INFORMATION AND ECONOMIC BEHAVIOR

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13. ABSTRACT

This paper surveys the ways in which recognition of limitations of information available to economic agents affects the workings of the system and the way in which the propositions of economic theory need restatement. The key point is the fact that probability distributions over economic variables are conditional upon signals on other, apparently irrelevant variables; further, this information is differentially available to different individuals and requires resources to acquire and transmit. Among the economic phenomena to which the information concept is relevant are (1) the response of the system to variables other than current prices, e.g., quantities and past prices; (2) research about both engineering and markets; (3) the possible disadvantages of information-gathering; (4) the incentive to emit signals, as in advertising and the acquisition of educational credentials; (5) the development of organizations as an economy in information acquisition and their costs of coordination; and (6) the prevention of some markets from existing and the preservation of other markets through non-market activities, including the development of ethical codes.

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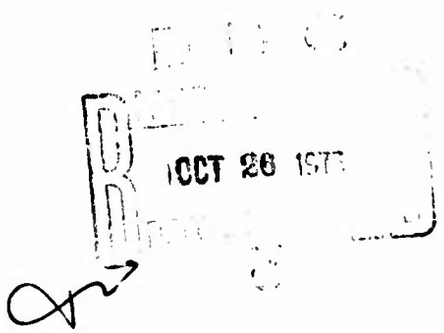

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Kenneth J. Arrow*

The members of an economy, the firms, the consumers, the investors, and the government, make choices. To give a common name to them all, I will refer to them as agents, for indeed their most salient characteristic is that they act. That they make choices implies that they have alternatives, that what was chosen was not inevitable but was in fact only one in a range of opportunities. The opportunities available to a consumer are determined by the income he has and the prices he has to pay for commodities of different use-values. The opportunities available to a firm might be all the technologically feasible combinations of inputs and outputs, in the present and in the future; this description allows for time lags between input and output and for durable producers' goods whose product is realized over a period of time. The opportunities available to an investor are basically returns over the future from alternative present portfolios. If the investor plans to use his returns for consumption in the future, or, for that matter, for reinvestment, then the true meaning of his opportunities is understood only in terms of the consumer goods or investment opportunities that will be available in the future and the prices which they will command on the open market.

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I have referred repeatedly to the future in the description of the opportunities open to individuals economic agents. Certainly a most salient characteristic of the future is that we do not know it perfectly. Our forecasts, whether of future prices, future sales, or even the qualities of goods that will be available to us for use in production or consumption, are surely not known with certainty, and they are known with diminishing confidence as the future extends. Hence, it is intrinsic in the decision-making process, whether in the economic world or in any other, that the opportunities available, the consequences of our decisions, are not completely known to us.

But it is important to note that uncertainty is a property of many decisions which do not extend into the future or at least only into the immediate future. For example, if I wish to purchase some good, especially one I have not bought recently, I may not know its price. Of course, I can ascertain it, but only by the expenditure of time and other scarce resources. I will in general end up making a purchase without the prices of all possible substitutes; it would be too costly to find them out.

Perhaps even more significant than uncertainty about prices is uncertainty about the nature of the goods being purchased, about their quality. This is most striking and obvious when it comes to the hiring of labor, at all levels up to and perhaps most especially the highest executive and academic levels. Any university professor

who has participated in making appointments knows how difficult it is to evaluate the research and teaching potential of junior faculty, and the same considerations hold for the hiring of most other forms of labor. Indeed, the same uncertainty occurs at every promotion opportunity, for previous experience is almost never a sure guide to future performance in new circumstances. Again, consider many complex durable goods, such as automobiles A genuine evaluation by the buyer in individual cases can really only be made, if ever, after considerable experience. The performance of an automobile or producers' durable, its durability, its need for repairs, are surely uncertain. Because of random variation from item to item, even previous experience does not permit confident generalization to new cases, though it does reduce the degree of uncertainty.

It is perhaps sufficient for me to mention the securities market to recognize an area in which considerations of uncertainty dominate.

One remark should however be made at this stage. In many cases of quality uncertainty, the economic effect is major only because of some degree of irreversibility or time lag. If the quality of a worker were displayed immediately upon being hired and could be recognized without undue cost and if the act of hiring were costless, the uncertainty about labor quality would have little economic significance; the worker could be fired if unsatisfactory, with little lost to the employer. Similarly, the purchase of a complex machine is risky because second-hand prices tend to be considerably

lower than new prices, and therefore the machine can be resold only with loss if it proves unsatisfactory. I should make clear at this stage that in many cases, these irreversibilities are themselves the indirect result of the prevalence of uncertainty; but I must defer explanation of this remark for a bit.

