discussion

Information Contracting in Financial Markets

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Bhattacharya and Pfleiderer (1985) (henceforth BP) analyze contracts between a group of uninformed investors and an informed agent hired to manage their wealth for them. The paper contributes to at least two areas. The contracts considered effectively allow the informed person to sell his information. It is thus concerned with the operation of markets for information. Section I concentrates on this aspect. In addition, BP extends the literature on the principal-agent problem and managerial contracts. Section II deals with this.

I. MARKETS FOR INFORMATION

Casual observation suggests that information about the returns to securities is often sold. This can take a direct form, such as market newsletters. Alternatively, it can be indirect: many forms of financial intermediation are intimately connected with the provision of information. For example, actively managed mutual funds perform research, and the resulting information is used to invest clients' funds. One of the features of full-service stockbrokers is that they give investment advice as well as executing orders. Similarly with many other types of intermediary, information comes as part of a package of services. In addition to being important in its own right, a full understanding of the market for information is therefore necessary for explaining the existence and operation of many of the intermediaries that are observed. Despite this, markets for information about securities are only rarely even mentioned. BP is one of the first papers to contain a formal analysis of how such markets work. This section starts by considering some of the special features of information markets and relates BP and other recent work to these markets. It then goes on to consider the role of this type of analysis in explaining intermediation.

Information is unlike any other commodity. As a result, information markets differ substantially from markets for other commodities. The first problem in selling information was pointed out by Hirshleifer (1971). Anybody

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can claim to have superior forecasting ability or to have done research on the returns to securities. How can a buyer be sure that the seller's claimed information has not simply been fabricated? This adverse-selection/moral-hazard problem is the central focus of BP and Allen (1985).

BP is concerned with the problem faced by investors who have formed a mutual fund. They wish to hire a manager to do research and then use the information acquired to manage their funds for them. There are two assets: a safe one and a risky one. The payoff to the risky asset is normally distributed. When managers do research, they observe a signal that is the sum of the risky asset's payoff and an independent normally distributed error: the higher a manager's ability, the greater the precision of his payoff estimate and also the greater his exogenous alternative earnings opportunities. The utility functions of managers and portfolio owners are exponential in final wealth and are observable. The portfolio owners' problem is to design a contract that ensures that a manager has a greater precision than their own and obtains at least as high a utility as in his alternative opportunity. BP's main result is to show that by using a payment schedule that is a quadratic function of the risky asset's payoff, it is possible to ensure that a manager correctly reveals his true conditional mean and precision. Moreover, the contract they derive is shown to be approximately optimal if the portfolio owners, taken together as a syndicate, are almost risk neutral.

Allen (1985) also focuses on the adverse-selection/moral-hazard problem. The structure of the model used is similar to BP in terms of the nature of the informed person's information and, there being two assets, normally distributed returns and exponential utility functions. However, rather than looking at the problem in the context of portfolio owners hiring managers, the informed person has a monopoly over the information he acquires and sells it directly to uninformed people. Thus the informed person obtains the surplus from his information, whereas in BP the portfolio owners receive it. Instead of the manager's alternative opportunity being exogenous, it is assumed that the informed person can either sell his information or use it to just invest in the two assets. Also the informed person's utility function is unobservable.

The sequence of events when information is sold is the following. Before the signal is observed, the seller announces a set of payment schedules to potential buyers, where the payment depends on the risky asset's payoff. There is one schedule for each possible signal. The buyers then decide whether or not to purchase the information. After contracts are signed, the seller observes the signal and announces the corresponding payment schedule to the buyer. Markets meet and the risky asset's payoff is realized. Finally, the buyers make a payment to the seller, determined by this and the announced schedule.

The main problem for the seller is to convince buyers that he will actually observe the signal after the contract is signed. This is achieved by constraining each of the payment schedules so that if the seller did not observe the signal, he would not be any better off from selling information than from just investing in the two assets. If he sells information, his total receipts come from two sources: payments from the information buyers and returns on his portfolio. Both his portfolio and the contracts he has signed with other buyers are assumed to be observable. Therefore, given a utility function for the seller, every buyer can work out for each schedule the seller's expected utility if he were uninformed, from going ahead and selling information. They can also work out his expected utility if he were uninformed and were to just invest in the two assets. Provided the latter is greater than the former for every payment schedule, buyers know that if the seller had the given utility function he must be going to observe the signal. Otherwise he would be worse off than if he had not tried to sell information. Since the seller's utility function is unobservable, this constraint must be satisfied for all the possible utility functions the seller could have.

