

QUALITY THEORIES IN AGRICULTURAL ECONOMICS

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Agricultural economics has many traditions of quality economics, one of which is based on assumptions of rational economic man. It is shown that the rational economic man approach is based on assumptions on supply and on consumer preferences which are not simplifications of reality but conflict with it. Further fundamental assumptions on the objectivity of characteristics conflict with all marketing and most mainstream economics. The boundary assumptions exclude most of reality, and the ad hoc assumptions exclude what remains.

Fundamental logical errors arise from the failure to distinguish between the theory appropriate to goods and that appropriate to the characteristics of goods. Further fundamental logical errors arise in the use of "characteristics space".

It is not possible to be sure in any instance that the assumptions of the theory hold in any case (though it may be easy to show that they do not). Under most epistemologies this means that it is not possible to test the theory by its predictions. It is impractical under others because of generally accepted problems. There has been no attempt to test the predictive accuracy of these theories scientifically.

It is shown that under five different epistemological approaches this set of weaknesses is fatal to the theory.

INTRODUCTION

With agricultural products it is particularly clear that quality is important in determining price and even market structure, and for this reason agricultural economics was the first to develop the economics of quality, starting with the hedonic approaches following from Waugh (1928). Most of these theories are based on the realities of agricultural products in agricultural markets. There is however another set of theories which is based on the assumption of rational economic man making optimal choices between goods on the basis of the objective characteristics of these goods, with perfect knowledge about the level of these characteristics and their prices. These are referred to here as REM theories. Some of these, such as the characteristics approach, come directly from the agricultural economists' normative models for missing annual feeds (Stigler, Gorman 1956), using them as descriptions of how rational economic man behaves. The seminal REM papers are Lancaster (1966, 1971, 1979),¹ Rosen (1974), Leland (1977), Ladd & Zober

¹ Becker (1965), Muth (1966), Ironmonger (1972), Gorman (1956) produced similar

theories but without Lancaster's rigour of analysis of fundamentals,

(1978), Ratchford (1979) and in a rather different vein, Outhakker (1952), Thiel (1952), Brems (1948, 1957). There are now well over 10,000 papers in this research tradition which depend crucially on the fundamentals laid down in the seminal papers even though additional assumptions and a long chain of logic means that the theory may look very different at first glance. These dominate the mainstream economics approach to quality and are also important in agricultural economics and marketing.

and so had little
impact.

In this paper the framework of the REM theories is examined at a fundamental level in order to identify weaknesses, common to the REM research programme. Repeated reference is made to Lancaster because his analysis of the fundamentals is particularly detailed, clear and rigorous. His work is the most cited in the economics of quality and indeed his 1966 paper is one of the most cited in economics.

It will be shown here that the fundamental assumptions are not simplifications but conflict with observed reality. The boundary assumptions and ad hoc assumptions are so restrictive as to forbid any real life situations. Conceptual and logical errors mean that the conclusions do not follow from the assumptions. It is formally impossible to test the theories by their predictions and no attempt has been made to do so. It is shown that this combination of weaknesses is fatal under any of five very different epistemological approaches used by economists. These weaknesses are at a very basic level so they affect all theories and models sharing this common basis of assumptions, concepts and logic.

This paper does not present any alternative to REM theories of quality, because there are already many established and in general use. There are, for instance, the hedonic approach, compensatory models, perceived quality, behavioural, behaviourist and heuristics approaches and the composite and complex approaches of agricultural marketing economics (e.g. Bowbrick, 1922) and the new mainstream economics (e.g. Earl 1986). One may weed the garden without first breeding new orchid hybrids.

FUNDAMENTAL ASSUMPTIONS

In agricultural economics it is normally held that theory must be based on assumptions that are both realistic and non-trivial. Some simplification is necessary and, indeed, desirable, but assumptions contrary to observed reality are not acceptable. If trivial or unrealistic assumptions are used, an infinite number of theories can be generated, which are of no value in the analysis of agriculture and are not normally included in the canon of agricultural economics. (Some other epistemological approaches are discussed in the final section of this paper).

It will be shown here that the fundamental assumptions of REM theory are contrary to observed reality : they are not in any sense simplifications. These assumptions

are fundamental in the sense that if they are dropped, the whole theory collapses. In the seminal papers that set out the foundations for the research programme, it is not possible to get beyond the first stage of the analysis if these assumptions are changed. With those papers published today, which build a long chain of analysis from these fundamental assumptions, the conclusions can be changed radically if there is even the slightest change to the fundamental assumptions - "for the want of a nail a kingdom was lost". It is not necessary to drop the assumption or change it radically.

The common fundamental assumption of the REM research programme are on a) consumer preferences, b) characteristics space, c) supply price and d) objectivity. Theories develop in many different directions from these fundamental assumptions, with different further assumptions, boundary assumptions and ad hoc assumptions.