The general effects of uncertainty on economic decision-making have been the object of intensive research for some time; the risk aversion of the average economic agent and its implications for such matters as portfolio selection, choice among alternative kinds of producers' durable goods, the choice between saving and consumption, and the capital structure of firms have been analyzed theoretically at considerable length and some significant empirical applications made.

It is not of the general theory of behavior under uncertainty that I wish to speak but of a particular aspect which has only recently begun to receive analytic attention. When there is uncertainty, there is usually the possibility of reducing it by the acquisition of <u>information</u>. Indeed, information is merely the negative measure of uncertainty, so to speak. Let me say immediately that I am not going to propose a quantitative measure for information. In particular, the well-known Shannon measure which has been so useful in communications engineering is not in general appropriate for economic analysis, for it gives no weight to the value of the information. If beforehand a large manufacturer regards it as equally

likely whether the price of his product will go up or down, then learning which is true conveys no more information, in the Shannon sense, than observing of the toss of a fair coin. The Shannon measure may however be a useful measure of the cost of acquiring information.

I will think rather of information as a general descriptive term for an economically interesting category of goods which have not hitherto been accorded much attention by economic theorists. One finds occasional discussions of the effects of changes in information, usually given some name like "expectation," in the old business-cycle literature which seems to have been largely displaced by post-Keynesian developments; of course, practical economic forecasters have always realized the importance of expectational information and indeed place increasing reliance on it as the quality of those data has improved. Albert Hart's pioneering work [1942] on flexibility in the choice of capital goods and other aspects of capital structure, some thirty years ago, was based on a recognition that the firm would acquire new information over time. Statistical theorists and communications engineers have gone the farthest in stressing the value of information. Statistics is, indeed, the science of extracting information from a body of data. More specifically, in the theory of design of experiments, R. A. Fisher, Jerzy Neyman, Abraham Wald, and a long line of successors have grappled with the problem of allocating scarce resources to maximize the information attained.

The statisticians' model of information seems appropriate for our purposes. The economic agent has at any moment a probability distribution over possible values of the variables interesting to him, such as present and future prices or qualities of goods. Call these his economic variables. He makes an observation on some other variable; call it a signal. The distribution of the economic variables given the signal is different than the unconditional distribution. The decisions made depend, of course, on the distribution of economic variables; but if this distribution is in turn modified by the signals received, then economic behavior depends on not only the variables we usually regard as relevant, primarily prices, but also on signals which may themselves have little economic significance but which help reduce the uncertainty in predicting other as yet unobserved variables.

Let me give some examples of signals for economic variables. In forming a probability distribution for future prices we may use as information not merely current prices but also past prices; there is information in the development of the prices over time. This particular argument is familiar and has long been used in justifying the role of distributed lags in prices in the explanation of supply or investment (for an excellent review, see Nerlove [1972]). Though a cardinal point in the teaching of economics is that "bygones are forever bygones" and past prices should have no effect on

future actions, yet it is clear that they may convey information about the future and therefore affect present actions.

But signals can be even less direct. In many circumstances, past quantity movements may be signals for the distribution of future prices. If sales of a commodity have been declining, this may easily be taken as an indicator that its price will not rise, or more precisely, that the probability of a rise is lower than it would have been if sales had been rising. An example, familiar to business analysts but a stranger to formal economic theory, is the signalling role of government economic policy. A tax cut in recession may have an effect, not merely directly in terms of released purchasing power but as a signal which raises the probability distribution of sales and therefore increases the incentive to invest.

Thus, at a very minimum, recognition of the concept of information and its possible changes over time implies a considerable revision of the theory of general economic equilibrium in the form which it has evolved over the last century and which has reached such a high level of power and depth at the hands of Hicks, Samuelson, Debreu, and others in the last thirty years. In this theory, the economic behavior of individuals is governed primarily by prices. From the viewpoint of the society as a whole prices are signals by which information about scarcities is transmitted among the members of society. The informational role of prices in resource allocation has especially been stressed by writers on the theory of socialism,

from Barone through Lange and Lerner; the most sophisticated and general statement is that of Hurwicz [1960]. The existence of uncertainty need not, in and of itself, destroy the primary role of prices in resource allocation, if markets exist not only for goods but for insurance against alternative possible outcomes. The basic contract to which a price attaches becomes one for delivery of a good contingent on the ocurrence of some state of affairs.[1/] Some such markets do exist, as for insurance and, in a modified form, for equities. Part of the reasons why more do not exist derive from the existence and distribution of economic information, as will be discussed below.

