

CHAPTER 37

ASYMMETRIC INFORMATION

So far in our study of markets we have not examined the problems raised by differences in information: by assumption buyers and sellers were both perfectly informed about the quality of the goods being sold in the market. This assumption can be defended if it is easy to verify the quality of an item. If it is not costly to tell which goods are high-quality goods and which are low-quality goods, then the prices of the goods will simply adjust to reflect the quality differences.

But if information about quality is costly to obtain, then it is no longer plausible that buyers and sellers have the same information about goods involved in transactions. There are certainly many markets in the real world in which it may be very costly or even impossible to gain accurate information about the quality of the goods being sold.

One obvious example is the labor market. In the simple models described earlier, labor was a homogeneous product—everyone had the same “kind” of labor and supplied the same amount of effort per hour worked. This is clearly a drastic simplification! In reality, it may be very difficult for a firm to determine how productive its employees are.

Costly information is not just a problem with labor markets. Similar problems arise in markets for consumer products. When a consumer buys

a used car it may be very difficult for him to determine whether or not it is a good car or a lemon. By contrast, the seller of the used car probably has a pretty good idea of the quality of the car. We will see that this **asymmetric information** may cause significant problems with the efficient functioning of a market.

37.1 The Market for Lemons

Let us look at a model of a market where the demanders and suppliers have different information about the qualities of the goods being sold.¹

Consider a market with 100 people who want to sell their used cars and 100 people who want to buy a used car. Everyone knows that 50 of the cars are “plums” and 50 are “lemons.”² The current owner of each car knows its quality, but the prospective purchasers don’t know whether any given car is a plum or a lemon.

The owner of a lemon is willing to part with it for \$1000 and the owner of a plum is willing to part with it for \$2000. The buyers of the car are willing to pay \$2400 for a plum and \$1200 for a lemon.

If it is easy to verify the quality of the cars there will be no problems in this market. The lemons will sell at some price between \$1000 and \$1200 and the plums will sell at some price between \$2000 and \$2400. But what happens to the market if the buyers *can’t* observe the quality of the car?

In this case the buyers have to guess about how much each car is worth. We’ll make a simple assumption about the form that this guess takes: we assume that if a car is equally likely to be a plum as a lemon, then a typical buyer would be willing to pay the expected value of the car. Using the numbers described above this means that the buyer would be willing to pay $\frac{1}{2}1200 + \frac{1}{2}2400 = \1800 .

But who would be willing to sell their car at that price? The owners of the lemons certainly would, but the owners of the plums wouldn’t be willing to sell their cars—by assumption they need at least \$2000 to part with their cars. The price that the buyers are willing to pay for an “average” car is less than the price that the sellers of the plums want in order to part with their cars. At a price of \$1800 only lemons would be offered for sale.

But if the buyer was certain that he would get a lemon, then he wouldn’t be willing to pay \$1800 for it! In fact, the equilibrium price in this market would have to be somewhere between \$1000 and \$1200. For a price in this range only owners of lemons would offer their cars for sale, and buyers

¹ The first paper to point out some of the difficulties in markets of this sort was George Akerlof, “The Market for Lemons: Quality Uncertainty and the Market Mechanism,” *The Quarterly Journal of Economics*, 84, 1970, pp. 488-500. He was awarded the 2001 Nobel Prize in economics for this work.

² A “plum” is slang for a good car; a “lemon” is slang for a bad car.

would therefore (correctly) expect to get a lemon. In this market, none of the plums ever get sold! Even though the price at which buyers are willing to buy plums exceeds the price at which sellers are willing to sell them, no such transactions will take place.

It is worth contemplating the source of this market failure. The problem is that there is an externality between the sellers of good cars and bad cars; when an individual decides to try to sell a bad car, he affects the purchasers' perceptions of the quality of the average car on the market. This lowers the price that they are willing to pay for the average car, and thus hurts the people who are trying to sell good cars. It is this externality that creates the market failure.

The cars that are most likely to be offered for sale are the ones that people want most to get rid of. The very act of offering to sell something sends a signal to the prospective buyer about its quality. If too many low-quality items are offered for sale it makes it difficult for the owners of high-quality items to sell their products.

37.2 Quality Choice

In the lemons model there were a fixed number of cars of each quality. Here we consider a variation on that model where quality may be determined by the producers. We will show how the equilibrium quality is determined in this simple market.

Suppose that each consumer wants to buy a single umbrella and that there are two different qualities available. Consumers value high-quality umbrellas at \$14 and low-quality umbrellas at \$8. It is impossible to tell the quality of the umbrellas in the store; this can only be determined after a few rainstorms.

Suppose that some manufacturers produce high-quality umbrellas and some produce low-quality umbrellas. Suppose further that both high-quality and low-quality umbrellas cost \$11.50 to manufacture and that the industry is perfectly competitive. What would we expect to be the equilibrium quality of umbrellas produced?

We suppose that consumers judge the quality of the umbrellas available in the market by the *average* quality sold, just as in the case of the lemons market. If the fraction of high-quality umbrellas is q , then the consumer would be willing to pay $p = 14q + 8(1 - q)$ for an umbrella.

There are three cases to consider.

Only low-quality manufacturers produce. In this case then the consumers would be willing to pay only \$8 for an average umbrella. But it costs \$11.50 to produce an umbrella, so none would be sold.

