Household Characteristics and Consumption Behaviour: A Nonparametric Approach

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Abstract: In this paper we apply nonparametric methods in order to discuss some empirical aspects of household consumption behaviour. First, we study the differences in the consumption behaviour between household types. We find that, except for food, there are no clear significant differences. Secondly, we derive the functional form for the food Engel curve, using specification tests consistent in the direction of nonparametric alternatives. Finally, we use this specification to discuss the misleading conclusions that could be reached from a mechanic interpretation of the rejection of Hausman's test, when applied to test the exogeneity of expenditure. The data is obtained from the Spanish Expenditure Survey 1980–81 and 1990–91.

Key Words: Engel curves; Household characteristics; Nonparametric Estimation; Consistent Specification Tests; Expenditure Endogeneity.

JEL Classification System-Numbers: C14, C21, C52, D12.

1 Introduction

During the last years there has been a considerable amount of applied research on modeling household consumption behaviour. A clear motivation is found on the need for estimating demand parameters as inputs in the evaluation of the effectiveness of different economic policies, in particular, fiscal policies (Blundell, 1988; Baccouche and Laisney, 1989; Pollak and Wales, 1992; Nichele and Robin, 1995).

Two facts are common to almost all of these works. First, nearly all of them model the same set of goods, i.e., food, cloth, domestic fuel, etc., and consider a whole collection of household characteristics so as to introduce as much heterogeneity as possible. Second, the functional forms used are selected based in tractability, although they may be supported by the economic theory.

* Article based on research funded by Spanish “Dirección General de Enseñanza Superior” (DGES), reference number: PB95-0292. We thank to Richard Blundell, Jordi Jaumandreu, Javier Ruiz-Castillo and participants in the seminars at Universidad Carlos III, Econometric Study Group (Bristol) and Fundación Empresa Pública for their valuable comments.

In this paper, our concern is to discuss both of these facts. In first place, we apply nonparametric inference techniques in order to analyze which goods are relevant when modelling household characteristics and consumption behaviour. Secondly, given that the estimated demand parameters are highly sensitive to the functional form of the Engel curve and to the way in which the relationship between consumption and household characteristics is specified, we apply different specification tests consistent in the direction of non-parametric or semiparametric alternatives. At last, we discuss the mechanic application of instrumental variable method when rejecting of Hausman's exogeneity test when applied to total expenditure.

The data was obtained from the Spanish Expenditure Survey for the periods 1980–81 and 1990–91 (Alonso-Colmenares et al., 1994; Cardelus et al., 1995). The observations we consider are based on couples with the head of the household employed. We have constructed eleven subgroups depending on whether or not they have children, the age of the wife and the size of the city where they live. The goods we consider are food, alcohol, cloth, domestic fuel, recreation and other non-durable goods. Summary statistics on the sample used can be found in Tables 1 and 2.

Table 1. Spanish Family Expenditure Survey, 1980–81; 1990–91. Sample: Head of Household Employed and between 20 and 65 years old. Children: number of children, 0, 1–2, and 3 or more. Age of Partner, younger or older 35 years old. Size of the City, larger or smaller 50th. habitants

Subsample	Children	Age Partner	Size City	Observations	
				1980	1990
1	0	more 35	less 50 th.	514	379
2	0	more 35	more 50 th.	508	197
3–4	0	less 35	–	407	378
5	1–2	more 35	less 50 th.	765	862
6	1–2	more 35	more 50 th.	1047	625
7	1–2	less 35	less 50 th.	942	1275
8	1–2	less 35	more 50 th.	1548	778
9	3 or +	more 35	less 50 th.	613	381
10	3 or +	more 35	more 50 th.	802	222
11	3 or +	less 35	less 50 th.	353	230
12	3 or +	less 35	more 50 th.	501	109

Table 2. Summary Statistic of the Budget Share and Log of Total Non-durable Expenditure for 1980–81 and 1990–91 samples

Goods	1980			
	Mean	St. Dev	Min.	Max.
Food	0.329	0.142	0.004	0.920
Alcohol	0.013	0.020	0	0.251
Cloth	0.080	0.063	0	0.645
Domestic Fuel	0.031	0.024	0	0.367
Transport	0.103	0.089	0	0.454
Recreation	0.039	0.049	0	0.685
Other Non-Durables	0.403	0.120	0.04	0.948
Total Log Expenditure	13.73	0.601	11.19	16.31

1990				
Food	0.254	0.118	0.003	0.781
Alcohol	0.009	0.017	0	0.267
Cloth	0.098	0.088	0	0.774
Domestic Fuel	0.036	0.028	0	0.454
Transport	0.124	0.119	0	0.829
Recreation	0.041	0.046	0	0.470
Other Non-Durables	0.438	0.140	0.0325	0.956
Total Log Expenditure	14.64	0.508	12.43	16.48

In the next Section, we use a nonparametric approach to study how changes in characteristics affect consumption behaviour. We conclude that, except for food, consumption is not significantly affected by changes in household characteristics. Focusing on food consumption, in Section 3, we apply newly developed specification tests, consistent in the direction of nonparametric alternatives, in order to determine the correct functional form for the budget share Engel curve. The different tests are, in general, unable to reject the null hypothesis of a Working-Leser specification. In Section 4 we discuss possible reasons which can explain why in applied work total expenditure is found to be endogenous when a Hausman's Test is applied.