But in any case the presence of information, the existence of signals and the expectation of future signals, implies that, as we have already seen, actual economic behavior is partly governed by non-price variables. This proposition at least opens the door for explaining the importance of quantity variables in the Keynesian system.[2/] It also agrees to some extent with Janos Kornai's recent [1971] critique of general equilibrium theory for exaggerating the role of prices as compared with quantities in determining the behavior of firms in any decentralized economy, whether socialist or capitalist. I should add that I am far from regarding the allocative functions of prices as negligeable; the demonstrable power of investment

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1/ For the theory of contingent markets, see Arrow [1971, Chapter 4], Debreu [1951, Chapter VII'.

2/ See especially the interpretation of Leijonhufvud [1968].

credits, tariffs, and excise taxes to influence the flow of resources does not allow that inference.

I have so far brought out one implication of the presence of information which reduces uncertainty, the economic relevance of non-price signals. But there are two more implications, which are, I think of even more fundamental importance in a reorientation of economic theory: (1) that information or signals have economic value and therefore are worth acquiring and transmitting even at some cost; (2) that different individuals have different information. In the rest of this lecture, I will argue that these two rather simple observations taken together are potentially rich in implications for the working of an economic system.

I should stress the word, "potentially." This is a report on a line of research, the bulk of which has taken place in the last decade. Some theoretical results have been obtained; very little empirical analysis has been attempted. The initiators were Jacob Marschak [1959] and George Stigler [1961], with subsequent contributions by many writers but perhaps especially Armen Alchian [1969], Roy Radner [1961], Jack Hirshleifer [1971], Michael Rothschild [1973], and A. Michael Spence [1973] together with some contributions of mine, [1971, Chapters 5-10, 12; 1973a; 1974; forthcoming]. These works do not form a coherent stream. They start from different points of view, deal with different aspects, and use different terminologies.

It is of some doctrinal interest to observe that they all come out of the much criticized neoclassical tradition, though they certainly represent developments of it; that is, they start from some concept of individual advantage-seeking in a world in which each agent has little market power, and they assume the equilibrium allocations which are arrived at are such that expectations are not falsified. A general definition of equilibrium in this context has been given by Hahn [1973], especially pp. 18-20. To be sure, the "expectations" are probability distributions rather than points, so that what is meant is that individual agents learn whatever it is that they could learn given their opportunities to observe.

The economic value of information offers no great mysteries in itself. It is easy to prove that one can always do better, whether as a producer or as a consumer, by basing decisions on a signal, provided that the signal and the economic variables are not independently distributed. But this remark has an implication for economic decisions; the economic agent is willing to pay for information, for signals.

We must now recognize that the signals available to an economic agent are not given to him but can be added to. The space of possible decisions has been enlarged to include the acquisition of information in addition to production and consumption. The research engineer can be thought of as eliciting signals from nature, analogous to the miner who draws minerals from the Earth; research is a form

of production. Information about the behavior of other economic agents, especially customers or workers, or about future or even present prices or qualities of goods are more straightforward examples of information whose acquisition is both possible and desired.

Clearly, firms do engage in information-gathering. They spend resources on engineering and market research. Moreover, there are large and significant exchanges of information through the market - newspapers, business advice, and, in a somewhat modified sense of market, all of education - in short, the whole realm of the production and distribution of knowledge which Fritz Machlup [1962] has so carefully measured. So, information is not merely a good that is desired and acquired but is to some extent a commodity like others whose markets we study.

But while information can be a commodity, it is one only to a limited extent. The presumption that free markets will lead to an efficient allocation of resources is not valid in this case. If nothing else, there are at least two salient characteristics of information which prevent it from being fully identified as one of the commodities represented in our abstract models of general equilibrium: (1) it is, by definition, indivisible in its use; and (2) it is very difficult to appropriate. With regard to the first point, information about a method of production, for example, is the same regardless of the scale of the output. Since the cost of information depends only

on the item, not its use, it pays a large-scale producer to acquire better information than a small-scale producer. Thus, information creates economies of scale throughout the economy, and therefore, according to well-known principles, causes a departure from the competitive economy.

