ECONOMICS OF INFORMATION

Sanjit S. Dhami*

*Department of Economics, University of Newcastle, Newcastle Upon Tyne, NE1 7RU, United

Kingdom; Tel: 191-2225141; email: Sanjit.Dhami@ncl.ac.uk .

THE ECONOMICS OF INFORMATION

[]A situation of 'asymmetric information' (AI) exists when of the two or more parties to a transaction, at least one of the parties has access to information that the other parties do not possess. For this situation to be of interest, AI typically affects the payoff of all parties. Economists distinguish between two types of AI. In the first type, known as *adverse selection*, AI exists before the two parties enter into a relationship. The second type, which is known as *moral hazard*, occurs when AI arises after the parties enter into a relationship.

[]Adverse Selection: Problems involving adverse selection are generally addressed through one of the two methods, *signaling* or *screening*. Each of these methods is explained below in sequence.

[]Signaling: In signaling models, the party which possesses the private information, offers the terms of exchange which the other party can either accept or reject. Consider an example of a car seller, who has private information about the quality of the car that he wishes to sell. The quality can either be good (peach) or bad (lemon). The buyer is uninformed about the quality[1]. Suppose that a peach is worth S_P and B_P dollars respectively to the seller and to the buyer, and the respective worth of a lemon to the seller and to the buyer is S_L and B_L dollars. Assume that $S_L < B_L$ and $S_P < B_P$ so that when both parties have full information on quality, trade will always take place. Moreover if the seller has the entire bargaining power, the price of a peach and lemon will respectively be $P_P = B_P$ and $P_L = B_L$.

[]Under AI, only the seller knows the quality of his car. The buyer's beliefs are that the respective probabilities of a peach and lemon are x and 1-x, therefore, he will be willing to pay $P = xB_P + (1-x)B_L$ for the car. If $P \geq S_P$ and $P \geq S_L$, the markets for peaches and lemons will

---

[1] This example is due to Akerlof (1970). The seller has an informational advantage before the two parties enter into a transaction, hence this example implies an adverse selection situation.

function actively. However if $S_L < P < S_P$, the seller of a peach will no longer find it worthwhile to sell his car. The market for good quality cars therefore disappears. Economists describe such a situation as one of 'market failure'.

[]AI problems plague most economic transactions. So how do markets cope with this problem? In our example, the peach seller could take some action that clearly distinguishes him from a lemon seller. Since a lemon will break down more often, a longer warranty will be more expensive for the lemon seller to service. Hence, the peach seller could offer a warranty $W(T)$ of length T, choosing T so that the lemon seller cannot possibly offer it. As soon as a buyer observes the warranty $W(T)$, he knows that the car is a peach, hence the lemon seller might as well offer no warranty at all. Since the seller is assumed to have the entire bargaining power, this implies that, as in the full information case, the respective prices of a peach and lemon are $P_P = B_P$ and $P_L = B_L$. Such an equilibrium is known as a '*separating equilibrium*' (SE). Although in a SE, the outcome is efficient[2] social welfare is lower because of the additional cost to the sellers of servicing their warranties.

[]Another possibility is a pooling equilibrium (PE), whereby the peach seller cannot design a warranty that sets him apart from a lemon seller. This occurs if in a SE, $P_P < S_P + W(T)$ i.e. the price received by the peach seller does not cover his valuation for the car and the warranty cost. In a PE, the buyer cannot tell the two types of sellers apart, so he will be willing to pay a price of only $P = xB_P + (1-x)B_L$. Clearly since $P > P_L = B_L$ and $P < P_P = B_P$, a lemon owner benefits while a peach owner is harmed in a PE relative to a SE.

