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UNCERTAINTY AND THE NEED FOR COLLECTIVE ACTION*

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Individuals frequently find it advantageous to undertake actions collectively when market breakdowns prevent the free market from leading to an efficient outcome. Usually such action is undertaken by a governmental unit. Here Professor Zeckhauser discusses how the presence of uncertainty, a lack of knowledge of which state of nature will obtain in the future, may hinder the working of the free market mechanism and create situations in which collective action is called for.

Individuals' future preferences for some classes of goods cannot be known with certainty. For example, an individual cannot know his future demand for firefighting services or various types of medical treatment. The efficient provision of such goods and services must take into account risk-spreading considerations and utilities in anticipation of use. The particular institutions available for providing these goods, perhaps taxes or user charges, may affect the decision whether the goods should be provided, and if so whether by a governmental unit. Insurance and markets for contingent claims have many related properties. They too might best be provided on a collective basis.

The collective provision of goods raises questions of equity if some individuals benefit at the expense of others. One can argue that if all would have agreed to a plan before the outcome became known, it would be equitable to undertake the plan after the fact. Government efforts such as aid to depressed areas and to the economically disadvantaged can be supported on this basis. Any such redistributive assistance schemes raise the incentives problem. Here it is examined with respect to an optimal income tax scheme.

In this paper, Professor Zeckhauser attempts to show that the presence of uncertainty creates special obligations and possibilities for collective or governmental action.

Introduction

In a perfectly competitive world it is well known that the free working of the market mechanism will lead to an efficient outcome, a Pareto optimum.¹ The neoclassical model of perfect competition requires perfect knowledge; there can be no uncertainty. The presence of uncertainty, a lack of knowledge of which state of nature will obtain in the future, makes the model inoperative. Ostensibly some corrective action will be required if an efficient outcome is still to be achieved. As with other forms of market breakdown such as externalities, public goods and declining marginal cost industries, some form of collective action might be an appropriate way to seek a remedy.

¹ A Pareto optimum is a situation in which it is impossible to increase the welfare of any individual without decreasing the welfare of some other individual. A situation that is not Pareto optimal is inefficient in the sense that we could find another situation (one which might be called Pareto superior to the first) which was better for at least one individual and worse for none.

*Robert Edelman and Professors Robert Haveman, Howard Raiffa and Thomas Schelling made helpful comments on this paper.

CONTINGENT CLAIMS MARKETS

A number of recent papers have shown that the presence of uncertainty need not prevent the free-market mechanism from achieving an efficient outcome. It may be possible to expand the class of traded goods to include what are sometimes called contingent claims. A contingent claim is a right to a variable amount of a commodity, the amount to depend upon the state of nature which obtains. In real life, quite frequently, a positive amount of the good is received only in the event of a single state. An insurance policy is a good example of a contingent claim. Typically it pays the face value of the policy should the state "death of the insured" prevail. Similarly, a lottery ticket is a contingent claim. It might give one the right to \$10,000 should the number 904521 be drawn.

Contingent claims markets need not lead to efficiency.* Transactions costs on these markets are far from negligible. The result is that the market price of a contingent claim may far exceed its actuarial value. Even if these markets were actuarially fair, other factors might prevent the achievement of a Pareto optimum. If there are substantial disagreements on probabilities or if probabilities are difficult to estimate, the free-market mechanism will not in general lead to an efficient outcome. However, the primary difficulty is not that existing contingent claims markets do not function effectively, but rather that these markets are established in but few areas. Many goods are difficult to trade on a contingent basis for reasons that will be elaborated later. In some instances it is impossible to make trades before the state of nature is known or at least a great deal of information has become available. This limits the risk-sharing advantages of trades of contingent claims. Once contingent claims trades have been made, incentive structures change, and the trading individuals may take actions that affect the probabilities that different states occur. For example, the individual who has insured his car may drive somewhat less carefully. On a realistic basis we cannot expect contingent claims markets to achieve optimality in a world with uncertainty. This paper examines the role of collective action, with the Government as the likely agent, in overcoming the inefficiencies that uncertainty engenders.

VARIETIES OF UNCERTAINTY**

Most of us are accustomed to look at uncertainties from the standpoint of the individual. Will there be good times? Will I prosper? Will a hurricane destroy my home? Will I be disabled in an accident? To the individual these questions may appear to be structurally similar. To the Government they may appear very different. If I am lucky in the first instance then so is everyone else. A hurricane will affect others, but hardly the whole country. An accident on the other hand is likely to involve just me or perhaps a few others. The Government is concerned with all citizens and would likely see these uncertainties in very different ways. The actions that it might or should take with respect to them might vary as well.

*Further discussion of this issue is found in the paper by Demsetz in this volume.

**Further discussion of this issue is found in the paper by Hirshleifer & Shapiro in this volume.

COLLECTIVE PROVISION WITH INDIVIDUAL'S PREFERENCES UNCERTAIN ²

An individual will rarely be able to determine exactly his future level of demand for a good. This demand will depend upon the evolution of his preferences something that he may not be able to predict accurately. This need not reflect an inability to know his own future mind. Rather, events over which the individual has little control may significantly affect his future preferences. An individual would have to know whether his house would catch fire to predict his demand for firefighting services. He would have to know whether he would be involved in an accident before he could estimate his need for hospital accident emergency room.