2 Characteristic Changes and Substitution in Consumption

It seems natural to think that a family with children will consume more food and less alcohol than a family without them. That is, changes in household characteristics generates a reallocation of consumption. In this section, we will try to determine those goods which are most affected by this reallocation process.

As is common in empirical literature, we will assume intertemporal separability (see, for example, Blundell et al. 1993). This implies that in a first stage, each household allocates the amount of income to be spent in the period (Blundell, 1988). Therefore, the reallocation in consumption induced by changes in household characteristics could be understood as a substitution effect in consumption generated by these changes.

In what follows we study the relationship between household characteristics and consumption behaviour by estimating the substitution effects that take place in consumption when household characteristics change. Henceforth, these effects will be termed characteristic substitution effect (CSE).

We have a random sample of N observations $\{(W_{1i}, W_{2i}, \dots, W_{Gi}, X_i, Z_i'), i = 1, \dots, N\}$, where W_{mi} is the consumption budget share of good m , X_i denotes income (total expenditure) and Z_i is a vector of variables representing household characteristics. Suppose that Z_i only takes a number of discrete values producing H household groups. Then, the Engel curve is given by

$$m_m^h(x) = E[W_{mi}|X_i = x, Z_i = z^h] \quad m = 1, \dots, G; h = 1, \dots, H. \quad (1)$$

The CSE between two different households a and b is given by

$$s_m^{(a,b)}(x) = m_m^a(x) - m_m^b(x). \quad (2)$$

This equation states that if expenditure is fixed at x and household characteristics change from b to a , consumption of good m will change in the proportion and sign stated by $s_m^{(a,b)}(x)$.

Notice that, by additivity,

$$\sum_{m=1}^G s_m^{(a,b)}(x) = 0 \quad a, b = 1, \dots, H. \quad (3)$$

When characteristics change, an increase in the consumption of one good must be compensated with a decrease in the consumption of some other good, given that consumers have the same level of expenditure, x . When characteristic changes, there is a reallocation of expenditure. Therefore, we could estimate how households with the same level of expenditure substitute in consumption when characteristic changes, and derive those goods which are more sensible to these changes.

The Engel's curves in (2) are estimated using kernels, plugging-in an estimate of the optimal bandwidth minimizing the integrated mean square error

Fig. 1. CSE of couples with partner older than 35 vs younger than 35 with no children and living in a small town

Fig. 2. CSE of couples younger than 35 without vs with children living in big cities

(see, e.g. Härdle, 1990 and Wand and Jones, 1995). Then, $m_m^h(x)$ is estimated by

$$\hat{m}_m^h(x) = \frac{\sum_{n=1}^N w_{ni} K((X_i - x)/h) I(Z_i = z^h)}{\sum_{n=1}^N K((X_i - x)/h) I(Z_i = z^h)},$$

where $I(A)$ is the indicator function of the event A and $K(u)$ is a kernel function (we have used the Gaussian density). The CSE is estimated by

$$\hat{s}_m^{(a,b)}(x) = \hat{m}_m^a(x) - \hat{m}_m^b(x) \quad m = 1, \dots, G; a, b = 1, \dots, H.$$

The estimation results are presented in figures 1 to 4 for some particular subsamples and in Table A3 we summarize the range of variation of the CSE for those goods more sensitive to changes in household characteristics. Notice that the subsamples are differentiated only by one characteristic. In the figures, each line represents the difference of the estimated budget share of a given good for two household types.

In Figure 1 we observe that for families with the same expenditure level, no children and living in small towns, the older couples tend to increase the consumption of food and decrease the consumption of transport, recreation and

Fig. 3. CSE of couples older than 35 without vs with children living in small town

Fig. 4. CSE of couples younger than 35 without and with children living in big cities

the aggregate of other non-durables, as compared with the younger ones. This substitution process depends on the level of expenditure.

Figure 1 also shows that goods such as alcohol, domestic fuel or cloth, play an insignificant role in the substitution process. Old and young couples behave similarly for those goods and this behaviour is not affected by the level of expenditure.

Similar conclusions are from the results summarized in Table 3. When we compare young couples with or without children, the consumption of food of the former is higher than the latter comparatively, diminishing the aggregate of non-durables. The consumption of other goods do not seem to be affected by changes in household characteristics.

