Part 8

MARKET FAILURES

The marginal private net product ... accrues to the person responsible for investing resources. In some conditions this is equal to, in some it is greater than, in others it is less than the marginal social net product.

Arthur C. Pigou, The Economics of Welfare, 1920

In Part 5 we saw that competitive markets can in some circumstances lead to an efficient allocation of resources. One major reason that this efficiency may fail to materialize is when firms have market power—a situation we studied in Part 6. In this final part of the book we look more broadly at additional reasons why the beneficial outcomes from competitive markets may not occur. We also examine potential ways of fixing such “failures” of competitive markets to make them work better.

There are three chapters in Part 8. In Chapter 15, we look in detail at the role of information in economic activity. We are especially concerned with situations in which economic actors may have differing information about a potential market transaction. We show why markets may perform poorly in these cases of “asymmetric information.”

Chapter 16 explores situations in which market transactions affect third parties not directly involved in these transactions. Two general types of such “externalities” provide the focus for this chapter. First we look at environmental externalities—that is, situations where market transactions benefit or harm third parties. We show that in some cases there are effective, market-based solutions to such problems.
A second type of externalities examined in Chapter 16 is “public good” externalities. These arise in situations where people cannot be excluded from benefiting from certain kinds of goods and, therefore, have an incentive to avoid paying for them. The solution to such problems is usually compulsory taxation, although the economic efficiency of that solution may often be open to question as well.

Finally, Chapter 17 takes a brief look at the rapidly expanding field of behavioral economics. We are especially concerned with situations where market participants may make mistakes or have other limits on their rationality. We show that if people make bad decisions, it is possible (though by no means certain) that a paternalistic government can make them better off by suggesting better decisions or prohibiting bad options.
ASYMMETRIC INFORMATION

In previous chapters, we have seen how markets can allocate goods efficiently and examined some of the factors (such as monopoly) that can prevent such a result. In this chapter, we will see that another factor, participants’ lack of full information about the market, can also lead markets to be inefficient. Using game theory, we will analyze a series of models in which one player has better information about the uncertain economic environment than others. This extra information is variously referred to as hidden, private, or asymmetric information. Game theory will enable us to better understand the range of clever strategies that might be used to cope with asymmetric information. Even if market participants can resort to such clever strategies, the market will be less efficient than if all participants had full information.

The tools developed in this chapter will allow us to analyze an array of important and interesting economic situations. How does a boss ensure that an employee is working hard when the boss cannot observe every move the employee makes? How does the firm ensure it hires talented employees when such talent is difficult to measure? Can the employer use a person’s education as a signal of talent? How should a coffee shop set its menu of prices and cup sizes to extract the most money from coffee drinkers, whose demands might be unknown to the shop? Will used-car markets
Asymmetric information

In a game with uncertainty, information that one player has but the other does not.

Principal
Player offering the contract in a principal-agent model.

Agent
Player who performs under the terms of the contract in a principal-agent model.

consist of mostly lemons if buyers cannot judge quality? Will high-risk consumers, the most expensive to insure, be the only ones to buy health insurance? When should a player bluff in poker?

Games of asymmetric information are the focus of much recent research in economics. Given the complexity of the subject, we will only provide a brief overview in this chapter, but it should be sufficient to give you a taste of the exciting developments in this area. We begin with perhaps the simplest setting in which to study asymmetric information, contracts between just two parties where one or the other has better information. Even in this simple setting, called the principal-agent model, a large number of interesting applications can be studied. Then we will move on to more complicated settings.

PRINCIPAL-AGENT MODEL

We will begin our study of games of asymmetric information by focusing on a simple but influential game, called the principal-agent model. The game involves a contract signed between two players in an environment involving uncertainty. The player making the contract offer is called the principal. The player who decides whether to accept the contract or not and then performs under the terms of the contract is called the agent. The agent is typically the party with the private information.

The principal-agent model encompasses a wide variety of applications as shown in Table 15.1. Note that the same party might be a principal in one setting and an agent in another. For example, a company’s CEO is the principal in dealings with the company’s employees but is the agent of the firm’s owners, the shareholders. We will study a number of the applications from Table 15.1 in detail throughout the remainder of the chapter, beginning with two that will help introduce some of the chapter’s main ideas in Application 15.1: Principals and Agents in Franchising and Medicine.

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Problems in principal-agent relationships arise in economic situations as diverse as fast-food operations and the provision of medical care. A closer examination shows that these two situations have much in common.

**Franchising**

Many large businesses operate their local retail outlets through franchise contracts. The McDonald’s Corporation, for example, does not actually own every place that displays the golden arches. Instead, local restaurants are usually owned by small groups of investors who have bought a franchise from the parent company. The widespread use of franchise contracts by McDonald’s and other retailers suggests that they are very useful in solving the principal-agent problems that arise in the industry.¹

One problem that has to be solved is to get retail outlets to operate at the lowest cost possible. Fast food restaurants operate on thin margins; a small cost increase may turn a very profitable outlet into an unprofitable one. Keeping costs low and operations running smoothly requires constant attention by the manager. It seems impossible for central headquarters to monitor the daily operation of thousands of far-flung restaurants. Franchise contracts offer a solution. The franchisee gets to keep a large share of the profits generated by the local restaurant, thereby providing significant incentives to manage it efficiently without direct monitoring.

In solving one problem, franchise contracts raise another. McDonald’s success depends on consistency across restaurants. A customer knows exactly what a McDonald’s hamburger will taste like from Maine to California. A franchisee who only keeps a share of local profits may be inclined to cut costs by cutting quality since the loss of consistency across franchises matters less to the local restaurant than the parent company. Franchise contracts contain additional provisions to help maintain consistent quality. McDonald’s franchisees, for example, must meet certain food-quality and service standards, and they must purchase their supplies (hamburgers, frozen fries, buns, napkins, and so forth) from firms that also meet standards set by the parent company. In return, the franchisee gets some management assistance and enjoys the reputation of the McDonald’s trademark (together with its national advertising).

**Doctors and Patients**

A similar set of problems occurs between physicians and their patients. When people are sick, they often have very little idea of what is wrong or what the most promising treatment is. They place themselves under a physician’s care in the belief that the physician has better information on which to base decisions about the proper course of action. The physician then acts as an agent for the patient. But there are several reasons why a physician might not choose exactly what a fully informed patient would choose. The physician generally pays none of the patient’s bills; to the physician, the price of anything prescribed is essentially zero. Indeed, since the physician may in many instances also be the provider of care, he or she may even benefit financially from the services prescribed. A number of studies have gathered evidence on such physician-induced demand, and most have reported relatively small but significant effects.

**Physicians as Double Agents**

Most medical care consumers have insurance. Because insurance companies must rely on physicians to deliver care, this raises a second principal-agent situation in which the companies need some way to ensure that physicians will not overprescribe care. With traditional fee-for-service insurance, providing such incentives to physicians is very difficult because the company cannot monitor every physician decision. This is one reason that many health care plans have adopted “prepaid” features such as those found in health maintenance organizations (HMOs). Under these plans, insured patients pay an annual fee covering all of their medical needs. That annual fee then becomes a budget constraint for physicians, who now may more carefully consider the costs of the care they deliver.

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The analysis is somewhat different depending on whether the agent has private information about an action under his or her control or about an innate characteristic outside his or her control (the agent’s “type”). See Table 15.1 for some examples of each case. The case of hidden actions is referred to as the moral-hazard problem and the case of hidden types is referred to as the adverse-selection problem. We will study each in turn, beginning with moral hazard.

MORAL HAZARD: MANAGER’S PRIVATE INFORMATION ABOUT EFFORT

We will base our discussion of the moral-hazard problem on the first case from Table 15.1, in which shareholders hire a manager to run the firm for them. The moral-hazard problem is that the manager can increase the firm’s profit by working harder, but the shareholders cannot observe the manager’s effort, and so the manager’s effort cannot be specified directly in a contract. Instead, the shareholders will have to induce the manager to work hard through the design of the manager’s incentive contract, which will link the manager’s pay to firm performance.

The setting can be modeled as a sequential game in which the shareholders move first, offering a contract to the manager, and the manager moves second, deciding whether to accept the contract, and if the contract is accepted, choosing how much effort to expend. We will use the subgame–perfect equilibrium concept, which in this context ensures that

1. the manager accepts the contract if it provides him or her with at least as high a payoff as the best alternative if the contract were rejected; and
2. the manager chooses effort to maximize his or her utility, taking into account contractual pay and effort costs.

In other words, the manager works in his or her self-interest, not in the interest of the shareholders directly. The manager only works in the shareholders’ interest indirectly if incentives are provided in the contract.

The last point is central to our analysis of the moral-hazard problem. When an organization involves more than one individual (here a firm involving shareholders and a manager), it cannot simply be assumed that they act in concert. Such an assumption would be inconsistent with everything we have assumed about the behavior of microeconomic agents. Throughout the text we have assumed that agents act in their own best interest, whether consumers maximizing utility, firms maximizing profit, or players playing best responses in games. Our analysis of the principal-agent problem can be thought of as the natural extension of maximizing behavior to organizations involving more than one party.

Full Information About Effort

Suppose first that shareholders can observe the manager’s effort perfectly. Figure 15.1 provides an illustration of this full-information case. In the top panel, the firm’s gross profit is shown to be increasing in the manager’s effort.
If the shareholders could specify the manager’s effort in a contract, they would choose the level $e^*$ producing the highest joint surplus. In the upper panel, $e^*$ corresponds to the greatest distance between the firm’s gross profit line and the manager’s effort cost curve. In the lower panel, $e^*$ is given by the intersection between the firm’s marginal gross profit curve (MP) and the manager’s marginal effort cost line (MC).

**GROSS PROFIT**

To be clear about the terms used here, “gross profit” will mean revenue minus the cost of all the inputs not including payments to the manager; “profit” without any modifier will mean what it usually does, namely revenue minus the cost of all inputs, including payments to the manager. By distinguishing between gross profit and profit we will be able to focus our attention on payments to the manager that flow from the incentive contract.
In the figure, the units of effort have been chosen so that the gross-profit curve is the 45-degree line, with one unit of effort leading to a $1 increase in gross profit (this is not a crucial point—the gross profit line could have any slope or indeed could be a concave curve). The cost of effort to the employee is increasing and convex. Effort is costly for the manager and becomes increasingly costly at high levels of effort.

The lower panel translates the gross profit and cost curves into their marginal counterparts by taking the slopes of the curves. Here, the efficient outcome (the outcome maximizing the joint surplus of shareholders and manager) is found by equating marginal gross profit for the firm with the marginal cost of effort for the employee, that is, the intersection between the two curves in the bottom panel of Figure 15.1. Effort level \( e^* \) would be the level required by the shareholders if effort were observable and a contract could be written with the manager along the lines of “in order to receive any pay, you need to exert \( e^* \) units of effort.”