Only high-quality manufacturers produce. In this case the producers would compete the price of an umbrella down to marginal cost, \$11.50. The

consumers are willing to pay \$14 for an umbrella, so they would get some consumers' surplus.

Both qualities are produced. In this case competition ensures that the price will be \$11.50. The average quality available must therefore have a value to the consumer of at least \$11.50. This means that we must have

$$14q + 8(1 - q) \geq 11.50.$$

The lowest value of q that satisfies this inequality is $q = 7/12$. This means that if 7/12 of the suppliers are high-quality the consumers are just willing to pay \$11.50 for an umbrella.

The determination of the equilibrium ratio of high-quality producers is depicted in Figure 37.1. The horizontal axis measures q , the fraction of high-quality producers. The vertical axis measures the consumers' willingness to pay for an umbrella if the fraction of high-quality umbrellas offered is q . Producers are willing to supply either quality of umbrella at a price of \$11.50, so the supply conditions are summarized by the colored horizontal line at \$11.50.

Consumers are willing to purchase umbrellas only if $14q + 8(1 - q) \geq 11.50$; the boundary of this region is illustrated by the dashed line. The equilibrium value of q is between 7/12 and 1.

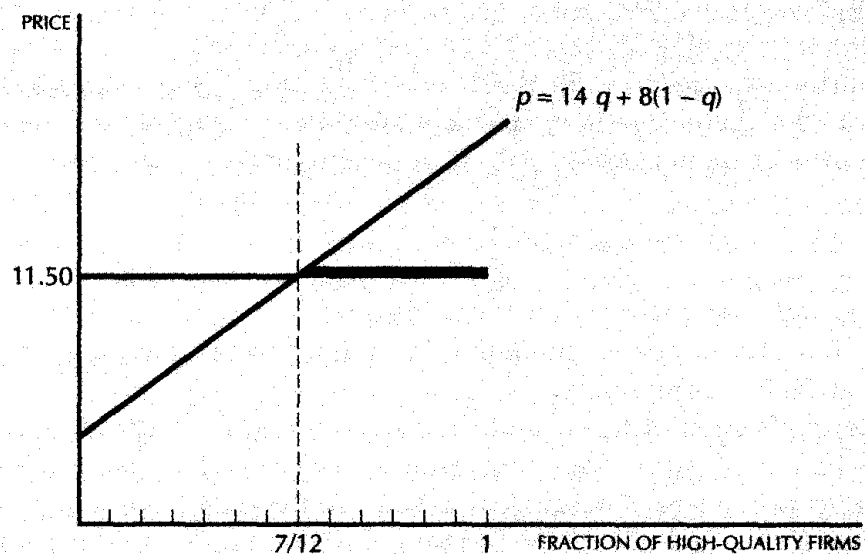
In this market the equilibrium price is \$11.50, but the value of the average umbrella to a consumer can be anywhere between \$11.50 and \$14, depending on the fraction of high-quality producers. Any value of q between 1 and 7/12 is an equilibrium.

However, all of these equilibria are not equivalent from the social point of view. The producers get zero producer surplus in all the equilibria, due to the assumption of pure competition and constant marginal cost, so we only have to examine the consumers' surplus. Here it is easy to see that the higher the average quality, the better off the consumers are. The best equilibrium from the viewpoint of the consumers is the one in which only the high-quality goods are produced.

Choosing the Quality

Now let us change the model a bit. Suppose that each producer can choose the quality of umbrella that he produces and that it costs \$11.50 to produce a high-quality umbrella and \$11 to produce a low-quality umbrella. What will happen in this case?

Suppose that the fraction of producers who choose high-quality umbrellas is q , where $0 < q < 1$. Consider one of these producers. If it behaves competitively and believes that it has only a negligible effect on the market



Equilibrium quality. The horizontal line represents the supply conditions: the market is willing to supply any quality of umbrella for \$11.50. The slanted line represents the demand conditions: consumers are willing to pay more if the average quality is higher. The market is in equilibrium if the fraction of high-quality producers is at least $7/12$.

price *and* quality, then it would always want to produce only low-quality umbrellas. Since this producer is by assumption only a small part of the market, it neglects its influence on the market price and therefore chooses to produce the more profitable product.

But every producer will reason the same way and only low-quality umbrellas will be produced. But consumers are only willing to pay \$8 for a low-quality umbrella, so there is no equilibrium. Or, if you will, the only equilibrium involves zero production of *either* quality of umbrella! The possibility of low-quality production has destroyed the market for *both* qualities of the good!

37.3 Adverse Selection

The phenomenon described in the last section is an example of **adverse selection**. In the model we just examined the low-quality items crowded out the high-quality items because of the high cost of acquiring information. As we just saw, this adverse selection problem may be so severe that it can

completely destroy the market. Let's consider a few other examples of adverse selection.

Consider first an example from the insurance industry. Suppose that an insurance company wants to offer insurance for bicycle theft. They do a careful market survey and find that the incident of theft varies widely across communities. In some areas there is a high probability that a bicycle will be stolen, and in other areas thefts are quite rare. Suppose that the insurance company decides to offer the insurance based on the *average* theft rate. What do you think will happen?

Answer: the insurance company is likely to go broke quickly! Think about it. Who is going to buy the insurance at the average rate? Not the people in the safe communities—they don't need much insurance anyway. Instead the people in the communities with a high incidence of theft will want the insurance—they're the ones who need it.

