CHAPTER 17
MARKETS WITH ASYMMETRIC INFORMATION

QUESTIONS FOR REVIEW

1. Why can asymmetric information between buyers and sellers lead to a market failure when a market is otherwise perfectly competitive?

Asymmetric information leads to market failure because the transaction price does not reflect either the marginal benefit to the buyer or the marginal cost of the seller. The competitive market fails to achieve an output with a price equal to marginal cost. In some extreme cases, if there is no mechanism to reduce the problem of asymmetric information, the market collapses completely. For example, in the used car case the buyer does not know for sure if they will be getting a high or low quality car, and as a result buyers will tend to be willing to pay less for a car than high quality owners are willing to accept. As a result, not many high quality cars will be offered for sale and this can lead to market failure.

2. If the used car market is a “lemons” market, how would you expect the repair record of used cars that are sold to compare with the repair record of those not sold?

In the market for used cars, the seller has a better idea of the quality of the used car than does the buyer. The repair record of the used car is one indicator of quality. One would expect that, at the margin, cars with good repair records would be kept while cars with poor repair records would be sold. Thus, one would expect the repair records of used cars that are to be sold to be worse than those of used cars not sold.

3. Explain the difference between adverse selection and moral hazard in insurance markets. Can one exist without the other?

In insurance markets, both adverse selection and moral hazard exist. Adverse selection refers to the self-selection of individuals who purchase insurance policies. In other words, people who are less risky than the insured population will, at the margin, choose not to insure, while people more risky than the population will choose to insure. As a result, the insurance company is left with a riskier pool of policy holders. The problem of moral hazard occurs after the insurance is purchased. Once insurance is purchased, less risky individuals might engage in behavior characteristic of more risky individuals. If policy holders are fully insured, they have little incentive to avoid risky situations.

An insurance firm may reduce adverse selection, without reducing moral hazard, and vice versa. Conducting research to determine the riskiness of a potential customer helps insurance companies reduce adverse selection. Furthermore, insurance companies reevaluate the premium (sometimes canceling the policy) when claims are made against the policy, thereby reducing moral hazard. Co-payments also reduce moral hazard by creating a disincentive for policyholders to engage in risky behavior.

4. Describe several ways in which sellers can convince buyers that their products are of high quality. Which methods apply in the following products: Maytag washing machines, Burger King hamburgers, large diamonds?

Some sellers signal the quality of their products to buyers through (1) investment in a good reputation, (2) the standardization of products, (3) certification (i.e., the use of educational degrees in the labor market), (4) guarantees, and (5) warranties. Maytag signals the high quality of its washing machines by offering one of the best warranties in the market. Burger King relies on the standardization of its hamburgers, e.g., the Whopper. The sale of a large diamond is accompanied by a certificate that verifies the weight and shape of the stone and discloses any flaws.

5. Why might a seller find it advantageous to signal the quality of a product? How are guarantees and warranties a form of market signaling?
Firms producing high-quality products would like to charge higher prices, but to do this successfully, potential consumers must be made aware of the quality differences among brands. One method of providing product quality information is through guarantees (i.e., the promise to return what has been given in exchange if the product is defective) and warranties (i.e., the promise to repair or replace if defective). Since low-quality producers are unlikely to offer costly signaling devices, consumers can correctly view a guarantee or an extensive warranty as a signal of high quality, thus confirming the effectiveness of these measures as signaling devices.

6. Joe earned a high grade-point average during his four years of college. Is this a strong signal to Joe's future employer that he will be a highly productive worker? Why or why not?

Yes, for the most part a high grade point average is a strong signal to the employer that the employee will perform at an above average level. Regardless of what he actually learned, it indicates that he is able to out-perform the majority of students. On the other hand, Joe could have padded his schedule with easy classes, and/or classes taught by easy professors.

7. Why might managers be able to achieve objectives other than profit maximization, which is the goal of the firm's shareholders?

