An important group of applications of mechanism design theory that has been somewhat overlooked relates to international economic policy making. These applications are particularly important in the current increasingly globalized world, in which national economic policies (e.g., monetary, fiscal, and exchange rate policy, as well as financial crisis management policies) can have substantial repercussions for other countries through real and financial channels. A better understanding of these linkages and repercussions for policy making can thus have very practical, real-life implications.

International economic policy coordination has been studied extensively (see, e.g., (Buiter, Marston, 1985)), usually with the help of game theory. The analysis of the strategic interactions among national economic policies using game theory highlights the "prisoner's dilemma" features of the strategic interaction: a coordinated policy response is preferable if all country authorities follow the coordinated strategy, but such a strategy is difficult to enforce as there are incentives for individual country authorities to deviate. To satisfy their own electorates, national policymakers may pursue policies that harm other economies, leading to suboptimal outcomes for all.

The contribution of mechanism design theory is that it asks an important follow-up question: is it possible to design the "rules of engagement" in a way that delivers a desirable (coordinated) strategy in the face of self-interested behavior, private information (i.e., information known to some policymakers but not others), and policy spillovers? In particular, a desirable feature of collective choice is (Pareto) efficiency, meaning that there is no solution that would make someone better off without making someone else worse off. Is there a mechanism that implements such an efficient collective choice in dominant strategies, i.e., strategies that nationally-minded policymakers will naturally pursue? If that were the case, one could be fairly confident that rational policymakers will indeed arrive at this collective choice.

A good real world example is the globalization of financial institutions, and its implications for international financial crisis prevention, management, and resolution. The globalization of financial institutions has appreciable benefits for the efficiency of the international financial system. However, it also comes with new risks. Specifically, financial systems are more prone to transmit shocks across markets and activities, such as those that came from the U.S. subprime mortgage market in 2007–08. The issue is particularly pertinent for EU countries because of their commitment to financial market integration, their specific cross-border regulatory set-up, and the emergence of pan-European financial institutions. The scope of these institutions' activities is often EU wide, but legal, regulatory, and supervisory jurisdictions are national, and so is accountability to the public. National confidentiality rules, for example, mean that national prudential authorities have access to different information, and no authority has a complete overview of prudential developments in all of Europe's major financial institutions. That is why when a crisis hits, "it could be a case of 'grab what you can get'" and "in a worst case scenario supervisors will ring fence assets in entities they supervise – preventing them from being used in other parts of the group where they may be needed, for example for collateral provision" (McCreevy, 2007). In short, in the hope of limiting the damage to their country's public purse, nationally-minded supervisors and policymakers may well do severe and unnecessary damage to EU taxpayers as a whole.

An intriguing question is whether a mechanism can be designed that ensures that by working in a self-interested way all authorities reach the equivalent of a co-operative, least-cost solution. Mechanism design theory highlights the difficulties in designing mechanisms leading to efficient strategies, especially in complex situations with numerous agents with different preferences and different informational advantages over one another. One of the findings of the theory is that with "self-interested" behavior (i.e., behavior reflecting national preferences), private information (information that is available only to the authority in one country) and policy spillovers across borders there is very likely no mechanism that makes each country policy-maker confident that he can act in the common good without risks or costs to his national economy.

The following is a somewhat more formal illustration of the same point, for the case of the financial supervision framework. The mechanism design problem is a fitting description of the cross-border financial supervision framework: a number of diverse agents (the national supervisory agencies, supervised entities, and their counterparts) are involved, all with private information and preferences that are generally not known to the other agents. To illustrate the resulting problems, let us limit the setting to *I national supervisory agencies*, indexed by $i = 1, ..., I$. These supervisory agencies must address a cross-border financial crisis by collectively choosing from a set X of possible resolutions a specific resolution x. Prior to the choice, each supervisor i privately gathers an information signal, θ_i (drawn from a prior distribution), which determines his ranking of the possible resolutions. The set of possible rankings of resolutions for supervisor i is denoted Θ_i. Each supervisor i is assumed to maximize expected utility, with a Bernoulli utility function $u_i(x, \theta_i)$. The ordinal preference relation over the various resolutions x in X associated with utility function $u_i(x, \theta_i)$ is denoted $\succ_i(\theta_i)$. Supervisor i's set of possible preference relations over X is therefore given by

$$\Re_i = \{\succ_i : \succ_i = \succ_i(\theta_i) \quad \text{for some } \theta_i \in \Theta_i\}$$