Although this set of constraints has a complex form in general, the assumption of exponential utility allows a tractable version to be found. The schedule that maximizes the seller's utility and satisfies the constraints can then be derived for each possible signal. As in BP's analysis, it involves a quadratic function of the risky asset's payoff, but the differences in assumptions mean the details are not at all similar. It turns out that the resulting set of schedules is such that it is possible for buyers to uniquely deduce the precision of the seller's signal and his degree of absolute risk aversion. Given these, a unique signal can be associated with each schedule. Thus the schedules themselves convey the seller's information. The payment to the seller is shared equally by the buyers. There must be enough buyers so that the cost to each makes the information worth purchasing. Since every buyer's benefit from the information is finite, only a finite number of buyers is necessary. Finally, it can also be shown that selling information is the informed person's optimal course of action: he is always better off doing this than simply using his information to invest in the two assets.

At the end of their paper BP make a conjecture concerning the situation where managerial utilities are unobservable (see Proposition 4). This case is similar to the problem solved by Allen (1985). A full analysis of their conjecture should shed further light on the relationship between the approaches.

The adverse-selection/moral-hazard problem is not the only important difference between markets for information and those for other commodities. Another results from the fact that the prices of assets can signal investors' private information (see Admati this volume). Usually, the more people that have a particular piece of information, the better prices reveal it and the less valuable it is. In contrast to standard commodities, there is thus a relationship between the amount that is sold and the value of that information to individual traders. This relationship does not arise in BP or Allen (1985). The model in BP is partial equilibrium in nature, and asset prices are taken to be exogenous. In Allen (1985) the number of information buyers is finite, but there is a continuum of asset traders, so the price of the risky asset is unaffected by the information market. As a result, the analysis of the adverse-selection/moral-hazard problem is greatly simplified.

Admati and Pfleiderer (henceforth AP) (1984, 1986) take the opposite approach. They focus on some of the implications of the link between the information market and the price of the risky asset in a similar framework with exponential utility and normally distributed returns. The adverse-selection/moral-hazard problem is avoided by assuming it is possible to observe directly whether people are informed.

AP (1984) considers the buyer's side of the information market. It looks at the value of the information contained in a noisy private signal given that prices are also noisy signals of the same information. There are thus externalities: even if a private signal is unaltered, any change in the noisiness of the price signal can affect the value of the information it contains. AP show that one implication of these externalities is that there may be a nonconcavity in the value of information: taken together two signals may be worth more than the sum of the values of each taken separately.

In AP (1986) the authors go on to consider the optimal strategy of a monopolist seller of information. The problem is that the more people the monopolist sells to, the more the price reflects his information and the less buyers are prepared to pay for it. One possibility for improving this trade-off is for the monopolist to add noise to his signal when he sells it. This has the advantage that the price reflects less information for a given number of sales, and so the seller can sell to more people. It has the disadvantage that it lowers the price that can be charged. AP show that if a seller has precise information he should randomize, but otherwise, he should not. They also demonstrate the seller is better off using individualized randomization, where different noise is added to each buyer's information, than "xerox" randomization where the same noise is added.

As argued initially, understanding information markets is important in explaining the operation and role of many financial intermediaries. An illustration of this is the paper by Ramakrishnan and Thakor (1984a). In their model, firms issuing securities hire information producers to certify their value. Similarly to BP and Allen (1985), the focus is on the moral-hazard problem, but they assume there is a direct noisy indicator of information producers' effort. Their resolution of this problem leads to a theory of intermediation that is not based on transaction costs (for a further discussion of this, see Diamond this volume).

Other examples of the relationship between the operation of markets for information and the role of intermediaries come from AP (1984) and Allen (1985). The nonconcavity in the value of information identified in AP (1984) suggests that information producers may find it profitable to join together and form an intermediary to sell the information. In Allen (1985) the continuum of traders implies that the value of the informed person's information is unbounded. However, the constraints necessary to solve the adverse-selection/moral-hazard problem cause his expected utility to be finite. An implication of this is that intermediation will be profitable: by reselling the information an intermediary can capture part of the value that the original seller cannot.

One of the differences between BP and AP (1986) and Allen (1985), which arises from the public good nature of information, suggests one possible explanation for why actively managed mutual funds exist as intermediaries. BP assume exogenously that portfolio managers do not transmit their information to portfolio owners: instead the owners initially specify the investments to be made in each possible situation, and the managers simply carry out the appropriate set of instructions once they have observed their information. In contrast, in AP (1986) and Allen (1985) the information is transmitted directly to buyers, and they make their own investments.

Since information is a public good, buyers may be able to resell it. In this case the original seller would have to compete with the resale, and this may severely limit the price he can obtain. This possibility is ruled out in A P (1986) and Allen (1985). One assumption that guarantees this is that resale is observable because the original seller can then outlaw it. Another possibility is that information transmission takes time. This implies information is more valuable to early buyers, and competition from resale is less severe. Where markets meet only once before asset payoffs are received, the seller can eliminate the problem by timing the transmissions to buyers so late that they cannot resell. However, in many other situations, resale can pose a serious problem for sellers. One way this can be avoided is for the seller to set up an actively managed mutual fund that would operate as in BP. Hence, taking account of the public good aspect of information provides an explanation for the existence of mutual funds. This differs substantially from the usual transaction cost theories.

