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Satiation, Escaping Satiation, and Structural Change: Some Evidence from the Evolution of Engel Curves

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ISSN 1430-4716

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Satiation, Escaping Satiation, and Structural Change: Some Evidence from the Evolution of Engel Curves*

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July 2008

Abstract

Certain properties of Engel curves have been linked to the occurrence of structural change in the economy (Pasinetti 1981, Metcalfe et al. 2006, Saviotti 2001). From an empirical perspective, however, very little has been done to examine (i) whether indeed satiation is a general property of Engel curves; (ii) whether the rate at which Engel curves converge to satiation may significantly change over time; and (iii) how stable Engel curves are across time such that it may be appropriate to use them to make predictions about structural change. Using data from the UK Family Expenditure Survey, this paper examines these three issues.

1 Introduction

It has been posited that the main driver of structural change is the manner in which household expenditure patterns change as household income rises. A key notion is that expenditure on any good has a satiation point: there is an upper limit on the amount of expenditure that is allocated by households to any one particular good or service, regardless of how much household income grows. Although expenditures on different commodities display this limit at different levels of real income, its attainment is eventually inevitable (Pasinetti 1981: 77). If per capita income increases over time, this leads to a dramatic slowdown in the growth rate of demand for some goods, as an increasing number of households reach the satiation point.

The justification for this assumption is based on evidence that Engel curves (hereafter ECs) display satiation in the form of zero or even negative slope from a certain level of income onwards. Yet in the face of the tremendous amount of variety prevalent amongst goods and services, relatively little has been done to empirically validate how general this property is. This paper examines the extent to which ECs across a wide variety of goods and services

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*We would like to thank the audience of the Workshop "The Role of Consumption for Structural Change in the Economy" (Max Planck Institute of Economics, Jena, July 2008) and in particular Ulrich Witt for very useful comments. We also thank Michael Enukashvili and Sebastian Müller for research assistance.

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display satiation. Moreover, we also examine the implicit assumption that the ECs are stable in that the point of satiation and the shape of the ECs do not change over time.

Our findings confirm that indeed a large majority of ECs tend to satiate, defined as the presence of zero or negative values in the EC derivatives. However, we find that the point at which they satiate shifts significantly over time. The proportion of households found in the part of the EC which is subject to satiation is also changing over time, following a random walk. Moreover, although satiation is confirmed as a general property, the opposite tendency emerges in some cases: for some goods there is an increase in the proportion of households whose expenditures on a good is beyond the satiation level.

Finally, in order to account for changes in the satiation points, we investigate co-movements among a set of relevant variables, including the satiation point, the proportion of households that have reached satiation, income distribution and inflation. This time series analysis casts some doubt about whether the shape of ECs can be used to predict a slowdown in the growth of sectoral demand, as there are some significant changes in the shape and position of the ECs. It also suggests that income distribution across households is an important explanatory factor of satiation, deviation from satiation, and shifts in EC. Concerning the magnitude of these shifts, it is interesting to note that these have a stable mean and variance over time. The role played by income distribution lends some evidence to the notion that firms and industries may respond to a slowdown in demand growth by innovating products and altering household expenditure patterns in such a way as to escape satiation pressure (Witt 2001).

In sum, these results support the notion that market economies undergo periodic structural change as they grow and the consumption patterns of households evolve. At the same time, any model of such structural change that makes projections about the growth rate of sectoral demand should not only be based on cross sectional ECs, but also needs to take into account how the ECs themselves tend to change over time. Such extra information improves our understanding of the theoretical link between evolving consumption patterns and structural economic change.

2 Theoretical Background

In “Structural Change and Economic Growth” (1981) Pasinetti sets out a vision of the economic growth which explicitly accounts for structural change as an endogenous outcome of the growth process. His central theme is that significant changes in an economy’s sectoral composition are the very consequence of economic growth. As growth in certain sectors reaches a limit, inventive effort and investment must be periodically redirected towards new, more productive, sectors.

The composition of demand plays a key role in driving structural change. Rather than assuming that demand expands uniformly across all goods and services as income grows, Pasinetti recognizes that the composition demand fundamentally changes as household income rises. Specifically, Pasinetti argues that there is an upper limit on how much an individual consumer is willing to spend on any good or service as income rises. In his words, “there is no commodity for which any individual’s consumption can be increased indefinitely. An upper saturation level exists for all types of goods and services although at different levels of real income" (Pasinetti 1981: 77).[1] Pasinetti hypothesizes that an EC relative to any good possess one of the shapes displayed in Figure 1.

The upshot is that there is a slowdown in the growth rate of demand faced by industries, causing a slowdown in relative productivity. At the same time, marginal increases in household expenditure are diverted to new products. Thus, industries supplying these new products meet accelerated growth in demand and attract labor and capital from old industries. In this way, the changing industrial composition critically hinges on the changing composition of consumption patterns.