Assumptions on Consumer Preference

REM theory is concerned with 'characteristics', which are the objective properties of goods. A good is a unique mixture of characteristics, so one combination of colour, seedlessness, juiciness, sugar and acids makes the 'good' Washington Navel Orange. Oranges in general are a 'group of goods'. The theory is not concerned with an individual's subjective preference or "attributes".

The research programme assumes that each consumer always prefers a good with more of at least one characteristics, so that an indifference curve between two characteristics in characteristics space looks like the traditional indifference curve between two goods in goods space (Figure 1). This fundamental assumption has been formalized by Lancaster (1971, p26) who shows that it is necessary to assume transitivity, completeness, continuity, strict convexity, non-satiation and all characteristics positively desired in order 'that the consumer's preferences can be expressed in terms of an ordinal utility function of the neo-classical kind with all its first order, partial derivatives positive'. The intention is to 'simply carry over traditional preference theory, applying it to collections of characteristics instead of collections of goods'.

A basic conceptual error arises here, as a result of applying theory appropriate to goods to a completely different situation, characteristics. In standard economics we are talking of two goods which may be bought separately to be consumed separately, steak and ice cream, or bread and wall paper for instance. When we are talking of quality the characteristics are necessarily bought together and usually consumed together. One does not buy the creaminess, the sweetness and the flavour of an ice cream separately, one buys ice cream.

Table 1 shows an extreme example, chosen to be favourable to REM theory. Here

two characteristics of a good are consumed together. The pleasure the consumer gets from more peppermint flavouring in the ice cream is independent of the amount of vanilla flavouring. The consumer buys a premixed product and can buy different goods (flavours of ice cream) but cannot change them once bought. In this example it is assumed that marginal utility first increases with the level of the characteristic, then becomes constant, then falls. The result is that when there is increasing marginal utility the indifference curve is concave to the origin, rather than convex as REM theory demands. People prefer to have all one characteristic or all the other. As quantities increase, a bull's eye appears, surrounding the optimum product mix. In order to get indifference curves like those of Figure 1 it is necessary to assume that there is a positive but declining marginal utility for all products at all levels and that this is true for all characteristics at all times. This is contrary to observed reality.

In practice, consumers seldom value quality characteristics independently. The preferred amount of peppermint in ice cream depends on the level of other flavours, on the cream and sugar content and so on. The utility obtained from one characteristic depends on the level of other characteristics so ratio and proportion of characteristics are important.

This can be seen in Figure 2 which shows a consumer's preferences for the characteristics "sugar" and "acid" in an orange. This consumer prefers an orange that is medium sweet, medium acid, so the highest indifference curve is at the centre of a bull's eye. If it is more acid it will be perceived as sour, if less acid as bland, and either way it will be on a lower indifference curve. This is in stark contrast to the theories of Lancaster, Rosen and others in the REM research programme which imply that consumers will always prefer the orange with the maximum amount of acid and sugar. It also raises the possibility of buying fewer oranges of a preferred characteristics mix, which these models do not allow. The fundamental assumptions of strict convexity, non-satiation, and all characteristics positively demanded clearly do not hold. In the previous example, it was shown that indifference curves like those in Figure 1 could be obtained when there was a positive but declining marginal utility, when the characteristics were valued independently. Here it has been shown that this is not usually so when the characteristics are valued separately.

A wide range of indifference curves can be expected in practice (Bowbrick 1992). Figure 3 for example shows the indifference curves for sugar and acid in apples. There is one utility peak for medium-acid, medium-sugar dessert apples and another one for high-acid, high-sugar cooking apples like Bramleys. The two peaks occur because there are two end uses, but the claimed advantage of REM models based on objective characteristics is that they work regardless of end uses and consumer

perceptions. Multiple peak indifference surfaces are common and some are caused by the laws of physics not idiosyncratic consumer preferences. For example, the utility of a superconductor depends on the temperature at which it is superconducting and Figure 4 shows twin peaks from different characteristics mixes in a good (Emsley, 1990). Similarly, a chord consisting of two notes as characteristics gives most utility when the notes are identical or an octave apart, and less utility at the discords in between. These multiple peak surfaces conflict with all the fundamental assumptions of REM theory.

Marketing has done empirical work into preferences for objective characteristics and this again conflicts with the fundamental assumptions. Figure 5 is an individual's preference surface for sugar in tea in a sophisticated tea tasting experiment where the colour of the tea and the amount of lemon were kept constant but the amount of tea and sugar varied (Huber, 1974). This individual is happiest with brown liquid containing five spoons of sugar and over a considerable range, does not mind how strong the tea is.

Figure 6 shows the common case where a pure product is preferred to a mixture and the indifference curve is concave.

