chapter sixteen

Moral hazard and incentives

Prologue to part IV

We turn now to the subject of *information economics*. Information economics is a broad subject with many variations and subtopics, and we will not do anything close to full justice to it here. In this chapter, we consider the problem of *moral hazard*, where one party to a transaction may undertake certain actions that (a) affect the other party's valuation of the transaction but that (b) the second party cannot monitor/enforce perfectly. A classic example here is fire insurance, where the insuree may or may not exhibit sufficient care while storing flammable materials. The "solution" to a problem of moral hazard is the use of *incentives* — structuring the transaction so that the party who undertakes the actions will, in his own best interests, take actions that the second party would (relatively) prefer. For example, fire insurance is often only partial insurance so that the insuree has a financial interest in preventing a fire.

In chapter 17 we look at problems of *adverse selection* where one party to a transaction knows things pertaining to the transaction that are relevant to but unknown by the second party. Here a classic example is life insurance, where the insuree may know things about the state of her health that are unknown by the insurer. The "solution" to problems of adverse selection is *market signaling*, where the party in possession of superior information signals what she knows through her actions. For example, an insurance company may offer life insurance on better terms if the insuree is willing to accept very limited benefits for the first two or three years the policy is in effect, on the presumption that someone who suffers from ill health and is about to die (or has substantial probability of dying) is unwilling to accept those limited benefits.

Whenever there are informational problems of these or other sorts it is natural to ask, What is the best contract that can be devised? We will investigate optimal incentives design in a simple setting in this chapter, but a more general attack on *optimal contract and mechanism design* stressing cases of adverse selection, which makes use of the *revelation principle*, will be given in chapter 18.

These three topics are all important, but they do not even begin to exhaust the important category of models and concepts from information economics. Particularly noticeable by their absence are models of *optimal search* and *coordination failures*, where parties desirous of making a particular exchange must search for potential trading partners and where the need for search discourages certain otherwise beneficial trading activity, and models of *rational expectations*, where some parties have information that would be useful to others, information that is conveyed at least in part by equilibrium prices themselves.

All these situations and others as well fall under the broad rubric of *information economics* because in each case the driving factor is the lack of information on the part of some market participants, whether about what others are doing, or what others know, or where the best trading opportunities are to be found. This feature was ignored in part II of the book (with a very few exceptions, notably in the analysis of price discrimination). Now this feature becomes the center of attention.

16.1. Introduction

As noted above, this chapter concerns transactions taken under conditions of *moral hazard* or, as it is sometimes called, *hidden action.*[1] We have already introduced one example: In the fire insurance business, an insurance company would want the insuree to store flammable materials carefully, keep quality fire extinguishers on hand, etc. To take other examples: If I lease a car from you that I return to you in three years, you want me to have it serviced regularly, to drive it carefully (no redlining), and so forth. If you hire me to do a particular arduous job, you want me to work hard at the tasks that are set for me.

In each of these examples, it is possible to monitor and enforce levels of care, or servicing, or effort. Insurance companies will send out inspectors, and some insurance contracts provide that no benefits will be paid if it can be shown that the insurer did not provide sufficient "due care."

[1] The terms of information economics, such as moral hazard, adverse selection, hidden action, hidden information, signaling, screening, and so on, are used somewhat differently by different authors, so you must keep your eyes open when you see any of these terms in a book or article. For example, we just equated moral hazard with hidden action; you will read elsewhere that there is a serious distinction between them. (My own opinion is that there is a distinction, but it is hardly serious.) I do not wish to subject you to a precise categorization, largely on the grounds that very interesting problems mix more than one form, and then how would we call them? As a consumer of the literature, you should pay less attention to these labels and more to the "rules of the game" the author specifies — who knows what when, who does what when.

A car lease contract may require that routine maintenance is performed. If I am working for you, you might hire monitors to observe my level of effort.

But in each case, perfect monitoring and enforcement may be impossible, and hence the transaction might be structured so that the party taking the action has relatively greater *incentive* to act in a way the second party prefers. The insurance company may only insure up to 90% of the building. If the leased car is sold after the lease period, the contract may call for the party that leased the car to get a share of the proceeds from the sale.[2] And you might tie my compensation to some observable measure of how hard I work.