Our figures and Table 3 confirm Engel (1895) results when comparing households of different size for a wider class of household characteristics. Our data show that the food budget share is also affected, *ceteris paribus*, by changes in the size of the city where couples live or by changes in age. We also find that, for a given level of expenditure, consumption on goods such as cloth, alcohol or recreation is similar for all households.

From the results above it seems that not all goods are relevant when modelling household consumption behaviour. Maybe, a different definition of the set of goods to be modelled should be considered. One possible reason to

Table 3. Summary of those goods which are more representative in the Characteristic Substitution Effect estimation. F: food; T: transport; C: cloth; R: recreation O: Other non-durables; NC: not clear, when no good dominates in the substitution process. Min and Max are the minimum and maximum of the substitution range

COMPARISON	1980	MIN	MAX	1990	MIN	MAX
Old Couples, No Child, Small vs Big Cities	F-O	-0.06	0.06	NC	-0.06	0.02
No Child, Small Town, Old vs Young Couples	F-O	-0.18	0.14	F-O	-0.11	0.11
Old Couples, Small Town, With vs Without Child	F-O-C	-0.05	0.04	F-O	-0.04	0.04
No Child, Big Cities, Old vs Young Couples	F-T-C-O	-0.09	0.07	F-T-C-O	-0.10	0.13
Old Couples, Big Cities, With vs Without Child	F-O	-0.05	0.04	NC	-0.05	0.08
Young Couples, No Child, Small vs Big Cities	F-O	-0.09	0.07	NC	-0.06	0.09
Young Couples, Small Town, With vs Without Child	F-O	-0.13	0.15	F-O	-0.11	0.13
Young Couples, Big Cities, With vs Without Child	F-O	-0.08	0.1	F-T-O	-0.14	0.10
Old Couples, With Child, Small vs Big Cities	F-O	-0.06	0.04	F-C-O	-0.05	0.03
With Child, Small Town, Old vs Young Couples	F-T	-0.06	0.06	F-T-O	-0.03	0.05
With Child, Big Cities, Old vs Young Couples	F-O	-0.04	0.04	F-T-O	-0.05	0.03
Young Couples, With Child, Small vs Big Cities	F-O	-0.05	0.03	O-C	-0.04	0.03

Fig. 5. Nonparametric regression of food budget share

explain what we observe could be that the separability hypothesis usually stated in empirical models is not valid, implying that prices and leisure decisions of other periods affect the consumption decision in the period we are interested on.

Given the above results on the food budget share, we report in figures 5 and 6 the food budget share Engel curves, estimated for different subsamples. These curves seem to be approximately linear. Among subsamples, Engel curves seem to differ only by a shift, which may justify the use of additive dummies in parametric settings (see e.g. Deaton et al., 1989, for Spanish cross-section data). Same conclusions are derived for 1990 data, although we omit these graphs.

3 Functional Form of Food Budget Share

Empirical functional forms are commonly selected in based of tractability. Specification test are usually done considering nested or non-nested tests, but unfortunately, they are only consistent in the direction of certain parametric

Fig. 6. Nonparametric regression of food budget share

alternatives. In this section we apply specification tests which are consistent in the direction of general nonparametric alternatives. That is, we want to test the hypothesis

$$H_0: \Pr\{m_m^h(x) = g_m^h(x, \theta_0)\} = 1 \quad \text{for some } \theta_0 \in \Theta$$

vs

$$H_1: \sup_{\theta \in \Theta} \Pr\{m_m^h(x) = g_m^h(x, \theta)\} < 1,$$

where $g_m^h(\cdot, \cdot)$ is a known function and Θ is a parameter space containing the unknown parameter θ_0 .

Gorman (1981) and Banks et al. (1994) suggest the general specification

$$g_m^h(x, \theta) = a_{m1}^*(z^h, \theta_1) + a_{m2}^*(z^h, \theta_2) \ln(x) + a_{m3}^*(z^h, \theta_3) (\ln(x))^2, \quad (4)$$

where $a_{mj}^*(\cdot, \cdot)$ is a known function depending on the characteristics of the household, z^h . This specification is common in the empirical literature which is supported by the economic theory, when we assuming a single price regime (Lewebel, 1991).