[]The basic principles outlined above have been exploited by most branches of economics[3]. Spence (1973) considered the problem of a worker seeking employment with a firm when the worker has

---

[2] Efficiency requires that if the car is worth more to the buyer than to the seller, then exchange must take place.

private information on his ability, which is either high or low. If education is relatively harder for the low ability worker to acquire, the high ability worker, in order to signal his type, can attain a level of education, which the latter cannot possibly attain. When the firm looks at the curriculum vitae of the worker, it finds out his type. In the starkest version of the model, education does not enhance the worker's ability; hence, it is socially wasteful. Nevertheless, education performs a useful role in revealing information to the firm. The social cost in this case would be to acquire unproductive education. Cho and Kreps (1987) have shown that a PE can be ruled out in this model.

[]Signaling models have also been used to explain debt to equity ratios (leverage) of companies. Suppose that investors are less informed about the firm's future profit prospects than the managers of the firm. Only a firm with good prospects can hope to repay a higher level of debt in the future, hence, a firm with good prospects can, by deciding on a high leverage, separate itself from a firm with bad prospects. Ex-post when investors observe a high leverage, they become informed of the firm's prospects. Myers and Majluf (1984) deal with these issues.

[]<u>Screening Models</u>: Unlike signaling models, in screening models the uninformed party offers the terms of exchange, which the informed party can either reject or accept. Suppose that an insurance company is negotiating the terms of life insurance with a potential client who has private information on his health. Assume that there are only two types of clients; type A who face some terminal illness and they are sure to die within the year and type B who face normal e.g. age related risk of dying. What is the optimal contract offered by the insurance company? The company offers two contracts (1) contract A specifies limited benefits that just leave the type A clients indifferent between accepting or rejecting contract A. (2) Contract B promises limited benefits for the first year, but high benefits in the

---

following years. Type A clients would never accept contract B; they are screened out[4].

[]As in signaling models, information revelation imposes additional costs. The most visible cost is the distortion in exchange that results from the lack of information. In the insurance example, for instance, in order to induce separation, type B clients must only be given limited benefits for the first year in the event that they die during that year. This problem does not arise when the insurance company has full information on the client's health.

[]The 'revelation principle' simplifies the solution to screening models. In the insurance example which captures the essential spirit of screening models, the revelation principle implies that the insurance company can directly asks the client his type. If the announced type is A then the client gets contract A and if the announced type is B the client gets contract B. It is apparent that each type will now truthfully announce his type. Treatments of the revelation principle can be found in Fudenberg and Tirole (1990) and Mas-Colell, Whinston and Green (1995).

[]Screening models have proved quite useful in the regulation literature[5]. In the prototype model due to Baron and Myerson (1982), a monopolist public firm has private information about its costs which can either be high or low. The problem facing a regulator is to design an optimal regulatory scheme when he only observes the monopolist's output, but not his cost. They show that in order to induce the low cost type to separate from the high cost type, the latter is regulated to produce too low an output level that the former would not find profitable to imitate. Therefore, there is a distortion relative to the full information case. Baron and Besanko (1984) extend this prototype model by allowing for occasional auditing of the monopolist's costs.

---

[4] Technically, contracts A and B must fulfill the incentive compatibility conditions, namely that each type does not find it worthwhile to accept the contract designed for the other type. In addition, a set of conditions known as the participation conditions require that participation in the scheme is voluntary.

[5] For a book length treatment, that is both authoritative and comprehensive, see Laffont and Tirole (1993).

[]A literature in public economics looks at the issue of financing a public good through contributions from citizens when the citizens have private information on their willingness to pay for the public good. The revelation principle can now be used to screen among the different types of each citizens, so that in equilibrium, each citizen prefers to announce his true underlying type[6]. Another application of AI is in optimal tax theory (see Mirrlees (1971)). The problem here is to design the optimal income tax on individuals when they have private information on their abilities. One startling result of this literature is that the marginal tax on the richest individual is optimally zero.