i.e., his preference ordering over alternative resolutions x is a function of the information signal θ_i. Furthermore, assume that the optimal collective decision depends on the full information set $\theta = (\theta_1, ..., \theta_I)$ because of the likely cross-border spillovers of domestic actions in a financial crisis. To capture this dependence, the literature introduces the notion of a collective choice function, defined as a function f: $\Theta_1 \times ... \times \Theta_I \rightarrow X$ that, for each possible profile of the supervisors' information signals $(\theta_1, ..., \theta_I)$, assigns a collective choice $f(\theta_1,...,\theta_I) \in X$, henceforth f(.). A desirable feature of the collective choice function is ex-post efficiency, defined as a situation where for no set of information signals $\theta = (\theta_1, ..., \theta_I)$ is there an $x \in X$ such that $u_i(x, \theta_i) \geq u_i(f(\theta), \theta_i)$ for every i, and $u_i(x, \theta_i) > u_i(f(\theta), \theta_i)$ for some i: in other words, no x exists that makes one supervisor better off without making someone else worse off. Another desirable feature is dominant strategy implementation: if a mechanism implements f(.) in dominant strategies, one can be fairly confident that a rational supervisor who has a (weakly) dominant strategy will indeed play it. This implementation will be robust even if supervisors have incorrect, and even contradictory, beliefs about the distribution of information signal realizations.

Unfortunately, in many cases, including a cross-border financial crisis, it is impossible to implement ex post efficient collective choice functions in dominant strategies. If the set of possible information signals is sufficiently rich (which is the case in major cross-border bank failures), then no collective choice function that is implementable in dominant strategies is also ex post efficient (Green and Laffont, (1979), provide a proof)). Specifically, a resolution alternative is now a vector $x = (k, t_1,.., t_1)$, where k denotes the resolution choice out of the set K and t_i monetary transfers between national economies. Suppose that for each supervisor

$$i = 1, ..., \mathrm{I}, \ \{v_i(\cdot,\theta_i) : \theta_i \in \Theta_i\} = \upsilon$$

that is, every possible valuation function from K to $\Re$ arises for some $\theta_i \in \Theta_i$. In other words, each supervisor is likely to see many possible resolutions to a crisis and, depending on his private information signal θ_i, orders and values these resolutions differently based on their expected costs to the national economy. Even allowing for monetary transfers among the supervisors' national economies, there is no collective choice function $f(\cdot) = \left(k^*(\cdot), t_1(\cdot),...,t_I(\cdot)\right)$, where k^* denotes a function that for all

$\theta_i \in \Theta_i$ satisfies $\sum_{i=1}^{I} v_i\left(k(\theta),\theta_i\right) \geq \sum_{i=1}^{I} v_i(k,\theta_i) \ \textit{for all } k \in K$ and where $\sum_{i=1}^{I} t_i(\theta) = 0$

Thus, ***with "self-interested" behavior*** (i.e., behavior reflecting the nationally-based accountability of supervisors) ***and private information***, there is no mechanism (including burden sharing) that makes each supervisor confident that he can reveal his private information without costs to his national economy. What is needed for efficiency is collective (joint) responsibility and accountability of national supervisors, including collective crisis cost minimization.[3]

This result of mechanism design theory implies that, to maximize their well-being, interconnected countries need to devise policy frameworks that internalize the spillovers their policies have on each other, thereby limiting "self-interested" behavior that is costly to others. This entails accepting more joint responsibility and accountability. Returning to the above example of EU financial stability, this seems to be the direction in which European policymakers intend to move, as illustrated by the October 9, 2007, ECOFIN agreement, which adopted a set of common principles for cross-border financial crisis management in cases with a potential systemic dimension.[4] The principles underscore the need for much closer cooperation between national authorities, in the interest of the common good. Specifically, they impose joint responsibility by prescribing that cross-border crisis management should aim to protect the stability of the financial system in all countries involved and in the EU as a whole, at the lowest overall collective cost. They internalize spillovers by arguing that the direct budgetary net costs resulting from managing a crisis should be shared between the affected countries, on the basis of equitable and balanced criteria. The les-

[3] This discussion is adapted from Čihák and Decressin (2007).

[4] See ECOFIN materials at:
www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ecofin/96351.pdf.

son of mechanism design theory is that these laudable intentions need to be operationalized with “rules of engagement” that will ensure cooperative behavior – rules that will necessarily entail sacrificing some national authority. The question now is how far policymakers are prepared to go.

5. Conclusion

Mechanism design theory addresses one of the biggest challenges in economics: how to arrange economic interactions so that, when everybody behaves in a self-interested manner, the result is something acceptable to all. Perhaps the key concept of the theory is incentive compatibility, which characterizes mechanisms in which everybody does best for themselves by sharing truthfully whatever private information they have.

The theory has numerous important applications. This article has focused on those for international policy making. The results of mechanism design theory in this area imply that countries need to devise policy frameworks that internalize the policy spillovers. This entails accepting more joint responsibility and accountability. It is perhaps in this spirit that one should view the IMF’s Multilateral Consultations (IMF, 2007), under which authorities from some of the world’s major economies agreed to publish jointly national policy actions that should in time generate a significant reduction in global current account imbalances. Similarly, should a major cross-border financial crisis strike in Europe, EU policymakers will have to act with a view to minimizing the EU-wide costs. In short, yesterday’s Nobel prize-winning theories are deservedly finding their applications today, including in the realm of international economic policy making.

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