It is difficult and costly for shareholders to constantly monitor the actions of the firm’s managers. The firm's owners are in a better position to engage in monitoring, but a manager’s behavior still cannot be scrutinized one hundred percent of the time. Therefore, managers have some leeway to pursue their own objectives.

8. How can the principal-agent model be used to explain why public enterprises, such as post offices, might pursue goals other than profit maximization?

Managers of public enterprises can be expected to act in much the same way as managers of private enterprises, in terms of having an interest in power and other perks, in addition to profit maximization. The problem of overseeing a public enterprise is one of asymmetric information. The manager (agent) is more familiar with the cost structure of the enterprise and the benefits to the customers than the principal, an elected or appointed official, who must elicit cost information controlled by the manager. The costs of eliciting and verifying the information, as well as independently gathering information on the benefits provided by the public enterprise, can be more than the difference between the agency’s potential net returns (“profits”) and realized returns. This difference provides room for slack, which can be distributed to the management as personal benefits, to the agency’s workers as greater-than-efficient job security, or to the agency’s customers in the form of greater-than-efficient provision of goods or services.

9. Why are bonus and profit-sharing payment schemes likely to resolve principal-agent problems, whereas a fixed-wage payment will not?

With a fixed wage, the agent-employee has no incentive to maximize productivity. If the agent-employee is hired at a fixed wage equal to the marginal revenue product of the average employee, there is no incentive to work harder than the least productive worker. Bonus and profit-sharing schemes involve a lower fixed wage than fixed-wage schemes, but they include a bonus wage. The bonus can be tied to the profitability of the firm, to the output of the individual employee, or to that of the group in which the employee works. These schemes provide a greater incentive for agents to maximize the objective function of the principal.

10. What is an efficiency wage? Why is it profitable for the firm to pay it when workers have better information about their productivity than firms do?

An efficiency wage, in the context of the shirking model, is the wage at which no shirking occurs. If employers cannot monitor employees’ productivity, then employees may shirk (work less productively), which will affect the firm’s output and profits. It
therefore pays the firm to offer workers a higher-than-market wage, thus reducing the workers’ incentive to shirk, because they know that if they are fired and end up working for another firm, their wage will fall. Firms may also pay efficiency wages in order to reduce turnover among employees. If employees are paid a higher wage then, all else the same, they will be happier at their jobs and less likely to leave and find a new job. High turnover rates can be costly for the firm in terms of having to continually train new employees.

EXERCISES

1. Many consumers view a well-known brand name as a signal of quality and will pay more for a brand-name product (e.g., Bayer aspirin instead of generic aspirin, Birds Eye frozen vegetables instead of the supermarket’s own brand). Can a brand name provide a useful signal of quality? Why or why not?

A brand name can provide a useful signal of quality for several reasons. First, when information asymmetry is a problem, one solution is to create a “brand-name” product. Standardization of the product produces a reputation for a given level of quality that is signaled by the brand name. Second, if the development of a brand-name reputation is costly (i.e., advertising, warranties, etc.), the brand name is a signal of higher quality. Finally, pioneer products, by virtue of their “first-mover” status, enjoy consumer loyalty if the products are of acceptable quality. The uncertainty surrounding newer products inhibits defection from the pioneering brand-name product.

2. Gary is a recent college graduate. After six months at his new job, he has finally saved enough to buy his first car.

a. Gary knows very little about the differences between makes and models. How could he use market signals, reputation, or standardization to make comparisons?

Gary’s problem is one of asymmetric information. As a buyer of a first car, he will be negotiating with sellers who know more about cars than he does. His first choice is to decide between a new or used car. If he buys a used car, he must choose between a professional used-car dealer and an individual seller. Each of these three types of sellers (the new-car dealer, the used-car dealer, and the individual seller) uses different market signals to convey quality information about their products.

