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Accounting for Changes in Tastes

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Health concerns are thought by many to have shifted consumption away from red meats, though econometric evidence is mixed. Testing for structural change is difficult, especially when one time series is used for both estimating demand equations and testing their stability. Specification errors may suggest a shift where none has occurred. Using nonparametric demand analysis, we find that meat consumption patterns in the United States and Australia can be explained using only relative prices and expenditures. Only imposing particular functional forms can reverse the conclusion, suggesting that specification errors in econometric demand studies can account for findings of taste changes.

It is a fallacy, of course, to say that there's no accounting for taste. [PIERRE FRANEY, *The New York Times 60-Minute Gourmet*]

I. Introduction

A common procedure in empirical demand analysis is to estimate a system of demand equations defined only over market prices and

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quantities and then to examine the compatibility of the results with utility maximization. In many cases, prices and expenditure seem inadequate in explaining observed patterns of consumption. Quite often, the rejection of symmetry or homogeneity restrictions, the presence of apparent dynamic influences on consumption, or significant unexplained trends in the data lead to the conclusion that "tastes" have changed over time.

The arguments of Stigler and Becker (1977) suggest a different interpretation of results of this type, and a different response. They proposed that it is more useful, and valid, to treat individual preferences as constant and to seek an economic explanation for any observed changes in demands for market goods. At the level of the individual, such changes may arise from changes in the shadow prices of household resources or changes in the household technology used to transform market goods into fundamental goods. Alternatively, even when individual demands are constant, per capita demands at, say, a national level could change as a consequence of demographic changes or changes in the distribution of income.

With the Stigler and Becker interpretation of demand theory, a finding of structural change in a model of per capita demands for market goods should not be surprising. It could result, for instance, from inappropriate aggregation of individual data, the exclusion of relevant variables such as the opportunity cost of time, or some other specification error.

As well as having implications for the validity of econometric work, shifts in market demands are of direct interest to industry and policymakers. The current concern over declining consumption of red meats provides an excellent example. There is at present a great emphasis on altering the nature of products and promotions to offset the effects of taste change in the meat industry. That it remains to be established whether the demand for red meat has, in fact, changed provided the initial stimulus for this study.

This paper focuses on a nonparametric method for testing whether market demands have shifted because of a change in tastes. The advantage of the approach is that it gives a test for stable preferences for market goods that does not require that they be of a particular form, such as the translog. We apply the technique to the demand for red meats using time-series data from the United States and Australia, testing for whether market prices and expenditures provide a complete explanation of consumption patterns.

The paper proceeds as follows. Section II contrasts two approaches to testing for structural change in empirical demand studies. Section III discusses the case of the demand for red meats, and Section IV addresses some caveats related to necessary aggregation and separability assumptions. The nonparametric method is described in Section V, and Sections VI and VII describe results and some of the issues surrounding tests for stable preferences. A summary of results, Section VIII, concludes the paper.

II. Parametric and Nonparametric Approaches to Structural Change

Searches for structural change in commodity demands can take two forms. Each one amounts to a check for the compatibility of data with some stable set of well-behaved preferences. The first approach is the more familiar one. A functional form is chosen for demand curves and the parameters are estimated. Tests for the stability of parameter estimates, statistical significance of trends, autocorrelation of residuals, or other diagnostics are then used to detect structural changes in the estimated system.[1] All such tests are conditional on the functional form's being correct; it is uncommon to see several alternatives examined, and it would not be desirable to attempt such a specification search without some systematic approach.

A definitive test would involve only the hypothesis that preferences are stable, not that they are stable and of a particular form. Such a test would produce either a yes or no answer to the question, "Is it possible to explain this data set with some demand system?" A nonparametric alternative to the traditional approach makes this possible while avoiding the problem of having to estimate all possible demand systems. It uses the results of revealed preference analysis, established by Samuelson (1938) and Houthakker (1950) and more recently advanced in papers by Afriat (1967) and Varian (1982, 1983).

As in the parametric approach, the null hypothesis is that there is a stable set of preferences so that variation in observed quantities consumed can be explained by changes in relative prices or expenditures. When consumers obey the strong axiom of revealed preference, there is a stable demand system that fully explains observed consumption patterns. This holds because the strong axiom is equivalent to the existence of a well-behaved utility function. The axiom need not hold in the data when structural changes occur, so a test for violations of the axiom is capable of identifying changes in preferences. In addition, the approach avoids the specification bias likely with arbitrarily selected functional forms or the pretesting inherent in specification searches.

