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Testing for the utility maximization hypothesis of consumers using the revealed preference theory

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The objective of this paper is to test the utility maximization hypothesis in various Western countries using the non-parametric approach based on the revealed preference theory. The data employed are annual time series covering the period 1964 to 1992 of per capita consumption and prices from Germany, France, the United Kingdom, Spain, Sweden and Canada. The results indicate that all sample countries are consistent with the weak, strong and generalized axioms of the revealed preference theory. This implies that the observed behaviour of these consumers is consistent with the condition of utility maximization or, in other words, that the hypothesis of stability of individual preferences is accepted.

Introduction

Demand theory is based on the hypothesis that the consumer chooses the bundle that is preferred from amongst all available bundles for a set of prices and expenditure. However, one fundamental question that emerges in the empirical analysis of consumers is whether this observed behaviour is consistent with the utility maximization hypothesis.

An extended approach to solving this question is to specify parametric functional forms for demand equations and to fit them to observed data.[1] The estimated demand functions can then be used to test the consistency of the data with the maximization hypothesis. However, this procedure will be satisfactory only if the functional forms are good approximations to the 'true' demand functions, an aspect that is not directly tested.

This problem has motived the appearance of an alternative methodology designed to analyse the consistency of consumer behaviour, namely the non-parametric approach, derived from the revealed preference theory.[2–9] This procedure does not need *ad hoc* functional specifications for demand equations because, on the basis of available information, quantities and prices, the non-parametric approach allows us to test if the data are consistent with the condition of utility maximization. Hence, we have a straightforward and efficient way of checking a finite amount of data for its consistency with the neoclassical model of consumer behaviour.

The distinction between the parametric and non-parametric approaches is very clear as regards the informative basis of analysis. The first method assumes that the demand functions are available, whereas the second assumes that only a finite number of observations on consumer behaviour are available. In this paper, the view is taken that

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the latter assumption is much more realistic and, knowing that the non-parametric approach provides tests of the utility maximization hypothesis with no additional assumptions concerning functional form, it is argued that the non-parametric approach is much to be preferred.

The objective of this paper is to test the utility maximization hypothesis in several Western countries using the non-parametric approach. We apply this technique using annual time series data covering the period 1964 to 1992 for several representative OECD countries, namely Germany, France, the United Kingdom, Spain, Sweden and Canada. I have not considered other countries in this study for several reasons. First, I do not include the United States because there are many detailed papers in the economic literature which have proved that there is a well-behaved utility function which can rationalize the US data.[10–13] Secondly, I have not considered Australia, Japan, Holland, Ireland or Italy because homogeneous time series of consumption having the same length as the corresponding sample countries do not exist. Total consumption is divided into five goods: (i) food, beverages and tobacco, (ii) clothing and footwear, (iii) gross rent, fuel and power, (iv) furniture, furnishings and household equipment and (v) miscellaneous goods and services. The results of this non-parametric analysis will be interpreted in terms of the stability of consumer preferences. That is to say, the fact that data are consistent with axioms of the revealed preference theory indicates that shifts in the patterns of consumption are attributable to variations in conventional economic factors (relative prices and total expenditure) and are not due to changes in consumer tastes.

The paper proceeds as follows. In the next section the non-parametric approach, as a procedure to test the utility maximization hypothesis, is briefly explained. Section 3 is dedicated to describing the sample data. In Section 4 it is verified that Western consumers satisfy the axioms of the revealed preference theory and, finally, the conclusions of the paper are summarized in Section 5.

The non-parametric approach

The non-parametric approach to demand analysis derives algebraic conditions on the demand functions implied by maximizing behaviour. These conditions, known as 'revealed preference' conditions, provide a complete list of the restrictions imposed by maximizing behaviour, in the sense that all the maximizing behaviour of consumers must satisfy these conditions and further that all behaviour that satisfies these conditions can be viewed as maximizing behaviour. Revealed preference theory is based solely on observed and measurable phenomena, namely the commodity bundles actually purchased by consumers, the prevailing prices and consumer income or total expenditure.

Non-parametric methods have been developed to test data for consistency with utility maximization by means of the weak (WARP), strong (SARP) and generalized (GARP) axioms of revealed preference. One attractive property of these tests is that they do not require a demand system to be specified and hence they suppose no explicit restrictions on functional form. Thus, these tests offer a convenient and informative means of scanning a consumption data set for evidence of violations of demand theory. Although

it would seem reasonable to expect researchers to apply the tests for consistency, at the very least at the minimum level, WARP, in fact only a very small fraction of journal articles that report parametric demand systems also report whether the data was tested for consistency with GARP. Many empirical papers can be found in the applied economic literature that have used non-parametric methods in consumer demand analysis.[10–18]