All agricultural products may be contaminated. Milk is valuable when pure, but less so when contaminated by insecticides, manure kerosene etc. The contaminants themselves may be valuable when "pure" and not mixed with milk. Obviously, anyone who buys a bottle of milk must consume the milk with the contaminants - it is not possible to extract the insecticides or kerosene at this stage.² In Figure 7 the diagonal is the product possibility curve - milk plus contaminants equal 100%. If no contamination is acceptable, and pure milk and pure diesel are valued, the indifference curves consist of points where the axes meet the diagonal. Figure 8 shows the situation where some contamination is acceptable and indifference curves are points on the product possibility curve. Since contamination is a problem with all agricultural products, curves like this will occur between some axes of all products. There is no product for which the fundamental assumptions apply.

It is possible to change the shape of indifference curves by redefining the characteristics, talking of fructose instead of sugar and distinguishing between malic acid and citric acid in apples for instance.

The fundamental assumptions of the REM theories of quality do not correspond with

² The complexities of curves consisting of ingredient products where characteristics add up to 100% and other types of product, and the complexities of substituting quantity for quality are discussed elsewhere (Bowbrick, 1992, 1997). They are of tangential interest to the present discussion.

reality. They are not in any sense simplifications: they are false;

- * It is unlikely, but possible, that the indifference curves between two characteristics will be as in Figure 1 as REM theory demands. It is extraordinarily unlikely that this will be so for all characteristics of a good.
- * It is probable that many indifference curves between characteristics of a good will be of other shapes like those shown here.
- * For all goods the threat of contamination means that some indifference curves will be very different to those assumed.

The fundamental assumption of REM theory is that all possible indifference curves are of the shape in Figure 1. Without this assumption it is not possible to proceed to the initial paradigm cases.

Fundamental Errors on Characteristics Space

REM theories of quality consist of analysis in "characteristics space" with axes of the form "[Level of] Characteristic A" and "[Level of] Characteristic B". Conceptual and logical errors in the fundamental assumptions on characteristics space invalidate the theory.

There is not, in fact, one single characteristic space of this form. Figure 9 (a and b) shows two sets of indifference curves plotted in a range of characteristics spaces and shows the very different shape of curves when the characteristics curves apply to the quantity in a stew, in a meal, in ice cream, in a standard sized meal and in ones diet (though one may wonder how many individuals have a concept of the level of chilli or garlic in their diet). Then similar curves are plotted for sugar and chilli which are less complementary.

Clearly any analysis that is valid for one of these characteristics spaces is invalid for any other. Lancaster uses up to fourteen such spaces interchangeably:

1. Total amount of characteristic in total consumption. This requires the assumptions of linearity and additivity. It appears to be the characteristics space used for the basic paradigm case.
2. Total amount of characteristic in the diet (1971, p17).
3. Total amount of characteristic in a single unit of a good. This is the space used for the automobile example (1971, pp.157-174).
4. One axis being "Cleaning power per dollar" for goods in the product group detergent (1966, p.153). This conflates two characteristics and introduces concepts like value for money. It does not appear in Lancaster (1971).
5. Level of characteristic obtained from one or more goods in one product group. This appears to be the characteristics space used for most of the analysis, including that which at first sight uses the paradigm case (1971, pp.125-9).
6. Characteristics per unit of a good (1979, p28).

7. A space with a "normalized" efficiency frontier, implying some kind of "normalized" definition of characteristics (1971). This is used for his second paradigm case. In fact different "normalized" spaces may be created starting from any of the six previous spaces and be related to total consumption, to an automobile etc. so there are many more than seven spaces used.³

It is not possible to proceed to Lancaster's second paradigm case of "normalized characteristics" without the boundary assumptions of linearity, additivity, perfect knowledge etc. which are discussed below.

Fundamental Assumptions on Supply

The supply assumptions of REM theory are also fundamental, as they are necessary for the first stage of the analysis, determining an individual's optimum purchase. The fundamental assumption is that the supply functions for all characteristics of every good are of the same form. It will be shown here that there are few products for which this is true of all or even most characteristics.

In traditional analysis based on separate goods it was reasonable to assume that all goods were positively priced and that one could get more of a good by paying more for it. REM quality theory carried this assumption over, assuming that characteristics were positively priced. One could only get a good with more of one characteristic by paying more (and the origin of the theory in agricultural economics stock feed mixing models is obvious here).

These assumptions are no longer reasonable when dealing with a good whose characteristics are necessarily supplied together. There is no obvious reason why it should cost any more to buy a good just because it has more of one characteristic. REM theory would require for instance that an orange with more acid content necessarily costs more. Figure 10, however, gives a more realistic picture. The constant outlay curves are highest around a medium-sweet, medium acid orange, as market demand is concentrated on these. The very acid and very sweet oranges are cheaper.⁴

³ Lancaster's "normalized" curves are presented in a "characteristics in total consumption" space, but most of his followers present the identical diagrams in a different space "[Normalized] level of characteristic [in total consumption] per dollar", without explanation.

