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ALLOCATION AND DISTRIBUTION THEORY: TECHNOLOGICAL INNOVATION AND PROGRESS

CHANGE AND INNOVATION IN THE TECHNOLOGY OF CONSUMPTION

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We typically think of technology as applying to production rather than consumption, and my first task is to establish just what I mean by the technology of consumption.

I am drawing on ideas which have been set out in some detail in another paper of mine which is to be, but unfortunately has not yet been, published elsewhere.[1] This paper, "A New Approach to Consumer Theory," sets out a model of consumption and the consumer with certain features which provide the basis for the present explorations. I must necessarily start with a brief description of those features.

"A New Approach. . ." presents the following view of consumption. Goods, as such, are not the immediate objects of preference or utility or welfare, but have associated with them characteristics which are directly relevant to the consumer. The term "characteristics" was chosen for its normative neutrality; in my earliest draft of this idea I called them "satisfactions," but that has too many connotations. The consumer is assumed to have a preference ordering over the set of all possible characteristics vectors, and his aim is to attain his most desired bundle of characteristics subject to the constraints of the situation. The consumer's demand for goods arises from the fact that goods are required to obtain characteristics and is a derived demand.

An analogy to production theory is starting to appear. We are viewing goods as inputs into a process in which these characteristics are the outputs. The structure of consumption activities is, however, typically different from the structure of production activities. In the typical production activity we have joint inputs and a single output, while we shall regard the typical consumption activity as having a single input (a good) and joint outputs (a bundle of characteristics). Some consumption activities may require several goods, or even other inputs. For example, the activity driving a car requires the use of a consumer capital good, the using up of other goods (gas and oil), and the labor

[1] In the *J.P.E.*, Apr., 1966.

of the consumer to give the bundle of characteristics associated with the activity. If we were discussing the theory of consumer durables, we would pursue this example further, but, in the present context, we shall think of the typical consumption activity as using up a unit of some good and deriving the bundle of joint characteristics from it.

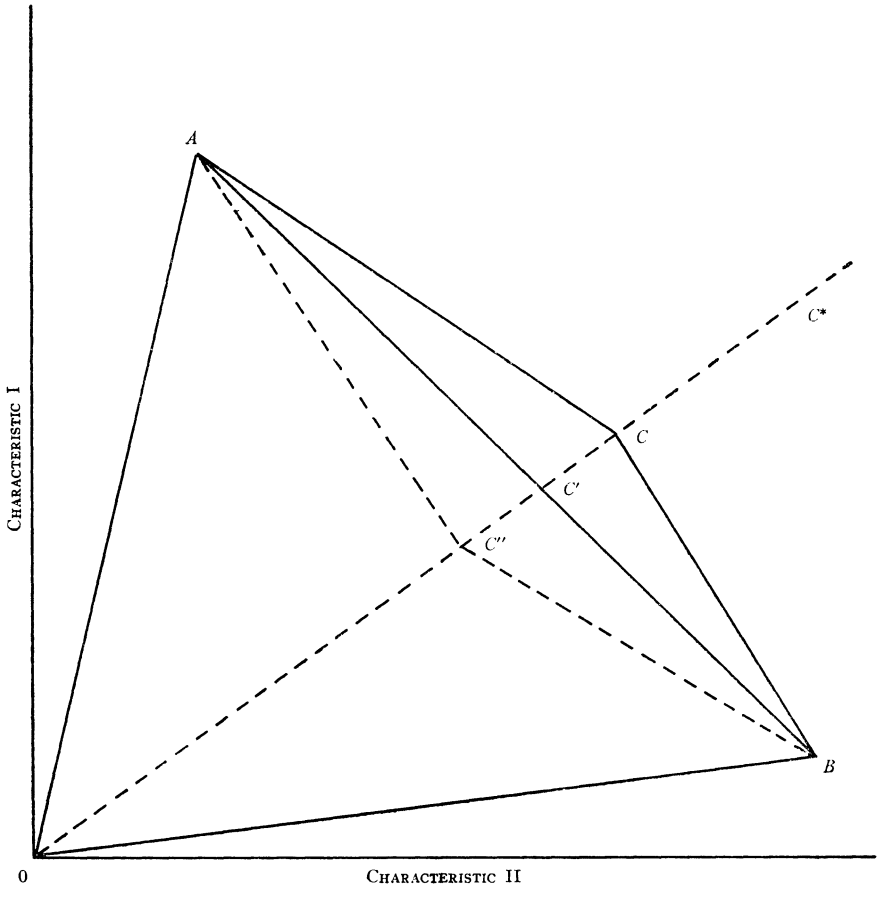
The jointness of the characteristics is really the core of the whole approach. If we eat an apple, we are enjoying a bundle of characteristics—flavor, texture, juiciness. Another apple may have the same flavor but associated with a different texture, or be more or less juicy. A single good may have more than one characteristic, and a single characteristic may be obtainable from more than one good. Goods which share a common characteristic may have their other characteristics qualitatively different, or they may give the same characteristics but in a quantitatively different combination. If the relationship between goods and characteristics was merely one-to-one in both directions, so that the only characteristic of an apple was appleness and the only source of appleness was an apple, then there would be no operational difference between the traditional approach to consumer theory and that being portrayed here.