But this means that the insurance claims will mostly be made by the consumers who live in the high-risk areas. Rates based on the *average* probability of theft will be a misleading indication of the actual experience of claims filed with the insurance company. The insurance company will not get an unbiased selection of customers; rather they will get an *adverse* selection. In fact the term "adverse selection" was first used in the insurance industry to describe just this sort of problem.

It follows that in order to break even the insurance company must base their rates on the "worst-case" forecasts and that consumers with a low, but not negligible, risk of bicycle theft will be unwilling to purchase the resulting high-priced insurance.

A similar problem arises with health insurance—insurance companies can't base their rates on the *average* incidence of health problems in the population. They can only base their rates on the average incidence of health problems in the group of potential purchasers. But the people who want to purchase health insurance the most are the ones who are likely to need it the most and thus the rates must reflect this disparity.

In such a situation it is possible that everyone can be made better off by *requiring* the purchase of insurance that reflects the average risk in the population. The high-risk people are better off because they can purchase insurance at rates that are lower than the actual risk they face and the low-risk people can purchase insurance that is more favorable to them than the insurance offered if *only* high-risk people purchased it.

A situation like this, where the market equilibrium is dominated by a compulsory purchase plan, is quite surprising to most economists. We usually think that "more choice is better," so it is peculiar that restricting choice can result in a Pareto improvement. But it should be emphasized that this paradoxical result is due to the externality between the low-risk and high-risk people.

In fact there are social institutions that help to solve this market inefficiency. It is commonly the case that employers offer health plans to their

employees as part of the package of fringe benefits. The insurance company can base its rates on the averages over the set of employees and is assured that *all* employees must participate in the program, thus eliminating the adverse selection.

37.4 Moral Hazard

Another interesting problem that arises in the insurance industry is known as the **moral hazard** problem. The term is somewhat peculiar, but the phenomenon is not hard to describe. Consider the bicycle-theft insurance market again and suppose for simplicity that all of the consumers live in areas with identical probabilities of theft, so that there is no problem of adverse selection. On the other hand, the probability of theft may be affected by the *actions* taken by the bicycle owners.

For example, if the bicycle owners don't bother to lock their bikes or use only a flimsy lock, the bicycle is much more likely to be stolen than if they use a secure lock. Similar examples arise in other sorts of insurance. In the case of health insurance, for example, the consumers are less likely to need the insurance if they take actions associated with a healthy lifestyle. We will refer to actions that affect the probability that some event occurs as *taking care*.

When it sets its rates the insurance company has to take into account the incentives that the consumers have to take an appropriate amount of care. If no insurance is available consumers have an incentive to take the maximum possible amount of care. If it is impossible to buy bicycle-theft insurance, then all bicyclists would use large expensive locks. In this case the individual bears the full cost of his actions and accordingly he wants to "invest" in taking care until the marginal benefit from more care just equals the marginal cost of doing so.

But if a consumer can purchase bicycle insurance, then the cost inflicted on the individual of having his bicycle stolen is much less. After all, if the bicycle is stolen then the person simply has to report it to the insurance company and he will get insurance money to replace it. In the extreme case, where the insurance company completely reimburses the individual for the theft of his bicycle, the individual has no incentive to take care at all. This lack of incentive to take care is called **moral hazard**.

Note the tradeoff involved: too little insurance means that people bear a lot of risk, too much insurance means that people will take inadequate care.

If the amount of care is observable, then there is no problem. The insurance company can base its rates on the amount of care taken. In real life it is common for insurance companies to give different rates to businesses that have a fire sprinkler system in their building, or to charge smokers different rates than nonsmokers for health insurance. In these cases the insurance

firm attempts to discriminate among users depending on the choices they have made that influence the probability of damage.

But insurance companies can't observe all the relevant actions of those they insure. Therefore we will have the tradeoff described above: full insurance means too little care will be undertaken because the individuals don't face the full costs of their actions.

What does this imply about the types of insurance contracts that will be offered? In general, the insurance companies will not want to offer the consumers "complete" insurance. They will always want the consumer to face some part of the risk. This is why most insurance policies include a "deductible," an amount that the insured party has to pay in any claim. By making the consumers pay part of a claim, the insurance companies can make sure that the consumer always has an incentive to take *some* amount of care. Even though the insurance company would be willing to insure a consumer completely if they could verify the amount of care taken, the fact that the consumer can *choose* the amount of care he takes implies that the insurance company will not allow the consumer to purchase as much insurance as he wants if the company cannot observe the level of care.

This is also a paradoxical result when compared with the standard market analysis. Typically the amount of a good traded in a competitive market is determined by the condition that demand equals supply—the marginal willingness to pay equals the marginal willingness to sell. In the case of moral hazard, a market equilibrium has the property that each consumer would like to buy more insurance, and the insurance companies would be willing to provide more insurance if the consumers continued to take the same amount of care . . . but this trade won't occur because if the consumers were able to purchase more insurance they would rationally choose to take less care!

37.5 Moral Hazard and Adverse Selection

Moral hazard refers to situations where one side of the market can't observe the actions of the other. For this reason it is sometimes called a **hidden action** problem.

Adverse selection refers to situations where one side of the market can't observe the "type" or quality of the goods on other side of the market. For this reason it is sometimes called a **hidden information** problem.

Equilibrium in a market involving hidden action typically involves some form of rationing—firms would like to provide more than they do, but they are unwilling to do so since it will change the incentives of their customers. Equilibrium in a market involving hidden information will typically involve too little trade taking place because of the externality between the "good" and "bad" types.

