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Mechanism design: Theory and application to welfare-to-work programs

In October 2007, Leonid Hurwicz, Eric Maskin, and Roger Myerson won the Nobel Prize in Economic Sciences “for having laid the foundations of mechanism design theory”. My aim is to give you a flavor of what mechanism design theory is and how we can apply it in practice. More in particular, I will apply insights from the theory to the design of welfare-to-work markets, i.e., markets in which governments contract firms in order to help unemployed people finding a job.

The set-up of this article is as follows. I will begin by discussing mechanism design theory in general. Next, I will analyze a simple game theoretical model of the welfare-to-work market. In this model, I will derive the theoretical properties of a simple mechanism that could be easily implemented in practice, and compare it to the theoretically optimal mechanism. Finally, I will conclude.

Mechanism design theory

What is mechanism design theory? The answer is actually quite simple, despite the fact that the theory itself is far from easy and despite the fact that the popular press came up with the wildest definitions. Mechanism design is about finding optimal rules under which people, firms, institutions or other agents interact.

Before mechanism theory existed, game theorists were concerned with the question: what do players do *given the rules of the game*? In contrast, mechanism design theorists assume that there is a principal who can choose the rules of the game in such a way that the players will act as he desires. Of course, the incentives of the players may conflict with the principal's interests, so the principal has to take these incentives into account. Well, I admit that this explanation still sounds pretty abstract, so that it is perhaps not very surprising that journalists were a bit confused about what mechanism design theory tries to achieve.

An example might help to create a clearer picture. Suppose that a government wants to maximize national income under the condition that it raises enough taxes to provide some minimum level of public goods. In this situation,

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the government is the principal and the citizens the players. The citizens have an incentive to work less hard the more taxes they have to pay, which has a negative effect on both national income and taxes. So, in finding the optimal taxation scheme, the government has to take this into account.

Welfare-to-work programs

Let us consider another practical application of mechanism design in more detail: the optimal design of welfare-to-work programs. In the Netherlands, unemployed people have the right to obtain welfare-to-work services so as to find a job more quickly than they otherwise would. The Work and Income Act (SUWI) of 2002 obliges the responsible public bodies to contract out welfare-to-work services to private providers. Currently, these providers account for a substantial fraction of the more than €5 billion euro of public resources spent on active labor market policies. However, in an overview on the effectiveness of active labor market policies in Europe, Kluve et al. (2007) argue that most money is not spent effectively.

So, the following question begs for an answer:

what is the most effective way to contract out welfare-to-work services to private providers? In a simple model, we will show how mechanism design theory can help in finding an answer. Particularly, we will model welfare-to-work markets as a situation in which the government has to select a private welfare-to-work service provider, and give it incentives to help people finding a job.

The model

Suppose, for simplicity, that there are two private providers willing to offer welfare-to-work services. Moreover, 25 unemployed people would like to obtain these services. The government contracts one of the providers. This provider will exert effort e in finding jobs for these people. We make the assumption that one unit of effort results in one person finding a job. The costs of a provider's effort are given by

$$C(e,t) = 25 e^2 / t, \quad (1)$$

where t is the provider's type. In other words, a provider is more efficient if it has a higher type t . Types are drawn independently from a uniform distribution on the interval $(0,100]$.

We assume that the project generates social welfare according to the following expression:

$$S(e,t) = 10e - T, \quad (2)$$

where T is the (net) transfer from the government to the provider that wins the project. The social benefits ($10e$) include all effects on the economy associated with people finding a job, and may be positively related to increased production, a decrease in social benefits (so that the government has to levy less distortionary taxes), and diminishing intergenerational welfare dependency. The social costs (T) refer to the monetary compensation the government has to pay to the provider in order to at least cover its costs.

The optimal mechanism under complete information

A socially optimal mechanism maximizes expected social welfare under the restriction that the providers play equilibrium strategies, and under a participation constraint (both providers should at least receive zero expected utility). If the government knows the providers' types, the optimal mechanism can be readily constructed. First, the government selects the most efficient provider, i.e., the provider with the highest type t . Second, the government induces this provider to choose effort

$$e^* = t / 5 \quad (3)$$

Finally, the government pays a transfer to the provider such that the provider's costs are exactly covered.

Notice that we made the strong assumption that the government knows the types of the providers. If types are unknown, the government could still ask the providers to reveal their type, and implement the optimal mechanism. However, the providers have a reason to lie: if they report a lower type, they can make more profit than if they are honest. In other words, this mechanism is not "incentive compatible".