It will be assumed that characteristics are, in principle, intrinsic and objective properties of consumption activities. Given arbitrary units, each consumption activity is defined by its inputs (most often assumed to be a unit of a single good) and by the vector of characteristics which forms its output. It will further be assumed that the activities are linearly homogeneous, so that doubling the goods input gives double the characteristics. Essentially psychological effects, such as the consumer's relative interest in different characteristics or effects similar to diminishing marginal utility, are assumed to make their appearance in the preference ordering of the characteristics vectors, not in the relationship between goods and characteristics.

The set of all possible consumption activities forms the consumption technology. In a highly developed economy, with many different goods and product variants, the technology will be complex; in a less developed economy, the technology will be simpler. In a country like the U.S.S.R. we may have a complex production technology combined with a relatively simpler consumption technology.

The consumption technology will relate goods on the one hand with characteristics on the other. In general, there is no reason why the number of characteristics and the number of goods should be related to each other (any more than the number of goods and the number of factors should be related in the production technology), and I shall make the working hypothesis that the number of goods in a complex consumption technology like that of the U.S. will probably exceed the

number of operationally distinguishable characteristics. There may well be several combinations of goods which give rise to the same bundle of characteristics, and this gives rise to a very important distinction between the present and traditional approaches to consumer theory.



Consider a simple example of a consumer in a world of two characteristics and three goods. Each good gives rise to a vector of the two characteristics, and the consumption technology consists of the activities, consuming each of the goods separately, and consuming them in linear combination. If we impose a budget constraint on the goods, we can explore the characteristics vectors attainable by the consumer. The attached diagram shows the two-dimensional characteristics space and the points A, B represent the characteristics attainable if the whole

budget is spent on goods A, B, respectively. By spending the whole budget on combinations of A and B, characteristics vectors represented by points along the line AB can be attained. Now consider the third good, C, which gives rise to the characteristics in proportions represented by the line OC^*. The price of C will determine how far out alonge OC^* the consumer can get by spending all his income on C. If this price is low enough, this point might be represented by C. All the attainable bundles of characteristics for the given price-income situation are given by the points A, B, C and their linear combinations, which are the points in and on the triangle ABC.

The consumer chooses his preferred characteristics bundle from the attainable set. Note that efficiency considerations arise—a radical departure from traditional theory—since, for any bundle of characteristics attainable by combinations of A and B, a larger bundle with the same proportions can be attained by C or by combinations of A and C or B and C. An efficient consumer will choose combinations on ACB, the efficiency frontier for characteristics. Just which point he chooses will depend entirely on his preferences. If consumers have well-distributed preferences and are efficient, we can expect to find that all three goods are sold, but that no single consumer consumes both A and B.