The new-car dealer, working with the manufacturer (and relying on the manufacturer’s reputation) can offer standard and extended warranties that guarantee the car will perform as advertised. Because few used cars carry a manufacturer’s warranty and the used-car dealer is not intimately familiar with the condition of the cars on his or her lot (because of their wide variety and disparate previous usage), it is not in his or her self-interest to offer extensive warranties. The used-car dealer, therefore, must rely on reputation, particularly on a reputation of offering “good values.” Since the individual seller neither offers warranties nor relies on reputation, purchasing from such a seller could make it advisable to seek additional information from an independent mechanic or from reading the used-car recommendations in Consumer Reports. Given his lack of experience, Gary should gather as much information about these market signals, reputation, and standardization as he can afford.

b. You are a loan officer in a bank. After selecting a car, Gary comes to you seeking a loan. Because he has only recently graduated, he does not have a long credit history. Nonetheless, the bank has a long history of financing cars for recent college graduates. Is this information useful in Gary’s case? If so, how?

The bank’s problem in loaning money to Gary is also one of asymmetric information. Gary has a much better idea than the bank does about the quality of the car and his ability to pay back the loan. While the bank can learn about the car through the reputation of the manufacturer (if it is a new car) and through inspection (if it is a used
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car), the bank has little information on Gary’s ability to handle credit. Therefore, the bank must infer information about Gary’s credit-worthiness from easily available information, such as his recent graduation from college, how much he might have borrowed while in school, and the similarity of his educational and credit profile to that of college graduates currently holding car loans from the bank. If recent graduates have built a good reputation for paying off their loans, Gary can use this reputation to his advantage, but poor repayment patterns by this group will lessen his chances of obtaining a car loan from this bank.

3. A major university bans the assignment of D or F grades. It defends its action by claiming that students tend to perform above average when they are free from the pressures of flunking out. The university states that it wants all its students to get As and Bs. If the goal is to raise overall grades to the B level or above, is this a good policy? Discuss with respect to the problem of moral hazard.

By eliminating the lowest grades, the innovating university creates a moral hazard problem similar to that which is found in insurance markets. Since they are protected from receiving a below-average grade, some students will have little incentive to work at above-average levels. The policy only addresses the pressures facing below-average students, i.e., those who flunk out. Average and above-average students do not face the pressure of failing. For these students, the destructive pressure of earning good grades (instead of learning a subject well) remains. Their problems are not addressed by this policy. Therefore, the policy creates a moral hazard problem primarily for the below-average students who are its intended beneficiaries.

4. Professor Jones has just been hired by the economics department at a major university. The president of the board of regents has stated that the university is committed to providing top-quality education for undergraduates. Two months into the semester, Jones fails to show up for his classes. It seems he is devoting all his time to research rather than to teaching. Jones argues that his research will bring prestige to the department and the university. Should he be allowed to continue exclusively with research? Discuss with reference to the principal-agent problem.

In the university context, the board of regents and its president are the principals, while the agents are the members of the faculty hired by the department with the approval of the president and the board. The dual purpose of most universities is teaching students and producing research; thus, most faculty are hired to perform both tasks. The problem is that teaching effort can be easily monitored (particularly if Jones does not show up for class), while the benefits of establishing a prestigious research reputation are uncertain and are realized only over time. While the quantity of research is easy to calculate, determining research quality is more difficult. The university should not simply take Jones’ word regarding the benefits of his research and allow him to continue exclusively with his research without altering his payment scheme. One alternative would be to tell Jones that he does not have to teach if he is willing to accept a lower salary. On the other hand, the university could offer Jones a bonus if, due to his research reputation, he is able to bring a lucrative grant or other donations to the university.

5. Faced with a reputation for producing automobiles with poor repair records, a number of American companies have offered extensive guarantees to car purchasers (i.e., a seven-year warranty on all parts and labor associated with mechanical problems).

a. In light of your knowledge of the lemons market, why is this a reasonable policy?