From the point of view of providing incentives, we would like to structure the transaction so that the party who is taking the "hidden action" bears fully the consequences of his actions. The insurance company may refuse to give insurance; instead of leasing the car, you may simply sell it to me; you may pay me as a function of the output I produce, using (for example) a piece-rate system, where I am paid a set amount for each piece of output I produce. But in each of these cases there may be "inefficiencies" in such a contractual form: A company owning a warehouse, if closely held by a few individuals, may be less able to bear the risk of having the warehouse burn down than is an insurance company with many shareholders. A leasing arrangement may produce tax savings relative to a direct sale, owing to pecularities in the tax system.[3] Piece-rate systems may be infeasible because the work involved is machine paced, or because the quality of worksmanship as well as quantity may be important, or because the piece-rate system may subject the worker to risks that the worker is less well equipped to bear than is the firm for which he works. So a balance must be struck between providing incentives and exploiting all the other advantages of trade in a particular setting.

16.2. Effort incentives: A simple example

All these words and vague generalities may be a bit hard to parse, so let us turn to an illustrative example. Imagine a situation in which one party, called the *principal*, hires a second party, called the *agent*, to perform some task. The agent is drawn from a large population of similar

[2] You *don't* see this in most car lease contracts in the United States, largely because leasing is motivated by tax considerations, and such a contract would void the tax savings.

[3] You may wonder why such a tax system would be created, but that is well beyond the scope of this book.

agents and is willing to undertake this task as long as his net utility from performing the task is at least as large as he can get at his next best opportunity; we refer to this level of utility as the agent's *reservation level of utility*. The agent, if and when he is hired, must then decide whether to work hard or not on this particular job. Hard work is not to this particular agent's taste, and so, all other things equal, he would prefer not to work hard. Whether this agent works hard or not determines the value to the principal of having this agent work. If the agent is not going to work hard, then the principal will get very little from the deal — so little that it is not worth her while to pay the agent his reservation wage (a wage high enough so that combined with not working hard the agent's net utility exceeds his reservation level of utility). But if the agent does work hard, then the principal will get enough out of the transaction to make it worthwhile for both sides.

Specifically, suppose that the agent's reservation level of utility is (completely arbitrarily, as the scale doesn't mean anything) 9. The agent derives utility from how much he is paid, w, and how hard he works, a. The level of a can be "hard" or "high," which we denote $a = 5$, or it can be "not hard" or "low," denoted by $a = 0$. The agent's overall (von Neumann-Morgenstern) utility from w and a is given by

$$U(w,a) = \sqrt{w} - a.$$

If the agent works hard, the accomplished task is worth \$270 to the principal. And if the agent doesn't work hard, the task will be worth only \$70 to the principal.

To get the agent to work at a low level of effort, the principal must offer the agent wages high enough so that $\sqrt{w} \geq 9$, or $w \geq \$81$. Since the job, if done with low effort, is worth only \$70 to the principal, there will be no deal of this sort.

But if the agent can be persuaded to expend high effort, then the principal must offer the agent wages high enough so that $\sqrt{w} - 5 \geq 9$, or $\sqrt{w} \geq 14$, or $w \geq \$196$. Since the principal values the job done with a high level of effort at \$270, this is a worthwhile deal for her. She should try to arrange this.

How? Perhaps she should write a contract that offers the agent \$197 (be generous!) for performing the task, and trust that the agent will indeed work hard. Trust is nice and can work (although we might try to think why it does), but the title of this chapter is "moral hazard," so we assume this won't work. If the principal offers this agent a fixed fee contract, we assume that the agent will take the money, put in low effort, and leave the principal paying \$197 for a task that is worth to her only \$70.

Another possibility is to offer a contract that calls for the agent's pay to depend on how much effort he puts in. The contract might read something like "I (the principal) agree to pay the agent \$197 if he works hard, and \$25 (say) if he doesn't." If this contract is enforceable, then the agent will optimally work hard — doing so gives him a utility of (slightly more than) 9, while taking the contract and not working hard would net $\sqrt{25} - 0 = 5$, which is less than his reservation utility level.

But is this contract enforceable? Suppose the agent signs it, doesn't work hard, and then claims that he did work hard. The principal will need some tangible evidence that he didn't work hard, evidence that will stand up in some legal proceeding. It may be that no tangible evidence exists, or even that the principal is unable to see any conclusive evidence about how hard the agent worked. (This may seem a bit strange to you, because the principal's valuation of the task depends on how hard the agent worked. But, in a bit, we'll see why there might be no conclusive evidence.) There may be conclusive evidence, but not evidence that a court of law, or whoever is going to enforce this contract, would accept as evidence. Or it may be that court costs are too high to make one side wish to enforce such a contract. For any of these reasons, writing this sort of contract might not work.