Let us now analyse how one can test if certain observations belonging to a representative consumer are in accordance with the utility maximization hypothesis. Let $\mathbf{q}^i=(q_1^i, \ldots, q_n^i)$ and $\mathbf{p}^i=(p_1^i, \ldots, p_n^i)$ denote the vector of quantities and prices corresponding to n goods and let us suppose that we have m observations $(\mathbf{q}^i, ^i)$ $(i=1, 2, \ldots, m)$. If a consumer chooses a bundle of goods $\mathbf{q}^i$ when an alternative bundle of goods $\mathbf{q}^j$ is obtained with the same budget outlay, the agent is revealing a preference for bundle $\mathbf{q}^i$ over bundle $\mathbf{q}^j$, that is, $\mathbf{q}^i$ is revealed preferred to $\mathbf{q}^j$, usually denoted as $\mathbf{q}^i R \mathbf{q}^j$.

The revealed preference theory requires some consistency conditions on consumer choice: the weak, strong and generalized axioms of this theory.

The weak axiom (WARP) states that if $\mathbf{q}^i$ is revealed preferred to $\mathbf{q}^j$, then $\mathbf{q}^j$ cannot be revealed preferred to $\mathbf{q}^i$. In other words, bundle $\mathbf{q}^j$ will only be chosen when it is cheaper than $\mathbf{q}^i$, that is, bundle $\mathbf{q}^i$ is not obtainable with the same outlay. Fig. 1 shows situations in which the axiom is satisfied and in which it is violated. Assuming only two goods, Q_1 and Q_2, the line through $\mathbf{q}^i$ represents the budget line when the consumer chooses bundle $\mathbf{q}^i$, and the line through $\mathbf{q}^j$ is the budget line when bundle $\mathbf{q}^j$ is chosen. The weak axiom would be satisfied if commodity bundle $\mathbf{q}^i$ is chosen when $\mathbf{q}^j$ is available, that is, $\mathbf{q}^j$ is in the budget set bounded by the budget line through $\mathbf{q}^i$, and $\mathbf{q}^j$ is chosen when $\mathbf{q}^i$ is unattainable

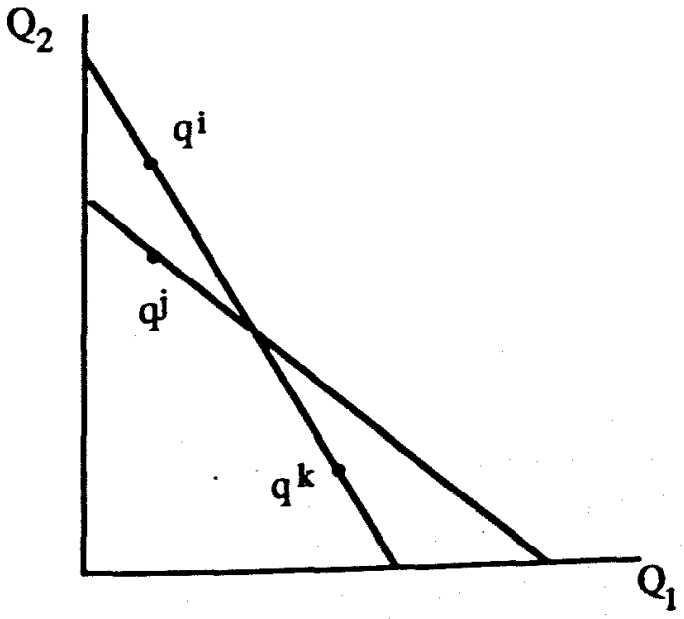

Fig. 1. The weak axiom of the revealed preference.

with the given budget, that is, when $\mathbf{q}^i$ is outside the budget set. On the other hand, the weak axiom would be violated if bundle $\mathbf{q}^k$, rather than $\mathbf{q}^i$, is chosen when $\mathbf{q}^j$ lies within the budget set but $\mathbf{q}^j$ is chosen when $\mathbf{q}^k$ is available.

This axiom can be expressed in terms of expenditures. For $\mathbf{q}^i$ to be revealed preferred to $\mathbf{q}^j$, then both $\mathbf{q}^i$ and $\mathbf{q}^j$ must be available for a given income: $\mathbf{p}^i\mathbf{q}^i \geq \mathbf{p}^i\mathbf{q}^j$, where $\mathbf{p}^i$ denotes the set of prices when $\mathbf{q}^i$ is chosen. Thus, the expenditure on $\mathbf{q}^i$ is at least as great as the expenditure on $\mathbf{q}^j$. If the weak axiom is satisfied, then: $\mathbf{p}^i\mathbf{q}^i \geq \mathbf{p}^i\mathbf{q}^j$ and $\mathbf{p}^j\mathbf{q}^i > \mathbf{p}^j\mathbf{q}^j$.