[]In Stiglitz and Weiss (1981), each of several potential liquidity constrained investors has access to a project. The project's profitability is private information to the investor and projects having greater expected returns are also riskier. If the project succeeds, the loan is repaid to the bank; if it fails, the investor declares bankruptcy and the bank gets nothing. An increase in the bank's interest rate has two effects. (1) Its profits increase in the event that the project is successful. (2) It attracts riskier investors at the margin because the greater amount that needs to be repaid can only be generated through riskier projects. Hence, the bank might be reluctant to raise the interest rates to a level that clears the loan market. Thus, credit might be rationed and investment curtailed[7].

[]In the context of bargaining, suppose that a seller is bargaining with a buyer over the sale of one unit of an indivisible object. The buyer has private information on his valuation for the object[8] which can either be v_L or v_H dollars with respective probabilities λ and $1 - \lambda$ that are known to the seller. The seller's known cost of supplying the object is c dollars. Suppose that $c < v_L < v_H$, so that under full information about the buyer's valuation, trade would always take place. Assume that the seller can

---

[6] See Fudenberg and Tirole (1992) for the solution to this problem under assumptions of varying complexity.

[7] See Blanchard and Fischer (1989) for the macroeconomic implications of credit rationing for monetary policy.

[8] Myerson and Satthertwaite (1983) present a model in terms of two sided AI; the buyer also has asymmetric information on the seller's cost of supplying the object. See Fudenberg and Tirole (1990) for a textbook treatment.

make a take-it or leave-it offer to the buyer i.e. he has the entire bargaining power. The seller should then either offer a price $P_L = v_L$ or a price $P_H = v_H$. It is easy to check that starting from any other price the seller can improve his profits by asking for either of these prices. At the price P_H, only the high valuation buyer purchases the object and the seller makes an expected profit of $[1-\lambda](v_H - c)$. A price of P_L attracts both types of buyers and the seller makes an expected profit of $(v_L - c)$. The price P_H is thus optimal for the seller when $[1-\lambda](v_H - c) \geq (v_L - c)$ [9].

[]The price P_H rules out the low valuation buyer, so trade might sometimes not occur even when efficiency dictates that it should. This is another instance of market failure; private markets do not always produce the efficient outcome under AI. These arguments are often cited as a rationale for governmental programs such as insurance and other social security programs that would not otherwise be fully provided in private markets.

[]Screening models become quite complex when parties interact repeatedly. Consider a subsidiary of a parent firm that has private information on its profitability that can be either high or low. The parent firm is required to set profitability targets for the subsidiary in a two-period model. If in the first period the subsidiary achieves a high profit, it gives away its type and hence its second period profit target will be high. If producing higher profits requires greater effort, then the high profit type might want to hide its type in the first period by producing low profits. Therefore, the parent firm learns nothing in the first period and it does not set too stringent a second period profit target for the subsidiary, which is exactly what the subsidiary desired [10].

[]There are two competing models of adverse selection which deal with repeated interaction. In the

---

[9] Check e.g. that it holds for $\lambda = 1/2$, $c = 1$, $v_H = 10$ and $v_L = 5$.

[10] This phenomenon is known as the ratchet effect. See chapters 9 and 10 in Laffont and Tirole (1993) for an introduction to models of repeated AI as well as for a good list of references.

first, the parties interact through a series of *short term contracts* (i.e. a new contract every period) and in the later, through a *long term contract* that is finalized at the beginning of the relationship. Long term contracts can be renegotiated as information on types becomes available in subsequent periods. Since parties can foresee this renegotiation in the future, they might as well renegotiate now; the principle of renegotiation-proofness[11].

[]<u>Moral Hazard</u>: The issue here is the appropriate design of incentive schemes for an agent who works for a principal but has private information on his effort level[12]. The principal only observes an imperfect indicator of the agent's effort, such as output, which could be influenced by factors beyond the agent's control. However, greater effort increases the probability of achieving higher output levels. The principal's offer of a wage to the agent must be based solely on the observable (and verifiable) output for otherwise, a court cannot enforce violations of the contract. If the agent is paid a fixed salary, he will shirk because he has no stake in output. Wage schemes based on output increase the agent's incentive to work by creating stakes in higher output levels. It is for this reason that salesmen are often paid on a commission basis.