**Incentive Schemes When Effort Is Unobservable**

Suppose now that the manager’s effort is not observable and so cannot be specified in a contract. Regardless of what interpretation is given to the term “effort,” it is realistic to assume effort is unobservable. Whether effort is interpreted as concentrating intensely on the job, undertaking productive yet distasteful activities (such as firing employees or issuing negative performance reviews), or doing without expensive perks (such as fancy offices or corporate jets), it is difficult to imagine how shareholders could monitor any of these things well.¹

Although the shareholders may not be able to observe the manager’s effort, they can observe the firm’s balance sheet, and in particular its gross profit, and may be able to provide incentives to exert effort by conditioning the manager’s pay on gross profit. The lines in Figure 15.2 represent incentive contracts. The steeper the slope of the incentive contract, also called the “power” of the incentive contract, the more closely the manager’s pay is tied to gross profit. Line \( S_1 \) corresponds to a constant wage that does not depend at all on how well the firm does. This incentive contract has the lowest-possible power. With lines \( S_2 \) and \( S_3 \), the manager’s pay increases with the firm’s gross profits. Line \( S_2 \) has a moderate slope and thus is a moderate-powered incentive contract. The manager’s pay increases with gross profit, but not very quickly. Line \( S_3 \) is a high-powered incentive contract. The manager’s pay increases one-for-one with gross profit.

Figure 15.3 graphs the marginal pay implied by the incentive contracts from Figure 15.2. Graphically, the marginal pay is the slope of the incentive contract. The marginal pay corresponding to the flat wage, line \( S_1 \), lies along the horizontal axis of Figure 15.3. Higher-powered incentive schemes correspond to higher marginal pay curves. The figure superimposes the manager’s marginal cost of effort from the lower panel of Figure 15.1. The manager’s equilibrium effort is given by the

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¹Some economists believe that, far from being lazy, managers have the opposite problem: they enjoy the prestige of running the biggest firm possible. Managers may try to “build an empire,” authorizing investment projects without regard to their profitability. It would be difficult for shareholders to second-guess which investments were profitable, given that the expertise to make such decisions may have been the reason for hiring the manager in the first place.
FIGURE 15.2  Incentive Contracts

Lines $S_1$, $S_2$, and $S_3$ correspond to various incentive contracts, which link the manager’s pay to the firm’s performance (here, gross profit). The slope of the incentive scheme is also called its “power.” It is a measure of how closely linked the manager’s pay is with firm performance, ranging from no linkage (constant wage, line $S_1$) to a one-for-one linkage (high power, line $S_3$).

FIGURE 15.3  Manager Equilibrium Effort Choice

The manager’s effort choice is given by the intersection of marginal pay and marginal effort cost. The marginal pay associated with constant wage scheme $S_1$ leads to no effort; effort is increasing in the power of the incentive scheme.
intersection between the marginal cost of effort and the marginal pay curves. The flat wage results in no effort ($e_1$). In other words, if the manager’s pay does not depend on the firm’s performance, he or she will have no incentive to exert effort. The medium-powered incentive contract results in moderate effort ($e_2$), and the high-powered incentive contract results in the highest effort of the three ($e_3$).

In sum, although the shareholders cannot observe effort directly, they can induce effort indirectly by having the manager’s pay depend on what can be observed, namely, gross profit. The manager’s effort incentives are determined by the slope of the incentive contract.

We can say more about the equilibrium effort induced by incentive contract $S_3$ from Figure 15.2. Because $S_3$ is the 45-degree line (equivalently, it has a slope equal to 1), it provides efficient incentives for the manager to exert effort. The marginal pay line, which the manager uses along with his or her marginal cost curve to compute equilibrium effort, is the same as the marginal gross profit curve from the bottom panel of Figure 15.1. Thus, the manager chooses the same effort as in the full-information case, $e^*$. This is a general result: the manager can be induced to exert the efficient level of effort, even if there is asymmetric information about effort, by having the manager’s incentive contract increase one-for-one with firm performance.

Incentive contract $S_3$ is equivalent to having the shareholders sell the firm to the manager. The manager captures all the increase in gross profit from an increase in his or her effort. Of course the shareholders would not give the firm’s profit stream away for free; they would require a fixed payment from the manager up front to buy their shares, and the manager would be willing to pay for the right to get all the firm’s gross profit. While having the manager buy out the firm may seem outlandish, during the period 2003–2007, management teams from private equity firms took over hundreds of companies in transactions involving hundreds of billions of dollars.

There are other practical ways of increasing the power of the manager’s incentive scheme besides selling the firm to the manager. The manager can be offered a bonus tied to the performance of the firm. The manager can receive shares of the firm’s stock, the value of which automatically fluctuates with the fortunes of the firm. Stock options, analyzed in Application 15.2: The Good and Bad Effects of Stock Options, are also a popular form of incentive pay for managers.

Problems with High-Powered Incentives

High-powered incentives would seem to solve the moral-hazard problem. Unfortunately, there are factors outside of our simple model that lead to problems with high-powered incentive schemes.

The problem that has received the greatest attention in the economics literature is risk aversion on the part of managers. Suppose that there is uncertainty regarding the firm’s gross profit. While the manager’s effort will increase the chance of high
Stock options grant to the holder the ability to buy shares at a fixed price. If the market price of these shares rises, option holders will benefit because they can buy the stock at less than the market price (and perhaps resell it, making a quick profit). Options are usually granted by firms to their executives as one way of providing incentives to manage the firm in a way that will increase the price of its shares.

### The Explosion in Stock Options

Use of stock options as a form of executive compensation has grown rapidly in recent years. In 1980, most firms did not offer options to their executives and, in those that did, the value of options constituted a fairly small percentage of total compensation. By 2000, top executives of the largest companies received more than half their total compensation in the form of stock options, sometimes amounting to options worth hundreds of millions of dollars. There are many reasons for the increased popularity of stock options as a form of compensation. Rising stock prices throughout the decade of the 1990s undoubtedly made this form of compensation more attractive to executives. From the perspective of firms, the accounting treatment of options (which are often assigned a zero cost to the firm granting them) made them a low-cost way to pay their executives. A special provision in the tax laws enacted in 1993 specified that firms could not deduct executive pay of more than $1 million per year unless that pay was tied to company performance—a further spur to the use of options.

### Incentive Effects of Options

Stock options clearly do succeed in tying an executive's compensation to the performance of a company's stock. By one estimate, stock options provide more than 50 times the pay-to-performance ratio provided by conventional pay packages.1 Dollar for dollar, options also provide more pay-to-performance incentives than would a simple grant of shares to the executive. For example, it would cost the firm $1 million to grant 10,000 shares of $100 stock to an executive. The executive would gain $100,000 from a 10 percent increase in firm value. If the executive were instead given 100,000 options to buy the stock at $100, the executive would gain ten times more ($1 million) from a 10 percent increase in firm value.


But the exact incentive effects of stock options are complex, depending on precisely how the options are granted and the ways in which the stock price for the firm performs. For example, options are less valuable when the firm pays large dividends to its shareholders, so the executive may have an incentive to hold back on dividend increases. For another example, options are more valuable when the price of a company's stock is more volatile. This is because the option holder's gain from stock price increases is unbounded above but is bounded below by zero for falls in the stock price (the option is simply "out of the money"). Options may therefore induce executives to make more risky investments than they ordinarily would.

### Unanticipated Incentive Effects: Accounting Fraud

Executives with significant holdings of stock options can make huge amounts of money if the values of their shares rise. In recent years, it has been common to see executives making hundreds of millions of dollars on such stock price movements. One unintended effect of giving CEOs such a large stake in seeing a higher stock price has been to encourage them to seek to manipulate information that can affect the price of their shares. Executives of the WorldCom Corporation, for example, hid nearly $4 billion in corporate expenses in 2001 so that their company would look more profitable. The firm's CEO benefited handsomely when he bailed out of the firm's stock. Accounting fiascos such as those at Enron and Tyco also seem to have been motivated in part by the desire to keep stock prices up so options holders could benefit. Whether stock-option contracts can be adjusted to reduce the incentives for such actions remains an open question.

### To Think About

1. Michael Eisner, CEO of the Walt Disney Corporation, once received over $500 million in stock options. Do you think he managed the company better than if he had been awarded only $50 million’s worth?
2. If the price of a company's stock declines, stock options may become worthless. What would be the effect of a policy that promised to adjust the purchase price specified in the option contract downward when this happens?
profits, there are other random factors outside of the manager’s control that also may matter. Agricultural output will depend on the weather. Clothing sales may depend on fads in fashion. If gross profit depends on random factors in addition to the manager’s effort, then tying the manager’s pay to gross profit will introduce uncertainty into the manager’s pay. The higher the power of the incentive scheme, the more uncertainty is introduced. Of course a constant wage has no uncertainty. On the other hand, a high-powered incentive scheme such as $S_3$ in Figure 15.2 will cause managerial pay to fluctuate one-for-one with these random economic factors. As discussed in Chapter 4, risk-averse individuals dislike uncertainty; they need to be paid to accept even fair gambles. Introducing uncertainty in the manager’s pay by tying it to uncertain gross profit exposes the manager to risk. Exposing the manager to risk is costly for the shareholders. The manager would trade a lower salary for less risk. The shareholders would profit from trading salary for risk because shareholders typically hold diversified portfolios of small amounts of many different firms’ stock. The benefits of diversification were discussed in Chapter 4. Diversified shareholders are likely to be much less risk averse than the manager and thus able to bear risk at very little cost. In the end, shareholders may prefer to lower the power of the incentive contract and thereby reduce the manager’s risk exposure.

Managerial risk aversion would not prevent the shareholders and manager from attaining the efficient outcome if effort were observable. The manager’s pay could be conditioned directly on effort, which would be in the manager’s control and about which he or she would have no uncertainty. Asymmetric information about effort forces the incentive contract to be conditioned on the firm’s uncertain gross profit rather than effort, which then exposes the manager to risk.

To summarize the main point of this subsection, there is a trade-off between effort incentives and risk. High-powered incentive schemes induce a lot of effort, but expose risk-averse managers to a lot of risk and may require a high fixed payment to the manager to accept the risk. At the other extreme, a constant wage induces no effort but does not expose the manager to any risk. The optimum in the presence of a risk-averse manager may involve some compromise between the two extremes.