The second and third consistency conditions concern transitivity of consumer choices. The strong axiom states that if $\mathbf{q}^i$ is revealed preferred to $\mathbf{q}^j(\mathbf{p}^i\mathbf{q}^i \geq \mathbf{p}^i\ \mathbf{q}^j)$, $\mathbf{q}^j$ is revealed preferred to a third bundle, $\mathbf{q}^k(\mathbf{p}^j\mathbf{q}^j \geq \mathbf{p}^j\mathbf{q}^k)$, and so on until $\mathbf{q}^l$ is revealed preferred to $\mathbf{q}^m$ $(\mathbf{p}^l\mathbf{q}^l \geq \mathbf{p}^l\mathbf{q}^m)$, for some sequence of bundles $(\mathbf{q}^i, \mathbf{q}^j, \mathbf{q}^k, \ldots, \mathbf{q}^m)$, then bundle $\mathbf{q}^m$ cannot be revealed preferred to $\mathbf{q}^i$ $(\mathbf{p}^m\mathbf{q}^m \leq \mathbf{p}^m\mathbf{q}^i)$.

On the other hand, the generalized axiom states that if $\mathbf{q}^i$ is revealed preferred to $\mathbf{q}^j$ $(\mathbf{p}^i\mathbf{q}^i \geq \mathbf{p}^i\mathbf{q}^j)$, $\mathbf{q}^j$ is revealed preferred to a third bundle, $\mathbf{q}^k$ $(\mathbf{p}^j\mathbf{q}^j \geq \mathbf{p}^j\mathbf{q}^k)$, and so on until $\mathbf{q}^l$ is revealed preferred to $\mathbf{q}^m$ $(\mathbf{p}^l\mathbf{q}^l \geq \mathbf{p}^l\mathbf{q}^m)$, for some sequence of bundles $(\mathbf{q}^i, \mathbf{q}^j, \mathbf{q}^k, \ldots, \mathbf{q}^m)$, then bundle $\mathbf{q}^m$ cannot be strictly revealed preferred to $\mathbf{q}^i$ $(\mathbf{p}^m\mathbf{q}^m < \mathbf{p}^m\mathbf{q}^i)$.

One can show that the strong axiom implies the Generalized Axiom, but not vice versa. Thus, GARP is a generalization of SARP, in the sense that the first allows multiple solutions to the consumer's optimization problem for a given price vector and total expenditure, that is, for a given budget constraint.

If some data satisfy GARP, then there is a satisfactory utility function $u(\mathbf{q})$ that will rationalize the observed behaviour, that is the utility derived from the revealed preferred bundle is greater or equal to the utility corresponding to the bundle not chosen $(\mathbf{p}^i\mathbf{q}^i \geq \mathbf{p}^i\mathbf{q}^j \leftrightarrow u(\mathbf{q}^i) \geq u(\mathbf{q}^j))$. By contrast, if the data contains a violation of this Axiom, then a non-satiated utility function that will rationalize the data does not exist. However, when can the observations be rationalized by a sufficiently well-behaved non-degenerate utility function? The best answer to this question is provided by the Afriat's Theorem:[2]

'The following conditions are equivalent:

(1) there exists a non-satiated utility function that rationalizes the data;
(2) the data satisfies GARP;
(3) there exist numbers U^i, $\lambda^i > 0$, i = 1, 2, ..., n, that satisfy the Afriat inequalities: $U^i \leq U^j + \lambda^j\mathbf{p}^j(\mathbf{q}^i - \mathbf{q}^j)$ for i, j = 1, 2, ..., n;
(4) there exists a concave, nonotonic, continuous, non-satiated utility function that rationalizes the data'.

Attention should be drawn to some features of Afriat's Theorem. First, the equivalence of (1) and (4) shows that if a particular data set can be rationalized by any non-trivial utility function at all, it can in fact be rationalized by a very satisfactory utility function. Secondly, the numbers U^i and λ^i which appear in (3) can actually be used to construct a utility function that rationalizes the data. U^i and λ^i can be interpreted as measures of the utility level and marginal utility of income. Thirdly, parts (2) and (3) give directly testable conditions that the data must satisfy if it is to be consistent with the

maximization model. Condition (3), for example, simply asks whether there exists a non-negative solution to a set of linear inequalities. The existence of such a solution can be checked by solving a linear programme with $2n$ variables and n^2 constraints. Unfortunately, the fact that the number of constraints rises with the square of the number of observations, makes this condition difficult to verify in practice for computational reasons.

Data

The data used in this paper are annual time series covering the period 1964 to 1992 for Germany, France, the United Kingdom, Spain, Sweden and Canada. They include total consumption and prices obtained from several issues of National Accounts, Vol. II (OECD), and population obtained from Labour Force Statistics (OECD). I have divided consumption by population to calculate per capital values which are assumed to correspond to a representative consumer in each sample country. Total consumption is disaggregated into the following categories: (i) food, beverages and tobacco, (ii) clothing and footwear, (iii) gross rent, fuel and power, (iv) furniture, furnishings and household equipment, (v) miscellaneous goods and services (medical care and health expenses, transport and communication, recreational, entertainment, education and cultural services, personal care and expenditures in restaurants, cafes and hotels).