[]Although a wage scheme based on output creates incentives for higher effort, it has one serious drawback. If output fluctuates too much (due to influences outside the agent's control) the agent faces too much of an income risk. The optimal wage scheme balances these opposing influences of incentives and risk. Mirrlees (reprinted in 1999) provided the initial framework that was extended by Holmstrom (1979) and Grossman and Hart (1983).

---

[11] See Hart and Tirole (1988) for the theory and for an application to the development literature see Muthoo (1998).

[12] For example, suppose that a manufacturer enters into a contract with a salesman to sell his product to the final customers. Subsequent to the signing of the contract, the salesman can either put in a high level of effort or he can shirk. The manufacturer only observes the final level of sales made by the salesman and not his effort. Notice that unlike adverse selection models, AI arises only after the contract has been signed.

[]Applications of the basic moral hazard model in economics are too numerous to list. Such models have been applied to agrarian contracts (Hayami and Otsuka (1993)), capital taxation on firms (Dhami and Mintz (1997)), and the existence of unemployment (Shapiro and Stiglitz (1984)) among the many diverse phenomena. For applications to political economy settings, see the entry on 'Economics and Politics' in this volume.

[]Holmstrom (1982) deals with a moral hazard model when several agents work for the same principal. The basic idea is that one agent's output provides information on another agent's effort. An example is the practice of firms, especially retail firms, of declaring an 'employee of the month'; this 'yardstick competition' whereby one agent's reward is conditioned on the performance of all others creates incentives for all agents to work hard.

[]Common –Agency is another extension in which an agent works for several principals. NATO can be considered as an agent of several principals (the countries that comprise NATO). The aims of the principals can be in conflict, e.g they might differ on the issue of sending ground troops into a troubled region. If there was a single principal, and he wanted to send in ground troops, NATO would do so. With common agency, some principals might create disincentives for NATO to send in ground troops, by e.g. refusing their countries to be used as launching pads for military action. Therefore, conflict among principals could result in very different incentives for NATO. Bernheim and Whinston (1986) provided the initial idea for this literature.

[]In the multitask agency literature (see Holmstrom and Milgrom (1990, 1991)), the agent performs several different tasks for the same principal. Consider e.g. the issue of performance related pay for schoolteachers, e.g. salaries which depend on student grades. Preparing students for exams is only one of the many tasks that teachers perform. They might e.g. spend time in improving the reasoning capabilities of students, enhancing their critical abilities, making them more curious of the things

around them etc.; tasks that are not necessarily well reflected in student grades. With performance related pay, teachers might shift effort from tasks that are otherwise crucial in the development of their students to those that are well reflected in student grades. Thus, the multitask agency literature suggests that optimal incentives might well be 'low powered' an example of which is fixed salaries.

[]The multitask agency literature has been applied to develop an incentive based theory of the firm (Holmstrom and Milgrom (1994)), to optimal multidimensional taxation (Dhami (1998a)) to agrarian labor contracts (Dhami (1998b)) and to an understanding of the optimal contractual forms in gasoline retailing (Slade (1996)).

[]Economics of information is a very large and rapidly expanding field and even a semester length course cannot do full justice to the theory and rich applications in several distinct fields. Given the aims of this volume, this survey has been very selective and brief. It has striven only to offer a flavor of some of the issues. The interested reader will find it profitable to pursue some of the original references listed below.

<div align="center">References</div>

Akerlof, G., "The Market for Lemons: Quality Uncertainty and the Market Mechanism" Quarterly Journal of Economics, 89 (1970):488[-]500.

Baron, D. and R. Myerson, "Regulating a Monopolist with Unknown Cost", *Econometrica*, 50 (1982):911[-]30.