Information is inappropriable because an individual who has some can never lose it by transmitting it. It is frequently noted in connection with the economics of research and development that information acquired by research at great cost may be transmitted much more cheaply. If the information is, therefore, transmitted to one buyer, he can in turn sell it very cheaply, so that the market price is well below the cost of production. But if the transmission costs are high, then it is also true that there is inappropriability, since the seller cannot realize the social value of the information. Both cases occur in practice, with different kinds of information.

But then, according to well-known principles of welfare economics, the inappropriability of a commodity means that its production will be far from optimal. It may be below optimal; it may also induce costly protective measures outside the usual property system.

Thus, it has been a classic position that a competitive world will underinvest in research and development, because the information acquired will become general knowledge and cannot be appropriated by the firm financing the research (see, e.g., Nelson [1959] and Arrow [1971, Chapter 6]; for a somewhat critical view, see Demsetz [1969]).

But Hirshleifer [1971] has pointed out that, if secrecy is possible, there may be overinvestment in information-gathering; each firm may secretly get the same information, either on nature or on each other, although it would of course consume less of society's resources if they were collected once and disseminated to all.

To dramatize the issue, let me give an example where information is socially useless but privately valuable. Imagine an economy of gatherers of different kinds of food. Weather is uncertain, and some types of food are in relatively greater supply in some kinds of weather than in others. There is an opportunity for mutually advantageous insurance contracts. Those who are relatively better off in one situation can pay the others then, in return for commitments to compensate in those weather situations in which the first group is relatively worse off. But now suppose that an opportunity arises for the accurate prediction of weather, though at some cost. Given the insurance market, it clearly pays any individual to buy the information and keep it a secret. He can then make large gains by betting on the weather that will in fact take place. But under the assumptions made there is no social gain. What is produced will be produced in any case. If the receivers of the weather information are small on the scale of the market, then there will be neither social gain nor social loss on the risk-sharing contracts. But if enough individuals buy the information, the market for risk-trading

is destroyed, for competition will change the odds to those conditional on the information received, which, if accurate enough, will leave little opportunity for insurance against unfavorable risks. Hence, there is a double social loss - the resources used unnecessarily in acquiring information and the destruction of a market for risk-sharing.

This example has been extreme, because it has, by assumption, excluded any possible gains in production. Ordinarily, we would assume that a knowledge of future weather would permit a reallocation of resources to activities which would be relatively more productive under the forecast weather. In that case, the signal has a positive effect on welfare. But this does not blunt the essential point, that there will very likely be an overinvestment in the acquisition of information whose private value is to gain at the expense of others. One would suppose that the securities markets and the extensive apparatus for private information-gathering there would exemplify this point. Further, the very acquisition of this information is apt to make the securities market less valuable as a means of risk-sharing.

When information is unequally distributed, there are incentives not only to acquisition of information but also to the emission of signals. If I know something about my product which will make it more attractive to others, or if my (low) price is not generally

known, I will be willing to incur costs to transmit this information to the outside world. Advertising is an obvious example of the emission of signals but not the only one. I want to abstract here from the emission of false signals, of deception, because in long-run statistical equilibrium the receivers of the signals will have had enough experience to know the statistical distribution of the economic variables (price or qualities) conditional on the signal. However, it is hard to define the process by which a signal gets to be recognized as such and how the receiver learns to discriminate among them. It would seem that in many cases at least collective action is needed to define signals. Suppose, for example, that one firm labelled different qualities of its product according to some scheme. This signal might have little effect in a market with many competitors, because the consumers would not find it worthwhile to expend the intellectual resources needed to learn the signalling scheme. A grade-labelling scheme adopted by collective agreement of the entire industry would be worth learning. It would become easier to observe the signals and correlate them with factual observations.

This argument was used by Kaysen [1949, pp. 294-5] to explain the then use of the basing-point system for pricing in steel and other industries. It is not easy to give a conventional economic explanation for this system and even less for the agreement among steel producers that price differentials among different grades of

steel be fixed. But if the steel industry is thought of as an oligopoly forbidden however from engaging in explicit collusion, it becomes very important for the attainment of a mutually satisfactory equilibrium that each firm may be able to observe the prices of other firms. If not, each firm will have the possibility of cutting prices without retaliation. If, in fact, the prices for every point of delivery and every grade are freely variable, then the capacity of the firms to observe each others' price behavior is very limited compared with their possible scope. But if relative prices of locations and qualities are fixed, then each firm's entire behavior is summarized in one number, and mutual observation becomes possible.