There are other problems with high-powered incentives besides risk aversion. First, the manager may not be able to afford to buy out the firm. Second, if the manager gets most of the benefit from increasing gross profit, the shareholders may not take all the steps they can to increase gross profit. For example, the manager of a McDonald’s franchise may be reluctant to sign a contract that has most of his or her pay tied to the franchise’s gross profit if there is the possibility that McDonald’s could open up a second franchise nearby and “steal” some business from the first. The manager of a baseball team may be reluctant to have his salary tied to the team’s winning percentage if he fears the owners may try to save salary expenses by trading away some of the better players. Third, even if the shareholders cannot take actions to affect gross profit, they may have a better idea about the firm’s prospects than an incoming manager. Shareholders might try to recruit the manager by inflating gross profit prospects, making a high-powered incentive contract seem lucrative for the manager. The skeptical manager might instead insist on a constant wage that would be the same whether or not shareholders were honest about prospects for the firm’s gross profit.
Substitutes for High-Powered Incentives

If it is too difficult for shareholders to offer the manager high-powered incentives for the reasons mentioned above, they may have to resort to other strategies to get the manager to work hard. One possibility is monitoring. As discussed above, measuring something as nebulous as effort might be prohibitively difficult. Even if it were possible to measure effort, many of the shareholders may hold so few shares of the firm’s stock that it might not be worth their while to supervise the manager individually. Shareholders could consider hiring someone to supervise the manager. But what would guarantee this supervisor would work hard? The same moral-hazard problems may confront the supervisor as the manager. In addition, there might be an incentive for the manager to bribe the supervisor to issue a good report about his or her efforts.

The possibility of firing the manager may provide crude incentives. Even if the shareholders themselves do not fire the manager, the manager may be fired as a result of a takeover. The way a takeover might work is that a corporate raider might see that a firm’s stock price is low due to an underperforming manager. The raider would buy a controlling share of the firm’s stock, fire the manager, bring in a new management team, and profit from the resulting increased stock price. The initial manager may wish to keep the firm performing well so that the stock price remains too high to be a takeover target.

Another possibility is that the manager works hard to look good for future employers. A successful lower-level manager may be a prime candidate for promotion to a higher level. A CEO who succeeds in running a small firm may be a prime candidate to run a larger firm. It can be argued that such situations may lead agents to overwork. Agents may try to convince potential employers that they are more talented than they really are by substituting hard work for any shortcomings in talent. Potential employers may not be fooled, but in the “rat race” that is the job market, agents may have to overwork just to avoid being mistaken for being less talented than they actually are.

Manager’s Participation

We have discussed part of the manager’s decision problem: the amount of effort she exerts in equilibrium given the terms of the contract. Recall that the effort choice was determined by the slope of the incentive contract. We need to study the decision of the manager to sign the contract to begin with. The decision to sign the contract, called the participation decision, is determined by the level of pay, which, holding the slope of the incentive contract constant, depends on the incentive contract’s intercept. Figure 15.4 draws several incentive schemes with the same slope, so they would induce the same level of effort.

Fixing the slope of the incentive scheme, the intercept of the scheme determines the manager’s participation decision. Depending on the best alternative available to the manager if he or she does not sign the contract, the intercept could be at 0 as with line $S_2$, could involve a positive fixed transfer as in $S_3$, or could involve negative fixed transfer (that is, a payment from the manager to the firm for the right to participate) as in $S_1$. The shareholders will choose the lowest intercept subject to having the manager participate.
but with different intercepts. Line $S_2$ has an intercept at 0. This is a pure profit-sharing arrangement. If no gross profit is earned, the manager gets no pay. Above that, the manager gets a share of the gross profit. Line $S_3$ has a positive intercept, equal to the fixed part of the manager’s pay earned even if the firm does not make any gross profit. This contract could be implemented by providing the manager with a fixed salary together with incentive pay in the form of bonuses, stock, or stock options. There is even the possibility of requiring a payment from the manager to participate, as with $S_1$. The manager has to “buy in” to participate. Such contracts are sometimes seen in franchising. A potential manager of, say, a McDonald’s franchise, is often required to put up some money to set up the local franchise, in return for a share of the franchise profits. This would correspond to a negative intercept as in $S_1$.

Among $S_1$, $S_2$, $S_3$, and other incentive schemes with the same slope, shareholders would offer the one with the lowest intercept the manager would be willing to accept. This leaves as much gross profit as possible for shareholders.

Summing Up

To sum up, it is natural to ask how the results in the presence of the moral-hazard problem accord with the results from the standard model of a perfectly competitive market with no asymmetric information. First, the presence of moral hazard raises the possibility of slack and inefficiency completely absent in the standard model. The manager does not exert as much effort as he or she would if effort were observable. Even if shareholders do the best they can in the presence of asymmetric information to provide incentives for effort, they must balance the benefits of incentives against the cost of exposing the manager to too much risk.

Second, although the manager can be regarded as an input like any other (capital, labor, materials, and so forth) in the standard model, in the presence of the moral-hazard problem the manager becomes a unique sort of input. It is not enough to pay a fixed unit price for this input as a firm would the rental rate for capital or the wage rate for labor. The manager’s productivity depends on the detailed structure of his or her compensation.

News reports on the recent meltdown of the financial system and government bailouts have widely cited the role of moral hazard in the crisis. Application 15.3: Moral Hazard in the Financial Crisis discusses how the concepts from this chapter can help make some sense of these news reports.

**ADVERSE SELECTION: CONSUMER’S PRIVATE INFORMATION ABOUT VALUATION**

Next we turn to the other main issue in the principal-agent model, the adverse-selection problem. In contrast to the moral-hazard problem, in which the agent has private information about an action he or she chooses after the contract is signed, with the adverse-selection problem, the agent has private information about his or her type (an innate characteristic) before the contract is signed.
Moral Hazard in the Financial Crisis

The term “moral hazard” has been used over and over again in the context of news stories about the recent financial crisis, a crisis some commentators think may send the global economy into a severe and prolonged recession. In this application, we will try to understand the use of the term in this context and connect it to the concepts introduced in this chapter.

Scope of the Crisis
As of this writing, the global economy is experiencing a severe financial crisis. All the major U.S. investment banks have failed, been taken over, or changed their status to commercial banks. Numerous commercial banks have experienced “runs” (races by depositors to withdraw funds before the bank runs out of reserves) or have failed. Access to credit for banks, firms, and consumers has essentially frozen. Global stock markets have experienced precipitous declines.

Although all the causes of the crisis are not yet fully understood, an important contributing factor seems to have been the bursting of the housing bubble. The sharp fall in house prices reduced the value of the mortgage loans and derivative securities held by investment and commercial banks. Banks’ losses were magnified because they borrowed to buy more of these securities, effectively “doubling down” on their housing market bet, a bet that promised huge gains if the housing market remained strong, but huge losses if not. The complexity of the securities combined with the uncertain direction of the global economy makes it difficult to have a clear forecast of banks’ and other firms’ solvency. In the face of this uncertainty, investors are reluctant to invest in anything other than government bonds, causing private credit markets to freeze up.

Government Bailouts
The U.S. and other governments have pursued radical policies to prevent further unraveling of the financial system, fearing that large bank failures and frozen credit markets would spread like a contagious disease, causing other bank failures and worsen the forecast economic recession. The U.S. Treasury facilitated the takeover of the investment bank Bear Steams by lending the purchaser, J.P. Morgan, nearly $30 billion on favorable terms (taking Bear Steams’ risky investments as collateral). Congress passed a $700 billion plan to bail out banks by having the government buy their troublesome mortgage and derivative securities, presumably at above-market prices. Most recently, governments around the world have begun supplying banks with additional capital by purchasing shares of bank stock.

Moral Hazard
Think of the government as the principal and a bank as an agent. The government/principal would like the bank/agent to behave in a prudent way (“effort” in this context) so that it does not have to be bailed out and so that it does not harm other banks that are interconnected with it in the financial system. The government tries to encourage prudent behavior through regulation and through the terms of the bailout. However, bailout policies such as buying up a bank’s bad securities at above-market prices or supplying capital to poorly performing banks have the same effect as reducing the power (slope) of the incentive scheme in Figure 15.2. Insulating the bank from some of the losses from its imprudent behavior provides the bank with less incentive to behave prudently.

The U.S. government took some measures to avoid setting a precedent that would encourage imprudent behavior. With the Bear Steams merger, it initially only agreed to facilitate the deal if the price offered to Bear shareholders was sufficiently low to serve as a punishment ($2, down from an historical high of $172). It refused to bail out another huge investment bank, Lehman Brothers. Provisions were added to the $700 billion bailout plan to punish participating CEOs by eliminating “excessive” pay, bonuses, and severance packages.

To Think About

1. What bailout policies seem to be working to calm financial markets? Now that governments are engaged in bailouts, is the media continuing to report on moral hazard as a significant problem in the financial markets?
2. In the absence of legally binding contracts, a principal can still mitigate agent moral hazard by maintaining a reputation that it will let the agent suffer for its actions even if this harms the principal in the short run, too. What other areas of life besides bank regulation do we observe principals trying to build such reputations?

1See, for example, D. Henninger, “Welcome to ‘Moral Hazard’,” Wall Street Journal (October 2, 2008): A17.
To make the analysis concrete, we will consider the application in which the principal is a monopoly firm and the agent is a customer. Consumers differ in how much they value the good, but these valuations are not observable to the monopolist. The monopolist offers the customer a menu of different-sized bundles at different prices. This setup is identical to the model of second-degree price discrimination studied in Chapter 11. With second-degree price discrimination, the monopolist is not restricted to a constant price per unit but rather offers a menu of bundles at different prices, perhaps involving price discounts for large purchases, and has the consumers select bundles from the menu themselves. We will build on the earlier analysis by being slightly more detailed here and highlighting the important features of the adverse-selection problem.

Examples of this sort of second-degree include a coffee shop’s offering a 12-ounce cup at $1.50 and a 24-ounce cup at $2.50. Bundles can be distinguished by quality instead of quantity as well. Airlines’ first class has plusher seats, more leg room, and better meals than coach class, comforts that may cost three or four times the coach fare. How does the monopolist decide on such a menu of quantity/price bundles or quality/price bundles, which constitutes, in effect, the contract offered to the customer? We will investigate this question carefully in the next several subsections.

**One Consumer Type**

In this section we examine the monopolist’s problem of selling a bundle to consumers who all obtain the same surplus from the good—that is, they are all the same type. To simplify the analysis, we will consider a single representative consumer. Whatever the size of the bundle the monopolist chooses to offer, it may as well ask the highest price for the bundle that the consumer would be willing to pay. The most the consumer would pay for the bundle rather than doing without it is called **gross consumer surplus**. Gross consumer surplus is related to (ordinary) consumer surplus, defined in Chapter 3. Both are measures of consumers’ valuation for a good. Whereas consumer surplus subtracts the amount the consumer pays for the bundle from the amount the consumer would be willing to pay, gross consumer surplus does not. Consider Figure 15.5, which reproduces the figure originally used to define consumer surplus (Figure 3.11). Gross consumer surplus equals the whole area under the demand curve, the shaded triangle and rectangle. Consumer surplus subtracts the amount paid for the good (the shaded rectangle), leaving just the shaded triangle. Since we are interested in computing how much the consumer is willing to pay for the bundle, the measure that does not subtract off consumer payments, gross consumer surplus, is the relevant concept here.