In normal circumstances, the inability of individuals to predict their future demands for goods is not of great consequence. A good is supplied to the market, and is consumed according to the individuals' preferences at that time. Only if action must be taken at present to insure an efficient level of provision for the good is it important to make accurate predictions. Thus, for example, if there is a significant lead-time for production, it will be most useful to be able to predict aggregate demand with some accuracy.

This section considers situations in which individuals who are unable to predict their individual portions of future total demand may find it useful to make some decisions on the collective provision of a good before preferences become known. For the most part it is concerned with goods which by their very nature make accurate prediction of future preferences impossible. At best, for such goods, it will be possible to attach some probability assessment to possible sets of preferences for the individual. The acronym PIP derived from probabilistic individual preferences is used to refer to the goods of this nature. Most frequently, the probabilities attached to these sets of preferences will be determined subjectively rather than objectively. For the present purposes, this distinction is not of importance.

OPTION VALUES*

Consider a community that must decide whether to supply itself with a PIP good, perhaps a supply of plasma at a blood bank, or a fire engine to protect its homes. Following conventional efficiency dictates, the community should estimate future levels of demand for the good and decide whether perfect price discrimination against future consumers would yield sufficient returns to enable discounted revenues to cover discounted expected costs. If the decision is negative, we are told that the community should not provide itself with the good. This stipulation holds whether or not consumption by one individual reduces the amount available to be consumed by another, whether or not the good has any aspects of a collective-consumption good.

Many PIP goods serve a preventive purpose; for example, programs to deter crime or to immunize against disease. If such goods

²Part of this section is to appear in the May 1969, *American Economic Review*. It is taken from my essay collection, *Studies in Interdependence*.

*Further discussion of this issue is found in the paper by Steiner in this volume.

are provided, it may never be known who are the major beneficiaries, who would have been the victims of the crime or the sufferers from the disease. For such goods, discriminatory pricing questions could only be asked on a hypothetical basis. If you have been identified as a future target of a mugging or a future victim of polio, how much would you pay to prevent the unfortunate happening from taking place?

In an article dealing with commodities "the purchase of which is infrequent and uncertain," commodities which are in effect PIP goods, Burton A. Weisbrod argued that even if there will be perfect price discrimination, the option values of potential consumers would influence the decision whether such commodities should be provided. He states, "If these consumers behave as 'economic men,' they will be willing to pay something for the option to consume the commodity in the future."³

The key question for Weisbrod, then, is, What will be the magnitude of these option values? The amount that an "economic man" will pay for the right to consume a commodity in the future will depend upon the price that he will be charged for the commodity. The discriminatory price of a good for an individual is the maximum price that he would pay for the good, an amount just short of the one at which he would refuse to purchase. As a consequence, if an economic man will be faced with perfect price discrimination, should he be interested in consuming the good, he will be indifferent whether or not he purchases it. He will not be able to reap any consumer's surplus at the time of purchase; the availability of the good will in no way be able to increase his welfare. His option value to keep the purchase available will be zero. I disagree with Weisbrod and assert that in this regard the conventional efficiency dictate is not called into question.

RISK SPREADING

The option value, discriminatory price approach to the allocation decision problem is not sufficiently rich. It overlooks some important considerations, one of which is the risk-spreading property of PIP goods. Every potential consumer of a PIP good is in an uncertain situation. He does not know whether he will wish to consume the good in the future. The value in use of many of these goods can be very high.⁴ If the actual consumer is to be faced with perfect price discrimination, then each potential consumer is in the position of having some probability of incurring a substantial charge.

However, it may not be necessary to charge the actual consumers even a small fraction of their discriminable price. The community of potential consumers as a whole can agree to share the costs of making the good available, with little or no additional cost to be borne by the actual consumers. In this way, each individual will bear a small certain cost rather than run the risk of a much larger, but considerably less

³ "Collective-Consumption Services of Individual Consumption Goods." *The Quarterly Journal of Economics*, LXXVIII (August 1964), p. 472.

⁴ This is particularly true of goods in this class which are primarily used to avoid or ameliorate unfortunate occurrences. Many goods with such a purpose fall into the class of PIP goods.

The expected time until a highly unlikely loss is incurred is great. All losses or expenses in this essay are assumed to be discounted. With uncertain occurrence time, the discounting process is complicated.

probable cost. If the individuals in the community are risk averters, this indirect form of risk sharing may be of value to them.

The possibility of risk sharing introduces a new consideration to the question as to whether the good should be provided. Let me illustrate with the fire engine example. Consider a community of 100 identical individuals, with identical utility functions for wealth, $\log(w)$, each with a house they value at \$10,000, and each with a nonhouse wealth of \$10,000. Every year one house, no more, no less, burns down. The community must decide whether to get a super fire engine that stops all fires instantaneously. The rental on the fire engine is \$12,000 per year in comparison to the \$10,000 that the individual whose house starts burning would pay for the services of the engine. (If the income effect for housing were positive, this would somewhat reduce the \$10,000 figure, and conversely.)⁵ Following conventional efficiency dictates, the community would compare the amount that could be secured for the good through perfect price discrimination with the cost of provision. It would decide not to rent the engine.