The educational system has become, partly inadvertently, an industry which sells signals for individuals to emit to the world. Its primary intended function is the acquisition of knowledge. But in the course of its own internal measuring of its success in this function, it automatically generates signals of ability in education. If it is in fact the case, or at least believed to be the case, that ability to produce is correlated with ability to absorb education, then the educational system does produce signals about productive ability. I have already argued that the observation of the productive quality of labor is costly to employers. Hence, it pays them to use signals emitted at no cost to them.

In turn, however, this creates an incentive for the student to continue his education beyond that which he would otherwise desire and beyond that level which is socially desirable.

The welfare analysis of the signalling function of education is similar to that of the private demand for weather information in our previous example. It may be, for example, that the educational system simply identifies individuals who are generally more able. They might be equally productive whether or not they are recognized. In that case, as in the simple case where weather information has no productive value, the screening would produce a redistribution of income among individuals but no increase in total product. The resources devoted to education beyond that desired as a consumption good would be simply wasted socially; further, if there is any aversion to risk about one's own abilities, the screening reduces welfare in the aggregate. If, however, individuals have differing advantages in different positions in the economy, then education may serve as a sorting process which will increase total product. This sorting process may, by the way, operate on both sides of the market; not only do employers know more about potential workers but the latter may learn more about their own abilities. But note that the social productivity of screening has to do with identification of comparative, not absolute, advantages. Since educational attainment inevitably signals the latter as well as the former, there is almost bound to be a socially excessive demand for education if

offered at cost with adequate credit facilities for the student investing in his future earnings.

We have now seen that the differentiation of information among individuals together with the existence of costs of acquiring information may lead to the emission of signals to others. But, as already suggested, the creation of new types of signals which can be understood and believed in is by no means a simple task. The educational system yields ability signals as a by-product of its main activities; it was not developed for that purpose. Creating a credible screening device de novo will in general be more difficult.

Let me turn to two other kinds of responses to the differentiation and the costs of acquisition of information: (1) adaptations to improve efficiency of information-processing may arise; (2) markets may fail to exist or else they may perform their functions in ways different from those usually assumed.

Let us take up the first point. How can a firm, for example, become more efficient in the acquisition of information? Now there are many elements in the cost of information-acquisition, but surely the most fundamental is the limitation on the ability of any individual to process information. No matter how much the technology of information-processing is improved, the ability of the human mind and senses to absorb signals will be a permanent limitation. Clearly, one strategy for increasing the input of information is to increase the number of individual receptors. One can have many

individuals linked together in a firm or other organization, each making different observations on the world. (There is no value in having them observe the same signals, provided they are observed without error.) Indeed, the market system as a whole has frequently been considered as an organization for the allocation of resources; the typical argument for its superiority to authoritative central allocation has been the greater intake of information through having many participants.

But multiplicity of observers creates a new problem, that of coordination. The items of information are typically complementary in value and have to be pooled in some way for best use. There is a need for communication channels, and these are costly. Clearly, if every signal received by each observer had to be transmitted to another, the total amount of information-handling would be greater than in the absence of organization. Economy arises only if the signals transmitted within the organization are summaries of the information received. The theory of sufficient statistics suggests one instance of economy; in certain contexts, all the information in a sample of many observations can be transmitted as two numbers, a statistic and an indicator of its reliability. Thus, the costs of transmission are much lower than those of acquisition, and it is possible that joining the observers into a single organization can represent a net economy. (See Radner [1961] for some aspects of the design of information structures for organizations.)

However, the establishment of a system of many observers linked by communication channels has long-run dangers of petrifaction. A communication system has some cost of initial investment which is irreversible. In particular, a communication channel is used to greatest capacity when it has an optimal code for transmitting messages. This "code" need not be interpreted literally; the term refers to all patterns of communication and interaction within an organization, patterns which make use of conventional signals and forms which have to be learned. Once learned, however, it is cheaper to reuse the same system than to learn a new one; there is a payoff on the initial learning investment but no way of liquidating it by sale to others. If external conditions change, an originally optimal communication system may no longer be the one that would be chosen if the organization were to begin all over again. Eventually, the communication system may be very inefficient in handling signals, and the firm may vanish or undergo a major reorganization.