⁴ If there are economics of scale in production of one characteristics mix, the most demanded mix may be cheaper. Similarly low cost supermarket distribution may make popular characteristics mixes cheaper than less popular mixes marketed through delicatessens.

This bull's eye constant outlay curve is very different to the curve assumed by REM theory. The indifference curve of one individual, also a bull's eye, is shown next to this set of constant outlay curves. This individual's optimum choice is clearly made at a point where both constant outlay curve and indifference curves are concave to the origin and there will be a trade-off between quantity or quality. This is contrary to the whole of REM theory which assumes that the acid in oranges is always positively required, and is always positively priced so that the most acid oranges are preferred and are the most expensive. It also has an optimum choice where the indifference curve is convex to the origin.

Most agricultural markets are price taking, and prices are determined by demand in the short run, so preferences like those in Figure 1-8 will lead to prices quite unlike those assumed by REM theory. Similarly, when input characteristics are different from the output characteristics, as in art, agriculture and most industry, there is no obvious reason why it should cost more to produce a good with a higher level of one characteristic. With many agricultural products those farmers with the skill to produce "high quality" from the same inputs other farmers use earn an economic rent.

Price making markets seem more promising at first sight. If a good is made by mixing ingredients and those ingredients are characteristics (as with feedstuffs) then the assumptions appear to hold. Less directly if a car or computer is made by bolting together components with different performances something similar may apply. However, it is not possible to operate such price making markets under the REM assumptions that all buyers perceive the same characteristics in each good and are perfectly informed on price etc.

It is not possible to plot an individual's multi dimensional indifference surface from observed purchases, especially in cases like Figure 10. This would require a very large number indeed purchases in directly comparable situations - with all other factors including prices of alternative goods held constant. It is seldom that an individual makes even a dozen purchases that would meet this criterion.

Fundamental assumptions on Subjective or Objective Quality

REM theories of quality are attractive because the analysis is based on objective characteristics, and ignore psychology, subjective preferences and so on. The approaches promise to be much cheaper and easier as a result. The fundamental assumptions of most such theories are (i) a good has objective characteristics, and consumers decisions are made solely on these; (ii) all individuals see the same characteristics in each good and perceive them identically; (iii) individuals may value the characteristics differently. The REM theories explicitly ignore subjective

attributes and may ignore characteristics which are difficult to measure⁵ produce accurate predictions when consumers use something akin to the researcher's attributes as cues or proxies for their own, very different, attributes. It is not necessary that the researcher knows the characteristics as defined in REM theory, or that the consumer values them. Another common formulation is "Market Research shows that consumer ascribe certain levels of attribute to each good in this product group. Regression analysis shows that the goods with the highest level of attributes X, Y and Z fetch the highest price. It is predicted that if the marginal producer can increase the level of X, Y or Z, whether by changing production specifications or by changing the brand image then he or she will get a higher price."⁶ This formulation does not require any knowledge of objective characteristics by the researcher or anyone else.

These assumptions are rejected by the whole of marketing and market economics and many branches of economics including information economics, the economics of advertising and the theory of monopolistic competition.

One approach used widely in marketing but inconsistent with the REM approach is that i) quality is in the mind of the consumer, and that ii) consumer value a good purely for the characteristics they attribute to it subjectively. Choices are not made on the objective characteristics but on subjective attributes. The characteristics may or may not be related to the attributes, but advertising, brand image etc. means that the relationship is seldom simple. Even if the consumers can see some characteristics, they may or may not use them as a proxy for characteristics.

Hedonic theory, is usually based on assumptions incompatible with REM theory. One formulation is "the research subjectively perceive that the goods on the market have certain characteristics (that is to say I have no objective knowledge of which are characteristic as defined by REM theory and, accordingly, no way of measuring

⁵ The characteristics which appear in the analysis are assumed to be objectively quantifiable, as well as objectively identifiable, even though they are important characteristics (colour for example) that do not fit this specification. Although colour can be objectively defined by primary colour composition and degree of saturation, colour differences cannot be put on a simple scale like size or horsepower or vitamin C content so that everyone agreed that good A has twice as much per pound as good B. Lancaster 1979,p.18

⁶ Consumer preference for an attribute, "refreshing" for an orange for instance may be linear and positive even when the preference for objective characteristics like acids, sugars and juiciness is not. This makes hedonic theory more applicable for attributes than with REM theory.

them). Regression shows that goods with more of attributes A, B & C get a higher price. I predict that if the marginal producer switches to producing a product with a higher level of A, B or C then he or she will get a higher price. This can

If the assumption of objectivity is dropped, then REM theory falls away.