Tables 1 and 2 provide a brief descriptive analysis using two indicators. First, we carry out an analysis of the rates of growth, obtaining the annual average rates for all categories for the sample period and for several subperiods. We choose the limit years according to the most representative years, from an economic point of view, of the last three decades, that is to say, both oil crises, of 1973 and of 1979. Secondly, we carry out an inflation analysis calculating the annual average rates for all magnitudes and for the same periods that we have taken into account in the first analysis.

In Table 1 we show the average annual rates of growth. First, we can observe that Spain displays the greatest average rates along the whole sample period in food, beverages and tobacco, furniture, furnishing and household equipment and miscellaneous goods and services, 1·76%, 4·59% and 4·97%, respectively; whereas the United Kingdom shows the highest value in clothing and footwear, 2·69%, and France in gross rent, fuel and power, 3·8%. On the other hand, Canada displays the lowest rate in food, beverages and tobacco, 0·43%, France in clothing and footwear, 0·99%, the United Kingdom in gross rent, fuel and power, 1·61%, and finally, Sweden in furniture, furnishing and household equipment and in miscellaneous goods and services, 0·89% and 2·39%, respectively. As regards time evolution, we find that the highest values are concentrated basically in the years running up to 1973. In particular, all five categories in France and in Spain, and four in Canada, show the greatest values in this first subperiod. By contrast, the lowest rates are distributed in the subperiods after 1979. Specifically, all magnitures in Spain and four in Germany and Sweden display the lowest values between 1980 and 1985, that is, after the oil crisis of 1979, and Canada shows the five lowest categories in

Table 1. Rates of growth (%)

	1965–73	1974–79	1980–85	1986–92	1965–92
Germany					
Food, beverages and tobacco	2·35	2·46	0·43	1·19	1·67
Clothing and footwear	3·68	1·57	–0·41	1·76	1·87
Gross rent, fuel and power	3·25	3·62	2·81	1·68	2·84
Furniture, furnishings and household eq.	5·69	3·31	–1·07	4·61	3·46
Miscellaneous goods and services	4·42	4·37	1·65	3·37	3·55
France					
Food, beverages and tobacco	1·99	1·91	0·84	0·90	1·47
Clothing and footwear	2·81	0·59	0·33	–0·45	0·99
Gross, rent, fuel and power	6·03	3·58	2·51	2·24	3·80
Furniture, furnishings and household eq.	5·62	2·98	–0·48	1·54	2·73
Miscellaneous goods and services	5·71	5·20	2·43	3·04	4·23
UK					
Food, beverages and tobacco	0·62	5·46	–0·62	0·30	1·31
Clothing and footwear	2·58	2·86	3·57	1·92	2·69
Gross, rent, fuel and power	2·25	1·25	1·38	1·29	1·61
Furniture, furnishings and household eq.	4·64	1·38	2·30	2·32	2·86
Miscellaneous goods and services	3·73	–0·85	2·63	4·87	2·80
Spain					
Food, beverages and tobacco	3·44	1·86	–0·10	1·14	1·76
Clothing and footwear	3·86	–0·41	–1·69	2·84	1·50
Gross, rent, fuel and power	4·20	2·30	1·00	2·04	2·57
Furniture, furnishings and household eq.	9·14	0·67	–1·27	7·11	4·59
Miscellaneous goods and services	8·14	3·97	1·89	4·39	4·97
Sweden					
Food, beverages and tobacco	0·67	1·35	–0·65	0·37	0·46
Clothing and footwear	1·42	4·85	0·05	3·18	2·30
Gross, rent, fuel and power	2·87	1·99	1·15	0·10	1·62
Furniture, furnishings and household eq.	2·01	0·40	–0·40	0·98	0·89
Miscellaneous goods and services	3·78	2·05	1·39	1·75	2·39
Canada					
Food, beverages and tobacco	2·47	0·83	–0·52	–1·17	0·43
Clothing and footwear	3·16	5·60	1·13	–2·14	1·92
Gross, rent, fuel and power	3·54	3·16	2·78	1·94	2·90
Furniture, furnishings and household eq.	5·90	2·62	2·05	–0·28	2·82
Miscellaneous goods and services	4·73	3·37	1·70	1·12	2·89

Table 2. Rates of inflation (%)