However, the individuals within the community are risk averters. They would be willing to pay a premium to reduce the variance in their payoffs. If they share the costs of providing the engine, they can accomplish this. Let x represent the certainty equivalent dollar value for the lottery that gives the individual's payoff in the absence of the fire engine. We have, $\log(x) = .99 \cdot \log(20,000) + .01 \cdot \log(10,000)$. This gives, $x = 19,861.85$, and $20,000 - x = 138.15$. To avoid one chance in 100 of a \$10,000 loss, each individual in the community would be willing to pay \$138.15. This amount can be looked at as the individual's option value for the right to consume at zero cost the fire engine's services at any time during a 1-year period. The sum of the individuals' option values would be \$13,815, an amount well in excess of the rental price.

What, then, of the decision not to rent the engine? Each individual would rather pay his share of the rental rather than be faced by the lottery that confronts him if the fire engine is not rented. If the only alternative to renting the engine is to let the houses burn and have individuals suffer the losses, then the engine should be rented, and the rental cost shared equally. This will involve a loss in efficiency with regard to resource use, but there will be a more than compensating gain because, unlike the costs of a fire, the costs of fire control can be spread among all the members of the community.

But another, more attractive alternative may be available. It may be possible to spread the cost of the fires through an insurance pool in the community. If each individual agreed to pay one-hundredth of all fire losses in the year, his annual cost would be \$100. This would give him a considerable saving over paying his share of the engine rental cost. If there are no institutional constraints to prevent the operation of an insurance plan, then so long as administrative costs

⁵ Income-type effects can be important if PIP goods are of exceptional value in use. For example, condition X has a 0.8 chance of being fatal. The discriminable amount an X-sufferer would pay for treatment B which would reduce this probability to 0 might not be much greater than that for treatment A (assuming B unavailable) which would merely reduce it to 0.4. If there were one unknown sufferer in a large community the result would be much different. The total discriminable payments from all members to make treatment A available to the unfortunate member would be approximately twice that for treatment B.

Where specific goods, such as houses, make up the potential losses to be prevented or insured, the amount that would be paid at the higher, before-loss income is the relevant amount for efficiency calculations.

are not prohibitive (below \$2,000 in this example), this alternative will be the most attractive.

THE COMMUNITY INSURANCE DECISION WHEN THE SIZE OF LOSS IS VARIABLE

The assumption that a single house will burn each year is certainly unrealistic. There may be major conflagrations, and even if house burnings are independent events, there will be some variance in the number of houses burned each year. The fire engine has the advantage that it eliminates all such variance in total cost to the community. This improves its attractiveness relative to an insurance scheme. If there is significant variance in the number of houses that burn each year, the community might choose the fire engine over the community-wide insurance plan even though the latter would have a lower expected cost per individual.

The limiting case of complete contagion would have the only possible fires in the community destroy all houses, the annual probability of such a catastrophe being one in 100. In this case the insurance plan would serve no risk-spreading purpose. The lottery for each individual's payoff would be the same as the one in the absence of insurance. Following the analysis above, the fire engine should be rented.

Assume that there were no fire engines. We observed that a risk-spreading plan in a community will be the more effective the less positive correlation there is between significant losses for its individual members. This observation may be of import if each individual will be charged a proportional premium above his share of community losses if an insurance plan is instituted, if, for example, there are administrative costs that are some fixed percentage of total reimbursed losses. The individuals might find it desirable to establish an insurance plan that would reimburse losses if one or two houses were lost in a year, but not if a great many had burned.

By way of illustration, assume that there are but four possibilities. The number of houses that burn in the community with the probabilities of occurrence are: 0, .75; 1, .15; 10, .07; 50, .003. The expected number of houses burned is one. Our community would find it desirable to reimburse losses from single-house fires if the premium over fair actuarial value were not more than 38.1 percent. It would be worth while to insure losses in 10 house fires as well if the premium were less than 33.9 percent. Only if the premium fell below 17.2 percent would the community wish to include losses from 50 house fires in its insurance plan.

UTILITIES OF ANTICIPATION VERSUS UTILITIES OF USE

There are some special characteristics of goods the future consumers of which are unknown that render the actuarial model of decision inadequate. The lottery model is essentially static. The decisionmaker is assumed to act as if the probabilistic outcome is to be determined immediately when his decision is made. Pleasure or pain derived from anticipation or anxiety over the outcome of the lottery does not enter into the model. But these feelings are not imaginary. We cannot afford to neglect these real and potentially significant utilities of sensation. They must be considered in addition to the familiar (what might be called) utilities of use.

Many individuals would gladly incur significant costs so that they could live in a community with a museum or symphony even though they are unlikely to make use of these cultural advantages. A shopper might pay to have a wide selection of goods available even though she knows she will probably choose her purchases from among a very few. We have in effect what might be called a utility of variety. Consumers like and get a positive utility from the fact that goods are kept available. From what we can observe, the amount that these individuals would pay to keep these facilities available is well in excess of the expected value to them, the probability they use them times the difference between the price they will be charged and the discriminatory price that they could be charged. For most individuals the discriminatory price would be low enough so that risk considerations do not play a major role. It would seem that another factor is present. It is what we might think of as the utility of knowing you can use something even though it is unlikely that you will use it. It is a utility that is defined independently of the use itself. In this way it is quite different from the actuarial aspects of payments for PIP goods (or those that Weisbrod discusses). This distinction is reinforced to the extent that payments for utilities of variety are independent of the prices that will be charged for the goods or the probabilities that they will be consumed.