Previous applications of the nonparametric technique include stud-

[1] This explains the use of the term "parametric" for this approach. For an analogous approach to the measurement of technical change, see Berndt and Khaled (1979).

ies by Landsburg (1981), Varian (1982, 1983, 1984, 1985), Hansen and Sienknecht (1985), Swofford and Whitney (1986), and Thurman (1987).[2] Two of these applications have been concerned with testing for stability of preferences over time. In his analysis of the demand for meat in the United States, Thurman (1987) found that 25 years of annual data were consistent with revealed preference theory and stable preferences. He noted that there has been steady growth in real expenditures and suggested that the method might have low power when used as a test for stable preferences. This observation was also made by Landsburg (1981) for several data sets from the United Kingdom and by Varian (1982). When budget lines shift steadily outward over time so that they rarely cross, there will be little chance of finding observations inconsistent with the axioms. Each year's consumption bundle is revealed to be preferred to all previous ones. Thurman argued that the finding was therefore necessary, but not sufficient, to conclude that preferences had remained stable.

In the sections that follow, we test for the stability of per capita demands for meat in both the United States and Australia using the nonparametric approach, and we examine the power of the test for stability under alternative assumptions. In the next section, we discuss the background for the study and review some of the necessary caveats when aggregated data are used in demand analysis.

III. The Context of the Study

Agricultural economists and other observers in both countries have paid increasing attention in recent years to the question of structural change in the demand for meat products, especially beef.[3] Per capita

[2] Varian (1982, 1983) discussed the application to consumer expenditure data and later extended the methods to tests for cost minimization by producers (Varian 1984) and to formal statistical testing for violations of the axioms (Varian 1985). Diewert and Parkan (1985) showed how tests for the separability of a subgroup of commodities could be performed using the nonparametric approach. Hansen and Sienknecht (1985) used the nonparametric approach as a preliminary test of expenditure data, which they used to compare a variety of demand systems. Finding that the data were consistent with revealed preference ensured that it was possible to fit demand systems to the data and that poor performance of a particular form would not be attributable to having used a data set inconsistent with demand theory. Finally, Swofford and Whitney (1986) checked for the consistency of observed quantities and user costs of several monetary assets to verify that a demand system with restrictions from utility theory could be used to model the demand for money and money substitutes.

[3] Studies on several aspects of the demand for meats in Australia and the United States include Christensen and Manser (1976), Main, Reynolds, and White (1976), Richardson (1976), Fisher (1979), Pope, Green, and Eales (1980), Haidacher et al. (1982), Nyankori and Miller (1982), Braschler (1983), Chavas (1983), Haidacher (1983), Moschini and Meilke (1984), Murray (1984), Martin and Porter (1985), Menkhaus, St. Clair, and Hallingbye (1985), Wohlgenant (1985), Alston and Chalfant (1987), Chalfant (1987), and Thurman (1987).

consumption of red meat has declined in recent years, and it is widely suggested in industry circles that this reflects a shift of consumer preferences due to dietary concerns. The notion that preferences have shifted dramatically has been used to justify attempts to shift them back through promotion, the development of new grading systems, and other product innovations.

Although these investments may well have a positive rate of return, independent of whether any taste change has occurred, finding stability of preferences would suggest, as Wohlgenant (1985) concluded, that production research might remain a better investment than attempting to shift consumer preferences that are in fact rather stable. In any event, a necessary first step in evaluating the rate of return to such activities is accounting for the various influences behind shifting consumption patterns. We used time-series data sets of per capita consumption and prices to examine the stability of preferences among meats in the United States and Australia. Given the paucity of evidence of a longitudinal nature, this is the typical sort of data set used in testing for structural changes.

To study Australian meat demand, we used Martin and Porter's (1985) data set for five meats: beef, chicken, lamb, mutton, and pork. These data include quarterly domestic disappearance for the five meats during the period 1962:1 to 1984:4. The data were not seasonally adjusted. It seems to be a harmless assumption to ignore most other commodities in the analysis, but omitting fish consumption data may bias results if fish substitutes for the included goods. Unfortunately, for Australia we do not have a consistent series for fish consumption or a fish price that can be incorporated into the analysis. We also used two data sets for the United States that have been studied previously. The annual data set (1947–78) reported by Blanciforti (1982) was used to examine the demand for beef, chicken, pork, and fish, and a similar data set that extends to 1983, from Wohlgenant (1985), was also tried.[4]

There are some interesting differences in consumption patterns and in the data between the two countries. Lamb and mutton are