The example from Figure 3.11 had a consumer with demand curve \( d \) buying 20 shirts at a price of $7 per shirt. Consumer surplus is given by the shaded triangle, and gross consumer surplus by the shaded triangle and rectangle.
difference between the revenue received from selling the bundle at the highest price it can charge and the cost of producing the bundle. In the top panel of Figure 15.6, the monopolist’s profit is the vertical distance between the gross consumer surplus and total cost curves. The profit-maximizing bundle \( q^* \) maximizes this distance. Equivalently, in the lower

**Micro Quiz 15.2**
Refer to Figure 15.5.
1. Compute consumer surplus.
2. Compute gross consumer surplus.

**Figure 15.6** Profit-Maximizing Bundle with One Consumer Type

Facing a single, representative consumer, the monopolist chooses a bundle \( q^* \) maximizing the consumer’s and monopolist’s combined surplus, found in the upper panel as the greatest vertical distance between gross consumer surplus and the total cost curves or equivalently in the lower panel by the intersection of the marginal consumer surplus and marginal cost curves. The monopolist charges a bundle price equal to the shaded area (\( A \) and \( B \)) and earns profit equal to the area of \( A \).
panel of the figure, \( q^* \) is given by the intersection of marginal surplus \( MS \) (the slope of the gross consumer surplus curve) and the monopolist’s marginal cost \( MC \). Just as in Figure 15.5, where gross consumer surplus equals the area under the demand curve down to the horizontal axis, in Figure 15.6 gross consumer surplus from the bundle equals the area under the marginal surplus curve up to \( q^* \). that is, the shaded area \( A \) and \( B \) on the graph. The monopolist receives this amount as revenue from the bundle. The monopolist’s profit equals the shaded area minus the shaded rectangle \( B \), which represents the total cost of producing this bundle, leaving triangle \( A \) for profit.

Two Consumer Types: Full Information

If the monopolist has full information about types and can act on this information (that is, can require a consumer to buy only the bundle directed at his or her particular type and not some other bundle and can prevent consumers from selling repackaged bundles among themselves), the analysis of two consumer types adds nothing new to the analysis of one consumer type. Figure 15.7 provides a graph for the two-type case that is related to the bottom panel of Figure 15.6. There is still one representative consumer, but with certain probability the consumer may have a high value for the product (the “high-value type”) and with complementary probability may have a low value (the “low-value type”). The marginal consumer surplus for the high-value type lies above the low-value type’s.

The profit-maximizing bundle for the low-value type involves \( q_L \) units, given by the intersection between the low type’s marginal consumer surplus and the monopolist’s marginal cost. The bundle price equals the area of the shaded regions \( (A \) and \( B) \). The monopolist’s profit equals the area of region \( A \). Similarly, the profit-maximizing bundle for the high-value type involves \( q_H \) units given by the intersection between the high type’s marginal consumer surplus and the monopolist’s marginal cost. The bundle price equals the area of the entire shaded region \( A, B, C, \) and \( D \), and the monopolist’s profit equals the areas of \( A \) and \( C \).

Two Consumer Types: Asymmetric Information

The menu of bundles that maximized profit in the full information case will not work if the monopolist cannot observe the consumer’s types. The \( q_L \)-unit bundle meant for the high-value type is priced to extract all of his or her consumer surplus. The high type would obtain positive surplus from instead purchasing the \( q_L \)-unit bundle meant for the low-value type. Figure 15.8 shows why. The high type’s gross consumer surplus from the \( q_L \)-unit bundle equals the area under the marginal consumer surplus curve up to the quantity \( q_L \), that is, the area of the shaded regions \( A, B, \) and \( C' \). After subtracting off the bundle’s price (the dark-shaded areas \( A \) and \( B \)), the high-value type is left with positive surplus equal to the area of the light-shaded region \( C' \). This is better than purchasing the \( q_H \)-unit bundle and getting no surplus.

The \( q_H \)-unit bundle sold at a price that extracts all of the high type’s consumer surplus is not incentive-compatible. Left to choose between the two bundles, the high type would have an incentive to choose the bundle meant for the other type. The \( q_H \)-unit bundle could be made incentive-compatible for the high type by
Facing a high-value and low-value consumer, the monopolist chooses bundles given by the intersections between marginal cost and each type’s marginal consumer surplus. The high type receives a larger bundle, $q_H$, than the low type, $q_L$.

The menu of bundles from Figure 15.7, reproduced here, would not be incentive compatible. The high-value consumer would gain surplus equal to the area of region $C'$ by purchasing the $q_L$-unit bundle meant for low-value consumers rather than the $q_H$-unit bundle.
reducing its price so that the high type would be left with at least as much surplus as if he or she bought the $q_L$-unit bundle. In particular, the price for the $q_H$-unit bundle would have to be reduced by the area of region $C'$ (and so equal the combined area of regions $A$, $B$, $C''$, and $D$).

The monopolist can do even better than this. The monopolist can reduce the quantity associated with the bundle meant for the low-value type. On the one hand, reducing quantity reduces the profit from the sale of the bundle to low-value consumers. But a bigger effect is that the bundle meant for the low-value type becomes much less attractive to the high-value type. The high-value type places a high value on quantity, and a reduction in quantity “scares him or her off” from choosing the low-value bundle. As a result, the monopolist does not need to leave the high type with as much surplus, and can raise the price charged for the $q_H$-unit bundle.

The profit-maximizing bundles are shown in Figure 15.9. Reducing the quantity in the low type’s bundle from $q_L$ to $q'_L$ does reduce the profit from sales to low-value consumers, by an amount equal to the cross hatched triangle, $E$. But this reduction in quantity makes the low type’s bundle much less attractive to the high type. After all, the high type obtains high marginal consumer surplus from additional units and so loses a lot if quantity is reduced. The price at which the $q_H$-unit bundle is sold can be increased by the area of the hatched region and still be incentive-compatible, that is, still ensure that the high type buys the $q_H$-unit, $F$, bundle rather than the bundle meant for the low type.

**Figure 15.9** Profit-Maximizing Bundles Under Asymmetric Information

By reducing the quantity associated with the low type’s bundle, the monopolist reduces the profit from sales to low types by the area of the triangle, $E$. This loss is more than offset by the fact that the low type’s bundle is less attractive to high types, and so the price charged to high types for the $q_H$-unit bundle can be increased (by the area of $F$).
By distorting the low type’s quantity, the monopolist sacrifices efficiency. The low type would be willing to pay more than what it costs to increase the size of his or her bundle. The monopolist’s gain is that it can squeeze more revenue out of the high type. As shown in Figure 15.9, the revenue squeezed from the high type (the area of region $E$) can be much larger than the loss from selling an inefficiently small bundle to the low type (the area of triangle $E$).

How much the monopolist distorts the low type’s quantity downward depends on how many consumers are of each type. If there are a lot of low-value consumers, the monopolist would not be willing to distort the quantity in their bundle very much, since the loss from this distortion would be substantial and there would not be many high-value consumers from whom to squeeze additional revenue. The more high-value consumers, the more the monopolist is willing to distort the quantity in the low type’s bundle downward. Indeed, if there are enough high-value consumers, the monopolist may decide not to serve the low-value consumers at all and just offer one bundle that would be purchased by the high types. This would allow the monopolist to squeeze all of the surplus from the high types, because they would have no other option left.

**Examples**

Consider the example of a coffee shop. Suppose it offers two cup sizes: small, directed at the typical coffee drinker, and large, directed at the true coffee hound. As a thought experiment, suppose the shop can identify which consumers are typical and which are coffee hounds and can force each type to buy the cup meant for it (so, for example, anyone identified as a coffee hound would be forbidden to buy one or more small cups of coffee). The profit-maximizing menu in this thought experiment might involve selling a 12-ounce cup for $1.50 to typical coffee drinkers and a 24-ounce cup for $5.00 to coffee hounds, extracting all the surplus from both.

Now leave this thought experiment aside and suppose, more realistically, that there is asymmetric information about types. The shop would not know which consumers are coffee hounds and so could not prevent them from buying the small cup. Coffee hounds indeed would buy the small cup, unless the price of the large cup were reduced, say to $2.00. The coffee shop could do even better by reducing the size of the small cup, say to 8 ounces, and selling it for a lower price, say $1.25. This would make the small cup less attractive to coffee hounds and allow the shop to increase the price for the large cup, say to $2.50. Notice that the coffee shop is not squeezing all of the profit out of the typical coffee drinker that it could. The typical coffee drinker may be willing to pay the extra 25 cents for 4 more ounces of coffee, and the marginal cost of these additional 4 ounces may be just a few pennies. But if a 12 ounce cup were available, coffee hounds may not be willing to pay as much as $2.50 for the 24 ounce cup. The size of the small cup is reduced, not to harm the typical coffee drinker, but to squeeze more revenue out of the coffee hounds. If enough customers are coffee hounds, the shop may decide only to offer the large cup at the price of $5.00 that extracted all of the coffee hound’s surplus in the thought experiment. The shop would effectively have full information about the consumer’s type because only coffee hounds would show up to buy at such a high price.
The same logic holds for airplane fares reinterpreting \( q \) to be the quality level of a single flight rather than the quantity in a bundle. Consumers only demand one flight at any one time, but the quality of that flight may vary depending on the size of the seat, the quality of the meal, and other amenities together represented by \( q \). The airline might offer two or three different classes of travel on one flight, say coach, business, and first class. The typical coach-class passenger may be willing to pay more than the marginal cost of expanding the seat size and serving a better meal: it may only cost, say, $50 (in terms of a larger airplane, more fuel, and better food ingredients) to gain enough leg room and to serve a decent enough meal to make the coach-class flight reasonably comfortable. But the airline may still keep coach seats small and limit meals. If coach class is too comfortable, there may be little reason for business- and first-class passengers to pay the exorbitant prices for those seats. Some discomfort in coach class “scare” business-class and first-class passengers from buying coach tickets.

Agent’s Participation

We have discussed one important issue with adverse selection in the principal-agent model: the contract has to be structured so that it is incentive compatible for the high types. The only remaining issue is the agent’s participation decision. In the monopoly-consumer application, consumers must choose to buy a bundle rather than go without. The high types earn positive surplus, so there is no question that they participate. The price for the low types’ bundle must be low enough that they purchase as well: the price must be no greater than their gross consumer surplus from the bundle (the area of shaded regions A and B in Figure 15.9). There is one case in which the low types’ participation decision does not matter. This is when, as discussed above, the monopolist does not bother to serve the low types and only offers a bundle to the high types.

Adverse Selection Leads to Inefficiency

It is worth emphasizing how adverse selection affects the efficiency of markets. Compared to the standard model in which firms have full information, market outcomes are typically less efficient in the presence of the adverse-selection problem. Output is lower. The monopolist sacrifices efficiency in order to extract more surplus from some consumer types.