We could have the principal monitor the agent's efforts, with a contract that gives the principal the right to fire the agent (at a low level of severance pay) if he doesn't work hard. Of course, the principal might still have to go to the courts to justify a termination, so the problems just mentioned might still be present. And there will be some cost of monitoring the agent; the principal, presumably, has better things to do with her time. The principal, if her time is especially valuable, might think of hiring some third party to monitor the agent. But then she'll have to pay this monitor, and she might be concerned that the monitor and the agent will collude against her; the agent might offer the monitor a bribe if the monitor will say that the agent did indeed work hard. Finally, the agent mightn't sign any such contract, fearing that the principal will fire him just before the task is completed. (In chapter 20, we'll consider how the principal's concern for her reputation among workers in general might reassure this particular worker on this count.)

Even if the principal cannot tie the worker's wage directly to his level of effort, the principal might be able to find some indirect measure of effort to which wages can be tied in a contract that will stand up in court. To give an example of this, we have to be a bit more specific about what this agent is doing. We suppose that the agent is a salesman, who will be representing the principal to a particular client. There are three possible outcomes to this interaction: The client can place no order with the principal; the client can place an order that is worth a (gross) \$100 with the principal; or the client can place an order that is worth a (gross) \$400 with the principal. The agent's level of effort affects the odds of each of these three outcomes. If the agent works hard at making the sale, then a \$400 sale results with probability .6, a \$100 sale with probability .3, and no sale with probability .1. If the agent doesn't work hard, there is a \$400 sale with probability .1, a \$100 sale with probability .3, and no sale with probability .6. The size of the sale is observable, and (we assume) the agent's wages can be made contingent upon this variable.

The principal is risk neutral. Note, in particular, where the \$70 and \$270 figures came from; these are the expected gross profits from the sale, for low- and high-effort levels, respectively. Note also that, unless the principal can observe the effort level of the agent directly, the data received (size of the order placed, if any) do not tell conclusively what level of effort was put in. A \$400 sale indicates that a high level of effort was more likely, but it isn't conclusive.

Case 1. A risk neutral agent

Now imagine that the agent is also risk neutral. (Note well: This isn't what we assumed above, and we'll get back to our earlier assumptions in a bit.) By this we mean that the agent's utility function is $u(w, a) = w - a$. For the duration of this case, we assume that the agent's reservation level of utility is 81, and high and low effort correspond to $a = 25$ and $a = 0$, respectively. With these new numbers, the same problem as we had before presents itself: The principal would be willing to hire the agent and pay him a bit more than \$106 if hard work could be guaranteed. This would leave the principal with a net profit of \$270 - \$106 = \$164. But the principal would be unwilling to expend the \$81 it would take to get the agent to work if the agent puts in low effort. And she would certainly be unhappy if she hired the agent for \$106 and then he put in low effort.

But now there is a simple solution. Offer the agent the following contingent contract: "If you make no sale, you pay me \$164. If you make a small sale (worth \$100 gross), you only pay me \$64. And if you make a large sale, you will be paid \$400 - \$164 = \$236. The agent, offered this, can choose one of the following three courses of action:

(a) Turn down the contract, and get reservation utility level 81.

(b) Take the contract and put in a low level of effort. This will net expected utility

$$(.1)(236) + (.3)(-64) + (.6)(-164) - 0 = -94.$$

(c) Take the contract and work hard. This will net expected utility

$$(.6)(236) + (.3)(-64) + (.1)(-164) - 25 = 81.$$

The agent is just indifferent between options (a) and (c), and if the principal sweetens the contract just a bit, the agent will prefer (c). The principal is quite happy with this. The agent, in his own interests now, will work hard. Indeed, the principal's net from the sale net of the payment to the agent is \$164 (less any sweetening) *with certainty*!

What our principal has done is to get the agent to internalize the effect of his effort decision. The agent now bears fully the cost of putting in less than a high level of effort.