	1965–73	1974–79	1980–85	1986–92	1965–92
Germany					
Food, beverages and tobacco	3·07	2·63	3·48	1·59	2·69
Clothing and footwear	3·38	4·31	3·99	1·80	3·31
Gross rent, fuel and power	6·18	6·74	4·89	1·99	4·98
Furniture, furnishings and household eq.	1·87	3·68	4·30	2·42	2·91
Miscellaneous goods and services	4·68	5·07	3·60	2·31	3·94
France					
Food, beverages and tobacco	4·74	8·49	9·67	2·70	6·09
Clothing and footwear	3·75	11·29	9·77	3·75	6·66
Gross, rent, fuel and power	6·94	10·94	11·74	3·70	8·02
Furniture, furnishings and household eq.	3·60	10·05	9·76	3·00	6·15
Miscellanaeous goods and services	4·52	9·31	9·72	2·72	6·21
UK					
Food, beverages and tobacco	5·17	15·07	8·46	5·30	8·03
Clothing and footwear	4·53	12·20	4·68	2·92	5·80
Gross, rent, fuel and power	7·57	15·40	11·33	5·90	9·64
Furniture, furnishings and household eq.	5·50	17·54	5·20	5·40	7·99
Miscellaneous goods and services	5·94	15·90	9·60	5·03	8·63
Spain					
Food, beverages and tobacco	7·35	16·18	8·25	5·96	9·09
Clothing and footwear	8·85	17·37	14·16	7·26	11·42
Gross, rent, fuel and power	6·42	17·98	14·00	5·87	10·38
Furniture, furnishings and household eq.	5·40	18·91	10·22	6·44	9·59
Miscellaneous goods and services	8·10	19·65	14·99	7·08	11·80
Sweden					
Food, beverages and tobacco	5·60	8·74	10·16	4·19	6·90
Clothing and footwear	3·27	7·07	9·70	2·47	5·26
Gross, rent, fuel and power	6·43	11·15	10·47	10·23	9·26
Furniture, furnishings and household eq.	4·96	11·63	7·88	5·22	7·08
Miscellaneous goods and services	5·37	10·70	10·30	6·27	7·79
Canada					
Food, beverages and tobacco	4·10	8·83	8·16	4·56	6·10
Clothing and footwear	2·67	4·88	5·58	4·23	4·16
Gross, rent, fuel and power	3·74	10·78	7·93	3·56	6·10
Furniture, furnishings and household eq.	1·96	9·57	6·69	3·28	4·93
Miscellaneous goods and services	4·65	9·18	7·85	3·79	6·09

the last subperiod, 1986–1992. Therefore, the existence of changes in the patterns of per capita consumption in all sample countries has been detected.

Table 2 displays the rates of inflation. The first result is that Spain is the country that shows the highest values along the whole sample period in all categories, close to 10%, whereas Germany displays the lowest ones, close to 3%. With respect to time evolution, we detect that the years immediately after both oil crises show the greatest rates. In particular, all categories in the United Kingdom and Spain and four magnitudes in Canada are the greatest in the subperiod 1974–1979 and three groups in France and in Sweden have the same property in the next subperiod 1980–1985. On the other hand, the lowest values are concentrated in the last years of the whole sample period. Specifically, all values in France, and four in Germany, the United Kingdom and Spain were the lowest between 1986 and 1992.

Results and interpretation

I now set out to prove that the microeconomic consumer behaviour in some representative OECD countries is consistent with the utility maximization. To this end, I will test the three axioms of the revealed preference theory: WARP, SARP and GARP.

The main results of the non-parametric approach are obtained using the NONPAR programme which is especially designed to carry out non-parametric analysis based on revealed preference.[19]

First, let us test the weak axiom. The corresponding non-parametric test proceeds as follows. We consider five goods and twenty-nine periods; then let **P** (26*5) and **Q** (16*5) denote the matrix of prices and quantities, respectively, and let the matrix $\mathbf{C}=\mathbf{PQ}'$ whose elements, C_{ij} represent the cost, at prices of time i, of buying the bundle of goods of period j. Thus, the elements in column j give the cost, at various price vectors, of obtaining the consumption bundle $\mathbf{q}^j$, while the elements in any row i allow a comparison of the costs of various bundles at the fixed set of prices $\mathbf{p}^i$. The leading diagonal represents the actual expenditure in each period i.

I then use a new matrix Φ, which is defined by dividing every element of C, C_{ij}, by the corresponding diagonal element, C_{ii}, that is $\Phi_{ij}=C_{ij}/C_{ii}$. If any element $\Phi_{ij}\leqslant 1$, then $\mathbf{q}^j$ has been revealed preferred to $\mathbf{q}^i$, that is, commodity bundle $\mathbf{q}^i$ was affordable at period j prices, but bundle $\mathbf{q}^j$ was selected. If $\Phi_{ij}\leqslant 1$ and $\Phi_{ji}\leqslant 1$, then the weak axiom is violated. Therefore, the elements of matrix Φ provides the basis for the test of the weak axiom.