In the past, American companies enjoyed a reputation for producing high-quality cars. More recently, faced with competition from Japanese car manufacturers, their products appeared to customers to be of lower quality. As this reputation spread, customers were less willing to pay high prices for American cars. To reverse this trend, American companies invested in quality control, improving the repair records of their products. Consumers, however, still considered American cars to be of lower quality (lemons, in
some sense), and would not buy them, American companies were forced to signal the improved quality of their products to their customers. One way of providing this information is through improved warranties that directly address the issue of poor repair records. This was a reasonable reaction to the “lemons” problem that they faced.

b. **Is the policy likely to create a moral hazard problem? Explain.**

Moral hazard occurs when the insured party (here, the owner of an American automobile with an extensive warranty) can influence the probability of the event that triggers payment (here, the repair of the automobile). The coverage of all parts and labor associated with mechanical problems reduces the incentive to maintain the automobile. Hence, a moral hazard problem is created by the offer of extensive warranties. To avoid this problem, all routine maintenance could be performed as long as the car is under warranty. Note though that manufacturers could stipulate that the warranties will not be honored unless the owner performs and pays for routine maintenance.

6. **To promote competition and consumer welfare, the Federal Trade Commission requires firms to advertise truthfully. How does truth in advertising promote competition? Why would a market be less competitive if firms advertised deceptively?**

Truth-in-advertising promotes competition by providing the information necessary for consumers to make optimal decisions. “Competitive forces” function properly only if consumers are aware of all prices (and qualities), so comparisons may be made. In the absence of truthful advertising, buyers are unable to make these comparisons because goods priced identically can be of different quality. Hence, there will be a tendency for buyers to “stick” with proven products, reducing competition between existing firms and discouraging entry. Note that monopoly rents may result when consumers stick with proven products.

7. **An insurance company is considering issuing three types of fire insurance policies: (i) complete insurance coverage, (ii) complete coverage above and beyond a $10,000 deductible, and (iii) 90 percent coverage of all losses. Which policy is more likely to create moral hazard problems?**

Moral hazard problems arise with fire insurance when the insured party can influence the probability of a fire and the magnitude of a loss from a fire. The property owner can engage in behavior that reduces the probability of a fire, for example, by inspecting and replacing faulty wiring. The magnitude of losses can be reduced by the installation of warning systems or the storage of valuables away from areas where fires are likely to start.

After purchasing complete insurance, the insured has little incentive to reduce either the probability or the magnitude of the loss, and the moral hazard problem will be severe. In order to compare a $10,000 deductible and 90 percent coverage, we would need information on the value of the potential loss. Both policies reduce the moral hazard problem of complete coverage. However, if the property is worth less (more) than $100,000, the total loss will be less (more) with 90 percent coverage than with the $10,000 deductible. As the value of the property increases above $100,000, the owner is more likely to engage in fire prevention efforts under the policy that offers 90 percent coverage than under the one that offers the $10,000 deductible.

8. **You have seen how asymmetric information can reduce the average quality of products sold in a market as low-quality products drive out the high-quality ones. For those markets in which asymmetric information is prevalent, would you agree or disagree with each of the following? Explain briefly:**

a. **The government should subsidize Consumer Reports.**

Asymmetric information implies an unequal access to information by either buyers or sellers, a problem that leads to inefficient markets or market collapse. Subsidizing the
gathering and publishing of information can be advantageous in general because it helps consumers make better decisions and promotes honesty on the part of the firm.

Although Consumer Reports provides evaluations for products ranging from hamburgers to washing machines, it refuses to let its name be used as an endorsement of a product. While government support of Consumer Reports would be likely to increase the ability of consumers to distinguish between high- and low-quality goods, it is probable that the Consumers Union, publisher of Consumer Reports, would reject government subsidization because such subsidization might taint the objectivity of the organization. Note that the government has already provided an indirect subsidy to the organization by granting the Consumers Union nonprofit status.

b. **The government should impose quality standards — e.g., firms should not be allowed to sell low-quality items.**

Option b involves a cost of monitoring. After imposing quality standards, the government must either administratively monitor the quality of goods or adjudicate disputes between the public and the manufacturers. Note, however, that low-quality goods may be preferred if they are sufficiently cheaper.

c. **The producer of a high-quality good will probably want to offer an extensive warranty.**

This option provides the least-cost solution to the problems of asymmetric information. It allows the producer to distinguish its products from low-quality goods because it is more costly for the low-quality producer to offer an extensive warranty than for the high-quality producer to offer one.

d. **The government should require all firms to offer extensive warranties.**

By requiring all firms to offer extensive warranties, the government negates the market signaling value of warranties offered by the producers of high-quality goods.