Equilibrium outcomes in this market appear to be inefficient, but one has to be careful in making such a claim. The question to ask is “inefficient relative to what?” The equilibrium will always be inefficient relative to the equilibrium with full information. But this is of little help in making policy decisions: if the firms in the industry find it too costly to collect more information the government would probably find it too costly as well.

The real question to ask is whether some sort of governmental intervention in the market could improve efficiency even if the government had the same information problems as the firms.

In the case of hidden action considered above, the answer is usually “no.” If the government can’t observe the care taken by the consumers, then it can do no better than the insurance companies. Of course the government might have other tools at its disposal that are not available to the insurance company—it could compel a particular level of care, and it could set criminal punishments for those who did not take due care. But if the government can only set prices and quantities, then it can do no better than the private market can do.

Similar issues arise in the case of hidden information. We have already seen that if the government can *compel* people of all risk classes to purchase insurance, it is possible for everyone to be made better off. This is, on the face of it, a good case for intervention. On the other hand, there are costs to government intervention as well; economic decisions made by governmental decree may not be as cost-effective as those made by private firms. Just because there are governmental actions that *can* improve social welfare doesn’t mean that these actions will be taken!

Furthermore, there may be purely private solutions to the adverse selection problems. For example, we have already seen how providing health insurance as a fringe benefit can help to eliminate the adverse selection problem.

37.6 Signaling

Recall our model of the used-car market: the owners of the used cars knew the quality, but the purchasers had to guess at the quality. We saw that this asymmetric information could cause problems in the market; in some cases, the adverse selection problem would result in too few transactions being made.

However, the story doesn’t end there. The owners of the good used cars have an incentive to try to convey the fact that they have a good car to the potential purchasers. They would like to choose actions that **signal** the quality of their car to those who might buy it.

One sensible signal in this context would be for the owner of a good used car to offer a **warranty**. This would be a promise to pay the purchaser some agreed upon amount if the car turned out to be a lemon. Owners of

the good used cars can afford to offer such a warranty while the owners of the lemons can't afford this. This is a way for the owners of the good used cars to signal that they have good cars.

In this case signaling helps to make the market perform better. By offering the warranty—the signal—the sellers of the good cars can distinguish themselves from the sellers of the bad used cars. But there are other cases where signaling can make a market perform less well.

Let's consider a very simplified model of the education market first examined by Michael Spence.³ Suppose that we have two types of workers, able and unable. The able workers have a marginal product of a_2 , and the unable workers have a marginal product of a_1 , where $a_2 > a_1$. Suppose that a fraction b of the workers are able and $1 - b$ of them are unable.

For simplicity we assume a linear production function so that the total output produced by L_2 able workers and L_1 unable workers is $a_1 L_1 + a_2 L_2$. We also assume a competitive labor market.

If worker quality is easily observable, then firms would just offer a wage of $w_2 = a_2$ to the able workers and of $w_1 = a_1$ to the unable workers. That is, each worker would be paid his marginal product and we would have an efficient equilibrium.

But what if the firm can't observe the marginal products? If a firm can't distinguish the types of workers, then the best that it can do is to offer the average wage, which is $w = (1 - b)a_1 + ba_2$. As long as the good and the bad workers both agree to work at this wage there is no problem with adverse selection. And, given our assumption about the production function, the firm produces just as much output and makes just as much profit as it would if it could perfectly observe the type of the worker.

However, suppose now that there is some signal that the workers can acquire that will distinguish the two types. For example, suppose that the workers can acquire education. Let e_1 be the amount of education attained by the type 1 workers and e_2 the amount attained by the type 2 workers. Suppose that the workers have different costs of acquiring education, so that the total cost of education for the able workers is $c_2 e_2$ and the total cost of education for the unable workers is $c_1 e_1$. These costs are meant to include not only the dollar costs of attending school, but also includes the opportunity costs, the costs of the effort required, and so on.

Now we have two decisions to consider. The workers have to decide how much education to acquire and the firms have to decide how much to pay workers with different amounts of education. Let us make the extreme assumption that the education doesn't affect worker productivity at all. Of course this isn't true in real life—especially for economics courses—but it helps to keep the model simple.

³ Michael Spence, *Market Signaling* (Cambridge, Mass: Harvard University Press, 1974).

It turns out that the nature of the equilibrium in this model depends crucially on the cost of acquiring education. Suppose that $c_2 < c_1$. This says that the marginal cost of acquiring education is less for the able workers than the unable workers. Let e^* be an education level that satisfies the following inequalities:

$$\frac{a_2 - a_1}{c_1} < e^* < \frac{a_2 - a_1}{c_2}.$$

Given our assumption that $a_2 > a_1$ and that $c_2 < c_1$ there must be such an e^* .

Now consider the following set of choices: the able workers all acquire education level e^* and the unable workers all acquire education level 0, and the firm pays workers with education level e^* a wage of a_2 and workers with less education than this a wage of a_1 . Note that the choice of the education level of a worker perfectly signals his type.

But is this an equilibrium? Does anyone have an incentive to change his or her behavior? Each firm is paying each worker his or her marginal product, so the firms have no incentive to do anything differently. The only question is whether the workers are behaving rationally given the wage schedule they face.