MISESTIMATION OF PROBABILITIES

There is the possibility that some individuals may misestimate the probability that they will wish to consume some good or service in the future. If there were a consistent bias toward overestimation, individuals would be willing to pay more than fair actuarial value to keep the good available. The converse is of course true.

This raises what might be more of a philosophical than an economic question. If individuals calculate their option values on an actuarial basis using expected consumers' surplus, and if they overestimate probabilities of use, should we correct for this bias? Let us say that the head of a community asks each individual how much he would pay to keep a museum available. Assume that the community head knows from experience that on the average individuals will overestimate the probability of future visits to the museum and will thus arrive at somewhat inflated option values. Has he done something useful if he deflates these values when he decides whether to provide the museum?

A number of considerations must be weighed in arriving at our answer. If all utilities are in use rather than anticipation, we would argue that the community head should modify the stated option values to reflect accurate probability estimates. If utility in anticipation is a meaningful concept, the question is more difficult and will depend on the specific parameters of specific cases.

Will individuals learn that their probability estimates were too high, that they made a mistake? We would surely agree that the more likely they are to find out, the more desirable it is to correct their misestimates. It is by no means clear by what means an individual would discover that his subjective probability estimate for an unlikely, non-replicated event was in error. The less danger there is of becoming informed, the more blissful is ignorance. Taking the argument to the

extreme, we might even argue that we should provide a little-used museum if we can convince community members that they are fairly likely to visit it. If the pleasures in anticipation are sufficient, the provision of the museum could yield positive utility to each individual who shares in the cost of making it available. This will result in a real, though unanimously favored, misallocation of resources.

This is tricky material. This brief discussion is hardly adequate. The primary present purpose is to point out that in some instances there are benefits to be gained from fleshing out the conventional skeletal framework for expected utility calculations.

PIP GOODS, INSURANCE, AND MARKETS FOR CONTINGENT CLAIMS

PROSPECTIVE AND RETROSPECTIVE BENEFITS

In our discussion thus far we have found a number of relationships and similarities between insurance mechanisms and PIP goods. An insurance policy gives one claim to future resources should some pre-specified event occur. One takes out the policy because it provides an expected positive benefit. It cannot be known in advance whether one will actually benefit from having the insurance policy. Generally, in retrospect, one will not prove to have benefited. The events that we insure against usually have a low probability of occurrence. When one shares in the provision of a PIP goods so as to be included as a potential consumer, one is in a similar position. There may only be a small chance of benefiting from the consumption of the good, but the benefit may be sufficient to make the premium (sharing in its provision) worth while.

Quite frequently, PIP goods are provided by a political unit of a nonvoluntary contribution basis. In insurance, the equivalent arrangement is some form of mandatory policy. The social security system is a good example of a nonvoluntary contribution, risk-sharing arrangement implemented by a political unit. At present, there are discussions in progress within the Federal Government on a mandatory flood insurance programs for those holding property on the flood plain. This type of provision, whether for PIP goods or insurance, can be justified on efficiency grounds only if the gains of some individuals, as measured by the excess of expected consumer's surplus over share of provision cost, more than outweighs the losses of these who would not join voluntarily.

An insurance policy may provide a nonactuarial benefit that in some sense is parallel to the utility of variety that is associated with PIP goods. It is a utility that is not directly connected with the use of the goods or the money that is received should the insured against event occur. It is the pleasurable sensation that is derived from knowing that one has protected one's self (or one's family) in case an unfortunate contingency should arise.

Thomas Schelling kindly suggested the following demonstration of the value of this "peace of mind," what we might call a utility of security. A man with a medical ailment is fully aware of the seriousness of his condition, but does not know whether it will exclude him from life insurance. He asks his wife to find out and to pay the premium if his life can be insured. We would likely agree that she may be doing something useful if she can deceive her husband should he be uninsurable, and convince him that his life can be insured.

INSURANCE AND MARKETS FOR CONTINGENT CLAIMS

When one takes out an insurance policy, one sacrifices current assets in exchange for a contingent claim to be paid, if at all, in the future. An insurance policy represents a trade in a contingent claims market, that is restricted in two ways. (1) In an open contingent claims market, future as well as present payments can be used to purchase contingent claims. This restriction will not be of consequence if there are perfect capital markets and if borrowing and lending rates are identical. (2) In an unrestricted contingent claims market, one can exchange a contingent as well as a certain claim for a contingent claim.

If one wished to take out medical disability insurance, rather than pay some fixed amount, it might be far preferable to agree to pay an appropriate fixed percentage of future income that would result in the same expected payment. Carrying this reasoning one step further, it would likely be even better if one could work out an arrangement under which the percentage was higher the higher was future income.

An arrangement like this one might be worked out if the Federal Government decides to provide financial assistance to individuals seeking higher education. To fund this program the Government could charge these individuals a percentage of future income, or better yet, a variable percentage that increased with income. This repayment could be transmitted easily along with normal income tax collections.

There may be situations in which contingent claims markets or insurance are not available but where good substitutes can be found. A farmer who cannot find a future market in the particular commodity which he produces can in effect insure his price if he can sell short a related or derivative commodity which will have parallel price movements. In financial markets it is often possible to secure a form of insurance through arbitrage-type operations; for example, one can sell short in a stock for which one holds convertible bonds. Some situations call for more inventive action. An individual who cannot buy storm insurance on his home in a hurricane belt might cover himself by investing in a roof repair company. In all these situations, the object is to diversify. The extensive literature on the subject of diversification is of consequence because perfect insurance and contingent claims markets do not exist. To the extent that balanced portfolios can be secured, a suitable substitute for these markets can be found.