For reasons of space in Table 3, I present only the matrix Φ for Spain (obviously matrix Φ for the rest of the sample countries are available). As can be seen, $\Phi_{ij}\leqslant 1$ and $\Phi_{ji}>1$, that is to say, the Spanish data satisfies the weak axiom of the theory of revealed preference. Exactly the same conclusion is obtained for Germany, France, the United Kingdom, Sweden and Canada.

Although I did not find WARP violations, it was also necessary to check for consistency with the strong or the generalized axioms. First, the data are consistent with SARP if no such intransitivities are found using Φ. As no such violations are detected, it

Table 3. Matrix Φ. Spain

	1964	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	1992
1964	1	0·9	0·8	0·8	0·7	0·7	0·6	0·6	0·5	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
1965	1·0	1	0·9	0·8	0·8	0·8	0·7	0·7	0·6	0·5	0·5	0·4	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0
1966	1·1	1·0	1	0·9	0·9	0·8	0·8	0·7	0·7	0·6	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0
1967	1·2	1·1	1·0	1	0·9	0·9	0·8	0·8	0·7	0·6	0·5	0·4	0·4	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0
1968	1·3	1·1	1·1	1·0	1	0·9	0·9	0·8	0·7	0·6	0·5	0·5	0·4	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0
1969	1·3	1·2	1·1	1·0	1·0	1	0·9	0·8	0·8	0·7	0·6	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0
1970	1·4	1·2	1·2	1·1	1·0	1·0	1	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0
1971	1·5	1·3	1·3	1·2	1·1	1·1	1·1	1	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·0
1972	1·6	1·5	1·4	1·3	1·2	1·2	1·1	1·0	1	0·8	0·7	0·6	0·5	0·4	0·3	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1
1973	1·8	1·6	1·5	1·5	1·4	1·3	1·3	1·2	1·1	1	0·8	0·7	0·6	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1	0·1	0·1
1974	2·1	1·9	1·8	1·7	1·6	1·6	1·5	1·4	1·3	1·1	1	0·8	0·7	0·5	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1
1975	2·5	2·2	2·1	2·0	1·9	1·8	1·7	1·6	1·5	1·3	1·1	1	0·8	0·6	0·5	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·1
1976	2·9	2·6	2·4	2·3	2·2	2·1	2·0	1·9	1·7	1·5	1·3	1·1	1	0·8	0·6	0·5	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1
1977	3·5	3·2	3·0	2·9	2·7	2·7	2·5	2·3	2·1	1·9	1·6	1·4	1·2	1	0·8	0·7	0·6	0·5	0·4	0·4	0·3	0·3	0·3	0·3	0·3	0·2	0·2	0·2	0·2
1978	4·2	3·8	3·6	3·4	3·2	3·1	3·0	2·7	2·5	2·3	1·9	1·7	1·4	1·1	1	0·8	0·7	0·6	0·5	0·5	0·4	0·4	0·3	0·3	0·3	0·3	0·2	0·2	0·2
1979	4·8	4·4	4·1	3·9	3·7	3·6	3·4	3·1	2·9	2·6	2·2	1·9	1·6	1·3	1·1	1	0·9	0·7	0·6	0·6	0·5	0·5	0·4	0·4	0·4	0·3	0·3	0·3	0·3
1980	5·2	4·7	4·4	4·2	4·0	3·9	3·7	3·4	3·1	2·8	2·4	2·1	1·8	1·4	1·2	1·0	1	0·8	0·7	0·6	0·6	0·5	0·5	0·4	0·4	0·4	0·4	0·3	0·3
1981	6·0	5·4	5·1	4·8	4·6	4·5	4·2	3·9	3·6	3·2	2·8	2·4	2·0	1·6	1·4	1·2	1·1	1	0·8	0·7	0·6	0·6	0·5	0·5	0·5	0·4	0·4	0·4	0·4
1982	6·9	6·2	5·8	5·6	5·3	5·2	4·9	4·5	4·2	3·7	3·2	2·8	2·4	1·9	1·6	1·4	1·3	1·1	1	0·8	0·8	0·7	0·6	0·6	0·6	0·5	0·5	0·5	0·4
1983	7·7	6·9	6·5	6·2	6·0	5·8	5·5	5·1	4·7	4·2	3·6	3·1	2·7	2·1	1·8	1·6	1·4	1·2	1·1	1	0·9	0·8	0·7	0·7	0·6	0·6	0·6	0·5	0·5
1984	8·5	7·7	7·3	6·9	6·6	6·5	6·1	5·6	5·2	4·6	4·0	3·5	3·0	2·4	2·0	1·8	1·6	1·4	1·2	1·1	1	0·9	0·8	0·8	0·7	0·7	0·6	0·6	0·5
1985	9·0	8·1	7·6	7·3	7·0	6·8	6·4	6·0	5·5	4·9	4·3	3·7	3·2	2·5	2·1	1·9	1·7	1·5	1·3	1·1	1·0	1	0·9	0·8	0·8	0·7	0·7	0·6	0·6
1986	9·8	8·9	8·4	8·0	7·7	7·5	7·1	6·6	6·1	5·4	4·7	4·0	3·5	2·8	2·4	2·1	1·9	1·6	1·4	1·2	1·1	1·0	1	0·9	0·8	0·8	0·7	0·7	0·6
1987	10·4	9·4	8·9	8·5	8·1	7·9	7·5	7·0	6·4	5·7	4·9	4·3	3·7	3·0	2·5	2·2	2·0	1·7	1·5	1·3	1·2	1·1	1·0	1	0·9	0·8	0·8	0·7	0·7
1988	10·9	9·9	9·3	8·9	8·5	8·3	7·8	7·3	6·8	6·0	5·2	4·5	3·9	3·1	2·6	2·3	2·1	1·8	1·6	1·4	1·2	1·2	1·1	1·0	1	0·9	0·8	0·8	0·7
1989	11·7	10·6	9·9	9·5	9·1	8·9	8·4	7·8	7·2	6·4	5·5	4·8	4·1	3·3	2·8	2·4	2·2	1·9	1·7	1·5	1·3	1·2	1·1	1·1	1·0	1	0·9	0·8	0·8
1990	12·4	11·2	10·5	10·1	9·7	9·4	8·9	8·3	7·7	6·8	5·9	5·1	4·4	3·5	3·0	2·6	2·4	2·1	1·8	1·6	1·4	1·3	1·2	1·1	1·1	1·0	1	0·9	0·8
1991	13·1	11·9	11·1	10·7	10·2	10·0	9·4	8·8	81	7·3	6·2	5·4	4·7	3·7	3·2	2·8	2·5	2·2	1·9	1·7	1·5	1·4	1·3	1·2	1·2	1·1	1·0	1	0·9
1992	13·8	12·5	11·8	11·3	10·8	10·6	10·0	9·3	8·6	7·7	6·6	5·7	4·9	4·0	3·4	2·9	2·7	2·3	2·0	1·8	1·6	1·5	1·4	1·3	1·2	1·2	1·1	1·0	1