In this model, the consumer faces a double choice. He makes an efficiency choice in rejecting goods combinations which do not enable him to reach the efficiency frontier and a private choice in finding his preferred point on the frontier. If the markets are competitive so that all consumers face the same prices, and given the linearity of the consumption activities, the shape of the efficiency frontier is the same for all individuals. Income differences appear only as scalar enlargements or reductions of the typical frontier. Thus efficient choice is objective and common to all individuals in a given price situation.

The efficiency frontier changes with relative prices, however. In the example given, if the price of C should rise so that the characteristics vector attainable by spending the whole income on that good moved to C'', AB would now be the efficiency frontier. No combination using C would be efficient and C would no longer have any buyers at that price. Price changes may give rise to a substitution effect between goods rising wholly from efficiency effects and unrelated to any convexity of the preference structure. This efficiency substitution effect has been discussed in detail in "A New Approach. . . ."

The general nature of the consumption technology has now been established, and the remainder of the paper will be devoted to answering the question, can we have change, innovation, and technical progress in consumption technology, just as we have in production?

In the case of production technology, considered in activity analysis form, changes in that technology can be regarded in one or more of the following ways: (1) "Magic wand" effects, in which a particular input combination that gave a certain output in 1965 gives a greater output in 1966. (2) Shifts from actual capabilities, or the upgrading in efficiency of those firms whose productivity is below the known technological potential. Strictly speaking, this is not a change in technology but it will manifest itself in aggregate data in a similar way. (3) An identified technical change arising from the introduction of specified new activities. (4) A change in the nature of inputs such as the introduction of new capital goods, new labor or management skills.

In analyzing production technology, output can be measured with relative ease, as can the input of broadly defined factors. This places much emphasis on magic wand effects, such as unexplained residuals. On the other hand, information concerning the detailed nature of inputs is more difficult to discover, so that the effects of changes in the nature of inputs are less emphasized. In consumption technology the situation is reversed; we have information concerning the changes in the goods which form the inputs, but little information concerning the outputs. We have no interest, therefore, in magic wand effects, but the other three effects can be important.

Since our model of consumer behavior provides scope for efficient choice and hence for the possibility that not all consumers are efficient, there is scope for technical progress in the special sense of increased consumption efficiency, even with no change in the nature of goods or consumption activities.

In consumption, as in production, the prime reasons for inefficient use of the existing technology are ignorance and lack of managerial skill. The consumer may not be aware that a certain good possesses certain characteristics or that certain goods may be used in a particular combination to give a specified bundle of characteristics. Producers or sellers may use advertising to ensure that no characteristics of their product regarded as particularly desirable should go unnoticed by consumers. They will go to less pains to ensure that consumers are aware of some other characteristics of their product.

Organization such as the Consumers Union exist to provide more objective information on the characteristics of goods than is easily available elsewhere. Some consumers are willing to pay for information which assists in attaining efficient points on their characteristics possibility sets and, on the model presented here, are rational to do so. However, since efficient choices are the same for all consumers, there is a clear argument in favor of public information on these matters and in favor of legal requirements, such as composition and contents label-

ing, designed to increase knowledge of the available consumption technology.

We can use our model to demolish the old argument, favored by sellers of established products, that, since consumers "reveal" their preference for the product already, labeling laws are unnecessary. Traditional theory may seem to lend some weight to this argument, but the present theory does not, since actual choice by consumers can no longer be regarded as revealing their preferences for characteristics—they may merely be making an inefficient choice.

The consumption technology, in a society like that of the United States, is very complex. Efficient consumption, even in the presence of adequate information concerning the technology, involves some managerial skill. As any social worker will testify, many households are noticeably deficient in this skill. Conventional consumer theory leads to a presumption that the family which spends its income on an eccentric collection of goods is simply revealing its preferences for that collection. Of course, this might be true, but it may also be that the family is consuming inefficiently. If the consumer's desired characteristics collection could be ascertained even in a very general way, some type of advising might lead to more efficient consumption.