If contingent claims markets are restricted and if opportunities for complete diversification are not available, there will be distortionary effects on many economic variables. This is particularly true where intertemporal allocations are concerned.

UNCERTAINTY AND INTERTEMPORAL RESOURCE TRANSFERS

The transfer of resources from present to future, what is commonly called savings, is both an intertemporal shift and a shift from a period in which income is known to one in which income is an uncertain variable. The greater is uncertainty about future income, expected income constant, the more a risk-averse individual will wish to transfer to the future. With fair and perfect contingent claims markets, uncertain incomes will not be of consequence. The risk-averting individual will be able to insure that he receives the expected value of his

future income.⁶ There will be no additional transfers in response to risk considerations. The absence of complete, perfect, and actuarially fair contingent claims markets makes transfers to the future greater than they would be in a perfect world with all desirable markets established. Considering this factor alone, the level of savings in society will be supraoptimal.

The question as to whether the freely arrived at rate of savings will be socially optimal has recently received much attention in the theoretical literature. Other essays in this collection discuss it at length in relation to the appropriate rate of discount for social projects and to the responsibility of the Government to provide for the future.* To the extent that they neglect the influence of uncertainty in our imperfect world of incomplete markets, their answers for discount rates should be raised and those for provision for the future diminished.⁷

COLLECTIVE PROVISION OF PIP GOODS, INSURANCE AND CONTINGENT CLAIMS MARKETS

PIP GOODS

Throughout this paper, I have discussed, with good reason, community or collective provision of these goods or trading arrangements. There are at least three factors that might make it best to provide PIP goods on a collective basis. (1) If the probability is small that any one individual will consume a good in a given short period of time, and if it must be kept continually available, there will be considerable waste if each individual provides for himself. We find it efficient to store plasma in a common pool in blood banks rather than have each individual keep a personal supply. (2) PIP goods possess aspects of collective-consumption goods and for the conventional reasons are best provided on a collective basis. For example, the consumption of the services of a fire engine by one individual in no way reduces the amount that is available to be consumed by another.⁸ An essential collective-consumption element of some PIP goods is that it is desirable to keep an inventory available. Thus, in our plasma example, the good itself is of the private consumption variety, but the existence of a stockpile upon which any member can draw has collective-consumption aspects, consumption of the "good" by one individual does not reduce the amount available to be consumed by another. (3) If PIP goods are provided on a collective basis, the costs of provision can be shared, and the as yet unknown consumers need not be charged any great amounts. In this way some useful risk-spreading can be accomplished.

EQUITY CONSIDERATIONS**

On an equity basis, we might object to the collective provision of collective-consumption goods that are not enjoyed equally by all contributors (assuming equal incomes and contributions to provision).

⁶ Contingent claims markets will not be actuarially fair unless some individuals are risk neutral, or if there is zero correlation among individuals' incomes.

⁷ This section greatly simplifies a complex problem. In my *Studies in Interdependence* I consider the effects of restricted contingent claims markets at greater length.

⁸ In the unlikely event that the demand periods for the services overlap, there will be the congestion problem that is frequently associated with "nearly-collective goods."

*Further discussion of this issue is found in the paper by Baumol in this volume.

**Further discussion of this issue is found in the paper by Weisbrod in this volume.

It might seem that such an objection would apply with a vengeance to PIP goods, but such is not the case. Collective provision of PIP goods can only be called inequitable if on a prospective basis it is clear that some community members will have a higher expected benefit. Even then, there might be disagreement.

Final judgment may depend whether higher probabilities of use or higher values in use are the primary explanation of higher expected benefits for some individuals. If the former, it might be relevant to know why the probabilities are higher, whether they depended upon conscious choices. On an equity basis, we would be more likely to object to a subsidized public facility to treat those injured skiing than to a subsidized public facility to treat those who suffer from a particular inherited illness, even though we may be better able to predict who will be the beneficiaries of the latter.

The lessons of equity considerations in situations of uncertainty have not been thoroughly enumerated. These lessons may be applicable to the most basic of philosophical considerations. If we state that society should establish a mechanism that insures individuals against unfavorable outcomes in the lottery of genetic inheritance, against the possibility that they will have low capabilities and little opportunity to earn in a competitive factor market, is our statement based on considerations of equity or on considerations of efficiency? Is it not possible that we would have all agreed in advance to such a scheme, that the insurance mechanism gets us to the *ex ante* contract curve? These questions and others that relate in similar fashion to such matters as the desirability of nonfault compensation of accident victims, the justness of racial differences in income, or the obligation of the developed countries to aid the underdeveloped world merit further consideration. They are touched upon in the section that follows.

INSURANCE AND CONTINGENT CLAIMS MARKETS

For reasons similar to those relevant for PIP goods, it may be desirable to provide contingent claims markets, and their somewhat restricted offshoots, insurance markets, on a collective basis. To provide such a market is to provide a mechanism that has many of the characteristics of a collective-consumption good. The use of the mechanism by one individual not only does not reduce the amount available to another, it is likely to increase the utility in use of the mechanism for them. Each additional consumer (trader) extends the market and makes it more perfect, thus providing a benefit for all other consumers.

