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Source: *The American Economic Review*, Vol. 59, No. 2, Papers and Proceedings of the Eighty-first Annual Meeting of the American Economic Association (May, 1969), pp. 546-552

Published by: American Economic Association

Stable URL: <https://www.jstor.org/stable/1823708>

Accessed: 28-05-2020 20:06 UTC

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## RESOURCE ALLOCATION WITH PROBABILISTIC INDIVIDUAL PREFERENCES\*

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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 fire-fighting services. He would have to know whether he would be involved in an accident before he could estimate his need for a 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 ensure 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 essay 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 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 purposes of this essay this distinction is not of importance.

### *The Efficient Provision of PIP Goods*

*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 are provided, it may never be known who are the major beneficiaries, who would have been the victims of the

\* This paper was condensed from Essay I of my dissertation, "Studies in Interdependence." Robert Edelstein, Emmett Keeler, and Professors Howard Raiffa and Thomas Schelling made helpful comments.

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 stated, "If these consumers behave as 'economic men,' they will be willing to pay something for the option to consume the commodity in the future."<sup>1</sup>

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. If he 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 poten-

<sup>1</sup>"Collective-Consumption Services of Individual Consumption Goods," *Q.J.E.*, Aug., 1964, p. 472.

tial 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.<sup>2</sup> 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 probable cost. If the individuals in the community are risk-aversers, 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 one hundred identical individuals, with identical utility functions for wealth,  $\log(w)$ , each with a house they value at \$10,000, and each with non-house 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

<sup>2</sup>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.

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.)<sup>3</sup> 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-aversers. 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 one hundred 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 one-year period. The sum of the individual's 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 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

<sup>3</sup> Income-type effects can be important if PIP goods are of exceptional value in use. For example, Condition X has a .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 .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.

one in one hundred. 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 (Virginia) 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 worthwhile to insure losses in ten 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 fifty house fires in its insurance plan.<sup>4</sup>

#### *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

<sup>4</sup>Omitted section: "The Individual Insurance Decision when the Size of Loss is Variable."

model is essentially static. The decision-maker 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 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.<sup>5</sup>

#### *PIP Goods, Insurance, and Markets for Contingent Claims*

*Prospective and Retrospective Benefits.* In our discussion thus far we have found

<sup>5</sup>Omitted section: "Misestimation of Probabilities."

a number of relationships and similarities between insurance mechanisms and PIP goods. An insurance policy gives one claim to future resources should some prespecified 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 good 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) worthwhile.

Quite frequently, PIP goods are provided by a political unit on a nonvoluntary contribution basis. In insurance, the equivalent arrangement is some form of mandatory policy; for example, social security. This 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 those who would not join voluntarily.

An insurance policy may provide a non-actuarial 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 is 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.

There may be situations in which contingent markets or insurance are not available but where good substitutes can be found. A farmer who cannot find a futures 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.<sup>6</sup>

### *The Collective Provision of PIP Goods*

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.<sup>7</sup> 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.

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). 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 of 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

<sup>6</sup>Omitted major section: "Inefficiency and Restrictions on Contingent Claims Markets."

<sup>7</sup>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."

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? This question and others that re-

late in similar fashion to such matters as the desirability of nonfault compensation of accident victims or the justness of racial differences in income merit further consideration.<sup>8</sup>

<sup>8</sup>Omitted section: "The Collective Provision of Insurance and Contingent Claims Markets."