is possible to rationalize the data; in other words, the data could have been generated by the maximization of a stable, well-behaved utility function.

The NONPAR programme allows us to test the GARP directly. According to Afriat's Theorem explained above, Table 4 shows the Afriad numbers U^i, $\lambda^i > 0$, which satisfy the Afriat inequalities: $U^i \leqslant U^j + \lambda^j \mathbf{p}^j(\mathbf{q}^i - \mathbf{q}^j)$. As the theorem establishes, this is equivalent to the acceptance of GARP in every country. In other words, I have proved that all countries were consistent with this axiom; that is to say, every data set could have been generated by a single neoclassical representative consumer in each country.

The non-parametric results can be interpreted in terms of a hypothetical structural change in consumer behaviour. The above descriptive analysis indicates the existence of changes in the patterns of good purchases which have occurred in the sample countries since the 1960s. These variations in consumption are due to modifications of the economic variables (relative prices and total expenditure) or are attributable to changes in the preferences of a representative consumer in each country.

Research on the existence of structural change in the behaviour of consumers can take two forms. The first consists in specifying a functional form for demand equations, to estimate it, and to test the hypothesis of stability of the parameters. However, as we have noted in the introduction of the paper, this parametric approach has the problem that all results are conditional on the functional forms being correct. To avoid this limitation, a second method to test for structural change has been proposed, namely the non-parametric approach, where the null hypothesis assumes the stability of preferences and thus the variations of quantities consumed can be explained by changes in relative prices and total expenditure. If consumers satisfy GARP, then there exists a stable demand system underlying the personal preference structure, which explains the observed quantities of goods. This is because GARP is equivalent to the existence of a well-behaved utility function.

In this paper, I have proved that the fact that no violations of GARP exist indicates the acceptance of the hypothesis of stability of preferences in some Western countries. In other words, the evolution of quantities demanded can be explained by the changes in economic variables. That is to say, as I do not detect violations, I can rationalize the data and, further, I can consider that observations have been generated according to the utility maximization of a representative consumer.

Table 5 summarizes the results of the paper. As can be seen, all countries' data sets are consistent with WARP, SARP and GARP.

Summary and conclusions

It is important to distinguish whether the observed changes in consumption are due to changes in economic factors or to changes in consumer preferences. The former may be counteracted by manipulating relative prices; the second may call for advertising, education campaigns and product innovations.