Case 2. A risk averse agent

Now go back to the original formulation, where the agent's utility function is $u(w, a) = \sqrt{w} - a$, his reservation utility level is 9, and $a = 5$ for high effort and $a = 0$ for low. If we could write a contract contingent on the effort level of the agent, then the best contract for the principal to write is one in which the agent gets \$196 (plus a bit, perhaps) if he works hard and some low amount (such as \$0) if he doesn't. This leaves the principal with an expected net profit of \$270 - \$196 = \$74.

But we assume that the principal can only make the agent's wages contingent on the (gross) size of the sale. In case 1, we could still find a contract that would make the principal as well off as if she could write a contract contingent on actual effort level. But in this case we cannot. Two countervailing forces are at work in this case:

(a) In this case, where the principal is risk neutral and the agent is risk averse, the most "efficient" arrangement is one in which the agent's wage is certain. Why? *In general, if one party to a transaction is risk averse and the other is risk neutral, then it is efficient for the risk neutral party to bear all the risks.* In the somewhat different context of syndicate theory in chapter 5, you saw this proved formally. The same formal techniques work here. So instead of subjecting you for a second time to the formal proof, let us give the intuition: If the principal pays the agent a random wage, then the agent evaluates the wage according to his expected utility. Being risk averse, if the wage is at all risky the agent values it at less than its expected value. But the principal, being risk neutral, values the cost of the wages paid at their expected value. If we imagine that the agent's wages had expected value $\bar{w}$, then the principal would see this as an outflow from her pocket equivalent to $\bar{w}$, but the agent would see this as an inflow to his pocket of something less than $\bar{w}$ as long as there is any risk at all.

(b) On the other hand, if we give the agent a riskless wage, the agent has no incentive to work hard. And if the agent doesn't work hard, the principal doesn't want to enter the transaction.

To induce the agent to work hard, we will have to give up some of the efficiency that is obtained by putting all the risk on the principal. The question is, How can we do this as efficiently as possible?

To answer this, suppose that we form a contract in which the agent is paid $\$x_0^2$ if no sale is obtained, $\$x_1^2$ if the small sale is made, and $\$x_2^2$ if the large sale is made. I am squaring the values so that when I apply the agent's utility function his utility in each contingency will be $x_i - a$, for $i = 0, 1, 2$. Hence, offered this contract, the agent has three choices:

(a) Refuse the contract, and get reservation utility 9

(b) Take the contract and put in a low level of effort, for an expected utility of

$$(.6)x_0 + (.3)x_1 + (.1)x_2$$

(c) Take the contract and put in a high level of effort, for an expected utility of

$$(.1)x_0 + (.3)x_1 + (.6)x_2 - 5$$

Assume for the moment that we wish to write the best possible contract (from the point of view of the principal) subject to the constraints that the agent will take the contract and put in a high level of effort. Then we wish to

$$\text{minimize} \quad (.1)x_0^2 + (.3)x_1^2 + (.6)x_2^2$$

subject to

$$(.1)x_0 + (.3)x_1 + (.6)x_2 - 5 \geq 9$$

and

$$(.1)x_0 + (.3)x_1 + (.6)x_2 - 5 \geq (.6)x_0 + (.3)x_1 + (.1)x_2.$$

That is, we wish to minimize the expected wage (since we are taking the perspective of the principal) subject to two constraints; the first is that the agent should sign on the dotted line, and the second is that the agent should then choose to put in the high level of effort. (We should add constraints that the x_i must all be nonnegative, but I'll proceed without them and add them in later if necessary.) These two constraints have names: The first is often called the *individual rationality* or *participation* constraint, and the second is called the *incentive* constraint.

You should have no difficulty solving this constrained optimization problem. To spare you all that needless effort, let us simply give the solution here: $x_0 = 5.42857, x_1 = 14, x_2 = 15.42857$. Both constraints bind at the optimum, which is fairly intuitive: The principal doesn't want to pay the agent any more than necessary to get him to work, and she doesn't want to put any more risk on the agent than is necessary to get the agent to work hard, because it is costly to her to put risk on the agent. Thus we have the following as the optimal contract, if our objective is to get the agent to take the job and to put in high effort:

If no sale is made, wages are $5.42857^2 = \$29.46$

If a \$100 sale is made, wages are $14^2 = \$196$

If a \$400 sale is made, wages are $15.42857^2 = \$238.0407$

The expected wage bill is $(.1)(29.46) + (.3)(196) + (.6)(238.0407) = \$204.56$, which leaves the principal with an expected profit of $270 - 204.56 = \$65.44$.