In conclusion, it can be seen from the above discussion that work on information markets is still at an early stage. Much remains to be done before a full understanding of them is obtained.

II. PRINCIPAL-AGENT RELATIONSHIPS

The second contribution of BP is to the literature on the principal-agent problem in general and managerial contracts in particular. As Ross (1973) points out (p. 135): "for some questions the *raison d'être* for an agency relationship is that the agent (or the principal) may possess different (better or finer) information about the states of the world than the principal (agent)." BP is one of the first papers to consider a situation where the motivation for the agency relationship is differences in information. This section relates their approach to other recent work on the principal-agent problem and managerial incentives.

Ross (1973) considers a model where the agent takes an unobservable action that determines the probability distribution of output that accrues to the principal. The agent incurs no disutility from taking this action: in the context of the shareholder-manager relationship, actions can be interpreted as investments. The principal's payment to the agent is a function of the level of output, which is observable. This schedule is chosen to maximize the principal's utility but must be such that the agent can obtain his reservation expected utility. If actions were observable, the optimal contract would specify the agent's first-best action, and the payment schedule would share the risk associated with that action optimally.

However, when actions are unobservable, this schedule may not provide the correct incentives for the agent to choose the first-best action. He may be better off choosing another action that gives him a higher expected return at the expense of the principal. In such cases the principal must design a second-best contract that takes into account that the agent chooses his action to maximize his expected utility. The resulting payment schedule optimally trades off the allocation of risk and the provision of incentives.

In Ross's model the principal knows the probability distribution associated with each possible action or investment but cannot observe which one the agent chooses. In contrast, in BP's model the principal knows the investment the agent makes but does not know the associated probability distribution. The principal must therefore choose the payment schedule to ensure that the agent has a precise estimate of the returns to the possible investments.

Much of the principal-agent literature subsequent to Ross's paper focuses on the case where the agent's action requires unpleasant effort (see, for example, Mirrlees 1974, Harris and Raviv 1979, Holmstrom 1979, Shavell 1979, and Grossman and Hart 1983). In the simplest version of this type of model, a risk-averse agent takes an action, and this action together with a random variable determines the output that accrues to a risk-neutral principal. The structure of the principal's problem is similar to that in Ross's model. If the agent's actions were observable, the optimal contract would specify the agent's first-best action and the principal would pay him a fixed fee: since the principal is risk neutral, it is optimal for him to absorb all the risk.

If the agent's actions cannot be observed directly and cannot be deduced from output because the random variable is also unobservable, this type of scheme is no longer desirable: If the agent is paid a fixed fee no matter what he does, he has an incentive to shirk. In order to make him work, it is necessary for his compensation to depend on his actions. This can be achieved by making his payment a function of output, but it has the disadvantage that he must bear some of the risk associated with the random variable. Usually the second-best contract will involve his receiving a higher expected wage and working less than with the first-best contract. This compensates him for the increased risk, so he still obtains his reservation utility. As for the principal, he is worse off than in the first-best case by an amount that depends on how reliably the output indicates the agent's action. The less reliable an indicator it is, the worse off the principal is. If there exist any proxies for the agent's effort in addition to output, then Holmstrom (1979) and Shavell (1979) have shown that the agent's compensation should also be based on these.

Many authors use variants of the principal-agent model to analyze managerial compensation schemes in more detail. For example, Diamond and Verrecchia (1982) adapt an example of Holmstrom (1982a) to include a capital market. In addition to the output being a proxy for managerial effort, it is shown how stock price and a measure of systematic risk may also be useful. The stock price reflects the private information of investors; taking it and the indicator of systematic risk together with output gives a better signal of managers' effort than does output alone. A closed-form solution is obtained for the optimal contract, and it is shown that the risk-neutral principal bears all the systematic risk. However, the agent must bear the nonsystematic risk, since it is this that prevents his actions being perfectly deduced from output. In contrast to standard valuation theories, such as the arbitrage pricing theory (APT) or the capital asset pricing model (CAPM), this implies that nonsystematic risk becomes important for capital budgeting decisions. The greater the nonsystematic risk, the less effective the proxies are as indicators of managerial effort, and the more risk the manager must bear to have incentives to work. The cost of this greater risk is borne by the shareholders, who therefore prefer projects with less nonsystematic risk. Ramakrishnan and Thakor (1984b) demonstrate similar results on the role of nonsystematic risk, in the context of a more general model. Whereas Diamond and Verrecchia make very specific assumptions concerning the risk neutrality of the principal, the utility function of the agent, and the distribution of asset returns, Ramakrishnan and Thakor consider the case where the principal is risk averse, the agent has a separable utility function, and asset returns are determined in an APT framework. (For other aspects of managerial incentives see Marcus 1982 and Beck and Zorn 1982.)