To put it another way, the firm's organization is designed to meet a more or less wide variety of possible signals. The wider the range planned for, the greater is the flexibility of the firm in meeting the unforeseen (that is what flexibility means), but the less efficient it is in meeting a narrower range of possibilities, as Hart [1942] pointed out.

I see the communication-economical point of view as explanatory of the internal structure of firms and more generally of other

economic organizations. The assumptions about the firm made in classical economic theory will have to be altered. It is assumed there to be a point - instead, it is an incompletely connected network of information flows. Thus, a change in the price of, say, a factor of production may be observed in some parts of the firm but not in the rest. The response will surely be different in general than if the firm reacted by altering its entire plan immediately.

Indeed, the whole idea of a firm with definite boundaries cannot be maintained intact. For example, the customers of a firm are, to some extent, part of it, as Chester Barnard [1938], pp. 77.] has maintained. There are direct information flows from customers in the form of complaints, requests for product alteration or special services, or threats to change to another firm, in addition to the anonymous alterations of demand at a given price which is the sole information link between a firm and its market in neoclassical theory. Some employees of a firm will have closer links to customers then to a least some of the other employees.

Finally, let me note that the fact of differential information as between contracting parties will prevent some efficient contracts from being made. The best examples are those in which uncertainty enters explicitly into the nature of the contract, various types of insurance being the most obvious examples. The most striking category of market failure due to differential information is that known in the insurance literature as <u>adverse selection</u>. Suppose

a population at risk, e.g., in life insurance, is divided into strata with differing probabilities of an untoward event. Suppose further that each individual desiring insurance knows which stratum he belongs to and hence the probability of risk for him, but the insurers cannot distinguish among the insured according to risk and therefore are constrained to make the same offer to all. At any given price for insurance, the high-risk individuals will buy more, the low-risk individuals less, so that the actuarial expectations will become more adverse than they would be with equal participation by all or that they would be in an ideal allocation with different premiums to different strata. The resulting equilibrium allocation of risk-bearing will be inefficient, at least relative to that which would be attainable if information on risks were equally available to both sides.

What is more, the patent fact of inefficiency under adverse selection may lead to altering the nature of the market transactions. The insurance company may find it profitable to engage in information-gathering activities to reduce the extent of adverse selection, for example, by medical examinations. Since there is a mutual gain to be made, such activities may become general even in a competitive market. But then the parties to a transaction have closer links that the simple impersonal exchange of money for services; the information must be gathered on identified individuals, not on anonymous customers.

Adverse selection in insurance is relatively transparent, but the same phenomenon is at work elsewhere in the economic system. George Akerlof [1970] has called our attention to this question with regard to the sale of used automobiles, where the seller will in general have more information about the properties of the object sold than the buyers; again something like adverse selection can seriously impair the operations of the market.

I would instance the whole capital market as another and very important example. Virtually all extension of credit involves some risk of default. Hence, indebtedness can never be in the form of anonymous promises to pay interest and principal. The purchaser of credit instruments buys them from specific individuals who are responsible; and in general he gathers information about the potential debtors. A good part of the activity of a bank is precisely in performing these tasks.

Closely related to adverse selection is the occurrence of "moral hazard," that is, the difficulty of distinguishing between decisions and exogenous uncertainty. (The adjective, "moral," is misleading in many contexts but is hallowed by long use.) An insurance policy, for example, may induce the insured to change his behavior, therewith the risks against which the insurance is written. Thus, insurance against fire will lead a rational individual to be less careful if care is at all costly. "Health insurance," more precisely insurance against medical costs, is a currently important illustration; the

insurance, once taken out, is equivalent to a reduction of the price of medical care, and therefore the rational individual will increase his consumption, which increases the amount of medical insurance payments and ultimately causes an increase in the premiums. This is a social cost, since an increase in medical expenditures by any individual increases the premium for all, so that the use of both the services of risk-bearing and those of medical care is inefficient (see Pauly [1968]; Arrow [1971], Chapters 5, 9).

Again economic institutions may compensate by introducing non-market informational devices. In the case of fire insurance, a company may inspect the premises and demand that certain precautions be taken as a condition for the policy, or, at least, adjust the premium according to the observed safety standards. In the case of health, it is theoretically possible to demand of medical treatment to see if they are really necessary, and there has indeed been a trend toward peer review, at least.