[4] As always when time-series data are used in food demand analyses, the available quantity data are not ideal. Testing for changes in tastes requires measures of quantities actually consumed and corresponding prices. Prices were available at the retail level for both countries. In both of the U.S. data sets, quantities were taken from the *Food Consumption, Prices, and Expenditures* reports issued by the Department of Agriculture. In those, retail quantities were estimated from wholesale data; no actual consumption data were available (Bunch 1987). This introduces possible measurement errors, to the extent that disappearance and consumption differ substantially. For Australia, only wholesale quantity data were available. If the proportion of wholesale to retail weights is the same for all meats through time, this is not a problem, only a redefinition of units of measurement. To the extent that dressing percentages do vary, potential bias is introduced into empirical analysis.

important in Australia but are relatively unimportant in U.S. consumption. In both countries, per capita chicken consumption has risen considerably over time, while consumption of red meats has declined. In Australia, consumption of beef, mutton, and lamb has declined, while the same is true of beef in the United States.

These trends in per capita quantities consumed are not inconsistent with relative price patterns. Increased consumption of chicken and reduced consumption of beef in both Australia and the United States may be explained by the fact that in both countries real chicken prices have fallen and real beef prices have risen. On the other hand, it is difficult to account for the broad changes in consumption patterns with increased health consciousness alone. Any widespread move by consumers away from red meats would be expected to affect pork in the same way in both countries, yet we observe pork consumption rising in Australia while it is relatively constant in the United States. Pork prices have diverged somewhat in the two countries, and that could account for the divergent movements of pork consumption.

On the whole, then, the behavior of meat consumption patterns is not grossly inconsistent with stable market demands, given the directions of movements of relative prices and incomes. Still, changes in preferences may have contributed to the observed changes in patterns of meat consumption, and many people have taken the trends in the data as evidence of structural change, primarily, a substitution of chicken for beef in both countries beyond what would have resulted from changes in prices and expenditures alone.

IV. Theoretical Restrictions Applied to the Demand Models

Considerable attention has been paid in the literature to whether it is justified to expect theoretical propositions that relate to the individual to hold for an aggregate or representative consumer, especially over a subset of goods. It is quite possible to reject the theoretical restrictions on the demand system solely because of biases induced by aggregation or by erroneous separability assumptions. That possibility would presumably carry over to tests of stable preferences. Even when individual preferences are stable, per capita demands could appear unstable because of aggregation bias or as a result of excluding a relevant good.

In practice, the analysis of aggregated data for consumption of a subset of goods can proceed in two ways. One approach is to abandon contact with the underlying theory, not invoking the restrictions of homogeneity, symmetry, and so on. A belief in aggregation or separability bias would justify this but would leave absolutely no guidance as to the nature of the demand curve that should be estimated.

The second approach, the preferred one, if its prevalence in the literature is any guide, is to model the data as having been generated by a representative consumer maximizing a stable utility function over the goods under study, subject to a constraint on expenditures. Separability assumptions are dictated by the difficulties in modeling a large number of goods, even if data limitations do not preclude a broader study.

In this study, we chose to require the existence of a representative consumer as part of our test for stability of preferences. In other words, we tested the stability of demands that are consistent with a set of underlying preferences, as opposed to ad hoc demand equations that do not satisfy the restrictions from consumer theory. Furthermore, we adopted the assumption that meats constitute a weakly separable group in each country. Rejection of the stable preferences hypothesis may be due to aggregation bias rather than shifts in individual consumption patterns or to omitted goods; however, if instability is not found, it seems safe to conclude that these are not significant problems.

An additional concern relates to the nature of the alternative hypothesis in structural change studies. Whether a parametric or nonparametric approach is used, there is often a lack of data about the nature of the structural change, and the alternative hypothesis is usually no more specific than that the null hypothesis is incorrect. It would be preferable to incorporate directly the determinants and the nature of any hypothesized structural change in a more specific alternative hypothesis. For example, proxies for increased health consciousness could be included. However, problems arise because of the number of possible influences, the lack of adequate data, and the uncertainty about the manner in which they might affect demands.

V. Nonparametric Analysis of Structural Change in the Demand for Red Meats

To test the stability of the demand for red meats, we ask whether relative prices and expenditures on meat can provide a complete explanation of meat consumption patterns. The null hypothesis in these tests is that observed data conform to the restrictions implied by a stable set of well-behaved preferences, under the necessary additional restrictions that meat constitutes a weakly separable group and that it is appropriate to analyze per capita consumption data as having been generated by maximization of a utility function by a representative consumer. In other words, all that is necessary for the null hypothesis to be correct is that we plot the data and superimpose on our plots a set of indifference surfaces and isocost planes consistent with the rational purchase of those quantities by a consumer facing observed relative prices.