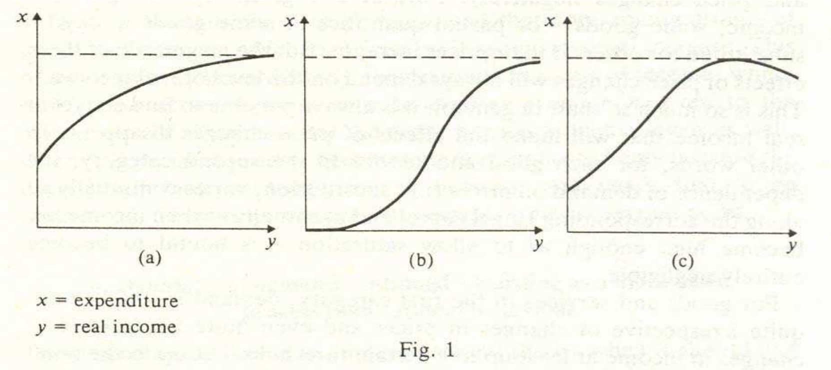

Figure 1: Source: Pasinetti (1981: 73). Pasinetti hypothesizes that "curves of type (a) are likely to fit the cases of goods which are absolutely necessary for physiological reasons (e.g. food), and curves of type (b) are likely to fit almost all other cases; while curves of type (c) represents the typical behaviour of inferior goods."

The notion that, for any good or service, household expenditure grows less than income growth occurs often in both the theoretical and empirical literature on household expenditure. Engel's (1856) famous article produced empirical evidence that the richer a household is, the less percentage of its income will be devoted to food expenditure (Engel's law). This does not necessarily imply the existence of a satiation point, although other scholars supported this latter claim in subsequent empirical studies.

The 1950s saw much empirical work on what functional form should be used when estimating ECs. Prais (1953: 89) argued that the "typical shape" of EC displays a satiety level "providing an upper limit to the quantity bought." He argued this was caused by the fact that as consumers become more affluent the basket of goods consumed tends to increase. As total expenditure is distributed across an increasingly wider range of expenditure, it is very unlikely that any good that was part of the initial consumption basket at low income levels

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[1] We use "satiation" instead of "saturation" to avoid confusion with the innovation diffusion literature. There, the latter term refers to the point in time when all potential adopters have adopted the innovation (Rogers 1962). "Satiation" instead refers to the slowdown of per capita expenditure on a particular good and service.

can maintain the same budget share as income rises. Elsewhere, Aitchison and Brown (1954) attributed the existence of satiation to psychological mechanisms which can be effectively described by the same theory used in biology to model reactions to stimuli (Weber-Fechner law).

From a more theoretical perspective, Pasinetti the existence of satiation to the physiological nature of human needs.[2] Once the needs are satisfied, the marginal utility of successive increments of the same goods tend to fall dramatically and can even become negative (Pasinetti 1981: 72). The generic example is food, whereby once the consumer has eaten enough, further helpings may be viewed with dislike by the consumer. If satiation has been reached, further increases in consumption expenditure are redirected to other goods and services. Thus implicit in Pasinetti's approach is that, on some level, the wants that humans possess are universally shared and beyond the control of free will. Pasinetti also implicitly assumes that the function of goods does not change. Witt (2001) posits that once a particular want is satiated, goods could be modified by suppliers to appeal to other, non-satiated wants. Hence satiation points in ECs could be avoided through such innovative activity.

At the same time, Pasinetti also acknowledges that with the growth of affluence, the physiological influence on consumption becomes relatively weaker: "at low levels of real incomes ... [consumers'] demand is dominated entirely by physiological urges. But, as per capita incomes grow higher and higher, choices grow wider and wider. Consumers' demand becomes dependent less and less on their instincts and more and more on their knowledge" (Pasinetti 1981: 75).

The fact that as income rises, the influence of physiological wants diminishes and influence of consumer knowledge increases casts doubt on the idea that all types of goods and services available in today's economy are subject to the same sort of satiation tendency. Nevertheless, since Pasinetti, this link between the growth rate of industries and the growth patterns of consumption has become a core feature of structural change models (Andersen (2001); Saviotti (2001); Aoki and Yoshikawa (2002); Metcalfe et al. (2006)). However, the basic question remains open: How well are these assumptions empirically validated? Little has been done to check whether the ECs relate to all goods have a satiation point, and if so, how this satiation point evolves over time.

3 Do Engel Curves Satiate?

This section investigates the extent to which satiation is a general property of Engel curves.[3] This is done by comparing the properties of ECs, in particular their shape and derivative,

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[2] Theorizing about the consumers wants has has a long tradition in economics and provides a rich basis for understanding the long run evolution of changing consumption patterns (Menger 1871, Marshall 1890, Georgescu-Roegen 1954, Witt 2001).

[3] It should be noted that there is a difference between *individual* and *statistical* satiation. The former refers to the property of an individual expenditure patterns. If individual expenditure patterns tend to satiate, this means that the increase in expenditure in response to rising income tends to slow down after a certain amount of income and to stay under a certain level of expenditure. Statistical satiation, on the other hand, is a property of a population of households, which only reflects individual satiation in the case of perfect aggregation. Here our attempt is to collect evidence on the statistical satiation property.

estimated across a wide range of goods and time periods, using data on British households from the Family Expenditure Survey.