It is important to observe that the problem of "moral hazard" is one of differential information. Consider the case of fire insurance. For simplicity, suppose there are three possible conditions not under the control of the insured: fire regardless of the insured's precautions; a condition which could create fire if the insured were careless but not otherwise; or no fire in any case. If the insurance company could observe which of these states has occurred, it would be possible for it to insure separately

against the first two cases. The rational buyer would purchase insurance against the first according to simple principles of risk aversion; with regard to the second, however, he would weigh the costs of insurance against those of the alternative of being more careful. Such an insurance market would lead to an efficient allocation. It is the cost of determining the occurrence of these states which leads the insurance company to write policies against fire as such, less efficient in terms of resource allocation but cheaper in terms of information. Similarly, an efficient health insurance system would be possible if the insurer could observe some measure of the severity of illness and simply pay a sum determined by that measure and independent of actual expenditures by the insured.

The general principle underlying these last few examples has been set forth by Radner [1968]. An insurance contract (in the most general sense, including any situation in which the final payoffs to the participants have an uncertain component) can be made only if the conditions under which the contract is to be executed can be observed by both parties. If one will observe a condition but not the other, then the contract cannot hinge on that condition's being satisfied, even though it would be in the interests of both parties to make such a condi ional contract if it could be credibly enforced. Whenever some markets are barred from existence, there is inefficiency, which is frequently reflected in strains on other markets.

It is important tonote that if the informational inequality is regarded as an irremoveable condition, there will in general be substitutes for competitive markets which will increase welfare though not to the point achievable under full equality of information. One possibility is that of non-linear price systems, where the premium paid for an insurance policy is not proportional to the amount of the policy. Roughly, the idea is that individuals who seek to buy more insurance are more apt to be high risks and hence should pay a higher marginal premium. The formal structure of these problems is analogous to that of imposing taxes on income as a substitute for the theoretically superior imposition of a tax on innate ability, the point being that income is partly a result of an individual's labor-leisure choice; see Mirrlees [1971], [1972].

One adaptation of the economic system to differential information is scarcely mentioned in our models; it is the development of ethical codes and the internalization of certain values (see Arrow [1973b]). Every profession, such as the medical, owes its economic function to the inequality of information between the professional and his client; what the latter is buying is most of all the superior knowledge of the former. But this is just a situation in which it is most difficult to expect a market to function, as just explained. The patient has little protection against the physician's recommendation of unnecessarily costly treatments. It is probably no

coincidence that ethical constraints on economic behavior are so strongly developed in the professions; they serve as an alternative to equal information, the physician's ethical motivation for the client's welfare being relied on to replace contracts which the latter could not enforce due to lack of knowledge.

In fact, ethical elements enter in some measure into every contract; without them, no market could function. There is an element of trust in every transaction; typically, one object of value changes hands before the other one does, and there is confidence that the countervalue will in fact be given up. It is not adequate to argue that there are enforcement mechanisms, such as police and courts; these are themselves services bought and sold, and it has to be asked why they will in fact do what they have contracted to do. In any case, the cost of enforcement becomes bearable only if most transactions take place without attempts at fraud, force, or cheating. Further, in transactions of any complexity, it would be too costly to draw up contracts which would cover every contingency. Some aspects have to be left for interpretation when needed, and it is implicitly understood that it will be possible to agree on the meaning of the contract, even though one party loses.

I expect that ethical codes and informal non-price organizations will continue to evolve, for example in the control of product quality, where needed to permit transactions which would be impossible because of differential information in markets where all individuals

behaved in a purely selfish manner. The evolution of ethical codes is facilitated by the fact that productive units are organizations, not individuals, and individuals are mobile among these organizations. Hence, ethical codes held by individuals, perhaps derived as part of business education, may survive even though detrimental to the profits of the firms, because the managerial element can accept a trade-off between profits, which only partly inure to it, and learned ethics which have been found to facilitate business in general.

These remarks are merely preliminary to a genuine study of the development of ethical codes in the economic world. The basic question is how best to emit those signals which will lead to accepted and understood ethical and authority relations and the conditions for their stability. The latter depends on some combination of perceptions and of the reality of mutual self-interest.

I hope I have said enough to indicate the importance of information as a variable affecting economic behavior and the rather diverse ways in which the economic system is affected by its scarcity and diversity.

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