WARRANTY AND INSURANCE CONTRACTS

Moral-hazard and adverse-selection problems present themselves in a unique way when the firm sells not a simple good such as coffee but a more complicated contract such as a warranty or insurance to the consumer. Whereas a cup of coffee costs the same to make regardless of to whom it is sold, the cost of fulfilling a contract may depend on the consumer’s action (moral hazard) or the consumer’s type (adverse selection).

Consider a warranty promising to replace a lawn mower with a new one if the first one breaks down. Whether the mower breaks down depends on its quality
(indeed, the warranty was presumably offered in the first place to address consumer concerns about the risk of low quality). But whether the mower breaks down also depends on consumer behavior. Does the customer operate it carefully, not smashing into fences and running over stumps? With an unconditional warranty, the consumer will have little incentive to prevent the mower’s breaking down by being careful. This will result in a higher number of mowers breaking down and being returned, and a higher replacement cost for the firm, than if the customer was more careful. Because the customer’s care is likely to be unobservable, there is little left for the firm to do except perhaps raise the price of the warranted good to reflect the higher cost or limit the terms of the warranty.

Lawn mower warranties may also lead to an adverse-selection problem. More careless users and also more intensive users will be attracted to mowers carrying full warranties, because the firm will bear the high cost of likely replacement instead of the consumer. An increase in the percentage of these “high-cost” consumers will force the firm to raise price in equilibrium, which may lead careful customers to drop the good and substitute instead toward a less-expensive good with more limited or no warranties. These effects may continue to spiral until only the most intense or careless users buy the good with the full warranty.

The same effects arise with insurance. Insurance shifts losses from the customer to the insurance company. This reduces the customer’s incentive to take care to avoid the loss, the moral-hazard problem again. The consumer is less inclined to drive carefully, buy fire extinguishers and alarms, lock the doors against thieves, eat well to avoid heart disease, and so forth. This inefficient care leads insurance to be more expensive than it would otherwise be. Often the only recourse the insurance company has to solve the problem is to provide less than full insurance (requiring some coinsurance or deductibles) so as to provide at least some incentive for the customer to take care.

As Application 15.4: Adverse Selection in Insurance discusses, the adverse-selection problem presents itself in an interesting way in insurance markets. The riskiest consumers obtain the most benefit from insurance, and so gravitate toward the fullest insurance policies, yet these are the consumers who are the most expensive to serve. This may lead insurance companies to try to find observable indicators of risk, so that the riskier consumers can be charged higher prices or be refused insurance. If companies cannot sort consumers based on observable characteristics, they can resort to menus with options involving more complete insurance, targeted at the higher risk classes, requiring significantly higher premiums. If the insurance company cannot resort to these strategies, it may be forced to raise prices, driving less-risky consumers (better drivers, owners of houses in safer areas, people with no known family history of disease) toward less complete insurance or, in the extreme, leading them to go without insurance.

As we have seen previously, with warranty and insurance markets the presence of private information (in the form of either the moral-hazard or adverse-selection problem) leads to inefficiency. It would be efficient for risk-neutral companies to provide full coverage to risk-averse consumers. But this may not happen in equilibrium with asymmetric information. The firm may only offer partial warranty or insurance coverage, perhaps imposing deductibles or copayments. “Safer” consumers may be priced out of the market entirely.
Adverse Selection in Insurance

The earliest application of the idea of adverse selection, and indeed the genesis of the term itself, was in the study of insurance markets. As we saw in Chapter 5, actuarially fair insurance can increase the utility of risk-averse individuals, implying that individuals who face very different probabilities of loss should pay different insurance premiums. The difficulty faced by insurers in this situation is in estimating an individual’s probability of loss so that insurance can be correctly priced. When insurers possess less information than do insurance buyers, adverse selection may undermine the entire insurance market.

A Theoretical Model
This possibility is illustrated in Figure 1, which assumes that two individuals initially face identical consumption prospects represented by point A. If person 1 has a relatively low risk of incurring state 2, costs of insurance will be low and this individual’s budget constraint is given by AE. If insurance is fairly priced, this risk-averse individual would choose to fully insure by moving to point E on the certainty line. For person 2, losses are more likely. Fair insurance costs are represented by AF. This person, too, might choose to be fully insured by moving to point F. If the insurance company cannot tell how risky a particular customer is, however, this twin solution is unstable. Person 2 will recognize that he or she can gain utility by purchasing a policy intended for person 1. The additional losses this implies means that the insurer will lose money on policy AE and will have to increase its price, thereby reducing person 1’s utility. Whether there is a final solution to this type of adverse selection is a complex question. It is possible that person 1 may choose to face the world uninsured rather than buy an unfairly priced policy.¹

Safe-Driver Policies
Adverse selection arises in all sorts of insurance, ranging from life insurance to health insurance to flood insurance to automobile insurance. Consider the case of automobile insurance. Traditionally, insurers have used accident data to devise group rating factors that assign higher premium costs to groups such as young males and urban dwellers, who tend to be more likely to have accidents. Such rate-setting procedures sometimes come under political attack as unfairly lumping both safe and unsafe drivers together. A 1989 ballot initiative in California, for example, sharply limited the use of rating factors by requiring them to be primarily individual-based rather than group-based. Because data on individuals are hard to obtain and are not very good at predicting accidents, the main result has been to force rates together for all groups. The main beneficiary of the law seems to have been young male drivers in Los Angeles. Figure 1 suggests that individuals in safer groups (females and rural California residents) may have been the losers.

To Think About
1. How are low-risk individuals made worse off by adverse selection?
2. Can you think of other types of situations where risk ratings might differ among individuals? How would you decide which risk differences should be reflected in differences in rates and which should not?

ASYMMETRIC INFORMATION IN COMPETITIVE MARKETS

The principal-agent model studied so far is a very simple setting since it involved just a single principal and a single agent. (Sometimes the agent was a representative of a larger population, but this did not complicate the analysis since the agents did not directly compete.) In this section, we will see how the results change in a market setting, with competing agents, or competing principals, or both.

Moral Hazard with Several Agents
Adding agents to the basic principal-agent model can make the moral-hazard problem better or worse, depending on the details of the setting. Suppose first that a single principal needs to hire a team of several agents to perform a task. The moral-hazard problem may be more severe in this setting. Each of the agents may slack off, relying on the efforts of the others. In large teams, it may be difficult to identify who is working hard and who is not, possibly leading all of them to slack. It is hard to provide a large number of agents with high-powered incentives because even if the firm is sold to the team of them, each would only obtain a small fraction of the firm’s gross profit.

On the other hand, if there are many agents in the market, but each works for a separate firm/principal, moral hazard may be less of a problem than it would be with one agent. By comparing the performance of their own firms with that of others’, uncertainty about agents’ efforts can be reduced. If a firm’s gross profit is low, but so are the gross profits of similar firms, it can be inferred that the poor performance was due to random market forces rather than the agent’s slacking off. On the other hand, if all firms but one perform well, it becomes increasingly clear that the one agent had slacked off. Such comparisons are most useful when firms operate in similar lines of business that are exposed to similar market forces.

Auctions and Adverse Selection
With the adverse-selection problem, how the results change when players are added also depends on the specifics of the situation. Consider the monopoly-consumer model, but suppose the monopoly has a limited number of units to sell to several competing consumers (if the monopoly produced an unlimited amount at a constant marginal cost, consumers would not end up competing even if there were many of them, so nothing would change from our previous analysis of the adverse-selection problem). The result would be an auction setting. Auctions have received a great deal of attention in the economics literature since William Vickery’s foundational work for which he won the Nobel Prize in economics.² Auctions continue to grow in significance as a market mechanism, used for selling goods ranging from airwave spectrums, to Treasury bills, to foreclosed houses, to collectibles on the Internet auction site eBay.

Competition among consumers in an auction can help the monopolist solve the adverse-selection problem. High-value consumers are pushed to bid high to avoid losing the good to another bidder. The exact outcome of the auction depends on the nature of the economic environment (which consumers know what information when) and the auction format.

There are a host of different auction formats. Auctions can involve sealed bids or open outcries. Sealed-bid auctions can be first price (the highest bidder wins the object and has to pay his or her bid) or second price (the highest bidder still wins but only has to pay the next-highest bid). Open-outcry auctions can be ascending, as in the so-called English auction when buyers yell out successively higher bids until no one is willing to top the last, or descending, as in the so-called Dutch auction when the auctioneer starts with a very high price and lowers it continuously until one of the participants stops the auction by accepting the price at that point. The monopolist can decide whether or not to set a “reserve clause,” which requires bids to be over a certain threshold or else the object will not be sold. Even more exotic auction formats are possible. In an “all-pay” auction, for example, bidders pay their bids even if they lose.

A powerful and somewhat surprising result due to Vickery is that in simple settings (risk-neutral bidders who each know their valuation for the good perfectly, no collusion, and so forth), many of the different auction formats listed previously (and more besides) provide the monopolist with the same expected revenue in equilibrium. To see why this result is surprising, consider two formats in more detail, a first-price, sealed-bid auction and a second-price, sealed-bid auction. Suppose that a single object is to be auctioned. In the first-price, sealed-bid auction, all bidders simultaneously submit secret bids. The auctioneer unseals the bids and awards the object to the highest bidder, who pays his or her bid. In equilibrium, bidders bid strictly less than their gross consumer surplus for the object (we will call this their valuations for short). Bidders would receive zero surplus from bidding their valuations (losing bidders get no surplus; the winning bidder would have to pay his or her entire surplus back to the monopolist and again get no surplus). By bidding less than his or her valuation, there is a chance that others’ valuations, and thus bids, are low enough so that the bidder wins the object and makes a positive surplus.

In a second-price, sealed-bid auction, the highest bidder pays the next-highest bid rather than his or her own. In this auction format, a bidder’s dominant strategy is to bid his or her valuation. This is an interesting result in its own right and worth analyzing in some detail. Let \( b_1 \) be player 1’s bid and \( b_2 \) be player 2’s. Table 15.2 presents the normal form for the game. It is partial in that it only shows player 1’s payoffs and only shows two strategies for player 1, bidding his or her valuation \( (b_1 = 50) \) and bidding less \( (b_1 = 30) \). Looking at the first column of the matrix, if \( b_2 < 30 \), player 1 wins the object, pays \( b_2 \), and obtains payoff \( 50 - b_2 \) whether he or she bids 30 or 50. The payoffs from the two strategies tie. Looking at the last column, if \( b_2 > 50 \), player 1 loses the object and gets payoff 0 whether he or she bids 30 or 50. Again, the payoffs from the two strategies tie. Looking at the middle column, however, if \( b_2 \) is between 30 and 50, then bidding 50 is better than 30 for player 1 because he or she loses the object and earns a payoff of 0 by bidding 30 but wins the object and earns payoff \( 50 - b_2 > 0 \) by bidding 50. As the underlined
payoffs indicate, bidding 50 is always at least as good for player 1 as bidding 30 and is strictly better against some of player 2’s strategies. Similar arguments can be used to show that bidding 50 dominates any of player 1’s alternatives, implying that bidding 50 is a dominant strategy for player 1.