An incentive compatible mechanism

What is a good alternative? Suppose that the providers play the following two-stage game. In the first stage, the government sells the project in a second-price auction. In this auction, the highest bidder wins the project and pays the bid of the other provider to the government. In the second stage, the government pays the winner 10 for every unemployed person that finds a job.

Let us find an equilibrium of this game using backward induction. In the second stage of the game, if a provider wins the project, it will choose effort e in order to maximize its profits

$$\Pi(e) = 10e - C(e,t) = 10e - 25 e^2 / t. \quad (4)$$

It is easy to show that the optimal effort level is given by

$$e^{**}(t) = t / 5, \quad (5)$$

which coincides with the optimal effort under complete information in (3). Note that the provider's profits are:

$$\Pi(e^{**}(t)) = t. \quad (6)$$

Now I turn to the first stage of the game. How much will a provider bid in the second-price auction? If it wins the auction, it will make profits t in the second stage of the game. So, a firm is willing to pay at most t . The second-price auction has an equilibrium in weakly dominant strategies in which both providers bid their type t . To see this, imagine that a provider with type t submits a bid $b < t$. Let B be the highest bid of the other bidder. Bidding b instead of t only results in a different outcome if $b < B < t$. If $B > t$, the provider does not win in either case, while if $B < b$, the provider wins and pays B in both cases. However, in the case that $b < B < t$, the provider receives zero utility by bidding b , while she obtains $t - B > 0$ when bidding t . Similarly, bidding $b < t$ only results in a different outcome if $t < B < b$. A bid of t results in zero utility, whereas bidding b yields the provi-

der a utility of $t - B < 0$. Therefore, a provider is always (weakly) better off by submitting a bid equal to her type.

The optimal mechanism

Observe that this two-stage game is not only incentive compatible, but it also implements the effort level that is optimal under complete information. Moreover, the rules of the game are quite simple, and can be easily explained to welfare-to-work service providers in practice. However, the two-stage game does not implement the optimal mechanism. Observe, for instance, that the winning provider can make quite some profit. Suppose that it has the highest possible type, i.e., $t = 100$. Then the firm always wins the auction, because it submits the highest bid. The other bidder submits a bid between 0 and 100 according to a uniform distribution. So, the provider's expected payment to the government equals 50. Note that the provider will find a job for 20 of the 25 unemployed people, so that the government has to pay 200 in return. Because the firm's costs of providing this effort are equal to 100, its profits are 50, which is equal to the social welfare. In other words, the government loses 50% of social welfare to make the mechanism incentive compatible.

It turns out that the government can do better than that. The government can increase social welfare in two ways. First of all, it can give less than full incentives to the firms, i.e., pay less than 10 per unemployed who finds a job. This is especially effective if applied to inefficient firms. Inefficient firms themselves will not contribute much to welfare in any case, so if the government pays then less than the full amount, efficient firms have less reason to pretend to be inefficient, so that the government will have to pay less informational rents. Secondly, and relatedly, the government screens out the lowest types, i.e., makes sure that they will not participate.¹

Unfortunately, the optimal mechanism has several practical difficulties. First, the government needs detailed information about the bidders. In particular, it needs to know their cost functions and the distribution of their types. It requires costly market research to obtain this information. Second, the optimal mechanism is demanding with regards to the government's commitment: it (1) requires a suboptimal level of effort from the winning agent, and (2) the government to withhold a welfare enhancing project when the efficiency parameter of the two providers turns out to be below a certain threshold value.

The good news is that the simple two-stage game that I discussed above performs almost as good as the optimal mechanism, provided that there are sufficiently many bidders. Note that the two-stage mechanism does not suffer from the informational problem: the rules of the game do not depend on the costs functions and the type distribution. Also the commitment problem is absent: the provider's effort in the two-stage mechanism coincides with the optimal effort under complete information. So, the government cannot "abuse" information revealed in the auction. In a recent study, I compared the two mechanisms in a simulation, and found that only five bidders are sufficient for the difference between the social welfare of the two mechanisms to be less than 1%.²

Conclusion

In this article, I've discussed mechanism design theory and applied it to welfare-to-work programs. The main lesson is that for these programs, fairly simple mechanisms may perform rather well relative to the theoretically optimal mechanism, especially in the case of sufficient competition. Still, the two-stage game that I propose has never been used in practice. Perhaps Kluge et al.'s (2007) conclusions about active labor market policies would have been more positive if governments had implemented this mechanism.

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¹ For details, see McAfee and McMillan (1986, 1987) and Laffont and Tirole (1987).

² See Onderstal (2006).