Would it be in the interest of an unable worker to purchase education level e^* ? The benefit to the worker would be the increase in wages $a_2 - a_1$. The cost to the unable worker would be $c_1 e^*$. The benefits are less than the costs if

$$a_2 - a_1 < c_1 e^*.$$

But we are guaranteed that this condition holds by the choice of e^* . Hence the unable workers find it optimal to choose a zero educational level.

Is it actually in the interest of the able workers to acquire the level of education e^* ? The condition for the benefits to exceed the costs is

$$a_2 - a_1 > c_2 e^*,$$

and this condition also holds due to the choice of e^* .

Hence this pattern of wages is indeed an equilibrium: if each able worker chooses education level e^* and each unable worker chooses a zero educational level, then no worker has any reason to change his or her behavior. Due to our assumption about the cost differences, the education level of a worker can, in equilibrium, serve as a signal of the different productivities. This type of signaling equilibrium is sometimes called a **separating equilibrium** since the equilibrium involves each type of worker making a choice that allows him to separate himself from the other type.

Another possibility is a **pooling equilibrium**, in which each type of worker makes the *same* choice. For example, suppose that $c_2 > c_1$, so that the able workers have a higher cost of acquiring education than the unable

workers. In this case it can be shown that the only equilibrium involves the workers all getting paid a wage based on their average ability, and so no signaling occurs.

The separating equilibrium is especially interesting since it is inefficient from a social point of view. Each able worker finds it in his interest to pay for acquiring the signal, even though it doesn't change his productivity at all. The able workers want to acquire the signal not because it makes them any more productive, but just because it distinguishes them from the unable workers. Exactly the same amount of output is produced in the (separating) signaling equilibrium as would be if there were no signaling at all. In this model the acquisition of the signal is a total waste from the social point of view.

It is worth thinking about the nature of this inefficiency. As before, it arises because of an externality. If both able and unable workers were paid their *average* product, the wage of the able workers would be depressed because of the presence of the unable workers. Thus they would have an incentive to invest in signals that will distinguish them from the less able. This investment offers a private benefit but no social benefit.

Of course signaling doesn't always lead to inefficiencies. Some types of signals, such as the used-car warranties described above, help to facilitate trade. In that case the equilibrium with signals is preferred to the equilibrium without signals. So signaling can make things better or worse; each case has to be examined on its own merits.

EXAMPLE: The Sheepskin Effect

In the extreme form of the educational signaling model described above education has no effect on productivity: the years spent in school serve only to signal the fixed ability of an individual. This is obviously an exaggeration: a student with 11 years of schooling almost certainly is more productive than one with 10 years of schooling due to the fact that they have acquired more useful skills during the additional year. Presumably part of the returns to schooling are due to signaling, and part are due to the acquisition of useful skills while in school. How can we separate these two factors?

Labor economists who have studied the returns to education have observed the following suggestive fact: the earnings of people who have graduated from high school are much higher than the incomes of people who have only completed 3 years of high school. One study found that graduating from high school increases earnings by 5 to 6 times as much as does completing a year in high school that does not result in graduation. The same discontinuous jump occurs for people who graduate from college. According to one estimate, the economic return to the 16th year of schooling

are about three times as high as the return to the 15th year of schooling.⁴

If education imparts productive skills, we might well expect that people with 11 years of education are paid more than people with 10 years of education. What is surprising is that there is a huge jump in earnings associated with high school graduation. Economists have termed this the **sheepskin effect**, in reference to the fact that diplomas were often written on sheepskins. Presumably, graduation from high school is some kind of signal. But what is it a signal of? In the educational signaling model described earlier, educational attainment was a signal of ability. Is that what high school graduation signals? Or is it something else?

Andrew Weiss, a Boston University economist, attempted to answer these questions.⁵ He looked at a set of data describing how workers assembled equipment and was able to obtain a measure of how much output they produced in their first month on the job. He found that there was a very small effect of education on output: each year of secondary education increased a worker's output by about 1.3 percent. Furthermore, high school graduates produced essentially the same amount of output as non-graduates. Apparently education contributed only a small amount to the initial productivity of these workers.

Weiss then looked at another data set that described various characteristics of workers in a variety of occupations. He found that high school graduates had significantly lower quit and absentee rates than nongraduates. It seems that high school graduates receive higher wages because they are more productive—but the reason that they are more productive is because they stay with the firm longer and have fewer absences. This suggests that the signaling model does give us insight into real-world labor markets. However, the actual signal sent by educational attainment is considerably more complex than the simplest version of the signaling model suggests.

37.7 Incentives

We turn now to a slightly different topic, the study of **incentive systems**. As it turns out, our investigation of this topic will naturally involve asymmetric information. But it is useful to start with the case of full information.

The central question in the design of incentive systems is “How can I get someone to do something for me?” Let's pose this question in a specific

⁴ See Thomas Hungerford and Gary Solon, “Sheepskin Effects in the Returns to Education,” *Review of Economics and Statistics*, 69, 1987, 175–77.

⁵ “High School Graduation, Performance and Wages,” *Journal of Political Economy*, 96, 4, 1988, 785–820.

context. Suppose that you own a plot of land but you are unable to work on the land yourself. So you try to hire someone to do the farming for you. What sort of compensation system should you set up?

One plan might involve paying the worker a lump-sum fee independent of how much he produces. But then he would have little incentive to work. In general a good incentive plan will make the payment of the worker depend in some way on the output he produces. The problem of incentive design is to determine exactly how sensitive the payment should be to the produced output.