In order to test H_0 in the direction of nonparametric alternative H_1 , two alternative strategies have been developed in the literature. On one hand, tests have been constructed based on a distance between a nonparametric fit

$\hat{m}_m^k(x)$ and the parametric fit $\hat{g}_m^h(x) = g_m^h(x, \hat{\theta})$, where $\hat{\theta}$ is some available $\sqrt{n}$ -consistent estimator of θ_0 . That is the test statistic is

$$T_n^1 = d(\hat{m}, \hat{g})$$

where $d(\cdot, \cdot)$ is a given distance function. These tests have been proposed by Horowitz and Härdle, 1994; Härdle and Mammen, 1993; Ellison and Ellison, 1992. An advantage of these tests is that their null asymptotic distribution is a normal. A disadvantage is that size and power of properties of the asymptotic test depends on the choice of the amount of smoothing, the bandwidth chosen for estimating the nonparametric model on the alternative hypothesis. This issue has not been addressed in the theoretical literature. However, the choice of a bandwidth number does not seem so crucial, critical values can also be approximated by wild bootstrap, as proposed by Härdle and Mammen (1993). Miles and Mora (1996) have performed an extensive Monte Carlo study, comparing alternative tests and studying their sensitivity to the bandwidth choice.

On the other hand, the estimation of the model under the alternative hypothesis and, hence, the choice of bandwidth can be avoided by using tests based on weighted empirical processes as suggested by Bierens (1982, 1991). The theory of these tests has been recently developed by Bierens and Ploberger (1996) and Stute (1996). Here, we implement the test suggested by Stute (1996) based on the fact that for any Borel measurable function $h(\cdot)$

$$\Pr\{h(x) = 0\} \Leftrightarrow \int_{-\infty}^x h(u) dF_x(u) \quad \forall x \in R, \quad (5)$$

where $F_x(\cdot)$ is the distribution function of X . So, (5) suggests the weighted empirical process

$$R_n(x) = \frac{1}{n} \sum_{i=1}^n (Y_i - g_m^h(x_i, \hat{\theta})) I(x_i \leq x), \quad (6)$$

where $I(A)$ is the indicator function of the event A , as a basis for a statistic suitable for testing H_0 in the direction of H_1 . A possible statistic is of the Cramer-Von Misses form

$$T_n^2 = \sum_{i=1}^n R_n(x_i)^2$$

though a Kolmogorov-Smirnov can also be implemented. The main disadvantage of T_n^2 is that its asymptotic null distribution is not distribution free. However, Stute et al. (1996) have proposed to approximate the critical values by wild bootstrap, obtaining very good results in practice.

A detailed presentation of the alternative testing procedures can be found in the Appendix.

Table 4 reports the implementation of the different test for testing model (4). Different bandwidth are provided for the test based on smoothers. We also provide the p -values computed by wild-bootstrap for the test proposed by Härdle and Mammen (1993) and for Stute (1996) tests. The bootstrap test

of Härdle and Mammen (1993) does not seem very sensitive to the choice of bandwidth, unlike the asymptotic tests. Also, care should be taken about the results of the Horowitz and Härdle test given that it is negatively biased (Proença, 1993 provides Monte carlo evidence with index models). A bootstrap approximation to its small sample distribution has been proposed by Härdle and Proença, (1993).

The null hypothesis is generally not rejected for the household types considered. We present the results for the 1980 data, evaluated at 1990 prices in Table 4. For the 1990 sample, the null hypothesis is not rejected in the majority of subsamples. For the 1980 survey, only the Härdle and Mammen's test rejects the null hypothesis for all selected bandwidth parameters in one cases. These results are confirmed by Stute's test.

Usually, applied work is concerned with the estimated parameters. Therefore, we have computed the average derivative estimator (ADE), see e.g. Stoker (1992), Härdle and Stoker, (1989), Powell, Stock and Stoker, (1989), and compared it with the slope coefficient of the Working-Leser specification (that is, linear in log of expenditure). The ADE estimates the parameter

$$\delta_m^h = E \left[\frac{\partial m_m^h(x)}{\partial x} \right] \quad h = 1, \dots, H.$$

The δ_m^h estimates also depend on the choice of a smoothing number. We have employed the same bandwidth number used for the regression estimates. A comparison between the ADE and the OLS coefficients are reported in Table 5. The ADE and the OLS coefficients are quite similar. We tested the significance of the quadratic term coefficient and did not reject, supporting the conclusions on the validity of a Working-Leser specification. This is in accordance with the results of Härdle and Mammen (1993).

Results in Table 5 also show that the coefficients between subsamples are quite similar for certain household groups, indicating that households characteristics seem to have only a shift translation effect on the Engel curves. Table 7 reports the results comparing the OLS slope coefficients of different subsamples. For some subsamples, the slope coefficients are significantly different, implying that some characteristics should interact with the expenditure variable in a parametric specification.

From this section we conclude that model (4) is not an incorrect specification for each of the household types food budget share Engel curve, and often, the Working-Leser specification is the correct one. Also, when considering a whole sample regression, interaction between characteristics and expenditure should be considered. From an empirical viewpoint this results seems reasonable given the linearity relation observed between the food budget share and the logarithm of total expenditure in the graphs above.