A time series of prices and quantities can therefore be checked for consistency with this hypothesis using revealed preference axioms. We examine the data using both the weak axiom and the strong axiom. The weak axiom is a convenient means to illustrate the method, but the strong axiom is required to verify that the data are consistent with utility maximization.

According to the weak axiom of revealed preference, a bundle a is revealed preferred to any other bundle b (denoted aRb) that could have been purchased instead (i.e., a is preferred to all points within the budget line that applies when a is purchased). The weak axiom is violated if any such bundle b is also revealed preferred to bundle a (i.e., a lies inside the budget line that applies when b is purchased). Such a result implies that both aRb and bRa, which could occur only if indifference curves had shifted, given our maintained hypotheses.

For each data point a, let $\mathbf{P}_a$ be the price vector and $\mathbf{Q}_a$ the quantity vector, each with length equal to N, the number of goods.[5] The cost of purchasing bundle a is then $\mathbf{P}_a'\mathbf{Q}_a$. A time series including prices and quantities of N goods can be examined for consistency with the weak axiom by forming a matrix $\mathbf{\Phi}$ with typical element $\Phi_{ab} = \mathbf{P}_a'\mathbf{Q}_b$ so that each element Φ_{ab} gives the cost at time a prices of purchasing the bundle of goods consumed at time b, as would enter the calculation of a cost-of-living index. For instance, the elements in each column give the cost at various price vectors of obtaining the consumption bundle b, while the elements in any particular row allow comparisons of the cost of the various bundles at a fixed set of prices.

If actual expenditures at time a exceed the cost of bundle b at time a prices, so that $\Phi_{aa} > \Phi_{ab}$, then aRb. Violation of the weak axiom occurs if it is also true that bundle a was affordable at time b, so that $\Phi_{bb} > \Phi_{ba}$ and bRa. When well-behaved, weakly separable per capita demands are kept as a maintained hypothesis, any such violation of the axioms of revealed preference must be interpreted as evidence of a change in preferences between time a and time b.

The absence of any violations is consistent with stable preferences. It is worth noting as well that this finding would confirm that it is permissible to impose symmetry and homogeneity on the demand

[5] For convenience, we use a single letter of the alphabet when the meaning is clear to denote both a particular observation and the bundle of goods consumed at that point, so that aRb and $\mathbf{Q}_aR\mathbf{Q}_b$ are equivalent.

system used to explain these data; that is, those restrictions are not inconsistent with the data.[6]

Finding that the data are consistent with the weak axiom does not rule out the problem of intransitivity. It is also necessary to check for consistency with the strong axiom. This involves a search for intransitivity in the data, to see if bundles a, b, and c can be found that together imply that aRb, bRc, and cRa. The number of bundles of goods that can come between a and c is limited only by the size of the data set. The data are consistent with the strong axiom if no intransitivities are found in the matrix $\mathbf{\Phi}$.

When no violations are found, it is possible to "rationalize" the data, to use Varian's (1982) term. The data set can then be said to have been generated by the maximization of a utility function by a representative consumer. In the event that some of the observations are inconsistent with the axioms, it is possible to test whether the deviations from utility maximization are significant ones. Diewert and Parkan (1985), Epstein and Yatchew (1985), and Varian (1985) each discussed ways to test for the statistical significance of such violations.

It is possible to think of each observed quantity consumed as being made up of two components, the true quantity and a measurement error. It is the true quantities that should be tested for consistency with utility maximization, not those measured with some error. The question then becomes whether there can be constructed a set of "small" measurement errors, to be subtracted from the observed quantities in such a way as to satisfy the strong axiom. Varian shows how comparison of the variance implied by the constructed measurement errors to a hypothesized value permits significance levels to be assigned to the deviations from the strong axiom.[7]

VI. Results Using U.S. and Australian Data

Using the Australian data set, we applied the weak criterion to the quarterly data used by Martin and Porter (1985) for the period

[6] Whether that will be true with a particular parametric demand system is another question, of course. Two papers that examine the validity of those restrictions in a parametric framework are Christensen, Jorgenson, and Lau (1975) using the translog and Deaton and Muellbauer (1980) using the almost-ideal demand system. A series of papers beginning with Laitinen (1978) have explored the statistical reasons for the tendency to reject these properties in practice.