Let x be the amount of “effort” that the worker expends, and let $y = f(x)$ be the amount of output produced; for simplicity we suppose that the price of output is 1 so that y also measures the value of the output. Let $s(y)$ be the amount that you pay the worker if he produces y dollars worth of output. Presumably you would like to choose the function $s(y)$ to maximize your profits $y - s(y)$.

What are the constraints that you face? In order to answer this question we have to look at things from the worker’s perspective.

We assume that the worker finds effort costly, and write $c(x)$ for the cost of effort x . We assume that this cost function has the usual shape: both total and marginal costs increase as effort increases. The utility of the worker who chooses effort level x is then simply $s(y) - c(x) = s(f(x)) - c(x)$. The worker may have other alternatives available that give him some utility $\bar{u}$. This could come from working at other jobs or from not working at all. All that is relevant for the design of the incentive scheme is that the utility that the worker gets from this job must be at least as great as the utility he could get elsewhere. This gives us the **participation constraint**:

$$s(f(x)) - c(x) \geq \bar{u}.$$

Given this constraint we can determine how much output we can get from the worker. You want to induce the worker to choose an effort level x that yields you the greatest surplus given the constraint that the worker is willing to work for you:

$$\begin{aligned} &\max_x f(x) - s(f(x)) \\ &\text{such that } s(f(x)) - c(x) \geq \bar{u}. \end{aligned}$$

In general, you will want the worker to choose x to just satisfy the constraint so that $s(f(x)) - c(x) = \bar{u}$. Substituting this into the objective function we have the unconstrained maximization problem

$$\max_x f(x) - c(x) - \bar{u}.$$

But it is easy to solve this problem! Just choose x^* so that the marginal product equals the marginal cost:

$$MP(x^*) = MC(x^*).$$

Any choice of x^* where the marginal benefit is not equal to the marginal cost cannot maximize profits.

This tells us what level of effort the owner wants to achieve; now we have to ask what he has to pay the worker to achieve that effort. That is, what does the function $s(y)$ have to look like to induce the worker to choose to make x^* the optimal choice?

Suppose that you decide that you want to induce the worker to put in x^* amount of effort. Then you must make it in his interest to do so; that is, you must design your incentive scheme $s(y)$ so that the utility from choosing to work x^* is larger than the utility of worker any other amount x . This gives us the constraint

$$s(f(x^*)) - c(x^*) \geq s(f(x)) - c(x) \quad \text{for all } x.$$

This constraint is called the **incentive compatibility constraint**. It simply says that the utility to the worker from choosing x^* must be greater than the utility of any other choice of effort.

So we have two conditions that the incentive scheme must satisfy: first, it must give total utility to the worker of $\bar{u}$, and second, it must make the marginal product of effort equal to the marginal cost of effort at the effort level x^* . There are several ways to do this.

Rent. The landowner could simply rent the land to the worker for some price R , so that the worker gets all the output he produces after he pays the owner R . For this scheme

$$s(f(x)) = f(x) - R.$$

If the worker maximizes $s(f(x)) - c(x) = f(x) - R - c(x)$, he will choose the effort level where $MP(x^*) = MC(x^*)$, which is exactly what the owner wants. The rental rate R is determined from the participation condition. Since the total utility to the worker must be $\bar{u}$ we have

$$f(x^*) - c(x^*) - R = \bar{u},$$

which says $R = f(x^*) - c(x^*) - \bar{u}$.

Wage labor. In this scheme the landowner pays the worker a constant wage per unit of effort along with a lump sum K . This means that the incentive payment takes the form

$$s(x) = wx + K.$$

The wage rate w is equal to the marginal product of the worker at the optimal choice x^* , $MP(x^*)$. The constant K is chosen to just make the worker indifferent between working for the landowner and working elsewhere; that is, it is chosen to satisfy the participation constraint.

The problem of maximizing $s(f(x)) - c(x)$ then becomes

$$\max_x wx + K - c(x),$$

which means that the worker will choose x so as to set his marginal cost equal to the wage: $w = MC(x)$. Since the wage is $MP(x^*)$, this means that the *optimal* choice of the worker will be x^* such that $MP(x^*) = MC(x^*)$ which is just what the firm wants.

Take-it-or-leave-it. In this scheme the landowner pays the worker B^* if he works x^* and zero otherwise. The amount B^* is determined by the participation constraint $B^* - c(x^*) = \bar{u}$, so $B^* = \bar{u} + c(x^*)$. If the worker chooses any level of effort $x \neq x^*$, he gets a utility of $-c(x)$. If he chooses x^* , he gets a utility of $\bar{u}$. Hence the optimal choice for the worker is to set $x = x^*$.

Each of these schemes is equivalent as far as the analysis goes: each one gives the worker a utility of $\bar{u}$, and each one gives the worker an incentive to work the optimal amount x^* . At this level of generality there is no reason to choose between them.

If all of these schemes are optimal, what could a nonoptimal scheme look like? Here is an example.

Sharecropping. In sharecropping the worker and the landowner each get some fixed percentage of the output. Suppose that the worker's share takes the form $s(x) = \alpha f(x) + F$, where F is some constant and $\alpha < 1$. This is *not* an efficient scheme for the problem under consideration. It is easy to see why. The worker's maximization problem is

$$\max_x \alpha f(x) + F - c(x),$$

which means that he would choose a level of effort $\hat{x}$ where

$$\alpha MP(\hat{x}) = MC(\hat{x}).$$

Such an effort level clearly cannot satisfy the efficiency condition that $MP(x) = MC(x)$.