We would suspect that in the absence of some form of collective provision, markets for trades in contingent goods will not be established in many desirable areas. Those markets that are established we would fear to be insufficiently extensive. Unlike most markets, it is essential to have many parties to single trades. The marginal costs of accommodating addition users are likely to be low in comparison to the fixed costs of starting and maintaining the market. Efficiency considerations would dictate that transactions costs be kept low, and that the market be supported by charges assessed independently of use or the frequency of use. It is hard to see how a private entrepreneur would go about setting up a market with such features.

There are, of course, privately supplied mechanisms that approximate mechanisms for contingent goods. The best example is insurance companies. To make ends meet and then some, insurance companies find it necessary to charge amounts considerably over fair actuarial value. We would speculate that the excess charge over actuarial value is well above the nonactuarial costs of including another individual in the insurance pool. This is inefficient. It is equivalent to charging more than marginal cost to a man who uses a public park. I have not been able to find any abundance of privately provided mechanisms that would call into question my contentions relating to the provision of markets for contingent goods.

I have argued above that the Government may see fit to provide PIP goods, particularly in those instances in which adequate insurance mechanisms are not available. At times the Government may participate directly in the provision of insurance protection. At present governments engage in many programs of this nature, including crop insurance, unemployment and disability insurance, and social security. Recently it has been proposed that the Federal Government provide insurance to high-risk ghetto businesses, and to those who might suffer from certain types of natural disasters.

The Government need not limit itself to conventional insurances services. It may identify areas in which individuals would have purchased insurance if only mechanisms had been available. The question is what to do if the would-have-been-insured-against misfortunes have already occurred.

Governments generally step in to aid disaster areas. This form of relief can be justified on efficiency grounds quite apart from humanitarian or altruistic considerations. Disasters take tremendous tolls of public and private property. Public property is rarely protected by insurance. Disasters are highly unlikely events. As such, transactions costs to provide insurance would be quite significant in comparison to actuarial costs. It may be efficient for the Government to operate as if an implicit arrangement had been reached that all will pitch in to help after an unfortunate occurrence, rather than collect premiums to be paid to the losers in case of disaster. Without any explicit agreement, the Government can serve as an insurer. It collects premiums in its general tax funds and pays out claims as needed.

Aid to depressed areas can be viewed in a similar light. In the 1920's all areas of the country, including then coal-rich Appalachia, might have agreed to an assistance scheme to those areas of the country that turned out to be depressed in the sixties. The Federal Government might carry out such assistance now on the efficiency argument that on an expected value basis this arrangement would have been desirable if only it could have been formulated in advance.

A similar argument can be made for assistance to people who are handicapped to some extent, perhaps because of inadequate intelli-

gence or physical disability. Is it not the case that if none of us knew our future position in society that we would have agreed to a redistribution scheme from the more to the less fortunate? Contracts of this nature can never be made. By the time parties reach the age at which they could consent the die has already been cast. Ivy League men know that they are the blessed. Ghetto dropouts are aware of the bleakness of their future. However, as unidentified fetuses not knowing which they would be, these two groups might have agreed to a massive redistribution scheme. Arguments in favor of radically progressive tax schemes can be made on this basis as well. If only the agreements were drawn before the state of nature was revealed or at least substantially hinted at, all would have agreed to a substantial redistribution of income.

The principle here is a most simple one. If at some time during the play of a game it becomes clear that all players would have agreed to a particular rule in advance, then invoke that rule. This dictate is particularly important in the situations here, because, for the most part, these rules cannot be agreed upon ahead of time.

TRADES IN CONTINGENT GOODS AND INCENTIVES—AN INCOME TAX EXAMPLE

Unfortunately, trades in contingent goods that have a risk-sharing objective may reduce incentives for individual effort. Consider a completely levelling income tax scheme. In a community of n individuals, an additional dollar earned by any individual will yield him but $1/n$ of a dollar in extra income. If n is large, there will be no financial incentive to work.

The incentives problem can be examined with an income tax example. A group of individuals wants to develop an optimal tax scheme. They are able to contract before any of them know their earning capabilities. The possible wages are 1, 2, 3, and 4 dollars per hour. One quarter of the individuals earn each wage rate. The probability, p_i , that an individual receives wage rate w_i is thus $\frac{1}{4}$ for all i .

Each of the individuals has a utility function in each 100-hour period. As arguments it has two variables: after-tax income, z ; and leisure hours, x . The utility function, assumed to be common to all is:

$$U(z, x) = z^{\frac{1}{2}} x^{\frac{1}{2}}.$$

Each individual is allowed to follow his individual preferences to decide how many hours, h , he wishes to work leaving him with $100-h$ hours of leisure. It is this area of free decision that gives rise to incentives considerations. An individual's before tax income, y , equals his wage rate times the number of hours he works,

$$y = wh.$$

The individuals contract on a tax scheme $T(y)$ that tells the amount of taxes an individual must pay on a given before-tax income. After-tax income for an individual whose wage is w and works h hours is:

$$z = wh - T(wh).$$

The tax scheme that maximizes expected utility is the one that maximizes:

$$\sum_i p_i U(w_i h_i - T(w_i h_i), 100 - h_i),$$

subject to the constraint that:

$$\sum_i p_i T(w_i h_i) = 0.$$

To simplify the search task, I considered only quadratic tax schemes. These schemes are sufficiently diverse in shape to allow a close approximation to the optimal scheme of general form.