'If different individuals were to "see" the same goods in fundamentally different ways, there would be little point in devising an analysis to take account of the objective properties of goods. For then either it is meaningless to speak of "objective" properties, or those properties which are objective are irrelevant to people's relationship to goods.'
(Lancaster, 1971, p.6).

The REM approach can only work if it is possible to plot the indifference curves of all individuals on the same set of axes, and if each individual faces the same supply. This is not possible under any of the following conditions: individuals (i) perceive different characteristics in a good, (ii) perceive non-existent characteristics like dietary fibre in beef, (iii) ignore "objectively important" characteristics like dangerous food additives, (iv) perceive a different set of a good's characteristics as being relevant, (v) value the same set of characteristics but perceive and measure them in different ways - even with perfect knowledge of an automobile's power, for instance, individuals might perceive it in terms of engine capacity, top speed, acceleration from a standing start or ability to pull a trailer for instance. In all these cases, neither the preferences of different individuals nor the supply facing them can be plotted on the same diagram.

A further set of constraints arises because subjectivity implies that people do not perceive characteristics correctly. In principle an individual could plot his or her own indifference curve, against attributes like "My perception of attribute A" or even "My perception of characteristic B". If these diagrams are brought together onto another diagram with axes, like "Perceived level of Attribute A" or "Perceived level of Characteristic B", the difference in perception means that a single good will occupy many different positions, perhaps as many as there are individuals. Similarly, price and budget lines will occupy different positions, depending on the "quality" they are perceived to apply to. These curves would ignore important aspects like

If a researcher were to replot the diagrams against his or her own perceptions, so that the same point always applied to the same good, the shapes of the indifference curves would change. The smooth indifference curves presented here would become very jagged, showing that someone thought that two boxes of brand X was equivalent to one box of brand Y with identical ingredients for instance. In this case, none of the REM assumptions of strict convexity, transitivity, completeness,

continuity, non-satiation and all characteristics positively desired can be expected to apply.

One of the biggest attractions of REM theory is that it claims to predict sales when the objective characteristics of a product are changed. In practice, attributes may change while characteristics remain constant because of advertising etc., or brand image may remain constant through repeated formulations of the product. This analysis confirms Lancaster's belief that REM theory cannot work if subjectivity is allowed. It is not possible to reach even the basic paradigm case where the preferences and decisions of different individuals are compared on the same diagram. In practice even those who work within REM theory find it very difficult to avoid using attributes, which suggests that the theory has no practical application.

BOUNDARY ASSUMPTIONS

Boundary assumptions set out the domain in which a theory is intended to work, and each of the REM theories has different boundaries. Surprisingly, these are seldom made explicit. The example of Lancaster (1966, 1971, 1979) is used here as he sets out his boundary assumptions and other assumptions rigorously and completely, as his formulation remains the paradigm case and as it is the dominant theory of quality today. Among the assumptions are:

- a) One unit of characteristic gives the same satisfaction whatever good it is part of. Chilli powder gives the same satisfaction in ice cream as in chilli con carne.
- b) It is the level of characteristic in total consumption that determines the satisfaction achieved, the level in any good is irrelevant. It does not matter whether the chilli powder is eaten neat, by the pound, or as a seasoning to many dishes.

None of his optimization or aggregation procedures apply where these assumptions do not hold. These assumptions are wrong if they are self-contradictory or if, as he admits is true of his 1975 paper, they rule out all reality.

These assumptions limit the application of his theory to situations like the perfectly informed farmer mixing chicken rations, (ignoring most of the constraints) and this is the theory from which REM theory evolved. It cannot be used elsewhere. Hender (1975), Lad & Zober (1977) and Lucas (1975) strongly criticized this theory for its over-restrictive boundary assumptions but, worryingly, only 1.5% of the people who have cited Lancaster in recent years have cited these criticisms.

AD HOC ASSUMPTIONS

Ad hoc assumptions are ones added to a theory because the theory will not work otherwise (Popper, 1972 pp15-16, 30, 1976 pp40,42). They are not to be confused with fundamental assumptions, boundary assumptions or realistic assumptions made

to fit a theory into a model of a real world situation. Typically each ad hoc assumption is an unrealistic assumption that limits the number of real life situations the theory can apply to. Each explicit ad hoc assumption introduces implicit assumptions. The more ad hoc assumptions there are, the less likely it is that the theory will apply to any real world situation. Lancaster is one of the few writers attempting to make his assumptions explicit. There are 40-60 explicit ad hoc assumptions in Consumer Demand with sixteen in Chapter 8 alone, some are

"The Cobb Douglas functional form is assumed." (Lancaster 1971 p73).

"Uniform distribution is assumed so that average income is constant ..."
(Lancaster, 1971, p79).