[7] As pointed out by a referee, one could also treat prices as random, or both prices and quantities. The nonlinear programming problem solved to find the nearest data set satisfying the strong axiom is altered by changing the source of measurement errors, but the interpretation is otherwise identical.

1967:1–1984:4.[8] We constructed the matrix $\mathbf{\Phi}$ described in the previous section, of dimension 72×72, so that the first row gives the costs of buying the 72 different bundles at 1967:1 prices, the second row the costs of the same bundles at 1967:2 prices, and so on.

It is easy to characterize $\mathbf{\Phi}$ under the null hypothesis: no violations of the strong axiom will be found. All observed choices are consistent with maximization of the same utility function.

Suppose that the alternative hypothesis is true, and there has been a substitution of chicken for beef due to health concerns or other factors not related to prices and expenditures. The hypothesis of stable preferences could be rejected if consumption patterns evolved along the following lines. First, a bundle (or bundles) purchased early in the sample was affordable later in the sample but was rejected in favor of a bundle with more chicken and less beef. This implies a preference for the bundle with more chicken. If this latter bundle was affordable earlier but was not chosen, we would conclude that, over time, preferences had shifted to chicken and away from beef. That is the only way to reconcile these events with rational choice and is also the only way to reject the stable preferences hypothesis using the nonparametric test; such a reversal of choices must be found.

We found no such switch of preferences. The data are almost entirely consistent with the hypothesis that relative prices and the level of expenditures completely explain shifts in consumption patterns. We found only two minor violations of the weak axiom of revealed preference, as shown in table 1.

In practice, it is convenient to form ratios of elements in $\mathbf{\Phi}$, which turn out to be quantity indexes. We computed these by dividing every element in $\mathbf{\Phi}$ by the diagonal element in the same row, forming the ratios Φ_{ij}/Φ_{ii} for all i, j combinations. These indicate whether the bundle of time j quantities was affordable at time i prices. Thus a ratio less than unity indicates that iRj. The size of the index can be used to judge the importance of any violation that occurs when jRi also occurs.

In table 1, these ratios are shown for the two pairs of data points found in violation of the weak axiom. These violations occur with the pair formed by time i = 1971:3 and time j = 1972:2 and with the one formed by time i = 1973:2 and time j = 1982:4. At time 1971:3 prices and expenditures, the bundle consumed in 1972:2 was affordable, though just barely. The ratio Φ_{ij}/Φ_{ii} of 0.99993 indicates that the latter period's bundle was just 0.007 percent cheaper than what was

[8] For the first 5 years of Martin and Porter's data (1962:1–1966:4), quarterly values for chicken consumption were imputed from annual quantities, so we deleted those data points (see Fisher 1979).

TABLE 1

RESULTS OF NONPARAMETRIC TESTS FOR CONSISTENCY WITH UTILITY MAXIMIZATION

Data Set Used			Are Data Consistent with SARP?*	Observations Violating the Axiom†			Number of Times $\Phi_{ij} < \Phi_{ii}$	
Country and Source	Sample Period	Goods		Period	Φ_{ij}/Φ_{ii}	Φ_{ij}/Φ_{ii}	Above Diagonal ($j > i$)	Below Diagonal ($j < i$)
Australia:								
Martin and Porter	1967:1–1984:4	Beef, chicken, lamb, mutton, and pork	No	i = 1971:3, j = 1972:2	.99993	.99924	1,088 of 2,556	1,345 of 2,556
				i = 1973:2, j = 1982:4	.99938	.99708		
Martin and Porter	1967:1–1984:4	Same, except 1971:3 mutton consumption reduced by 1% and 1973:2 mutton consumption increased by 6%	Yes	...	...	...	1,088 of 2,556	1,344 of 2,556
Martin and Porter	1967:1–1984:4	Beef, chicken, lamb, and pork	Yes	...	...	...	847 of 2,556	1,630 of 2,556
United States:								
Blanciforti	1947–78	Beef and veal, fish, pork, and poultry	Yes	...	...	...	33 of 496	456 of 496
Wohlgenant	1947–83	Beef and veal, fish, pork, and poultry	Yes	...	...	...	73 of 666	581 of 666
	Constructed Data Sets, Expenditure Elasticities Assumed Equal to One							
Australia:								
Martin and Porter	1967:1–1984:4	Beef, chicken, lamb, mutton, and pork	Yes	...	...	...	1,036 of 2,556	1,444 of 2,556
United States:								
Wohlgenant	1947–83	Beef and veal, fish, pork, and poultry	Yes	...	...	...	250 of 666	380 of 666

* SARP denotes the strong axiom of revealed preference.