At last, in the next Section, we use the above specification to discuss some misleading results that could appear when testing for exogeneity of total expenditure and adopting the mechanic instrumental variable approach when we the null is rejected.

Table 4. Results of Ellison and Ellison, Horowitz and Härdle, and Härdle and Mammen Specification Test for 1980–81 data. The Ellison and Ellison statistics is asymptotically distributed as a Standard Normal. The Horowitz and Härdle statistics is asymptotically distributed as a Standard Normal and the test is a one side test. Härdle and Mammen P-values were obtained by Wild Bootstrap with 200 resamples. Stute P-values were obtained by Wild Bootstrap with 500 resamples

Sample	Ellison and Ellison		Horowitz and Härdle		Härdle and Mammen			Stute	
	$h = 0.15$	$h = 0.2$	$h = 0.15$	$h = 0.2$	$h = 0.15$	$P-v$	$h = 0.2$	$P-v$	S
1	-0.741	-0.288	-3.51	-3.794	0.069	0.87	0.056	0.80	0.113
2	-0.015	-0.059	-2.34	-2.98	0.079	0.43	0.057	0.43	0.113
3-4	-0.74	-0.11	-4.29	-6.51	0.022	0.76	0.017	0.074	0.116
5	-0.989	0.06	-1.85	-1.155	0.063	0.48	0.042	0.63	0.122
6	0.154	2.09	-0.98	-4.05	0.098	0.02	0.088	0.03	0.116
7	1.027	0.434	-2.10	-3.65	0.057	0.36	0.041	0.41	0.124
8	0.324	0.452	-8.33	-13.22	0.027	0.66	0.022	0.58	0.112
9	2.272	-0.20	-1.43	-0.57	0.048	0.72	0.038	0.66	0.115
10	-0.423	-0.560	-3.06	-3.76	0.021	0.84	0.017	0.78	0.115
11	1.327	-0.17	-0.69	0.24	0.054	0.58	0.041	0.54	0.111
12	0.37	-0.22	-2.24	-3.94	0.016	0.9	0.016	0.86	0.112

Table 5. Average Derivative Estimator and OLS estimation of the slope of the Food Engel Curve Working-Leser Specification

Subsample	1980 (1990 prices)		1990	
	OLS	ADE	OLS	ADE
1	-0.169 (0.010)	-0.172 (0.014)	-0.114 (0.011)	-0.115 (0.014)
2	-0.156 (0.011)	-0.157 (0.016)	-0.137 (0.014)	-0.117 (0.0212)
3-4	-0.124 (0.010)	-0.126 (0.015)	-0.094 (0.001)	-0.113 (0.012)
5	-0.175 (0.010)	-0.184 (0.013)	-0.146 (0.006)	-0.145 (0.010)
6	-0.167 (0.010)	-0.152 (0.011)	-0.124 (0.010)	-0.118 (0.012)
7	-0.170 (0.010)	-0.160 (0.013)	-0.134 (0.005)	-0.143 (0.008)
8	-0.157 (0.005)	-0.153 (0.009)	-0.118 (0.007)	-0.123 (0.010)
9	-0.194 (0.008)	-0.194 (0.014)	-0.162 (0.010)	-0.156 (0.016)
10	-0.178 (0.007)	-0.186 (0.013)	-0.142 (0.012)	-0.130 (0.016)
11	-0.186 (0.013)	-0.177 (0.022)	-0.158 (0.013)	-0.132 (0.022)
12	-0.186 (0.009)	-0.196 (0.016)	-0.135 (0.0164)	-0.124 (0.0232)

4 Exogeneity of Expenditure and Specification Tests

It is known that instrumental variables introduce small sample bias. Therefore, if we are interested on the estimated parameters, care should be taken when using the instrumental variable methods.

In the last section, we have concluded that for many household groups the food Engel curves have the form

$$E(W_{mi}|X_i = x, Z_i = z_i^h) = \alpha_m^h + \beta_m^h \log(x), \quad h = 1, \dots, H. \quad (7)$$

Table 6. Testing the Significance of the Expenditure Quadratic Term in the Food Engel Curve

SAMPLE	P-VALUE 1980	P-VALUE 1990
1	0.2067	0.9719
2	0.3487	0.2254
3-4	0.8032	0.2024
5	0.7930	0.8603
6	0.0407	0.4574
7	0.7225	0.3402
8	0.3053	0.7551
9	0.3777	0.7642
10	0.7375	0.9760
11	0.0540	0.5597
12	0.1130	0.6466

Table 7. Rejection results of testing the significance difference between the parameters of Table A6. Results are given in terms of the subsample for which the difference is significant