Here is a way to summarize this analysis. In order to design an efficient incentive scheme it is necessary to ensure that the person who makes the effort decision is the **residual claimant** to the output. The way the owner can make himself as well off as possible is to make sure that he gets the worker to produce the optimal amount of output. This is the output level where the marginal product of the worker's extra effort equals the marginal cost of putting forth that effort. It follows that the incentive scheme must provide a marginal benefit to the worker equal to his marginal product.

EXAMPLE: Voting Rights in the Corporation

Normally shareholders in a corporation have the right to vote on various issues related to the management of the corporation while bondholders do not. Why is this? The answer comes from looking at the structure of payoffs to stockholders and bondholders. If a corporation produces X dollars of profit in a given year, the bondholders have first claim on these profits, while the amount that is left over goes to the stockholders. If the total claim by the bondholders is B , then the amount that goes to the stockholders is $X - B$. This makes the stockholders the residual claimants—so they have an incentive to make X as large as possible. The bondholders on the other hand only have an incentive to make sure that X is at least B , since that is the most that they are entitled to. Hence giving the stockholders the right to make decisions will generally result in larger profits.

EXAMPLE: Chinese Economic Reforms

Prior to 1979 Chinese rural communes were organized along orthodox Marxist lines. Workers were paid according to a rough estimate of how much they contributed to the commune income. Five percent of the commune's land was set aside for private plots, but peasants were not allowed to travel to cities to sell the output from their private farms. All trade had to take place through a highly regulated government market.

At the end of 1978 the Chinese central government instituted a major reform in the structure of agriculture, known as the "responsibility system." In the responsibility system, any production in excess of a fixed quota was kept by the household and could be sold on private markets. The government removed restrictions on private plots and increased the amount of land devoted to private farming. By the end of 1984, 97 percent of the farmers operated under this responsibility system.

Note that the structure of the system is very much like the optimal incentive mechanism described above: each household makes a lump-sum payment to the commune but can keep anything in excess of this quota. Hence the *marginal* incentives for household production are the economically appropriate ones.

The effect of this new system on agricultural output was phenomenal: between 1978 and 1984, the output of Chinese agriculture increased by over 61 percent! However, not all of this increase is due to better incentives; at the same time these reforms were going on, the Chinese government also changed the controlled prices of agricultural goods, and even allowed some of these prices to be determined on private markets.

Three economists attempted to divide the increase in output into the part

due to better incentives and the part due to the change in prices.⁶ They found that over three-fourths of the increase was due to the improvement in incentives, and only one-fourth was due to the price reforms.

37.8 Asymmetric Information

The above analysis provides some insights about the use of different sorts of incentive schemes. For example, it shows that renting the land to a worker is better than sharecropping. But this really proves too much. If our analysis is a good description of the world, then we would expect to see rental or wage labor used in agriculture and never see sharecropping used, except by mistake.

Clearly this isn't right. Sharecropping has been used for thousands of years in some parts of the world, so it is likely that it fulfills some kind of need. What have we left out of our model?

Given the title of this section it is not hard to guess the answer: we've left out problems involving imperfect information. We assumed that the owner of the firm could perfectly observe the effort of the worker. In many situations of interest it may be impossible to observe the effort. At best the owner may observe some *signal* of the effort such as the resulting production of output. The amount of output produced by a farmer may depend in part on his effort, but it may also depend on the weather, the quality of the inputs, and many other factors. Because of this kind of "noise," a payment from the owner to the worker based on output will not in general be equivalent to a payment based on effort alone.

This is essentially a problem of asymmetric information: the worker can choose his effort level, but the owner cannot perfectly observe it. The owner has to guess the effort from the observed output, and the design of the optimal incentive scheme has to reflect this inference problem.

Consider the four incentive schemes described above. What goes wrong if effort is not perfectly correlated with output?

Rent. If the firm rents the technology to the worker, then the worker can get all of the output that remains after paying the fixed rental fee. If output has a random component, this means that the worker will have to bear all the risk from the random factors. If the worker is more risk averse than the owner—which is the likely case—this will be inefficient. In general, the worker would be willing to give up some of the residual profits in order to have a less risky income stream.

⁶ J. McMillan, J. Whalley, and L. Zhu, "The Impact of China's Economic Reforms on Agricultural Productivity Growth," *Journal of Political Economy*, 97, 4, 1989, 781–807.

Wage labor. The problem with wage labor is that it requires observation of the *amount* of labor input. The wage has to be based on the effort put in to production, not just the hours spent in the firm. If the owner can't observe the amount of labor input, then it will be impossible to implement this kind of incentive scheme.

Take-it-or-leave-it. If the incentive payment is based on the labor input, then we have the same problem with this scheme as with wage labor. If the payment is based on *output*, then the scheme involves the worker bearing all the risk. Even missing the "target output" by a small amount results in a zero payment.

Sharecropping. This is something of a happy medium. The payment to the worker depends in part on observed output, but the worker and the owner share the risk of output fluctuations. This gives the worker an incentive to produce output but it doesn't leave him bearing all the risk.

The introduction of asymmetric information has made a drastic change in our evaluation of the incentive methods. If the owner can't observe effort, then wage labor is infeasible. Rent and the take-it-or-leave-it scheme leave the worker bearing too much risk. Sharecropping is a compromise between the two extremes: it gives the worker some incentive to produce, but it doesn't leave him with all the risk.