The optimal quadratic tax scheme, the one that maximizes expected utility, is:

$$T(y) = -.0007y^2 + .372y - 30.125.$$

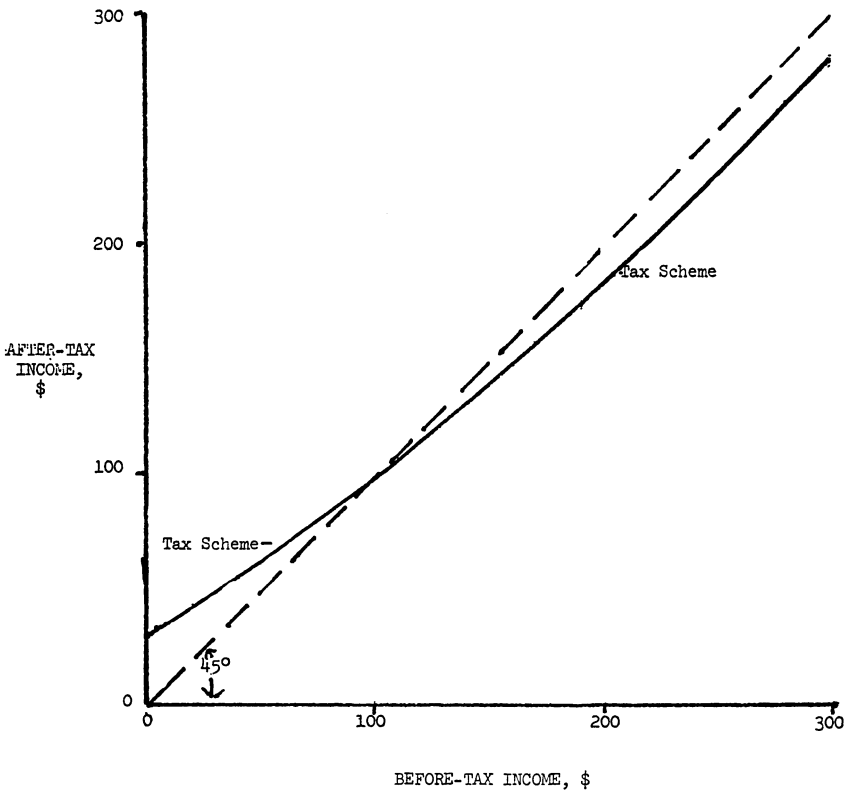
The shape of this tax function is rather interesting. The marginal tax rate continually falls over the relevant range although the average tax rate is rising. This tax scheme is progressive on an average though not on a marginal basis. At first glance this may seem a bit perplexing, but the explanation is quite evident. The large negative constant in the tax scheme represents a lump sum payment that each individual receives. This provides the progressivity. The decreasing marginal rate insures that high income people will maintain the incentive to work. The table below gives the outcome with the optimal scheme.

VALUES FOR THE OPTIMAL SCHEME

Wage rate	1	2	3	4
Leisure.....	72.178	58.500	53.316	50.347
Before-tax income.....	27.822	83.000	140.052	198.614
After-tax income.....	48.139	87.072	131.809	182.468
Average tax rate.....	-.730	-.049	.059	.081
Marginal tax rate.....	.343	.256	.176	.094

The diagram below illustrates the ideal tax scheme.

IDEAL TAX SCHEME



This result is only suggestive of the type of outcome that can be achieved with this type of analysis. It is interesting however, that with no special consideration of the problems of the poor or the lowly skilled, it produces results remarkably like those of the negative income tax at the bottom end of the income scale.⁹

THE GOVERNMENT'S ATTITUDE TOWARD RISK*

In many instances a government will be in a position to insure individual's risks with very little risk to itself. This will be the case, for example, with disability insurance. The number of people disabled is a predictable figure with fairly little variance. However, in many

⁹ The mathematics of this example has been omitted here. Other simulations have been run for other utility functions and distribution of earning opportunities without achieving markedly different results. A more detailed paper is available on request.

This same type of analysis can be applied to other related problems, such as the optimal plan for car insurance. The optimal result usually involves some form of limited risk sharing; it involves a tradeoff between risk sharing and the maintaining of incentives.

*Further discussion of this issue is found in the paper by Hirshleifer & Shapiro in this volume.

instances there will be significant positive correlation among the losses of a great number of individuals. Natural disasters can create losses ranging into the hundreds of millions of dollars. In periods of economic slack, unemployment compensation and welfare payments may increase significantly. Research and development efforts like that for the SST may be so risky that even an organization such as the Federal Government must take cognizance of the tremendous variability in potential cost. On the largest scale of all, the cost of a war is a variable that is difficult to predict within the many billions of dollars.

Some of these projects fall to the Government as part of the natural course of its activities. Others, such as the development of the SST, are taken on because the risks are too great for private entrepreneurs. How should the Government evaluate risky payoffs? The answer depends on the answer to the underlying question risky to whom? If a project is small in terms of the entire Government, and if its payoffs are relatively uncorrelated with other aspects of national income, the Government need not consider variability in its payoff. In this context the Government can be thought of as a mutual investment company that need not consider risks that are large in comparison to the portfolios of any of its individual investors but very small once parceled out among all of its investors.