Subsample	1980 Size		1990 Size	
	5%	10%	5%	10%
1	4	4, 9	5, 9, 11	5, 7, 9, 11
2		4, 9, 10, 11, 12	4	4
3-4	ALL, except 2	ALL	ALL, except 1	ALL, except 1
5	4	4, 8	1, 4, 6, 8	1, 4, 6, 8
6	4, 9	4, 9	4, 5, 9, 11	4, 5, 9, 11
7	4, 9	4, 9	4, 9	1, 4, 8, 9, 11
8	4, 9, 10, 11, 12	4, 5, 9, 10, 11, 12	4, 5, 9, 11	4, 5, 7, 9, 10, 11
9	2, 4, 6, 7, 8	1, 2, 4, 6, 7, 8	1, 4, 6, 7, 8	1, 4, 6, 7, 8
10	4, 8	2, 4, 8	4	4, 8
11	4, 8	2, 4, 8	1, 4, 6, 8	1, 4, 6, 7, 8
12	4, 8	2, 4, 8	4	4

Therefore, total expenditure is, under this specification, exogenous. However, in many studies (see, for example, Deaton, (1986) and Blundell, (1988) among others), it has been argued that total expenditure is endogenous, and this argument has been supported by implementing a Hausman's test. Then, the result in the last section seems to be in contradiction with the generally argued endogeneity of total expenditure.

A possible reason for this contradiction could be found in the way that characteristics variables enter in the model, when running a regression for the whole sample, using dummy variables. Let the characteristics be represented by a dummy variable, z^i , one for each possible characteristic, $i = 1, \dots, C$, e.g., $z^1 = 1$ if household have children or 0 otherwise. The exhaustive model, taking into account all the possible interactive effects and the specification derived in the last section, is given by

$$W_{mi} = \alpha_m^r + X_i \beta_m^r + \sum_{c=1}^{C^*} Z_i^c (\alpha_m^c + X_i \beta_m^c) + \sum_{c=1, c < q}^{C^*} Z_i^c Z_i^q (\alpha_m^{cq} + X_i \beta_m^{cq}) \\ + \sum_{c=1, c < q < s}^{C^*} Z_i^c Z_i^q Z_i^s (\alpha_m^{cqs} + X_i \beta_m^{cqs}) \dots + \prod_{c=1}^{C^*} Z_i^c (\alpha_m^{12\dots C} + X_i \beta_m^{12\dots C}) + u_i$$

where u_i is the error term, and r is the reference household, e.g., r could be couples with wife older than 35, living in small towns and without children, and C^* excludes those characteristics defining the reference household. The interaction terms of higher order, e.g. the interaction terms of second order are $z_n^c z_n^q$, which pick up the differential effects of a simultaneous change in characteristics, e.g. the simultaneous effect of a change from the reference household to a subsample of young couples with children will be captured by the second order interaction terms. As noted by Andrews and Whang (1990), there is an equivalence between the above specification and the non-parametric approach.

We have estimated the above exhaustive model for the food budget share and for the set of characteristics we were considering. We took as the reference household the old couples, without children and living in small towns, for which the Working-Leser specification seems correct. We detected that some interaction terms of second order between dummy variables, and between dummy variables and expenditure were significant. The second order interaction terms between characteristic dummy variables have a p -value of 0.023 and with total expenditure a p -value of 0.046 (Table 8). Based on an R-square selection criteria, we have selected the model presented in Table 9. As could be expected by the figures of Section 2, the additive dummies have a relative important impact on the food budget share, while the interaction terms between dummies and expenditure, although significant, are of relatively less relevance. Notice also that the interaction term between age and number of children is significant, capturing the simultaneous change from the reference household to young couples with children. In empirical specifi-

Table 8. Estimation of the food Engel Curve for the whole sample including higher order interaction terms between dummies and between dummies and expenditure, based on 1980–81 data

Variables	Coefficient	T-Value
C	2.802	18.08
AGE	-0.889	-3.61
SIZEC	-0.460	-2.25
CHILDREN	0.003	0.057
AGESIZE	0.508	1.635
AGECHIL	0.306	2.878
SIZECHI	0.098	1.188
ASC	-0.178	-1.293
EXPEND	-0.182	-15.81
AGEEXP	0.060	3.295
SIZEXP	0.032	2.161
CHIEXP	0.001	0.2443
ASEXP	-0.038	-1.672
ACHEXP	-0.021	-2.700
SICHEXP	-0.007	-1.175
ASCEXP	0.013	1.322

Testing Joint Significance of interaction terms:

Dummy Variables (AGESIZE, AGECHIL, SIZEHI, ASC): *p-value* 0.0236

Dummy Variables and Expenditure (ASEXP, ACHEXP, SICHEXP, ASCEXP):
p-value 0.0461

VARIABLES USED IN TABLE A8:

AGE: Dummy: 1 partner younger 35; 0 otherwise.

SIZEC: Dummy: 1 if city is bigger 50.000 habitants; 0 otherwise.