Compare this with the "first best" contract — the contract where the principal gives the agent a flat wage of \$196 and relies on trust or the compulsion of a monitoring scheme to ensure that the agent puts in a high level of effort. To give the agent the right incentives, we had to have him bear some of the risk by rewarding him in case of the outcome that is more likely if he puts in greater effort. This cost the principal an expected \$8.56.

16.3. Finitely many actions and outcomes

A general formulation

The technique just used generalizes very nicely to a class of principal-agent problems. We imagine an agent who may agree to undertake a task for a principal, and who then chooses an *action* a to take out of some finite set $A = \{a_1, \ldots, a_N\}$. The action choice by the agent is not observed by the principal; instead the principal sees an imperfect signal of what the agent did. We model this by saying that the principal (and the agent) observe a *signal* s that is drawn from a finite set $S = \{s_1, \ldots, s_M\}$. If the agent chooses action a_n, the probability that signal s_m is produced is π_{nm}, where $\sum_{m=1}^{M} \pi_{nm} = 1$ for each n. The principal is unable to write a contract that makes the agent's compensation directly dependent on a; the best she (the principal) can do is to make his compensation a function of s.

Note carefully that we refer to the agent's choice of *action* instead of his choice of *effort*. We do not preclude the interpretation of a as a level of effort, and in a later subsection we will specialize to a case that has that interpretation quite naturally. But for now we don't rule out other interpretations.

Both for ease of exposition and for some of the results we later give, we make our first assumption:

Assumption 1. *The probability $\pi_{nm} > 0$ for all n and m.*

In words, every outcome is possible under every action.

The agent's utility depends on the wages he receives, denoted by w, and the action he takes, denoted by a. His preferences over lotteries concerning his income obey the von Neumann-Morgenstern axioms, and $U(w,a) = u(w) - d(a)$ is his von Neumann-Morgenstern utility function. Note carefully that we assume that $U(w,a)$ is *additively separable* into a piece that depends on wages, $u(w)$, and a piece that depends on the action selected, $-d(a)$. (The letter d here is a mnemonic for disutility.) We assume that the agent has a reservation utility level u_0. And we add the following innocuous assumption.

Assumption 2. *The function u is strictly increasing, continuously differentiable, and concave.*

Concavity of u is just risk aversion for our agent (in terms of lotteries over his wages). We don't preclude that u is linear.

The principal cares about the action chosen by the agent and about the wages she pays to him. Specifically, we suppose that $B(a)$ for some function B gives the gross benefits to the principal of hiring the agent if the agent chooses action a, and the principal's net benefit is $B(a)$ less the expected wages she must pay.

This formulation is far from general. We are assuming that the principal is risk neutral, and we assume a very special form of utility function for the agent. Much of what follows can be extended somewhat to encompass more general formulations. In particular, Grossman and Hart (1983), from whom a lot of what follows is taken, assume throughout that the agent's utility function takes the somewhat more general form $U(w,a) = f(a)u(w) - d(a)$ for a strictly positive function f. You will be asked to look at more general formulations in the problems.

Solving the basic problem

The basic problem is to find the optimal incentive scheme for the principal to offer the agent. To solve this problem, we proceed as follows.

Step 1: For each $a_n \in A$, what is the cheapest way to induce the agent to take the job and choose action a_n? Cheapest here is measured in terms of the expected wages that must be paid. Following the pattern of our example from the previous section, we solve this problem by solving a constrained maximization problem.

The variables in this maximization problem are the levels of "wage-utility" the agent is given as a function of the signal s. That is, we take variables x_m for $m = 1, \ldots, M$, where if $w(s_m)$ is the wage paid to the agent if the signal is s_m, then

$$x_m = u(w(s_m)).$$

We assume the $u(\cdot)$ is a strictly increasing and continuous function, and we let v be the inverse of u; that is, $v(z) = w$ if $u(w) = z$. Thus the wage paid to the agent if signal s_m is produced, as a function of the variable x_m, is just

$$w(s_m) = v(x_m).$$

Thus, as a function of the variables $\{x_1, \ldots, x_M\}$, the expected wages the principal must pay if the agent takes action a_n is

$$\sum_{m=1}^{M} \pi_{nm} v(x_m).$$

If the agent is offered wages as a function of signal as given by $v(x_m)$, what constraints must be met to be sure that he will select action a_n? We first must be sure that in choosing a_n the agent achieves at least his reservation level of utility,

$$\sum_{m=1}^{M} \pi_{nm} x_m - d(a_n) \geq u_0.$$

Note two things here. First, the expected utility of wages to the agent is $\sum_{m=1}^{M} \pi_{nm} u(v(x_m))$, which since v is the inverse of u is just $\sum_{m=1}^{M} \pi_{nm} x_m$. Second, we have a weak inequality, which means that if the constraint is binding the agent is indifferent between taking the job or not. It is standard to work with weak inequalities, presuming that the agent, if indifferent, will resolve ties in the interests of the principal. (See the later subsection on game theoretic connections.)