Baron, D. and D. Besanko, "Regulation, Asymmetric Information and Auditing", Rand Journal of Economics, 15 (1984):447[-]70.

Bernheim, B. and M.D. Whinston, "Menu Auctions, Resource Allocation, and Economic Influence", Quarterly Journal of Economics, 101 (1986):1[-]31.

Blanchard, Olivier J. and Stanley Fischer, Lectures on Macroeconomics, Cambridge: The MIT Press,

1989.

Cho, I.-K., and D. Kreps, "Signaling Games and Stable Equilibria", Quarterly Journal of Economics, 102 (1988):179[-]202.

Dhami, Sanjit., "Income Uncertainty, Measurement Problems and Optimal Multidimensional Income Taxation", University of Essex Discussion Paper No. 492, 1998a.

Dhami, Sanjit., "A Multitask Agency Theory of Optimal Agrarian Labor Contracts", University of Essex Discussion Paper No. 490, 1998b.

Dhami, Sanjit., and Mintz, Jack., "Risk, Moral Hazard and the Role of Capital Taxes", University of Essex Discussion Paper No. 475, 1997.

Fudenberg Drew and Jean Tirole, Game Theory, Cambridge: The MIT Press, 1992.

Grossman, S. and Oliver Hart, "An Analysis of the Principal-Agent Problem", *Econometrica*, 51 (1983):7[-]45.

Hayami, Yujiro and Keijiro Otsuka, The Economics of Contract Choice: An Agrarian Perspective, Oxford: Clarendon Press, 1993.

Hart, O., and J. Tirole., "Contract Renegotiation and Coasian Dynamics", *Review of Economic Studies*, 55 (1988):509[-]-40.

Holmstrom, Bengt., "Moral Hazard in Teams" *Bell Journal of Economics*, 13 (1982):324[-]40.

---------- "Moral Hazard and Observability" *Bell Journal of Economics*, 10 (1979):74[-]91.

Holmstrom, Bengt and Milgrom, Paul. "Regulating Trade Among Agents" *Journal of Institutional and Theoretical Economics*, 146/1 (1990):85[-]105.

--------- "Multitask Principal Agent Analysis: Incentive Contracts, Asset Ownership and Job Design" *Journal of Law Economics and Organization*, 7/2 (1991):201[-]28.

--------- "The Firm as an Incentive System" *American Economic Review*, 84 (1994):972[-]91.

Laffont, Jean-Jacques and Jean Tirole, A Theory of Incentives in Procurement and Regulation, Cambridge and London: The MIT Press, 1993.

Mas-Collel, A., M.D. Whinston, and J.R. Green, Microeconomic Theory, Oxford: Oxford University Press, 1995.

Mirrlees, J. A., "The Theory of Moral Hazard and Unobservable Behaviour: Part I", *Review of Economic Studies*, 66/1 (1999):3[-]22.

Mirrlees, J. A., "An Exploration in the Theory of Optimal Income Taxation", *Review of Economic Studies*, 38 (1971):175[-]208.

Muthoo, A., "Renegotiation-Proof Tenurial Contracts as Screening Mechanisms", *Journal of Development Economics*, 56 (1998):1[-]26.

Myers, S. and N. Majluf, "Corporate Financing and Investment Decisions when Firms have Information that Investors do not have", *Journal of Financial Economics*, 13 (1984):187[-]221.

Myerson, R. and M. Satterthwaite, "Efficient Mechanisms for Bilateral Trading", Journal of Economic Theory, 28 (1983):265[-]81.

Slade, Margaret E., "Multitask Agency and Contract Choice", *International Economic Review*, 37/2 (1996): 465[-]486.

Spence, A. M., "Job Market Signaling", Quarterly Journal of Economics, 87 (1973):355[-]74.

Stiglitz, J. and Andrew Weiss, "Credit Rationing in Markets with Imperfect Information", American Economic Review, 71 (1981):393[-]410.