† Φ_{ij} denotes the cost at time i prices of purchasing the quantities observed at time j.

actually consumed (and revealed preferred). When the cost of the 1971:3 bundle is computed at 1972:2 prices and compared with that period's expenditures, the earlier bundle is revealed inferior, costing almost 0.08 percent less. This is shown by the ratio $\Phi_{ji}/\Phi_{jj} = 0.99924$. Similarly, the comparisons for time $i = 1973{:}2$ and time $j = 1982{:}4$ show that the cost of these bundles was virtually the same at the prices that were observed in either period. These comparisons show violations of the weak axiom, but negligible ones. Independent of the statistical significance of any of these violations, the deviations from one do not occur in significant digits, given the precision of measurement of quantities consumed.

Moreover, we found that with minor adjustments in the values for mutton consumption in two periods, 1971:3 and 1973:2, these violations of the weak axiom are no longer present. We selected mutton as the culprit for a number of reasons, in part because the observed value for 1971:3 was unusually high (near the maximum of the entire series) and that for 1973:2 was somewhat low, in comparison with adjacent sample values. Any of the other commodities could have been used. As shown in table 1, reducing 1971:3 mutton consumption by 1 percent, from 5.37 kilograms to 5.316 kilograms, and raising 1973:2 mutton consumption from 2.41 kilograms to 2.55 kilograms was sufficient to remove the violation of the weak axiom. The extent of the adjustments necessary to restore the data set to consistency with utility maximization is certainly plausible as a correction for measurement error. In any case, the small corrections needed are not of the sort that would lead to the conclusion that preferences are shifting away from red meats. They involve only mutton.

Mutton consumption was a minor component of meat expenditures and declined steadily throughout the sample, to the point that mutton's share was never above 5 percent of meat expenditures after 1975:1. Also, Beggs (1987) noted that in later quarters mutton prices were inferred from the lamb price, providing an additional reason to suspect that the mutton data are less reliable than the data for other meats. Consequently, we omitted the mutton data and tested for stability of the demand for the four other meats, equivalent to assuming them to be separable from mutton. We also aggregated the values for mutton and lamb consumption and tested that data set. No violations were found in either case. As noted by Epstein and Yatchew (1985, p. 155), a statistical procedure is not needed with such an outcome.

With the original data set, we also applied the more general test for violations of the strong axiom but found no further cases beyond the two observations inconsistent with the weak axiom in the actual data.[9]

[9] We thank Hal Varian for providing us with his programs for nonparametric demand analysis, which were used for checking consistency with the strong axiom.

Again, with mutton excluded or aggregated with lamb consumption, there were no violations. These findings support the hypothesis that observed consumption patterns in the Australian data set are consistent with a stable set of demands. Even if the measurement error interpretation is unacceptable and instead one questions the series for mutton consumption, there do not appear to have been shifts away from lamb and beef toward chicken.

Using the U.S. data for 1947–78 from Blanciforti (1982), we observed the same outcome: no violations of revealed preference were discovered. An identical result was obtained with the data used by Wohlgenant (1985), which include the years 1947–83. This represents an additional 5 years of more recent data and takes the sample well beyond the dates when most observers consider structural changes to have occurred.

The revealed preference results indicate that these data sets are consistent with maximization of a stable utility function. A complete explanation of changes in consumption patterns over time can be given using prices and expenditures. Whatever biases have been induced by the separability assumption or by imposing restrictions from the theory of the individual consumer with per capita data, they are not of a form that causes us to reject the stability of a well-behaved set of demands defined over the included goods. Only if the hypothesis of stable preferences is replaced with one that requires stable preferences of a particular functional form can rejection occur.

VII. The Interpretation and Power of the Nonparametric Test

One drawback to testing hypotheses with the nonparametric approach appears to be the unknown power of the test. Is the failure to reject the hypothesis of stable preferences a strong indication of the absence of structural change, or could the data be consistent with revealed preference even in the presence of substantial structural change?

The power issue relates to observations made by Landsburg (1981) and Varian (1982) that when the nonparametric method is applied to aggregate consumption series, one is unlikely to find a violation of revealed preference axioms because the budget lines drawn for annual observations rarely cross. Aggregate consumption of every good is rising through time in such applications, so each bundle of goods is revealed preferred to all previous ones. Concerns over power therefore relate not so much to the method as to the data set under study. If growth in real expenditure dwarfs variation in relative prices, it is likely that less will be revealed about substitution relationships among goods than if real expenditure remained relatively constant. This will be true using either parametric or nonparametric methods.