9. **Two used car dealerships compete side by side on a main road.** The first, Harry’s Cars, always sells high-quality cars that it carefully inspects and, if necessary, services. On average, it costs Harry $8,000 to buy and service each car that it sells. The second dealership, Lew’s Motors, always sells lower-quality cars. On average, it costs Lew only $5,000 for each car that it sells. If consumers knew the quality of the used cars they were buying, they would gladly pay $10,000 on average for Harry’s cars, but only $7,000 on average for Lew’s cars.

Without more information, consumers do not know the quality of each dealership’s cars. In this case, consumers would figure that they have a 50-50 chance of ending up with a high-quality car, and are thus willing to pay $8,500 for a car.

Harry has an idea: He will offer a bumper-to-bumper warranty for all cars he sells. He knows that a warranty lasting Y years will cost $500Y on average, and he also knows that if Lew tries to offer the same warranty, it will cost Lew $1000Y on average.

(a) **Suppose Harry offers a one-year warranty on all cars it sells.**

(1) What is Lew’s profit if it does not offer a one-year warranty? If it does offer a one-year warranty?

(2) What is Harry’s profit if Lew’s does not offer a one-year warranty? If it does offer a one-year warranty?

(3) Will Lew’s match Harry’s one-year warranty?

(4) Is it a good idea for Harry’s to offer a one-year warranty?

Without offering the warranty, Lew’s is able to make $2,000 per car (7000-5000). If it were to offer the warranty, each car will now cost Lew’s $6,000, but as consumers will not be able to determine the quality of the cars they will be willing to pay $8,500 for a car, and Lew’s will make $2,500 per car (8500-6000).
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If Lew’s does not offer a one-year warranty then Harry’s can buy its cars for $8,000, sell the cars for $10,000, and make a profit of $1,500 per car after the $500 warranty cost. If Lew’s does offer a one year warranty then Harry’s will only be able to sell its cars for $8,500 and the company will not make any profit.

Lew’s will match Harry’s warranty because if it does then its profit increases from $2,000 to $2,500 per car.

Harry’s should not offer the one-year warranty unless it thinks that Lew’s will act irrationally and not offer the one-year warranty. Given Lew’s will match the warranty, Harry’s is better off not offering the warranty.

(b) What if Harry offers a two-year warranty? Will this generate a credible signal of quality? What about a three-year warranty?

If Harry’s offers a two-year warranty each car will cost $9,000. It will earn $1,000 per car as consumers will recognize the higher quality of its cars. Lew’s will not offer a two year warranty because if they do they will only earn profit of $1,500 per car, which is less than the $2,000 they would earn without offering the warranty. The two year warranty is a credible signal.

With a three-year warranty Harry’s would be making $500 per car, the same that it would have made had it not signaled the higher quality of its cars with a warranty. Therefore, Harry’s would not offer a three-year warranty.

(c) If you were advising Harry, how long a warranty would you urge him to offer? Explain why.

Harry’s will need to offer a warranty of sufficient length such that Lew’s will not find it profitable to match the warranty. Let $t$ denote the number of years of the warranty, then Lew’s will offer a warranty according to the following inequality:

$$7000 - 5000 \leq 8500 - 5000 - 1000t, \text{ or } t \leq 1.5.$$ 

Therefore, I would advise Harry’s to offer a 1.5 year warranty on his cars as Lew’s will not find it profitable to match the warranty.