With an understanding of equilibrium bidding in second-price auctions, we can compare first- and second-price, sealed-bid auctions. Each format has plusses and minuses regarding the revenue the monopolist earns from it. On one hand, bidders shade their bids below their valuations in the first-price auction but not in the second-price auction, a “plus” for second-price auctions. On the other hand, the winning bidder pays the highest bid in the first-price auction but only the second-highest bid in the second-price auction, a “plus” for first-price auctions. The surprising result is that these plusses and minuses balance perfectly so that they both provide the monopolist with the same expected revenue.

In more complicated settings, the long list of different auction formats do not necessarily yield the same revenue. One complication that is frequently considered is to suppose that the good has the same value to all the bidders but they do not know exactly what that value is. Each bidder only has an imprecise estimate of what that value might be. For example, bidders for oil tracts may have each conducted their own surveys of the likelihood that there is oil below the surface. All bidders’ surveys taken together may give a clear picture of the likelihood of oil, but each one separately may only give a rough idea. For another example, the value of a piece of art depends in part on its resale value (unless the bidder plans on keeping it in the family forever), which in turn depends on others’ valuations; each bidder knows his or her own valuation but perhaps not others’. Such a setting is called a common-values setting.

<table>
<thead>
<tr>
<th>Bidding Valuation 50 is Player 1’s Dominant Strategy in a Second-Price Auction</th>
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<tr>
<td>( b_2 ) &lt; 30</td>
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<td>( b_1 = 30 )</td>
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<td>( b_1 = 50 )</td>
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Micro Quiz 15.3

The analysis in Table 15.2 shows that player 1 prefers to bid 50 (his or her valuation) rather than 30 (a lower bid than his or her valuation). Use a similar analysis to show that player 1 would prefer to bid 50 than 70 (a higher bid than his or her valuation).

Common-values setting

Object has the same value to all bidders, but each only has an imprecise estimate of that value.
The most interesting new issue that arises in a common-values setting is the winner’s curse. The winning bidder realizes that every other bidder probably thought the good was worth less than he or she did, meaning that he or she probably overestimated the value of the good. The winner’s curse sometimes leads inexperienced bidders to regret having won the auction. Sophisticated bidders take account of the winner’s curse by shading down their bids below their imprecise estimates of the value of the good, so that they never regret having won the auction in equilibrium.

Analysis of the common-values setting becomes complicated, and the different auction formats listed here no longer yield equivalent revenue. Roughly speaking, auctions that incorporate other bidders’ information in the price paid tend to provide the monopolist with more revenue. For example, a second-price auction tends to be better than a first-price auction because the price paid in a second-price auction depends on what other bidders think the object is worth. If other bidders thought the object was not worth much, the second-highest bid will be low and the price paid by the winning bidder will be low, helping to solve the winner’s curse problem.

The Market for Lemons

Whereas in the auction setting we supposed there was a single seller who was matched with several potential buyers, we could imagine markets in which many buyers and many sellers are matched. A particularly intriguing problem may arise in such markets if each seller has private information about the quality of the good he or she is selling. As George Akerlof showed in the article for which he won the Nobel Prize in economics, in equilibrium sometimes only the lowest-quality goods, the “lemons,” get sold.¹

To gain more insight about this result, consider the used-car market. Suppose used cars are of two types (good cars and lemons) and only the owner of a car knows which type his or her car is. Since buyers cannot differentiate between good cars and lemons, all used cars of a particular type will sell for the same price—somewhere between the true worth of the two types. The owner of a car will choose to keep his or her car if it is a good one (since a good car is worth more than the prevailing market price) but will sell the car if it is a lemon (since a lemon is worth less than the market price). Consequently, only lemons will be brought to the used-car market, and the quality of cars traded will be less than expected.

The lemons problem leads the market for used cars to be much less efficient than it would be in the standard competitive model in which quality is known (indeed, in the standard model, there is no issue about knowing the quality of different goods, since typically they all are assumed to be of the same quality). Whole segments of the market disappear—along with the gains from trade in these segments—because higher-quality items are no longer traded. In the extreme, the market can simply break down with nothing being sold (or perhaps just a few of the worst items).

The lemons problem can be mitigated by trustworthy used-car dealers, by development of car-buying expertise by the general public, by sellers providing proof that their cars are trouble-free, or by sellers offering money-back guarantees.

But anyone who has ever shopped for a used car knows the problem of potential lemons is a very real one. Application 15.5: Looking for Lemons discusses the evidence for the lemons problem in markets ranging from trucks to baseball free agents.

SIGNALING

Our analysis of the adverse-selection problem so far has mainly focused on the case in which the uninformed party makes the first move, offering a contract to the party with private information. For example, the monopolist made the first move by offering a menu of different bundles to consumers, who had private information about their valuations (their types); consumers moved next by choosing which bundle to purchase.

The reverse is also possible. The player with private information can take the first action and thereby signal something about his or her type. Examples abound. A student may seek additional education as a signal that he or she is unusually talented to prospective employers. A person may drive a fancy car as a signal of wealth to prospective spouses or buy large diamond rings as a signal of his or her affection. A professional-looking Web site may signal to customers that the business is not a fly-by-night operation. An incumbent firm may price low to convince future entrants that it is a “tough” competitor. A high bet may signal that a poker player has a good hand (though the player may be bluffing).4

In formal terms, such settings are known as signaling games. In a signaling game, Nature moves first, choosing the first player’s type at random from a number of possibilities. The first player’s type is private information, unknown to the second player, who only knows the probabilities that Nature might choose one type or the other. The first player makes a move called a signal since it is observed by the second player. Based on the information provided by the signal, the second player updates his or her beliefs about the first player’s type. Then the second player chooses his or her move and the game ends.

Spence Education Model

We will analyze signaling games in terms of a single application, Spence’s education model,5 named after Michael Spence, who received the Nobel Prize in economics for developing it (a prize shared with George Akerlof, encountered earlier in the lemons problem, and Joseph Stiglitz, another foundational contributor to the economics of asymmetric information). Workers have an equal chance of being one of two types, high skill or low skill. A low-skill worker generates no producer surplus for the firm, and a high-skill worker generates gross profit $\pi$ (where gross

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4The lemons problem can be thought of as a version of a signaling model. By offering a car for sale, the seller is signaling something about the quality of the car, namely, that the car is not so high quality that the seller is willing to keep it rather than selling it at the going market price. Of course, this is a signal that the seller would rather not send.

Economists have spent some time trying to find markets in which the quality deterioration predicted by the lemons model is apparent. Here, we look at three such investigations.

**Pickup Trucks**

Although used pickup trucks might be expected to exhibit quality deterioration because of asymmetric information between buyers and sellers, that does not appear to be the case. A 1982 study of pickup purchases during the 1970s found that about 60 percent of such trucks were bought used. After controlling for the mileage that trucks had traveled, the author found no difference in the repair records for trucks purchased new versus those purchased used. The author offered two explanations for the relatively good quality of used pickups. First, pickup buyers may have some expertise in truck repair or can gain that expertise by looking at several pickups before buying. Second, it seems possible that, in some cases, sellers provide repair records in order to get good prices for their trucks.

**Free Agents in Baseball**

Professional baseball players become “free agents” after playing a certain number of years with the teams that initially sign them. Because a player’s present team may know much more about his physical condition than do the would-be hirer, the market for “used players” may provide another case where asymmetric information leads to quality deterioration. Consistent with this idea, one study found that free agents have a shorter career than did those who were re-signed by their own teams. Of course, teams undoubtedly recognize the adverse incentives inherent in the trading of free agents. So, detailed physical examinations and other kinds of tryouts have become commonplace in recent years. No team wants to be saddled with a multi-million-dollar “dud” if that can be avoided.

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**To Think About**

1. Each of these examples suggests that buyers may take steps to address problems raised by asymmetric information. Do sellers have similar incentives to provide information to buyers?

2. The late 1990s saw a huge number of initial offerings of common stock by Internet start-up companies. How might the lemons model be applied to these initial offerings? Did subsequent events bear out the model?

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**Thoroughbreds**

Many racehorse “yearlings” are sold at auction. One of the largest of these is the Keeneland auction that is held in September near Lexington, Kentucky. An article examining the sale prices from this auction in 1994 found evidence that lemons may appear among the thoroughbreds. The authors divided sellers at the auction into two groups—those stables that both breed and race horses and those that are only in the breeding business. They reasoned that breeder-only stables would bring all of their yearlings to the auction but that those stables that also raced would have an incentive to keep the best horses for themselves. Although a would-be buyer has relatively little information about the racing quality of any yearling, he or she knows the nature of the stable from which it comes and therefore is in a position to suspect that the racers’ offerings will contain relatively more lemons.

Evidence on auction prices tended to confirm these expectations. The authors found that, after holding constant such factors as the yearling’s parents, yearlings from stables that are heavily involved in racing tended to have lower prices than did those from breeder-only stables. Specifically, the authors estimated that each race that a stable entered in 1993 tended to reduce the price of its 1994 yearlings by nearly one percentage point. Apparently, buyers at the Keeneland auction were cautious about buying yearlings from breeders who may have incentives to take the best horses out of their offerings.
profit means profit not including the worker’s wage, which will be computed and subtracted off later). Skill is private information for workers and cannot be observed by employers. Before the hiring decision, workers can obtain education. We will make the extreme assumption that education does nothing to enhance a worker’s productivity directly. Rather, it may provide a signal of skill to future employers because high-skill workers find it easier to obtain more education. Let $c$ be the cost of obtaining an education, where $c = c_l$ for a low-skill worker, $c = c_H$ for a high-skill worker, and $c_l > c_H$. The assumption that it is easier for high-skill workers to obtain education is crucial in the signaling model. If education were as costly or more costly for the high-skill workers to obtain, education could not provide a signal of skill.

The game tree for the Spence signaling game is shown in Figure 15.10. Nature moves first, choosing the worker’s skill, low or high, with probability $\frac{1}{2}$ each. The worker observes his or her skill and then makes the decision to get an education or not (this could be thought of as additional education beyond high school or an advanced degree beyond college, such as an MBA). The firm observes the education decision but not the worker’s type. Assume the firm is representative of a large

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**FIGURE 15.10** Spence Signaling Game in Extensive Form

Nature chooses worker skill at random. The worker then makes an education decision. The ovals around selected decision points for the firm indicate that the firm observes the worker’s education decision but not skill. The payoffs, calculated in the text, provide the worker with a competitive wage based on the representative firm’s beliefs about the worker’s skill.
number of firms that compete for the worker. The worker’s wage is set competitively; that is, all the expected gross profit is incorporated into the wage, so the firm earns zero expected profit after subtracting off the wage.