We examined this problem using our data sets. It seems reasonable to expect the power of nonparametric tests to be higher for disaggregated goods such as these than for more aggregated goods. Quantities consumed do not all rise uniformly with time, and relative price variation is likely to be greater, relative to variation in real expenditure, than for more aggregated bundles of goods. However, this is much more true of the Australian data than the U.S. data, mainly because the U.S. data are annual and cover a longer time period. Between observations and across the sample, the growth in real expenditure is greater in the U.S. data.

The matrix $\mathbf{\Phi}$ used to perform the tests illustrates this notion of power. Recall that the data were arranged chronologically, so that the first row relates to period 1 prices, the second to period 2 prices, and so on, while the columns involve observed quantities in the same way. When real expenditures rise through time, it is likely that the cost at any time t of buying bundles purchased earlier in the sample will be less than observed expenditures at time t. Similarly, the cost of bundles purchased later in the sample, when measured at time t prices, is likely to exceed actual expenditures at time t. The extreme case occurs when all numbers below the diagonal in $\mathbf{\Phi}$, call them Φ_{ij} $(i < j)$, are less than the diagonal elements Φ_{jj} for any time period j and, at the same time, all elements above the diagonal, Φ_{lj} $(l > j)$, exceed Φ_{jj}.

To indicate the importance of this type of problem, for each data set we checked the number of occurrences of $\Phi_{ij} < \Phi_{ii}$ for entries above and below the diagonal. The results are given in table 1.

In the Australian data, there are 1,088 instances in which observed bundles were affordable at price and expenditure levels observed earlier in the data set. While this is less than the 1,345 observed below the diagonal, it is not so small that concerns over power need be great. On the other hand, with Wohlgenant's data set, there are 73 above the diagonal and 581 below. This reflects the greater growth in real expenditures for meats over the longer time period covered by these data. Real expenditures were smallest in the sample in 1951, reaching their peak in 1976 at a level over 40 percent higher. They declined slightly and almost monotonically from there to 1983. A similar pattern exists in Blanciforti's data.

Even when the power is low in nonparametric tests, relative to some desired level, it does not follow that the parametric approach should be adopted. There are two reasons for this. First, the same concerns over the nature of the data set would affect tests that require the estimation of demand systems. In a parametric analysis, it seems likely that when Engel curves explain more of the variation in quantities consumed, less is revealed about substitution between goods, just as with the nonparametric approach. Second, when a particular form for the demand system is estimated, the test for stable preferences is replaced by a test for stable preferences of the translog, almost-ideal, or some other form. It is well known that an arbitrarily chosen demand system may perform very badly as an approximation of the mechanism by which the data were generated (e.g., Deaton 1986). Rejection of hypotheses such as stability or homogeneity could then be due to use of the wrong functional form rather than a rejection of the economic proposition.

This problem and the concern over growth in real expenditures in time-series data sets led us to consider an alternative procedure. It is easy to see that the power of our test for stable preferences depends on the variation in relative prices being large relative to that of expenditures, though it is hard to quantify the power relationship. Monte Carlo simulations might be formulated to do so under a variety of conditions, but care must be taken in applying such results to data sets that might not follow the mechanisms used to generate the simulations.

Another procedure that might be used to increase the power of nonparametric procedures involves using the data set under study rather than simulated data. It suffers from the same criticism as the parametric approach: it is arbitrary and requires the use of a joint hypothesis, but we find it considerably more intuitive.

The problem with the parametric approach is that there would have to be a search over an infinite number of functional forms to "prove" that stable preferences do not exist; every structural change test with a particular functional form can only indicate instability of that form. Picking a functional form is a means of imposing prior beliefs on a demand system in an attempt to glean more information from the data set. However, we would expect that no one has any priors about functional forms, apart from a requirement that they be compatible with economic theory and a preference that they be somewhat parsimonious.