A crucial difference between the production and consumption sectors is that the market mechanism does not tend to guarantee efficiency in consumption in the same way it does in production. In a society at subsistence level, the inefficient consumer may not survive. In a more affluent society he will survive, but will remain at a lower welfare level than that potentially available to him. Again, this leads to the presumption that public consumer education would be socially valuable.

A relatively static technology, in consumption as in production, will, if coupled with stable relative prices, probably lead to a situation in which the efficient activities become generally known and traditional. Traditional consumption patterns will be efficient only within a relatively unchanging choice situation and only optimal for consumers whose preferences on characteristics approximate the society mode. Tradition will be less useful when the technology is changing rapidly, when relative prices are changing considerably, or when the consumer's preferences diverge from the mode. Furthermore, the typical consumer will inherit his traditions from his social background, and they may not serve him at a radically different income level. We are all aware that the *nouveau riche* may consume differently from persons already established in the higher income group. This analysis suggests that it is at least possible that the desired characteristics of the new and old rich need not be different: the newcomers may be less efficient in achieving their aims. The same considerations may work in reverse;

so that a consumer suddenly thrust from a wage income to welfare payments may take some time to discover efficient methods at the new income level, although at this level efficiency may be crucial.

One suspects that there may be great scope for increasing consumption efficiency in the kind of changing situations outlined above. These include the transition from peasant to market economies and from rural to urban societies in developing countries and, within countries, among social groups migrating from one region to another or from one income level to another.

Because the market system does not place pressure on consumers to be efficient, this aspect of technical progress has been stressed more than it might be in discussing production. But innovation in the true sense occurs in the consumption technology, and this takes place primarily through the introduction of new goods or new variants and product differentiation.

Traditional consumer theory is at its most unenlightening when confronted by the problem of new goods. Introduction of a new goods requires either that the preference function defined on n goods is thrown away, and with it all the knowledge of behavior based on it, and replaced by a brand new function defined on $n + 1$ goods, or the fiction that the consumer has a potential preference function for all goods present and future and that a new good can be treated as the fall in that good's price from infinity to its market level. Neither approach gets us very far.

In the present model, it may be that the good is so revolutionary that its characteristics are not possessed by any existing goods. We are no better off, in this case, than in the traditional one. But most new goods can be regarded as simply giving rise to existing characteristics in new proportions, and we have available an operationally meaningful way of approaching the problem. A new good of this kind—and this probably covers nearly all new goods and certainly all product variants —adds a new activity to the technology and is, in the proper sense of the word, an innovation in that technology Whether the innovation is efficient depends entirely on the price of the new product. If the price is too high, its characteristics correspond to a point within the efficiency frontier and it will not be purchased by efficient consumers, except perhaps initial experimentation to discover whether it is efficient or not. If the price is sufficiently low, however, the new good will push part of the efficiency frontier forward and will enter the efficient technology. Unless that particular part of the frontier happens to contain no consumer's preferred characteristic collection, the new good will sell. Furthermore, the introduction of a successful new good will result in an increase in welfare, if other prices are unchanged.

It may not always be clear whether we should classify a new good as an innovation on the production or the consumption side, but it certainly seems most useful to regard a variant of an exist-product, involving no fundamental change in the technical nature of the production process, as an innovation in consumption technology. In terms of our model of consumption, the difference between a new product and a product variant is only the degree to which the characteristics mix of the new product differs from that of existing products. We have, in this model, a satisfactory technique for analyzing product differentiation.

Consider a simple model with two characteristics, derivable in different proportions from two goods. We can use the same diagram as before and suppose A, B to represent the two goods. If the goods are divisible and can be used in combination, the attainable characteristics collections for a consumer, given the budget constraint, correspond to the line AB. The introduction of a third good, C, whose characteristics vector lies between those of A and B can be regarded as a product variant, and this good will sell if its price is low enough to bring the characteristics vector to point C' or beyond in the diagram. Given this product variant, further variants lying between A and C, and C and B would, if suitably priced, expand the efficiency frontier and therefore be sold. If the relationships between the technical properties of the product variants and their relative prices is such as to give a convex frontier with every variant represented by a corner of the frontier, then all variants will be in demand, provided consumers preferences are well distributed.