EXAMPLE: Monitoring Costs

It is not always easy to observe the amount of effort an employee puts into his or her job. Consider, for example, a job as a clerk in a 24-hour convenience store. How can the manager observe the employees' performance when the manager isn't around? Even if there are ways to observe the physical output of the employee (shelves stocked, sales rung up) it is much harder to observe things like politeness to customers.

There is little doubt that some of the worst service in the world was provided in the formerly Communist countries in Eastern Europe: once you managed to attract the attention of a clerk, you were more likely to be greeted by a scowl than a smile. Nevertheless, a Hungarian entrepreneur, Gabor Varszegi, has made millions by providing high-quality service in his photo developing shops in Budapest.⁷

Varszegi says that he got his start as a businessman in the mid-sixties by playing bass guitar and managing a rock group. "Back then," he says, "the only private businessmen in Eastern Europe were rock musicians."

⁷ See Steven Greenhouse, "A New Formula in Hungary: Speed Service and Grow Rich," *New York Times*, June 5, 1990, A1.

He introduced one-hour film developing to Hungary in 1985; the next best alternative to his one-hour developing shops was the state-run agency that took one month.

Varszegi follows two rules in labor relations: he never hires anyone who worked under Communism, and he pays his workers four times the market wage. This makes perfect sense in light of the above remarks about monitoring costs: there are very few employees per store and monitoring their behavior is very costly. If there were only a small penalty to being fired, there would be great temptation to slack off. By paying the workers much more than they could get elsewhere, Varszegi makes it very costly for them to be fired—and reduces his monitoring costs significantly.

EXAMPLE: The Grameen Bank

A village moneylender in Bangladesh charges over 150 percent interest a year. Any American banker would love a return of that size: why isn't Citibank installing money machines in Bangladesh? To ask the question is to answer it: Citibank would probably not do as well as the moneylender. The village moneylender has a comparative advantage in these small-scale loans for several reasons.

- The village moneylender can deal more effectively with the small scale of lending involved;
- The moneylender has better access to information about who are good and bad credit risks than an outsider does.
- The moneylender is in a better position to monitor the progress of the loan payments to insure repayment.

These three problems—returns to scale, adverse selection and moral hazard—allow the village moneylender to maintain a local monopoly in the credit market.

Such a local monopoly is especially pernicious in an underdeveloped country such as Bangladesh. At an interest rate of 150 percent there are many profitable projects that are not being undertaken by the peasants. Improved access to credit could lead to a major increase in investment, and a corresponding increase in the standards of living.

Muhammad Yunus, an American-trained economist from Bangladesh, has developed an ingenious institution known as the Grameen Bank (village bank) to address some of these problems. In the Grameen plan, entrepreneurs with separate projects get together and apply for a loan as a group. If the loan is approved, two members of the group get their loan and commence their investment activity. If they are successful in meeting

the repayment schedule, two more members get loans. If they are also successful the last member, the group leader, will get a loan.

The Grameen bank addresses each of the three problems described above. Since the quality of the group influences whether or not individual members will get loans, potential members are highly selective about who they will join with. Since members of the group can only get loans if other members succeed in their investments, there are strong incentives to help each other out and share expertise. Finally, these activities of choosing candidates for loans and monitoring the progress of the repayments are all done by the peasants themselves, not directly by the loan officers at the bank.

The Grameen bank has been very successful. It makes about 475,000 loans a month with an average size of \$70. Their loan-recovery rate is about 98 percent, while conventional lenders in Bangladesh achieve a loan-recovery rate of about 30 to 40 percent. The success of the group responsibility program in encouraging investment has led to its adoption in a number of other poverty-stricken areas in North and South America.

Summary

1. Imperfect and asymmetric information can lead to drastic differences in the nature of market equilibrium.
2. Adverse selection refers to situations where the type of the agents is not observable so that one side of the market has to guess the type or quality of a product based on the behavior of the other side of the market.
3. In markets involving adverse selection too little trade may take place. In this case it is possible that everyone can be made better off by forcing them to transact.
4. Moral hazard refers to a situation where one side of the market can't observe the actions of the other side.
5. Signaling refers to the fact that when adverse selection or moral hazard are present some agents will want to invest in signals that will differentiate them from other agents.
6. Investment in signals may be privately beneficial but publically wasteful. On the other hand, investment in signals may help to solve problems due to asymmetric information.
7. Efficient incentive schemes (with perfect observability of effort) leave the worker as the residual claimant. This means that the worker will equate marginal benefits and marginal costs.

8. But if information is imperfect this is no longer true. In general, an incentive scheme that shares risks as well as providing incentives will be appropriate.

REVIEW QUESTIONS

1. Consider the model of the used-car market presented in this chapter. What is the maximum amount of consumers' surplus that is created by trade in the market equilibrium?
2. In the same model, how much consumers' surplus would be created by randomly assigning buyers to sellers? Which method gives the larger surplus?
3. A worker can produce x units of output at a cost of $c(x) = x^2/2$. He can achieve a utility level of $\bar{u} = 0$ working elsewhere. What is the optimal wage-labor incentive scheme $s(x)$ for this worker?
4. Given the setup of the previous problem, what would the worker be willing to pay to rent the production technology?
5. How would your answer to the last problem change if the worker's alternative employment gave him $\bar{u} = 1$?