An alternative way of imposing prior information on the analysis is to perform the equivalent of "detrending" the data by making an adjustment for real expenditures. This involves imposing prior beliefs about income elasticities, which seems more natural than imposing priors about functional form. Income elasticities are easily linked to past experience with similar data sets and can be connected with the Bayesian approach to inference with much less difficulty than can the problem of selecting the functional form.[10]

To see if our conclusions concerning the stability of preferences

[10] See Rossi (1985) for an example of selection of functional form using Bayesian techniques.

were a consequence of real income growth alone, we imposed prior beliefs about income elasticities as follows. First, each data point was adjusted for changes in the level of real expenditures (actual expenditures on meats divided by the consumer price index), on the basis of an assumed expenditure elasticity of one. We replaced the observed quantity of good i at time t with an adjusted value, calculated using $\hat{Q}_{it} = Q_{it} \times (1 - DINC_t)$, where $DINC_t$ is the percentage by which real expenditures at time t exceed the minimum for the sample.

After this adjustment to reduce variations in the level of expenditures, the constructed quantities should lie mostly on budget lines that cross. The remaining variation in quantities consumed was then tested for consistency with revealed preference. To a certain extent, this violates the spirit and intent of the approach; additional assumptions are introduced and become joint hypotheses that are being tested. However, this might be preferable to the application of the test to unadjusted data, depending on one's view. It is certainly preferable to imposing an arbitrary functional form or searching over alternative specifications.

Our results are shown in table 1. If alternative income elasticities are considered, it would be possible to report intervals for each elasticity within which there is no significant violation of revealed preference. The user of such information would be free to choose whether the constructed intervals are reasonable as a description of reality. The same exercise could be performed using price elasticities if the constant elasticity assumption is acceptable.

The results continue to support the stable preferences hypothesis. Even after the quantities consumed were adjusted by the level of expenditures, they were consistent with the strong axiom of revealed preference. Variations in constructed quantities, after adjustment for changes in the level of real expenditures, are consistent with maximization of a stable utility function.

VIII. Summary and Conclusions

This paper has used a nonparametric approach to test for structural change in the demand for meat, applied to the United States and Australia. A check for consistency with the axioms of revealed preference showed that the data from both countries could have been generated by stable preferences. Therefore, any conclusions from these data sets that tastes have changed must come in the form of restrictions on the nature of these demand systems (e.g., to be of the almost-ideal form). The data alone do not indicate changes in preferences. Relative prices, instead, can account for the observed shifts in consumption patterns.

There is some uncertainty about the power of such a test. Power is likely to be low for most data sets consisting of aggregate consumption since each year's consumption bundle will be revealed preferred to that of the previous year. For disaggregated goods such as meats in the data sets we examined—where relative prices have varied considerably while real expenditure on the meats group varied less—the test seems likely to have sufficient power. Unfortunately, while this notion of power is analogous to the usual statistical definition, it is harder to quantify.

Our investigations of data constructed from the observed quantities using a procedure that adjusts for growth in real expenditures supported the findings with unadjusted data. We imposed restrictions on expenditure elasticities, corrected for expenditure effects, and found that variation in relative prices continued to explain the remaining shifts in consumption patterns.

It will be of interest to attempt to estimate a demand system and elasticities consistent with the stable preferences indicated by the revealed preference results. Experimentation with alternative functional forms would be required, and the drawbacks with that have been discussed. Several authors have questioned the approximation potential of models such as the translog or almost-ideal. It may be that testing for structural change as Wohlgenant (1985) did, using the variable number of parameters of the Fourier flexible form, will avoid misspecification implicit in more restrictive forms. That approach falls between the fixed-parameter forms such as the almost-ideal and the completely nonparametric approach using revealed preference.

The assumptions concerning weak separability and aggregation over consumers can be challenged. However, our nonparametric results do support the stability of well-behaved separable per capita demands for beef, chicken, lamb, mutton, and pork in Australia and for beef, fish, pork, and poultry in the United States. On this basis, we interpret past work as rejecting the stability of particular functional forms for those demands rather than as an indication of structural changes in demand.

We began the paper by distinguishing taste changes reflected in commodity demands from those discussed by Stigler and Becker defined over fundamental goods. To most people, there seem to be fairly compelling reasons to believe that consumer preferences for meat have changed. It may be the case that household production functions have shifted over time and that meat is being perceived and used differently by consumers. Yet when conventional demand theory is applied to market demands, we find that we are unable to reject the stability of a set of preferences defined over market quantities of meat items.

Stigler and Becker appealed to economists to augment their models to account for changes in demand. Our results indicate that, in the case of meat, there are not any changes to be accounted for. Moreover, we found nearly identical results in two countries where the conventional wisdom is that preferences have changed in important ways in recent years. This duplication of results adds force to our conclusion that we can account for the conventional wisdom: the models that indicated structural change did so because of the chosen functional form.

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