"Goods are completely separable, sharing no characteristics" (Lancaster, 1971 p126).

All other goods may be treated as identical, all being equally close or distant substitutes for this group. (Lancaster 1971, pp128-9).

A characteristic may be treated as irrelevant if it does not appear in the preferences of a large proportion of the consumer population (Lancaster 1971, p146), which implies that we can ignore the fact that 20% of the population loves garlic.

"The most heroic assumption is the uniformity assumption on the nature and distribution of preferences ... In geometric terms it implies that the transformed indifference curves in specification-quantity space are all of identical shape and are tangent to the [Product Differentiation Curve] at the specification corresponding to the most preferred good" (Lancaster 1979, p47).

When one is dealing with a group of closely related goods, all other goods may be treated as equally close substitutes for this group (Lancaster 1971 pp128-9). [He uses "good" in the sense of a single product line].

There is a uniform distribution of income so that average income is constant over preferences and there is a rectangular distribution of preferences, with constant density taken to be unity (Lancaster 1971, p79).

The consumption technology is linear, after ignoring invariant

characteristics, and a characteristic is irrelevant if there is a linear dependence in the technology (Lancaster 1971 p142). "In many cases it will be appropriate to assume that characteristics technically related in this way are also related in the view of the consumer so that he reacts to any one the related characteristics not to each of them separately." (Lancaster 1971, p144).

There are in addition many ceteris paribus assumptions. These are quite unexceptional if they are dropped at a later stage of the analysis. Since they are not, they are ad hoc assumptions in disguise.

It is not possible to determine whether or not the assumptions apply in any case, to determine an individual's transformed indifference curves in specification - quantity space for instance. Formally, they are no different from assumptions about how many angels can dance on the end of a pin.

Surprisingly, Lancaster in Variety, Welfare & Efficiency (1979) draws from these assumptions a wide range of conclusions on "welfare, variety & the GNP", "intra industry trade between identical economies", "variety in capital goods", "the optimal division of labour", and "variety and economic development".

Two Stage Models

Lancaster's (1966) two-stage model was abandoned as unworkable in his later work. It had the infinitely more restrictive assumption that characteristics are derived from

consumption activities in which goods, singly or in combination are the inputs. It can only work if, for instance, all consumers eating meals prepared from a shopping basket perceive the same output characteristics, regardless of which set of meals is prepared from it, or who cooks them.

CAN PREDICTIONS BE TESTED?

It is not possible to test economic theories directly, as they are not presented in a way that applies to the real world. Instead they must be tested indirectly. Do models of real world situations and markets using Theory A predict better than models, otherwise identical, using Theory B? This test is possible if and only if there is no doubt that all the assumptions of the theory apply. If this were not so, inaccurate predictions could be taken as evidence that the assumptions did not hold in this case, rather than that it was bad theory. It is no criticism of a theory that it does not work outside its boundaries.

It has been shown above that there is a strong reason to believe that the assumptions do not hold in any real situation. It is further shown that it is not possible to determine in any market that most individuals have the preferences assumed (though it may be easy to show that they do not).

Accordingly it is not possible to say in any case whether a bad prediction was due to

the assumptions of the REM theory, not holding, or whether a good prediction occurred precisely because a bad theory was used in the wrong place.

TESTING REM THEORIES BY THEIR PREDICTIONS

Some of the epistemologies discussed below do not require realistic assumptions or correct logic : they require only that the predictions of a theory have been tested repeatedly and have been found to be consistently good predictors. This may be modified to the statement that they have been found to be good predictors in X% of cases, which requires that a much greater sample has been tested.

It could be extremely difficult and expensive to carry out such a programme of tests in the necessary systematic fashion. Several extensive literature searches have failed to show any evidence of such a programme for any one of the REM theories or their variants. Even if a programme had been attempted, it is doubtful whether meaningful results would have been obtained as there are well recognized problems identified by the Victorians,⁷ Hutchinson (1938), Machlup (1963) and "sophisticated falsificationists" (including Popper) in refuting a theory in this way.

Very few uses of the theory have been designed as tests : rather researchers have

⁷ "The ingenuity of these nineteenth century writers knew no bounds when it came to giving reasons for ignoring apparent refutations of an economic prediction, but no grounds, empirical or otherwise, were ever stated in terms of which one might reject a particular theory" Blaug (1980, p55).

used the theory as a tool to make a prediction. The situations chosen have not been selected as random samples of a specific type of situation from a known population, and very few of the uses are reported - some gave "negative" results and are unpublishable and others are commercial secrets. One cannot therefore, comb the literature and show that Theory X gives a better prediction in y% of cases.