Signaling games often have multiple equilibria, and that is true in this game. In searching for these equilibria, it often helps to look for two different kinds, separating equilibria and pooling equilibria. In a separating equilibrium, each different type of worker chooses a different action, so the action is a perfect signal of the worker’s skill. In a pooling equilibrium, all types choose the same action, so the equilibrium action is an uninformative signal. The uninformed player knows nothing beyond the initial probabilities Nature used to draw the first player’s type.

Separating Equilibrium

Let’s begin by looking for a separating equilibrium. There is only one sensible possibility for a separating equilibrium: the high-skill type chooses to get an education and the low-skill type does not. (The other possibility is that the low-skill type obtains an education and the high-skill type does not, but this outcome does not make sense.) How would the competitive wage be set in this equilibrium? If the firm sees the worker get an education, it knows the worker must be high skill and will generate gross profit of \( \pi \). Competition among firms for the worker would drive the wage up to \( \pi \) and the firm would earn zero profit net of the wage. If the firm sees that the worker did not get an education, it knows the worker must be low skill and would generate no gross profit. The firm will pay the worker a wage of zero. To summarize the strategies in this separating equilibrium, the high-skill type gets an education and the low-skill type does not. The firm pays wage \( \pi \) to an educated worker and zero to an uneducated worker.

Recall that to check for a Nash equilibrium in the simple games in Chapter 5, we needed to check whether any player would want to deviate. In signaling games, the equilibrium check is a bit more involved. We need to check whether any type of any player would want to deviate. In our education game, let’s check first that the firm would not want to deviate from the proposed separating equilibrium. There is no reason for the firm to offer higher wages, since it is able to hire the worker at the present wages. If the firm offers a lower wage, it will lose the worker to some other firm on the competitive market and will earn zero profit, which is not strictly more than it earns in equilibrium (also zero profit). Next we need to check whether either type of worker would want to deviate. In equilibrium, the high-skill worker earns the wage \( \pi \) minus the cost of education \( c_H \). If the high-skill worker deviates by choosing no education, the firm would believe the worker is low skill and pay a zero wage, and the worker would earn nothing (though he or she would save the cost of getting an education). For the high-skill worker not to want to deviate,

\[
\pi - c_H < 0. \tag{15.1}
\]

In equilibrium, the low-skill worker’s payoff is zero. If the low-skill worker deviates by pretending to be high skill and obtaining an education, he or she would earn the high-skill wage \( \pi \) minus the cost of education \( c_L \). For the low-skill worker not to want to deviate in this way,

\[
\pi - c_L > 0. \tag{15.2}
\]
Putting conditions 15.1 and 15.2 together, a separating equilibrium requires $c_H < \pi < c_L$. In other words, for the separating equilibrium to work, the gap between the high- and low-skill workers’ cost of obtaining an education must be large enough that the return to education, $\pi$, falls somewhere in between the two types’ costs of obtaining an education.

In the separating equilibrium, each worker is paid according to his or her productivity. There is some deadweight loss in that the high type has to pay the cost of getting an education, which is socially wasteful since it does not add to productivity. An education is still a worthwhile investment for the high type because it results in a better wage.

**Pooling Equilibria**

Next we will look for a pooling equilibrium, in particular, the pooling equilibrium in which both types of worker obtain an education. The idea is that the low-skill worker chooses the same action as the high-skill worker to prevent being distinguished from the high-skill types and paid a lower wage. In equilibrium, the firm learns nothing about the worker’s skill from seeing the fact that the worker is educated. The firm’s best guess is that the worker is high or low skill with equal probability $\frac{1}{2}$, the same probabilities that Nature used to choose the worker type initially. The firm’s expected gross profit from the worker equals the probability of high skill, $\frac{1}{2}$, times the gross profit from a high-skill worker, $\pi$, plus the probability of low skill, $\frac{1}{2}$, times the gross profit from a low-skill worker, $0$: $(1/2)(\pi) + (1/2)(0) = \pi/2$. Thus the competitive wage is $\pi/2$.

We need to check whether any type of any player would want to deviate from the proposed pooling equilibrium. As with the separating equilibrium, here the competitive wage is set so that the firm earns zero expected profit and would not gain from deviating. The question remains whether either type of worker would want to deviate by choosing not to get an education. Since education is costliest for the low-skill worker, it is this type’s deviation we have to worry about. In equilibrium, the low-skill worker earns the wage $\pi/2$ minus the cost of education $c_L$.

What it earns by deviating to “no education” depends on the competitive wage paid to uneducated workers, which in turn depends on what the firm believes about an uneducated worker’s skill. The rules of probability provide little guidance as to what this belief should be because seeing an uneducated worker is a totally unexpected event for the firm; the firm never encounters such a worker in equilibrium. Game theorists have devoted considerable attention to this thorny question of what might be sensible beliefs after something unexpected happens, and there is unfortunately no settled answer. In the present application, it is plausible to assume that the firm has pessimistic beliefs about an uneducated worker’s skill, that is, the firm believes that if the worker chooses not to get an education, he or she is certainly a low-skill worker.\(^6\) If so, by deviating to “no education,” a low-skill worker would

\(^6\)Alternatively, it is also plausible to assume that the firm learns nothing about the worker’s type if it observes an uneducated worker. Given this belief, there is no reason for workers to obtain an education, and the pooling equilibrium, in which both types obtain an education, would not exist.
save the cost of education but would get a wage of zero for a total payoff of zero. The low-skill worker would choose not to deviate if \( \pi/2 - c_L > 0 \). For the proposed pooling equilibrium to work, the low-skill worker’s cost of pooling with the high-skill type by obtaining an education cannot be too high relative to the expected wage.

We could also look for a pooling equilibrium in which both types choose not to get an education. Whether or not such an equilibrium exists again depends on the firm’s beliefs following an unexpected event, this time, the unexpected event of seeing an educated worker. As long as the firm is not too confident that an educated worker is high skill, there will exist a pooling equilibrium in which both types of worker do not get an education.

**Predatory Pricing and Other Signaling Games**

The Spence model is but one application of signaling games. Another important application, alluded to in Chapter 12 on imperfect competition, is predatory pricing, where an incumbent firm prices low for a sufficient time to induce the exit of a rival. As noted in Chapter 12, it is difficult to rationalize predatory pricing as an equilibrium strategy unless there is some private information in the game.

One possibility is that the incumbent has private information about its cost. The lower the incumbent’s cost, the lower the prices it would charge, whether it is a monopolist or competes against an entrant. The lower the incumbent’s prices, the less an entrant would earn in competition with the incumbent. The incumbent’s cost may be so low that the entrant would be unprofitable in competition with it. If the entrant knew the incumbent’s costs were this low, it would not enter the market or would exit if it had entered. Such a low-cost incumbent may gain from signaling its costs are low to separate itself from a higher-cost one against which entry might be profitable. The low-cost incumbent could try to signal its type by pricing low during an initial period, low enough that a high-cost type would rather have the entrant in the market rather than charge such a low price during the initial period. The predation game may also have equilibria in which the high-cost type of incumbent pools with the low-cost type by pricing low during the initial period, if by doing so it would prevent entry by preventing the entrant from learning its type.

As mentioned previously, there are a wide variety of other applications of signaling games. Poker can be analyzed as a signaling game. An interesting feature of poker is that extreme types on both ends, players with very good hands as well as players with very bad hands, gain from pooling with other types. A player with a very good hand would like opponents to believe his or her hand is not so good so that they continue betting; a player with a bad hand would like to bluff that his or her hand is good so that others fold.
Inefficiency in Signaling Games

The presence of private information typically leads to inefficiency in signaling games. In the Spence education model, depending on the equilibrium, one or the other type of worker, or even sometimes both, obtained an education even though education had no social benefit in terms of raising productivity. In the standard model in which firms had full information about worker productivity, there would be no need for workers to seek wasteful education. This is a typical finding in signaling games. Players with private information depart from the efficient action choice to provide an informative signal to other players.7

SUMMARY

In this chapter, we extended our analysis of game theory to situations in which one player has private information, either about its type (adverse selection) or an action it can choose (moral hazard). Some of the main points in this chapter are the following:

- Compared to the standard competitive model in which there is full information, private information typically leads markets to operate inefficiently. Depending on the model, private information (also called asymmetric information) can lead to slack, undersupply, or distortion of other economic decisions. In the extreme, asymmetric information can lead the entire market to break down.

- Inefficiency does not stem from a failure of firms to maximize profit or consumers to maximize utility. Players are still assumed to maximize their payoffs, but maximizing payoffs in the presence of asymmetric information leads to inefficiency.

- The principal-agent model is a simple starting point to study games with asymmetric information. The principal must design the contract it offers to the agent carefully, recognizing that the contract must give the agent the incentives to make the right choices and must be attractive enough to get the agent to accept the contract in the first place.

- With the moral-hazard problem, the agent will only work hard if given an incentive contract tying pay to performance. But tying pay to performance has the drawback of exposing the agent to risk for which the agent has to be compensated.

- With the adverse-selection problem, the principal may distort the low type’s contract option in order to make it less attractive to the high type. This allows the principal to increase the price charged for high type’s contract option.

- Having consumers compete in an auction helps the monopolist solve the adverse-selection problem. In simple settings, many different auction formats produce equivalent revenues, but this no longer holds in more complicated settings.

- In a “lemons market,” sellers have private information about their own good’s quality. The market may unravel as no seller with a quality good would be willing to sell at the prevailing price.

- In a signaling game, the player with private information about its type makes the first move. Signaling games often have multiple equilibria, including separating equilibria, in which the first mover’s action perfectly identifies its type, and pooling equilibria, in which all types choose the same action.

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7 The need to signal private information can increase efficiency in rare cases. Paradoxically, if the market is already inefficient, say because of monopoly or externalities, adding another source of inefficiency in the form of private information can improve matters. For example, in the predation model with a monopoly incumbent firm, lowering its price to signal low cost leads to higher consumer surplus and perhaps higher social welfare, at least in the initial period.
REVIEW QUESTIONS

1. Consider the moral-hazard problem that arises when a risk-averse manager, whose effort is unobservable, runs a firm on behalf of shareholders. Explain how the trade-off between incentives and risk prevents the firm from obtaining the fully efficient outcome. How can the moral-hazard problem be eliminated if effort is observable? How can the moral-hazard problem be eliminated if effort is unobservable but the manager is risk neutral?

2. Many contracts between professional athletes and the teams on which they play involve incentive provisions. Can you provide some examples? Do you think moral hazard is a serious problem for professional athletes? Why or why not? Discuss the problem of using incentive contracts for unproven rookies, whose playing time may depend on the discretion of the coach. How might incentive contracts worsen the problem with performance-enhancing drugs such as steroids?