If we consider the situation from the production end and look through the consumption technology, we see that a producer is ultimately selling characteristics collections rather than goods. The degree of product differentiation will depend on the possibilities, at the production end, of producing variants with characteristics, and at prices, that gives a convex frontier.

A producer with some monopoly power (and we might note that the theory of product differentiation presented here does not require imperfect competition as a prerequisite) will seek the profit maximizing price and differentiation policy. A theory of imperfectly competitive behavior can be built up by pursuing the above analysis, but it is not proposed to do this here.

If products cannot be utilized in combination, the analysis of product differentiation is somewhat different. Consider a highly simplified model of automobiles as consumption activities, expressed in terms of two characteristics, transportation per dollar of gas and comfort. Let two variants, Cadillacs and Volkswagens, be represented by A and B in the diagram. Now one cannot obtain a combination of these charac-

teristics by taking half a Cadillac and half a Volkswagen, so that, although the points A and B are on the frontier, points on AB are not. Then a variant priced to give point C'' might be preferred by some consumers to either A or B, and the convexity of the price-characteristics relationship is not a necessary condition for marketability in this case.

New goods and differentiated products may not simply add to the spectrum of consumption activities; they may replace previous goods. This replacement will occur when the characteristics and price properties of the new product push the frontier forward in such a way that some existing good is no longer part of the efficient set. This will, of course, happen if the new good, for the same outlay, gives more of all characteristics in approximately the same proportions as the old. Such a change seems to correspond to what is often meant by an "overall improvement in quality." In other cases a quality improvement may correspond rather to an increase in some characteristics, with the others unchanged.

Although the introduction of a new product or a new variant can be expected to increase welfare in the simple Paretian sense if the new product is actually purchased and if the existing product is still available at the old price, this may not be the case if the seller takes the old product off the market as he puts the new one on. If the new product, however much of some characteristics it may offer per dollar of outlay, offers less of some other characteristic than the old, then some consumer may be deprived of part of the efficient technology relevant to his particular tastes.

The distinction between the technology of production and that of consumption is a great convenience in analysis but is not based on an absolute criterion of any kind. The ultimate constraints on the system are resources; the ultimate products are characteristics. Some resources may be used to first produce goods which are all intermediate goods in the final analysis, and these goods may then be used in the consumption technology to produce characteristics. But some resources may directly enter the consumption technology without the production of goods as intermediates. As the technologies of both production and consumption change, activities may move back and forth between the consumption and production sectors. This is particularly true of the service and distribution phases of production.

Ultimately the supply of resources, particularly labor, is determined by characteristics. A particular job will have associated with it several characteristics: some will be, in relation to characteristics derived from goods, of a negative kind, but some may well be of a positive kind. The traditional idea of "nonmonetary advantages" has been an attempt to face this obvious fact. We can expand the idea of the con-

sumption technology to include the activities associated with the consumer's sale of labor or other resources. Since labor as an activity may have some characteristics associated with it that are shared by goods, the particular work a consumer performs may partly determine his choice of goods. A taxi driver may spend less of his budget on taking weekend drives than the social norm; yet traditional theory would find no connection between his consumption and his occupation.

New occupations and even new work conditions can be considered as changes in consumption technology. They may also lead to changes in production technology, but this is not necessarily the case.

It would be possible to follow through the kind of analysis we have been making here at very much greater length than is available, but I think the point has been made. There is a technology of consumption. It is the subject of continual change and innovation, just as is the production technology. This change does lead to increased welfare, but the direction from which change comes, the incentives for change, and the analysis and measurement of change differ considerably between production and consumption.