10. As Chairman of the Board of ASP Industries you estimate that your firm’s annual profit is given by the table below. Profit ($\Pi$) is conditional upon market demand and the effort of your new CEO. The probabilities of each demand condition occurring are also shown in the table.

<table>
<thead>
<tr>
<th>Market Demand</th>
<th>Low Demand</th>
<th>Medium Demand</th>
<th>High Demand</th>
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<tbody>
<tr>
<td>Market Probabilities</td>
<td>.30</td>
<td>.40</td>
<td>.30</td>
</tr>
<tr>
<td>Low Effort</td>
<td>$\Pi=$5 million</td>
<td>$\Pi=$10 million</td>
<td>$\Pi=$15 million</td>
</tr>
<tr>
<td>High Effort</td>
<td>$\Pi=$10 million</td>
<td>$\Pi=$15 million</td>
<td>$\Pi=$17 million</td>
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You must design a compensation package for the CEO that will maximize the firm’s expected profit. While the firm is risk neutral, the CEO is risk averse. The CEO’s utility function is:

$$\text{Utility} = W^{.5} \text{ when making low effort}$$

$$\text{Utility} = W^{5} - 100, \text{ when making high effort},$$

where $W$ is the CEO’s income. (The -100 is the “utility cost” to the CEO of making a high effort.) You know the CEO’s utility function, and both you and the CEO know all of the information in the preceding table. You do not know the level of the CEO’s effort at time of compensation or the exact state of demand. You do see the firm’s profit, however.
Of the three alternative compensation packages below, which do you as Chairman of ASP Industries prefer and why?

PACKAGE 1: Pay the CEO a flat salary of $575,000 per year.

PACKAGE 2: Pay the CEO a fixed 6 percent of yearly firm profits.

PACKAGE 3: Pay the CEO a flat salary of $500,000 per year and then 50 percent of any firm profits above $15 million.

The issue here is how to get your CEO to make high effort but not give away the company store – that is, too much in profits. For each package, first calculate whether the executive will make high or low effort. Then calculate firm profits under each effort to decide if the package works to your advantage. Then select that package which maximizes your profits. CEO Utility under the three packages:

PACKAGE 1: the CEO will give low effort to maximize utility:

Low Effort: $E(U) = (575,000)^{.5} = 758.29$

High Effort: $E(U) = (575,000)^{.5} - 100 = 658.29$.

PACKAGE 2: the CEO will give high effort to maximize utility:

Low Effort: $E(U) = .3(.06x5,000,000)^{.5} + .4(.06x10,000,000)^{.5} + .3(.06x15,000,000)^{.5} = 758.76$

High Effort: $E(U) = .3(.06x10,000,000)^{.5} + .4(.06x15,000,000)^{.5} + .3(.06x17,000,000)^{.5} - 100 = 814.835$

PACKAGE 3: the CEO will give high effort to maximize utility:

Low Effort: $E(U) = .3(500,000)^{.5} + .4(500,000)^{.5} + .3(500,000)^{.5} = 707.11$

High Effort: $E(U) = .3(500,000)^{.5} + .4(500,000)^{.5} + .3(1,500,000)^{.5} - 100 = 762.40$

Now calculate the expected firm profits under each plan net of expected compensation:

PACKAGE 1:

Low Effort: $E(\Pi) = .30x5m + .40x10m + .30x15m - (.575m) = $9.425 million$

PACKAGE 2:

Low Effort: $E(\Pi) = .30x5m + .40x10m + .30x15m - (.3x.3m + .4x.6m + .3x.9m) = $9.4m$

High Effort: $E(\Pi) = .30x10m + .40x15m + .30x17m - (.3x.6m + .4x.9m + .3x1.02m) = $13.254m$

PACKAGE 3:

Low Effort: $E(\Pi) = .30x5m + .40x10m + .30x15m - (.3x.5m + .4x.5m + .3x.5m) = $9.5m$