We must be sure that choosing a_n is better than choosing some other action n'. This is modeled by imposing the constraints

$$\sum_{m=1}^{M} \pi_{nm} x_m - d(a_n) \geq \sum_{m=1}^{M} \pi_{n'm} x_m - d(a_{n'}), \; n' = 1, \ldots, N.$$

The two comments made in the previous paragraph apply here as well. Note that we have included the constraint for $n' = n$, although it is satisfied trivially.

There may also be constraints on the level of wages that can be paid. A standard constraint of this sort is that wages may be constrained to be nonnegative. For example, this was implicit in our example, since the agent's square-root utility function is not defined for negative wages. In such cases we would add constraints such as $x_m \geq v(0)$. We will not carry constraints such as this along in our formulation, although at one point we will comment on the effect that such a constraint might have.

So we have step 1: For each action a_n

$$\begin{aligned} &\text{minimize} \sum_{m=1}^{M} \pi_{nm} v(x_m) \\ &\text{subject to} \sum_{m=1}^{M} \pi_{nm} x_m - d(a_n) \geq u_0, \text{ and} \\ &\sum_{m=1}^{M} \pi_{nm} x_m - d(a_n) \geq \sum_{m=1}^{M} \pi_{n'm} x_m - d(a_{n'}), \; n' = 1, \ldots, N. \end{aligned}$$

Call the value of this problem (that is, the value of the objective function at the optimal solution) $C(a_n)$. This is the *minimal expected cost of inducing the agent to select action* a_n. We will use the label (Cn) for this problem, a mnemonic for cost of action number n. The first constraint is called the *participation* constraint, and the other constraints are called the *relative incentive* constraints.

For readers who know about such things: Because u is concave, v is convex, and this is a well-behaved mathematical programming problem. We are minimizing a convex function subject to linear constraints, so that satisfaction of the first-order equations and the complementary slackness conditions (and the problem constraints) is necessary and sufficient for a solution. General convex programming algorithms can be employed to solve this problem numerically.

For a given a_n, there may be no solution at all on grounds that the set of values (x_m) that meet all the constraints is empty; examples are easy to construct. In this case we would say that $C(a_n) = +\infty$. Note that $C(a_n)$ is finite for at least one n. If we set $x_m \equiv u_0 + \min_n d(a_n)$, then the constraints are all satisfied for the problem (Cn^*) where n^* is the index of the effort level that has minimal disutility. In fact, for cases where u is concave this is the solution to (Cn^*), a result that you should find easy to prove following chapter 5 or from the first-order equations. (See later.)

The problem of nonexistence of any solution to the constraints is the only sort of problem concerning existence of a solution to (Cn) that may arise: If there is some set of variables (x_m), which meets all the constraints, then there is an optimal solution. You are asked to show this in problem 9; hints as to how to prove this are given there. It is worth noting that this result depends crucially on the assumption that $\pi_{nm} > 0$ for all n and m; see problem 7.

Step 2. For which $a \in A$ is $B(a) - C(a)$ maximized? This is a simple maximization problem.

Since we know that $C(a_{n^*})$ is finite where n^* is as before, and since each $C(a_n)$ is either finite or equal to $+\infty$, there is always a solution to the principal's overall problem.

If we wish to be very careful about this, we have to wonder what happens if $B(a) < C(a)$ for all a. Is it viable for the principal to refuse to hire the agent at all or, rather, for the principal to make a wage offer that the agent is sure to turn down? If so, what are the consequences for the gross benefits of the principal? We will not be tidy about this possibility but instead implicitly assume that some level of effort a can be implemented at a cost sufficiently low to make it worth the principal's while to do so.

The key to this technique is the way that it takes the problem in steps. First we find the minimum cost way to induce action a for each $a \in A$, and then we choose the optimal a by comparing benefits and costs.