CHILDREN: Number of Children.

AGESIZE: Product of AGE and SIZEC.

AGECHIL: Product of AGE and CHIL

SIZECHI: Product of SIZE and CHILDREN

ASC: Product of AGE, SIZE and CHILDREN

EXPEND: Total Non-durable Expenditure

AGEEXP: Product AGE and EXPEND

SIZEXP: Product SIZEC and EXPEND

CHIEXP: Product CHILDREN and EXPEND

ASEXP: Product AGE SIZE EXPEND

ACHEXP: Product AGE CHILDREN EXPEND

SICHEXP: Product SIZEC CHILDREN EXPEND

ASCEXP: Product AGE SIZEC CHILDREN EXPEND

cations, it is not common to include the interaction terms which capture the effect of simultaneous changes in characteristics, which could introduce an omitted variable problem. The omission of these interaction terms could induce to reject the null hypothesis when using the Hausman test.

Another reason for rejecting the null hypothesis can be found in the validity of the instrumental variables used. We had applied the Hausman test to the specification (5) for each subsample. Although the null should not be rejected,

Table 9. Model derived from that of Table A8 based on an R-square selection criteria

Variables	Coefficient	T-Value
C	2.555	25.33
AGE	-0.246	-2.95
SIZEC	-0.205	-2.39
CHILDREN	0.108	3.374
AGECHIL	0.026	10.31
EXPEND	-0.164	-22.01
AGEEXP	0.012	1.960
SIZEXP	0.014	2.206
CHIEXP	-0.006	-2.79

given the results of the previous section, we found that the null is sometimes rejected, depending on the set of instrumental variables used (Table 10). Then, the same set of instrumental variables do not need to be valid for different subsamples, and therefore, this cast doubts on the use of the same set of instrumental variables for the whole sample, as it is common in the empirical literature (this is in accordance with Wooldridge, 1996 and Mroz, 1987). Notice that when estimating a whole demand system, Hausman's test is applied equation by equation, which is equivalent to what we have done above if we were only considering the food equation of the system (Deaton, 1986). Finally, another argument for the contradiction between the results of the specification tests and Hausman test could be found in the overrejection problem of the Hausman's test.

To conclude, the rejection of the null when applying a Hausman's test could arise from reasons other than the total expenditure endogeneity (Spencer and Berk, 1981). This implies that adopting the mechanic instrumental variable approach could seriously bias the estimates.

5 Conclusions

This paper has applied nonparametric regression techniques for studying the relationship between consumption and household characteristics based on the Spanish Expenditure Survey. We have seen that food consumption is affected

Table 10. Results of applying Hausman Test for different subsets of Instrumental Variables and for each of the Subsamples with 1980–81 data. R: reject the null. N: non-reject

INSTRUMENTAL VARIABLE	1	2	3–4	5	6	7	8	9	10	11	12
Subset 1	R	R	R	N	N	R	R	N	N	N	N
Subset 2	R	N	N	N	N	R	R	N	R	R	N
Subset 3	R	N	N	N	N	R	R	N	R	R	N
Subset 4	R	R	R	R	R	R	R	R	R	R	R
Subset 5	R	R	R	R	R	R	R	R	R	N	N

Note: The subset of Instrumental Variables where define as follow:

Subset 1: husband age and husband age square.

Subset 2: Subset 1 + Semester dummy variable

Subset 3: Subset 2 + Partner Age divided and Multiply by Husband Age

Subset 4: Subset 3 + Education + Owning a Car + Blue Collar

Subset 5: Subset 4 + Log Income.

by household characteristics but other goods such as cloth, recreation and alcohol are not specially affected. Specification tests, consistent in the direction of nonparametric alternatives, support the Working-Leser model for the food Engel curve for many household groups considered. Finally, we have shown that the null hypothesis can be rejected, when applying Hausman's Test, due to different reasons, like the way household characteristics are introduced or the validity of the instrumental variables.

Appendix

Let (X, Y) denote a $R^d \times R$ random vector and assume that Y is integrable so that the regression function

$$m(x) = E[Y|X = x] \quad x \in R^d,$$

is well defined. Parametric modeling assumes that m belongs to a given family $\mathcal{M} = \{m(\cdot, \theta) : \theta \in \Theta\}$, where $\Theta \subset R^p$, assuming that $m(x) = m(x, \theta_o)$ for some true parameter θ_o . Statistical inference based on $\mathcal{M}$ should be accompanied by a test for $H_0 : m \in \mathcal{M}$ versus $H_1 : m \notin \mathcal{M}$.