In contrast to analyses of the principal-agent problem that assume the agent's actions involve unpleasant effort, BP assume the agent expends no costly effort in acquiring his superior information. Instead their focus is on the screening problem caused by the fact that people have different abilities and hence different precisions. An interesting variant of BP's model would be the case where everybody has the same ability, but obtaining more precise information involves greater disutility. This analysis would involve the agent's choice of precision in the same way that the agent chooses effort in the standard models discussed above.

Holmstrom (1982b) suggests another type of situation in which the interests of a principal and agent may diverge. Similar to BP, the agent's role is to provide information to the principal. However, in contrast to BP, the reason interests differ is that the manager is concerned with the effect of investment outcomes on his future reputation, whereas the firm is interested in the profitability of investments. In Holmstrom's example, the job of the agent or manager is to find investment projects and suggest them to superiors, who make the actual decisions. He cannot misrepresent information about any project he suggests, but he can refrain from suggesting them. Initially his ability, which is associated with his expected marginal product, is unknown by himself and by the firm. This symmetry is preserved throughout. Further information on his ability is provided by the outcomes of projects. If the manager is paid his expected marginal product, undertaking projects that reveal a lot of information about his ability makes his future income stream riskier. If he is risk averse, he may be better off hiding such projects. They may be profitable, however, and hence desirable from the firm's point of view.

In a subsequent paper Holmstrom and Ricart i Costa (1984) (henceforth HR) consider the same issue in a more general model and derive the optimal contracts firms should use. The ideal way of solving the problem would be to fully insure the manager's human capital risk. This would involve paying everybody the initial expected marginal product no matter what their ability turned out to be. However, this type of solution is not usually feasible because the legal system prohibits contracts that tie employees to a firm. Consequently, it is optimal to pay a reduced wage during the first period and then partially insure in subsequent periods. Those who turn out to have an ability below a certain level receive a downwardly rigid wage; those above receive their marginal product to ensure they do not leave the firm. However, it may be optimal to pay bonuses for investing, since this can provide incentives to bring forward proposals. The rules for investment decisions are also part of the insurance provided to managers. These rules require that the hurdle rate is above the opportunity cost of capital, and there may also be capital rationing.

HR's analysis differs substantially from those of other repeated principal-agent problems. Fama (1980) suggests managers' concern for their reputation can, in contrast, play a significant role in providing incentives to work. In his model, a manager's ability, which is again associated with his expected marginal product, cannot be directly observed and is subject to random change. If a manager reduces his effort below the optimal level, output will also be reduced on average. A low output will be taken as a signal that a manager's ability has declined. As a result, his compensation in subsequent periods will fall. Fama gives an example with a zero discount rate where, in the long run, managers bear the full cost of any deviation from the optimal effort level. They therefore have the correct incentives even though contracts are not used at all.

If there were no repetition of the relationship in HR's model, there would be no divergence of interests. Thus, time is a cause of the problem. However, in many other recent papers repetition improves efficiency (see, e.g., Radner 1981, Rubinstein and Yaari 1983, and Rogerson 1985). For example, Radner (1981) considers a standard principal-agent relationship where effort causes disutility. He shows that if there is no discounting and the principal is risk neutral, then as the number of repetitions goes to infinity the first-best can be arbitrarily closely achieved. Repetition improves efficiency for two reasons. First, it allows risk to be diversified across time. Second, it provides valuable information about the distribution of output and, hence, about the agent's actions.

Holmstrom and Milgrom (1985) suggest another type of repeated principal-agent model. In this the agent produces a sequence of observable outputs that accrue to the principal. The level of each output in the sequence depends on the cost spent by the agent and a random variable, neither of which can be observed by the principal. At the end of the sequence the principal makes a payment to the agent, which is a function of the history of outputs. The agent's utility depends on this payment less the total costs expended in producing the sequence. In this model, repetition is not a cause of the divergence of interests, as in HR. Neither does it increase efficiency, as in Radner (1981). Instead, repetition results in a rich set of actions for the agent to choose from.

Holmstrom and Milgrom are able to show that this richness can lead to optimal incentive schemes where payments are simple linear functions of aggregate output.

As the quotation from Ross (1973) at the beginning of the section stresses, the existence of many principal-agent relationships is due to the fact that the agent has, or can acquire, superior information. Despite this, only a few papers have considered situations of this type. As with markets for information, research in this area is still at an early stage.

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