3. For each of the following types of insurance, explain how the moral-hazard problem might arise. Explain how the adverse selection problem might arise.
   a. Life insurance
   b. Health insurance
   c. Homeowners’ insurance
   d. Automobile insurance
   e. Unemployment insurance
How might an insurance company adjust the insurance contract to mitigate the moral-hazard and adverse-selection problems?

4. A computer manufacturer offers an optional extended warranty on the laptops it sells. What signal does the fact that the manufacturer offers this warranty send to potential consumers about laptop quality? Does this reduce consumers’ incentives to purchase the extended warranty? Suppose consumers are of two types, heavy users who travel with laptops, exposing them to the risk of accidental damage, and light users. Explain how market forces may lead the price of the extended warranty to reflect the heavy users’ risk of damage rather than the average consumers’.

5. Consider the problem of a monopolist setting a menu of price/quantity bundles when there are two types of consumer and types are unobservable. The source of inefficiency in this setting is that the monopolist distorts the quantity in the low demanders’ bundle. Why does the monopolist do this? Explain with reference to Figure 15.9. Why isn’t the quantity in the high demanders’ bundle also distorted?

6. The famous comedian Groucho Marx once quipped that “I would never join a club that would have me as a member.” Modified to apply to market settings, the quote might be rewritten, “I would never buy from a seller who was willing to sell to me.” Under what sort of market conditions would this quote apply? Connect this quote to Akerlof’s lemons model. Among other things, use this quote to help identify the source of inefficiency in the lemons model.

7. Why is it a good idea to bid your (known) valuation in a second-price, sealed-bid auction? Why is it a bad idea to bid your (known) valuation in a first-price, sealed-bid auction? Explain, with reference to the “winner’s curse,” why it is an even worse idea to bid what you think your valuation is when you are not exactly sure of its value.

8. Consider a signaling model in which the first player may be one of two types. What determines the other player’s beliefs about the first player’s type before observing the first-player’s signal? After observing the first player’s signal, what beliefs must the second player have about the first player’s type in a separating equilibrium? What beliefs must the second player have in a pooling equilibrium?

9. In the Spence model of education signaling we studied, what was inefficient about the equilibria? Why did the presence of asymmetric information (the fact that firms do not know the workers’ productivities, but the workers themselves do) lead to this inefficiency? We saw that there were at least three possible equilibria that arose under certain conditions: a pooling equilibrium in which both types (high and low productivity) obtained an education, a pooling equilibrium in which neither type did, and a separating equilibrium in which only the high-productivity worker obtained an education. Are any of these equilibria more efficient than the others? Do workers enjoy having private information, or does your answer depend on the worker’s type?
10. Suppose you invented a test that can easily measure worker productivity in Spence’s signaling model. Who would be interested in paying for the test? Would workers pay to take it? Would firms pay to be able to administer it? One way for the firm to “test” workers is to have an initial probationary period during which it observes workers’ productivity and fires them or adjusts their wages according to how the workers perform. What effect would this strategy have on the return to education? Can you think of real-world markets in which firms use such strategies?

PROBLEMS

15.1 Draw the following incentive contracts on the same graph, with gross profit (revenue minus costs for all inputs, not including payments to the manager) for the firm on the horizontal axis and manager pay on the vertical axis as in Figure 15.2. Draw a second graph with the marginal pay implied by each contract.
   a. The manager is paid $50,000 plus a 40% share of gross profit.
   b. The manager buys out the firm (so the manager gets all the gross profits) for $100,000.
   c. The manager is paid a constant $75,000.
   d. The manager is paid $60,000 plus a bonus if the firm’s gross profit is more than $90,000.

15.2 Clare manages a piano store. Her utility function is given by

\[
\text{Utility} = w - 100
\]

where \( w \) is the total of all monetary payments to her and 100 represents the cost to her of the effort of running the store. Clare’s next best alternative to managing the store provides her with zero utility. The store’s gross profit depends on random factors. There is a 50% chance it earns $1,000 (where by earnings we mean gross profits, not including payments to the manager) and a 50% chance it earns only $400.

a. If shareholders offered to share half of the store’s gross profit, what would her expected utility be? Would she accept such a contract? What if she were only given a quarter share? What would be the lowest share she would accept to manage the firm?

b. What is the most Clare would pay to buy out the store if shareholders decided to sell it to her?

c. Suppose instead that shareholders decided to offer her a $100 bonus if the store earns $1,000. What fixed salary would Clare need to be paid in addition to get her to accept the contract?

15.3 Return to problem 15.2. Suppose that Clare can still choose to exert effort, as in the previous problem, but that she can also choose not to exert effort. If she does not exert effort, she has no effort cost, so her utility is just the wage, \( w \); the shop’s return is $400 for certain.

a. If shareholders offered to share half of the store’s gross profit, what effort would Clare choose? Would she accept such a contract? What if she were only given a quarter share? What would be the lowest share that would get her to exert effort?

b. Suppose instead that shareholders decided to offer her a $100 bonus if the store earns $1,000. Show that this would not get her to work hard. What is the minimum bonus that she would need to be paid? What fixed salary would she need to be paid in addition to get her to accept the contract?

15.4 A ready-to-eat cereal manufacturer faces two types of consumers, adults and children, having the following schedule of gross surpluses for each additional unit of cereal consumed.

<table>
<thead>
<tr>
<th>OUNCE OF CEREAL</th>
<th>MARGINAL SURPLUS THIS OUNCE PROVIDES ADULTS IN CENTS</th>
<th>MARGINAL SURPLUS THIS OUNCE PROVIDES CHILDREN IN CENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Second</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Third</td>
<td>12</td>
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<tr>
<td>Fourth</td>
<td>8</td>
<td>16</td>
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<td>Fifth</td>
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<tr>
<td>Sixth</td>
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<tr>
<td>Seventh</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Cereal costs $0.15 per ounce to produce. The manufacturer has full information about types because adults hate sweet children’s cereal and children hate the fiber-filled adult cereal. What is the optimal bundle to offer adults and to children in this full-information setting?
15.5 Ahab’s Coffee has 150 customers. Fifty of them are small and 100 are big, with appetites for coffee matching their size. Small people value coffee at $0.10 per ounce for the first 8 ounces and nothing for more than that. Large people value coffee at $0.15 cents per ounce for the first 10 ounces and nothing for more than that. Coffee costs $0.05 per ounce to produce.

a. What is Ahab’s profit-maximizing strategy if it can sell a small cup to small people and a large cup to large people and prevent anyone from buying one or more of the other sized cups (either for their own consumption or to resell to other people). How much profit does Ahab’s earn, and how much surplus does each type of consumer obtain?

b. For the rest of the question, suppose it is illegal for Ahab’s to charge prices based on people’s size. Show that the strategy from part a would not work now by computing the surplus big customers would get from buying a small cup and showing this is more than their surplus from buying a large cup.

c. What is the most Ahab’s can charge for a 10-ounce cup and an 8-ounce cup and still have some customers buy each sized cup? Calculate the profit Ahab’s can earn from such a pricing strategy.

d. Show that Ahab’s can do better than in part c by reducing the size of the small cup from 8 ounces to 6 ounces.

e. Show that Ahab’s does even better than in part c or part d if it ignores small customers and just sells one size of cup, which big customers end up buying.

15.6 L. L. Bean, among other stores, has a policy of replacing shoes that wear out with new ones. Suppose there are two types of shoe buyers. Half of them have desk jobs and only have a 20 percent chance of wearing out their shoes. The other half have active jobs (construction, nursing) and have a 60 percent chance of wearing out their shoes. A pair of shoes costs $25 to produce.

a. If the store cannot distinguish between the two types, what is the lowest price it can charge for shoes and still break even on average? (This is the price that would prevail in a competitive market.)

b. What would happen to the equilibrium if the desk workers’ valuation for shoes was less than the market price in part a? What is a possible source of inefficiency in this new equilibrium?

c. Compute the competitive equilibrium if shoe manufacturers can charge an extra price for shoes with a replacement guarantee, assuming that only the active workers purchase the guarantee.

15.7 Tess and Meg are the only two bidders in an auction for a van Gogh painting. Each can be one of two types with equal probability: a low-value consumer with valuation $1 million or a high-value consumer with valuation $2 million. Each knows her own type but only knows the probabilities of the other’s type.

a. Suppose they compete in a sealed-bid, second-price auction. What are the equilibrium bidding strategies? Compute the seller’s expected revenue.

b. Repeat part a supposing there are three identical bidders. What if there are N bidders?

c. Explain how your answer from parts a and b can be used to compute the seller’s expected revenue from a first-price, sealed-bid auction.

15.8 Suppose 100 cars will be offered on the used-car market, 50 of them good cars, each worth $10,000 to a buyer, and 50 of them lemons, each worth $2,000.

a. Compute a buyer’s maximum willingness to pay for a car if he or she cannot observe the car’s type.

b. Suppose that there are enough buyers that competition among them leads cars to be sold at their maximum willingness to pay. What would the market equilibrium be if sellers value good cars at $8,000? At $6,000?

15.9 A firm earns gross profit (profit not including the wage) of 100 from a low-ability worker and 200 from a high-ability worker. A quarter of the workers are low-ability and the rest are high-ability.

a. If competitive firms have no signals available, what is the equilibrium wage they would pay?

b. Under what conditions on the cost of getting an education for each type, \( c_1 \) and \( c_{1b} \), is there a separating equilibrium?

c. Suppose \( c_L = 30 \) and \( c_{1b} = 0 \). Outline a pooling equilibrium in which both types get an education. Be sure to specify the firm’s out-of-equilibrium beliefs if it were to meet an uneducated worker. Similarly, outline a pooling equilibrium in which neither type gets an education.
15.10 An incumbent firm may be a low-cost type, with constant marginal cost of production 10, or a high-cost type, with marginal cost of production 20, with probabilities \( t \) and \( 1 - t \), respectively. The incumbent’s type is private information. The incumbent produces as a monopolist in the first period. An entrant who has marginal cost 15 may enter the market between periods. Entry requires at least a small fixed investment. If the entrant comes in the market, it learns what the incumbent’s marginal cost is, and firms engage in Bertrand competition in homogeneous products in the second period (see Chapter 14 for a discussion of Bertrand competition). Consumer demand is the same in each period. Suppose there is no discounting between periods, so the incumbent’s objective is to maximize the sum of first- plus second-period profit.

a. What is the Nash equilibrium of the second-stage game if the entrant enters? Solve the game for each type of incumbent.

b. Argue that the entrant would not enter if it believes the incumbent is certainly low cost but would enter if it believes the incumbent is certainly high cost.

c. Assume that the low-cost type’s monopoly price is greater than 20. Use your answer from part b to argue that 20 is the highest possible price that the low-cost type of incumbent can charge in a separating equilibrium.