Statistics for testing this hypothesis:

Härdle and Mammen (1993):

$$T_n = nh^{d/2} \int (\hat{m}_h(x) - \mathcal{K}_{h,n}m(x, \hat{\theta}))^2 \pi(x) dx$$

where h is the bandwidth parameter, $\hat{m}_h(x)$ is the nonparametric regression, $\mathcal{K}_{h,n}m(x, \hat{\theta})$ is the nonparametric regression of the parametric fit and $\pi(x)$ is a weighting function, equal to zero at the 5% observations at the tails and one otherwise. Because of the slow order of convergence of their statistic, Härdle and Mammen proposed using wild bootstrap to approximate the critical value. For this purpose:

- i – Define the nonparametric residuals, $\tilde{e}_i = Y_i - \hat{m}_h(X_i)$.
- ii – Define the bootstrap residuals, $e_i^* = \tilde{e}_i V_i$ where $\{V_i\}_{i=1}^n$ are independent and identically distributed random variables of a two point distribution such that $E[V_i] = 0$, $E[V_i^2] = 1$, $E[V_i^3] = 1$. The distribution chosen is such that $\Pr[V_i = -(\sqrt{5} + 1)/2] = (\sqrt{5} + 1)/2\sqrt{5}$ and $\Pr[V_i = (\sqrt{5} + 1)/2] = (\sqrt{5} - 1)/2\sqrt{5}$.
- iii – Define $Y_i^* = m(X_i, \hat{\theta}) + e_i^*$ and with the bootstrap sample $\{(X_i, Y_i^*)\}_{i=1}^n$ calculate the test statistic value, T_n^* .
- iv – Repeat the process B times to obtain $\{T_{nj}^*\}_{j=1}^B$. Then, the critical values of the true distribution of the Härdle and Mammen statistic can be approximated by the critical values of $\{T_{nj}^*\}_{j=1}^B$. For example, if $B = 100$ and the significance level is 0.05, then we should reject if the value of the statistic is greater than $T_{n(95)}^*$, where $\{T_{n(j)}^*\}_{j=1}^B$ is the ordered sequence.

Ellison and Ellison (1992):

$$T_n = \frac{(Y_i - m(x, \hat{\theta}))' W_n (Y_i - m(x, \hat{\theta}))}{\sqrt{2\hat{\sigma}^2 s(W_n)}}$$

where W_n is a weighting matrix with elements

$$w_{ij} = K((x_i - x_j)/h) / \sum_{i \neq j} K((x_i - x_j)/h) \quad \text{if } i \neq j,$$

where $K(u)$ is a gaussian kernel,

$$s(W_n) = \left(\sum_{i,j} w_{ij}^2 \right)^{1/2},$$

and $\hat{\sigma}^2 = n^{-1} \sum_{i=1}^n [Y_i - m(X_i, \hat{\theta})]^2$. They show that $T_n \rightarrow \mathcal{N}(0, 1)$, with a finite sample correction bias.

Horowitz and Härdle (1994):

The model to be tested in this case is a semiparametric model, where the hypothesis are given by

$$H_0 : E[Y|v(x, \theta) = v] = F(v) \text{ versus}$$

$$H_1 : E[Y|v(x, \theta) = v] = H(v)$$

where $v(\cdot)$ and $F(\cdot)$ are assumed to be known and H is unknown. Then, given

$$T_n = h^{1/2} \sum_{i=1}^n \pi(v(x, \hat{\theta})) \{ (Y_i - F(v(x, \hat{\theta}))) \times (\hat{F}_n(v(x, \hat{\theta})) - F(v(x, \hat{\theta}))) \}$$

where $\hat{F}_n(v(x, \hat{\theta}))$ is the nonparametric regression of $F(v(x, \hat{\theta}))$ and $\pi(v(x, \hat{\theta}))$ is a weighting function, that as before, excludes the 5% observations at the tails. The null can be accepted or rejected at ζ level according to whether $(T_n/\hat{\sigma})$ exceeds the $1 - \zeta$ quantile of the standard normal distribution, being a one sided test. For the formula for estimating the variance, see Horowitz and Härdle, 1994.

Stute (1995): Let

$$R_n^1(x) = n^{-1/2} \sum_{i=1}^n I(X_i \leq x) [Y_i - m(X_i, \hat{\theta})]$$

where $I(A)$ is the indicator function of event A , $\hat{\theta}$ is a $\sqrt{n}$ consistent estimator of θ . Under fairly general assumptions, R_n^1 converges in distribution to a centered Gaussian limit R_∞^1 . The test is not distribution free, and it is only possible to tabulate under exceptional circumstances. Hence a wild bootstrap approximation has been proposed (Stute et al., 1996). The statistic is given by

$$W_n^2 = \sigma_n^{-2} \int_0^1 [R_n^1(x)]^2 F_n(dx)$$

where σ_n^2 can be estimated by any consistent estimate of σ^2 .

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First version received: March 1997

Final version received: April 1997