High Effort: $E(\Pi) = .30x10m + .40x15m + .30x17m - (.3x.5m + .4x.5m + .3x1.5m) = $13.3m$

To maximize the expected profits of ASP Industries, you recommend compensation PACKAGE 3 which uses a flat salary and then a large bonus when the firm does exceptionally well and makes $17 million. You prefer this package because it maximizes firm expected profits net of compensation – here at a value of $13.30 million.
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Notice that if you just gave a very large bonus when the firm did exceptionally well, CEO risk aversion would lead him to make low effort -- or more likely work for someone else. The flat salary offsets the disincetive effects of a risky -- but motivating -- package. This is the usual form of executive compensation. Notice too that compensation is tied to firm profitability.

When the worker gives high effort, always check that your profits are higher under high effort than under low effort. You might be getting high effort, but you are giving away too much so that you really prefer that the worker be lazy! Well not really, but you a giving away too much of firm profits to motivate your employees. If you find this to be a problem, then reduce compensation while keeping high effort until profits from high effort beat profits from low effort. Then you have a compensation plan that makes some sense.

11. A firm’s short-run revenue is given by \( R = 10e - e^2 \), where \( e \) is the level of effort by a typical worker (all workers are assumed to be identical). A worker chooses his level of effort to maximize his wage net of effort \( w - e \) (the per-unit cost of effort is assumed to be 1). Determine the level of effort and the level of profit (revenue less wage paid) for each of the following wage arrangements. Explain why these differing principal-agent relationships generate different outcomes.

a. \( w = 2 \) for \( e \geq 1 \); otherwise \( w = 0 \).

There is no incentive for the worker to provide an effort that exceeds 1, as the wage received by the worker will be 2 if the worker provides one unit of effort but will not increase if the worker provides more effort.

The profit for the firm will be revenue minus the wages paid to the worker:

\[ \pi = (10)(1) - 1^2 - 2 = 7. \]

In this principal-agent relationship there is no incentive for the worker to increase his or her effort as the wage is not related to the revenues of the firm.

b. \( w = R/2 \).

The worker will attempt to maximize the wage net of the effort required to obtain that wage; that is, the worker will attempt to maximize:

\[ w - e = \frac{10e - e^2}{2} - e, \text{ or } 4e - 0.5e^2. \]

To find the maximum effort that the worker is willing to put forth, take the first derivative with respect to effort, set it equal to zero, and solve for effort.

\[ \frac{d(4e - 0.5e^2)}{de} = 4 - e = 0, \text{ or } e = 4. \]

The wage the worker will receive will be

\[ w = \frac{R}{2} = \frac{10(4) - 4^2}{2} = 12. \]

The profits for the firm will be

\[ \pi = (10(4) - 4^2) - 12 = 12. \]

With this principal-agent relationship, the wage that the individual worker receives is related to the revenue of the firm. Therefore, we see greater effort on the part of the worker and, as a result, greater profits for the firm.

c. \( w = R - 12.5 \).
Again, the worker will attempt to maximize the wage net of the effort required to obtain that wage; that is, the worker will attempt to maximize:

\[ w - e = \left( 10e - e^2 \right) - 12.50 - e, \] or \( 9e - e^2 - 12.50 \)

To find the maximum effort that the worker is willing to put forth, take the first derivative with respect to effort, set it equal to zero, and solve for effort:

\[ \frac{d(9e - e^2 - 12.5)}{de} = 9 - 2e = 0, \] or \( e = 4.5 \).

The wage the worker will receive will be

\[ w = R - 12.50 = \left( (10)(4.5) - 4.5^2 \right) - 12.5 = 12.25. \]

The profits for the firm will be

\[ \pi = ((10)(4.5) - 4.5^2) \cdot 12.25 = $12.50. \]

With this principal-agent relationship, we find that the wage of the worker is more directly related to the performance of the firm than in either \( a \) or \( b \). We find that the worker is willing to supply even more effort resulting in even higher profits for the firm.