The published literature is also misleading in another way : many of the papers do not use the theory they cite and much of what purports to be based on REM theory is in fact based on quite different theory, often attribute theory based on Waugh (1928). Lancaster complained of this (1971, pp113-4). Recent examples include: Larue, 1991; Williams, 1991; McDaniels, Kamlet and Fischer, 1992; Ortono and Scacciati, 1992; Thomas, 1993; Berliant and Raa 1991; Thomas 1993; Johnson and Fornell, 1987; Heffernan, 1990.

HEDONIC PRICES

In the preceding sections reference has been made to hedonic analysis which goes back to Waugh (1928) which was market based, not REM based. This was established 35 years before most REM theory and is logically independent of it. Nevertheless Rosen (1974) is an attempt to justify Waugh from a REM standpoint and Lancaster is seen to have the same objective by Earl (1986) and Steenkemp (1989) among others. Rosen's fundamental assumptions are close to Lancasters,

though the analysis develops in a different direction. The failings of REM theory discussed above, mean that this support is invalid.

In addition, however, REM theory uses different prices from that used in hedonic theory.⁸

In REM theory the consumer makes a choice on the prices and characteristics of all goods on offer. This requires price list valid at the time, not a regression : it is not necessary to know "the price of a characteristic". Regressions give little weight to those prices at which few transactions took place in the past and none of those at which none took place. This means that most of the options open to a marginal consumer are missing from a hedonic price.

⁸ "Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amount of characteristics associated with them. Econometrical, implicit prices are estimated by the first-step regression analysis (product price regressed on characteristics) in the construction of hedonic price indexes". (Rosen, 1974, p.34). The REM analysis is confusing: Rosen (1974) appears to assume that the set of prices facing buyers is at the same time:

- a market clearing price
- an average equilibrium price at the end of a day's trading
- the price facing each buyer and each seller at all periods through the day

Figure 10 shows how easy it is to get totally misleading prices from linear hedonic regressions. If most transactions had taken place in the SW quadrant prices would appear to be positive, if in the NE both would appear to be negative. If most transactions were in the SE or NW one characteristic would be positively prices, one negatively. There would be a poor fit if transactions were scattered randomly. Yet this is a situation where there is a clear, consistent and logical relationship between the price of goods and the level of their characteristics.

Why would a consumer with a price list wish to know the regressions or the "price of each characteristic"? Market research suggests that people are more likely to rank goods by their characteristics or attributes and then by their prices and then make a choice. REM theories and hedonic theories deal with different types of prices so REM theory can neither support nor refute hedonic theory.

HOW SERIOUS ARE THESE WEAKNESSES?

Economists are not agreed on the grounds for rejecting theories, so the impact of the criticisms raised may be examined in the light of a range of epistemological viewpoints. The criticisms are:

Fundamental Assumptions

- A. The fundamental assumptions on preferences are wrong. They are contrary to observed fact. They are not simplifications of reality. It is improbably

that any individual will have preferences like those assumed for any product group.

- B. Serious logical errors arise from confusions about characteristics space.
- C. The fundamental assumptions on supply are wrong in most cases. They may apply in price making markets but here other REM assumptions do not apply.
- D. The REM theories depend crucially on assumptions of objectivity. Most economists and market researchers think it essential to include subjectivity in any analysis.

Boundary Assumptions

- E. Boundary assumptions rule out most of the real world.

Ad Hoc Assumptions

The large number of ad hoc assumptions means that the theories do not apply to any real world situation.

Do the assumptions apply?

It is not possible to say in any situation that the fundamental boundary or ad hoc assumptions apply, though it may be possible to say they do not. It is not possible to plot a multi dimensional indifference surface for an individual, or in practice the prices facing an individual. Accordingly, bad predictions may arise because the

theory is operating outside its domain, not because it is a bad theory.

Has the Theory been tested?

There has been no programme of crucial tests on any of the REM theories or their variants.

Epistemological Positions

All REM theory is constructed in the belief that there is a special virtue in applying strict logic to stated assumptions, this belief is implicit in nearly all economic literature. The logical errors in REM theory are fatal under virtually all epistemologies.

Agricultural economists usually believe that there is a virtue in working from what we know - observed facts about agricultural markets - to what we do not know - predictions. Many economists can expect to lose their jobs if they make patently false assumptions, that beef grows on trees, for instance, however accurate the predictions of the resulting model. From this epistemological viewpoint the REM theories must be rejected because they conflict with observed reality.

Some other epistemological positions are discussed below. These are seldom made explicit in the literature and there is often considerable confusion.

Theory as Logic

Most practical agricultural economists appear to believe that theory is a string of logic. It is possible to take some or all of the logic from a theory and "cut & paste" it, to create a model of a specific market. In much the same way engineers use mathematics and realistic assumptions on soil, water flow and slopes to design irrigation systems. All that can be expected of a theory is that it is logically correct; it cannot be expected to apply everywhere and it does not represent the truth. An infinite number of logically correct theories can be generated, most of them being of no value whatsoever. It is normal to select ones which

- a) are logically correct
- b) have assumptions close to the reality of the situation being modelled
- c) are "easy to use" or subjectively pleasing.