In this paper, I have used a non-parametric method, derived from the revealed preference theory, to test whether or not the data are consistent with a conventional static

Table 4. Afriat numbers

	Germany		France		UK		Spain		Sweden		Canada	
	U^i	λ^i	U^i	λ^i	U^i	λ^i	U^i	λ^i	U^i	λ^i	U^i	λ^i
1964	99·35	1·00	98·57	1·00	98·37	1·00	97·66	1·00	98·55	1·00	98·89	1·00
1965	99·43	1·00	98·62	1·00	98·43	1·00	97·80	1·00	98·63	1·00	98·95	1·00
1966	99·49	1·00	98·69	1·00	98·48	1·00	97·92	1·00	98·69	1·00	99·01	1·00
1967	99·51	1·00	98·76	1·00	98·52	1·00	98·01	1·00	98·75	1·00	99·08	1·00
1968	99·56	1·00	98·83	1·00	98·58	1·00	98·09	1·00	98·80	1·00	99·14	1·00
1969	99·64	1·00	98·94	1·00	98·63	1·00	98·18	1·00	98·87	1·00	99·20	1·00
1970	99·73	1·00	99·03	1·00	98·72	1·00	98·26	1·00	98·93	1·00	99·24	1·00
1971	99·82	1·00	99·13	1·00	98·82	1·00	98·37	1·00	99·00	1·00	99·33	1·00
1972	99·90	1·00	99·23	1·00	98·93	1·00	98·50	1·00	99·09	1·00	99·42	1·00
1973	99·97	1·00	99·32	1·00	99·05	1·00	98·67	1·00	99·18	1·00	99·54	1·00
1974	99·04	1·00	99·46	1·00	99·20	1·00	98·85	1·00	99·30	1·00	99·68	1·00
1975	99·13	1·00	99·57	1·00	99·36	1·00	98·99	1·00	99·43	1·00	99·80	1·00
1976	100·21	1·00	99·69	1·00	99·50	1·00	99·16	1·00	99·56	1·00	99·91	1·00
1977	100·28	1·00	99·79	1·00	99·65	1·00	99·36	1·00	99·64	1·00	100·00	1·00
1978	100·34	1·00	99·91	1·00	99·78	1·00	99·52	1·00	99·73	1·00	100·09	1·00
1979	100·40	1·00	100·03	1·00	99·94	1·00	99·67	1·03	99·82	1·00	100·19	1·00
1980	100·47	1·00	100·15	1·00	100·07	1·00	99·78	1·00	99·93	1·00	100·29	1·00
1981	100·52	1·00	100·28	1·00	100·17	1·00	99·91	1·00	100·03	1·00	100·40	1·00
1982	100·55	1·00	100·41	1·00	100·25	1·00	100·04	1·00	100·14	1·00	100·46	1·00
1983	100·60	1·00	100·51	1·00	100·34	1·00	100·16	1·00	100·22	1·00	100·54	1·00
1984	100·65	1·00	100·59	1·00	100·41	1·00	100·26	1·00	100·31	1·00	100·61	1·00
1985	100·69	1·00	100·66	1·00	100·49	1·00	100·35	1·00	100·39	1·00	100·69	1·00
1986	100·71	1·00	100·71	1·00	100·58	1·00	100·46	1·00	100·48	1·00	100·76	1·00
1987	100·75	1·00	100·77	1·00	100·67	1·00	100·56	1·00	100·58	1·10	100·83	1·00
1988	100·78	1·00	100·82	1·00	100·78	1·00	100·65	1·00	100·66	1·18	100·90	1·00
1989	100·83	1·00	100·88	1·00	100·86	1·00	100·75	1·00	100·75	1·25	100·96	1·00
1990	100·91	1·00	100·93	1·00	100·91	1·00	100·83	1·00	100·85	1·32	100·99	1·00
1991	100·97	1·00	100·96	1·00	100·96	1·00	100·92	1·00	100·99	1·36	101·00	1·00
1992	101·00	1·00	101·00	1·00	101·00	1·00	101·00	1·00	101·00	1·00	100·97	1·00

demand system, that is, with stable consumer preferences. To do this, I have employed time-series data sets (1964–1992) of per capita consumption and prices for Germany, France, the United Kingdom, Spain, Sweden and Canada, in order to test the weak, strong and generalized axioms of revealed preference theory.

I have proved that there are no violations of these axioms in any of the sample countries. That is, all sample national data are consistent with the neoclassical theory of consumer behaviour and, therefore, a well-behaved preference map can be constructed which accords with the observed consumption pattern.

Table 5. Results of non-parametric tests for consistence with utility maximization

Country	Are data consistent with WARP?	Are data consistent with SARP?	Are data consistent with GARP?
Germany	Yes	Yes	Yes
France	Yes	Yes	Yes
UK	Yes	Yes	Yes
Spain	Yes	Yes	Yes
Sweden	Yes	Yes	Yes
Canada	Yes	Yes	Yes

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