There may be some Government projects whose uncertain payoffs are directed to specific groups. A small speculative area redevelopment project may be a small risk when looked at for the Government as a whole, but substantially risky for the potential beneficiaries. They might prefer a more conservative project with a lower but more certain expected payoff. The ideal situation in which the Government insures the risks from the speculative project may not be administratively feasible. Here, the Government, in its role as a sort of mutual investment company, must take account of its customers attitudes toward risk. If they prefer the safer project, that is the one that should be undertaken.

A project for which there are substantial uncertainties presents each affected individual with an uncertain set of benefits and costs. It presents him, in effect, with a lottery on net payoffs (benefits minus costs). The efficiency-oriented Government should evaluate the payoffs from uncertain projects in terms of the certainty equivalents of those who pay for and receive its benefits. A certainty equivalent of a lottery for an individual is the "for sure" amount that would afford him a utility equal to the expected utility he would reap from the uncertain payoffs provided by the lottery. It is the greatest amount that he would pay (if negative) or the least amount that he would accept (if positive) rather than participate in the lottery of payoffs that the project would present to him. If the sum of the affected individuals' certainty equivalents is positive, the project should be undertaken.¹⁰

With this efficiency approach, it need not be the case that the Government will undertake projects that yield positive expected benefits nor reject projects whose expected benefits are negative. A project that produces substantial benefits in times of general well-being will be

¹⁰ This is a gross simplification. It neglects distributional considerations, and assumes that the project does not compete with others that also offer net positive benefits. Certainty equivalents defined at present incorporate discounting considerations.

much less attractive to individuals, will have lower certainty equivalents, than one whose payoffs are negatively correlated with other aspects of income. The latter type of project, for example dikes for flood control, viewed in isolation is a creator of risks. However, when viewed together with all other payoffs it helps to create what in effect is a more balanced portfolio for the entire Nation. As such, it is even to be preferred to a certain payoff equal to its expected value.

In some cases, the direct payoffs from a project itself may not vary greatly, but the project may be responsible for variations in other payoffs. The unexpectedly high cost of the Vietnam war has had the effect of making the Nation forgo much needed domestic social welfare projects. If Congress attempts to hold the Federal budget relatively constant, uncertainties on costs will make their risky aspect felt indirectly through substantial fluctuations in other benefits. If Congress lets the budget swing in response to fluctuating costs, variations in tax rates or the size of the Government debt will be the way the risk is transmitted to the individual.

THE GOVERNMENT AS A SOURCE OF INFORMATION*

The acquisition of information may enable us to ameliorate the effects of uncertainty, it may permit us to make informed predictions about future states of nature. We can then change our actions in response to these predictions so as to increase our expected payoffs. Accurate weather forecasting enables farmers to plant and reap at appropriate times. Perceptive forecasts of economic conditions enable corporations to make wise investment and production decisions. Information is a superb example of a public good. Its consumption by one individual in no way reduces the amount that is available to be consumed by another. (In certain competitive situations its value in use, though not its quantity, may be reduced.) As a public good, information is efficiently provided at zero marginal cost. It is natural then that information provision should often be handled by the Government.

In actuality, not only does the Government provide ordinary forecasting and information provision services, but it also carries out testing and grading operations that would be costly and expensive for the individual consumer. In the absence, let us say, of Federal grading of meat, quality would be highly uncertain and the market would function less well. The FDA tests new drugs and makes the results available to all. The argument for Government action here is that of economies of scale. It is much more efficient to have a single organization provide the information rather than have everyone provide it for himself.

THE GOVERNMENT AS AN ECONOMIC AGENT

Most of the discussion above relates to the role of the Government in overcoming the market imperfections that are created by the presence of uncertainty. In recent years, the Federal Government has come

*Further discussion of this issue is found in the paper by Davis & Kamien in this volume.

to play a conscious economic role in our society. The primary goal of this participation is to maintain the economy along a full employment, low inflation growth path. Ideally the Government acts as a stabilizing force, curbing demand when inflation is a danger, stimulating the economy when it shows a bit of slack. There can be much debate about the effectiveness of these actions, but one thing is clear, the Government's role is to keep the economy from swinging wildly.

It would be incorrect to conclude that the advantage from reducing these swings is primarily one of reduction of risk. The consequences of excess and inadequate demand are undesirable. However, the method in which the Government achieves this stabilization may be through a form of uncertainty reduction. As Keynes emphasized, convergent expectations can control the business cycle. If all businessmen independently would like to invest heavily, but all thought that others would not, a slack economy would be the self-fulfilling fear. The converse would be the case if all thought heavy spending would be the order of the day. However, if the Government assures everyone that it will step in to keep things on an even keel, then galloping or collapsing expectations are not likely to ever take over. The promise (or threat) of Government participation might be enough to prevent the very conditions in which the Government promises to participate. If everyone believes in the exceptional fiscal and monetary skills of the Government, they may never get a severe test.

CONCLUSION

In recent years, there has been an impressive expansion of knowledge on the subject of uncertainty in economics. For the most part the role of the Government in a world of uncertainty has not been stressed. This paper has attempted to show that the presence of uncertainty creates special obligations and possibilities for collective or governmental action.