This falls outside the subject of this article.

Situation specific models, unlike the theories, are intended to describe the truth.

They can be tested by the realism of their assumptions, their logic, or the accuracy of their predictions.

This epistemology rejects REM theory because its assumptions are not realistic and because its logic is correct. It is not possible to say that the assumptions apply in the situation described by a model (though it may be possible to say that they do

not), so the theory is formally untestable, and is "unscientific" in Popper's sense.

Theory as Truth

Another epistemological position is that theory bears a similar relation to truth as the physical sciences do. There is only one truth, and it can be discovered by observation. If the theory represents truth, its assumptions must correspond to the truth, and its logic must be correct. REM theory fails on both these grounds.

Models describe the truth in one situation. Again their assumptions must correspond to the truth and their logic must be correct, so REM theory cannot be used. A model is rejected if its predictions are wrong. It is implicit in the theory as truth epistemology that the assumptions are true in all situations, so the failure of a prediction, shows either that this is false or that the theory is wrong for other reasons.

Theory as Probability

The 'theory as truth' approach may be modified to the 'theory as probability' where it is probable, normal, common or occasionally the case that the assumptions apply in real life. Where they do, the theory is the truth.

One application of this is similar to the "Theory as Logic" approach. First the reality

of a situation is identified, then theory with assumptions appropriate to this reality is selected, then a model is constructed which represents truth and can be tested by the realism of its assumptions, by its logic or by its predictions. REM theory is rejected by this approach for the same reasons as in the "Theory as Logic" approach.

Another application is to apply the theory to a range of situations even though it is not known whether the assumptions apply. It is believed that the assumptions probably, normally, commonly or sometimes do apply, and that the theory then describes the truth. This is appropriate where it is easy to test models by their predictions and difficult to verify their assumptions - which is the reverse of the agricultural economics situation. The resulting models may be tested for realism of assumption, logic and predictive accuracy. The REM theories cannot be used here because of unrealistic assumptions and incorrect logic. Furthermore the approach is only useful if economic have some knowledge of the probability that the assumptions will hold in a certain type of situation. There has been no attempt to assess the probability with REM theory with replicated tests of predictions, using sample situations drawn from a defined parent population etc. As the probability falls, the number of replications rises. More replications are needed when one takes into account that it is generally accepted that there are many perfectly valid reasons why a good theory should produce bad predictions.

"As If" Theory

Another set of epistemological approaches accepts that REM theory does not correspond to the truth, as individuals clearly do not behave like Economic Man, but argues that aggregate consumer behaviour is as if consumers did behave like Economic Man. It is possible therefore to use REM theories as though they were true, even when their assumptions are clearly wrong⁹ truth. It is also possible to say that any logical extension of the theory or model when combined with realistic assumptions also represents the truth. This is not possible with "as if" theory. The fact that one formulation appears to be a good predictor is no indication that a logical extension will be, much less a logical extension combined with new assumptions, realistic or otherwise.

It is seldom claimed in fact that such "as if" models are universally applicable.

"Probably as if"

A less extreme formation is that consumers in aggregate probably, normally, usually or sometimes act as though a theory was true, even though it is accepted that the

⁹ These epistemologies may be linked to methodological approaches like those of Mises (1949), Menger, Robbins (1935), Knight (1940, 1941), Machlup (1963) or Friedman (1953) which argue that the testing or verification of assumptions is unnecessary or undesirable. One school of thought is that theories based on unrealistic assumptions, not simplified assumptions, is actually to be preferred (e.g. Trail, 1995, Sternthal, 1995). This appears to be based on an unusual interpretation of Friedman.

theory is not true. Again there is an infinite number of possible theories derived from unrealistic theories, many of which will occasionally give accurate predictions.

Again the only way to select which to use is by a screening process. However, since there is only a probability that the predictions will be accurate, a much larger number of replications would be needed than for the "as if" formulation. This has not been attempted for REM theory.

If one formulation of one version of any REM theory proves to be often an accurate predictor, this is no indication that a logical extension of the theory nor an extension with realistic assumptions will be. Nor is it any indication that other versions of this or any other version of REM theory will be.

The belief that one version of REM theory is frequently a good predictor can only be justified by repeated, replicated experiments. Even if this had been done, it would be unsatisfactory. It would be risky to base an investment on the belief that some of the theory justifying it "frequently" works, without having any reason to believe that it works in this instance. With the other epistemologies, theory as logic, theory as truth and theory as probability, one can make a reasoned decision even in a totally new environment, with some confidence that the results will be correct.

Conclusion

It is concluded that the REM theory of quality is rejected under the common epistemologies used in economics.