We begin by estimating the derivative of ECs and examining how common it is for these to intersect with zero. If the derivative is zero at some levels of income (proxied by total consumption), the EC is horizontal for those levels. The EC for a particular good g is estimated by regressing the amount of expenditure Y allocated to g on total expenditure X:

$$Y_i = m(X_i) + \epsilon_i \tag{1}$$

The subscript i refers to households $1, \ldots, n$. To estimate (1), we rely on a nonparametric approach, since there is no *a priori* ground for imposing a functional form on the dependence of a specific expenditure to total consumption. In fact, using a parametric estimation would restrict the range of possible values we could obtain for the derivative of the EC. Using nonparametric techniques, we can remove such restrictions and gain a flexibility in estimation since nonparametric methods allow the data to determine the shape of the regression curve (see Engel and Kneip 1996 for discussion).

In particular, we apply the kernel smoothing method proposed by Gasser and Müller (1984) and Gasser et al. (1991). This estimator, besides having an asymptotic bias that is preferable to the Nadaraya-Watson estimator, has the advantage of being easily applicable to the problem of estimating derivatives:

$$y' = m'(X) + \nu \tag{2}$$

The kernel function used is a fourth-order kernel, and the bandwidth parameter is chosen via the *plug-in* approach proposed by Herrmann (1997), which is able to deal with heteroscedasticity, typical feature of household budget data.

Table 1 shows, using expenditure data from about 13 categories of commodities and 8 subcategories of food, the years in which the estimated EC derivatives display positive values across all income levels. That is, in the years listed in the table, the corresponding ECs have a positive slope and are monotonically increasing. For most goods, within an interval of 28 years (16 for some categories), only a few years are listed in the table. In the majority of the cases, the EC derivatives intersect the line $y = 0$. In only a few instances do the ECs monotonically increase. Monotonically increasing ECs emerge for some types of goods more frequently: for household goods and household services they emerge 6 times in 16 years; for leisure services they emerge 5 out of 16 years; for clothing and footwear they emerge 6 out of 28 years, for housing and alcohol they emerge 5 out of 28 years. Whereas for other categories of commodities (tobacco, fares and other travel) and several sub-categories of food ECs have a constantly positive slope in very few or no years.

These results support *prima facie* the hypothesis that satiation is a general properties of ECs. However, some commodities seem to have a greater tendency to satiate in comparison with others. Or, to put it in another way, some categories seem to display a tendency of deviate from satiation in some years. More detailed evidence is needed for both hypotheses.

The finding that satiation is a general property of ECs is further confirmed by the fact that a mathematical form that imposes a satiation level to the EC fits the data well relative to other forms which do not impose a satiation level. Imposing a sigmoid (S-shaped) curve (see again second diagram in Figure 1) implies that the EC derivative is increasing until a certain

Table 1: Years for which no statistical satiation occurs: slope of EC is strictly monotonic positive (derivative > 0).

Commodities	years (within the interval 1974-2001)
housing	2000 - 1998 - 1996 - 1980 - 1974
fuel, light, and power	1984 - 1978
food	1982 - 1987 - 1997
alcohol	1996 - 1994 - 1992 - 1990 - 1974
tobacco	1978
clothing and footwear	2000 - 1998 - 1991 - 1990 - 1980 - 1976
household goods*	2001 - 2000 - 1999 - 1995 - 1991 - 1989
household services*	2000 - 1999 - 1998 - 1997 - 1995- 1986
personal goods and services*	1990 - 1986
motoring*	1988 - 1987
fares and other travel*	none (*satiation occurring in all years*)
leisure goods*	2000 - 1997
leisure services*	2001 - 1999 - 1997 - 1996 - 1989
beef	1995 - 1983
lamb	none (*satiation occurring in all years*)
pork	1983 - 1978 - 1976
fish	1992 - 1991
eggs	2001 - 1991
milk	none (*satiation occurring in all years*)
soft drinks	1997 - 1986 - 1984 - 1975
sugar	none (*satiation occurring in all years*)

** here only the interval 1986-2001 is considered.*

Source: UK FES data 1974-2001.

level of x, after which it is decreasing until remaining zero. We use the standard functional form of the sigmoid curves:

$$y = \frac{a}{1 + \exp(-bx + c)}. \tag{3}$$

Figure 2 shows how the fit of (3) by nonlinear least squares is very close to the kernel fit for all the group of goods taken into consideration. However, kernel estimation for leisure goods, leisure services, and household deviate 'upwards' from their respective sigmoid curves more clearly than other commodities. This could be interpreted as a tendency to deviate from satiation that becomes apparent in the expenditure patterns of these goods at relatively high levels of income. Figure 2 reports the results both when all households are considered (diagrams 1-4) and when only two-member households are considered (diagrams 5-8). The results remain robust when we restrict our analysis to two-member households. The main difference is that the kernel estimation is more unstable at higher income levels when only two members are considered, due to the relatively lower number two-members households at high income levels.

Table 2 reports the coefficients of determination (R squared) of the nonlinear least squares

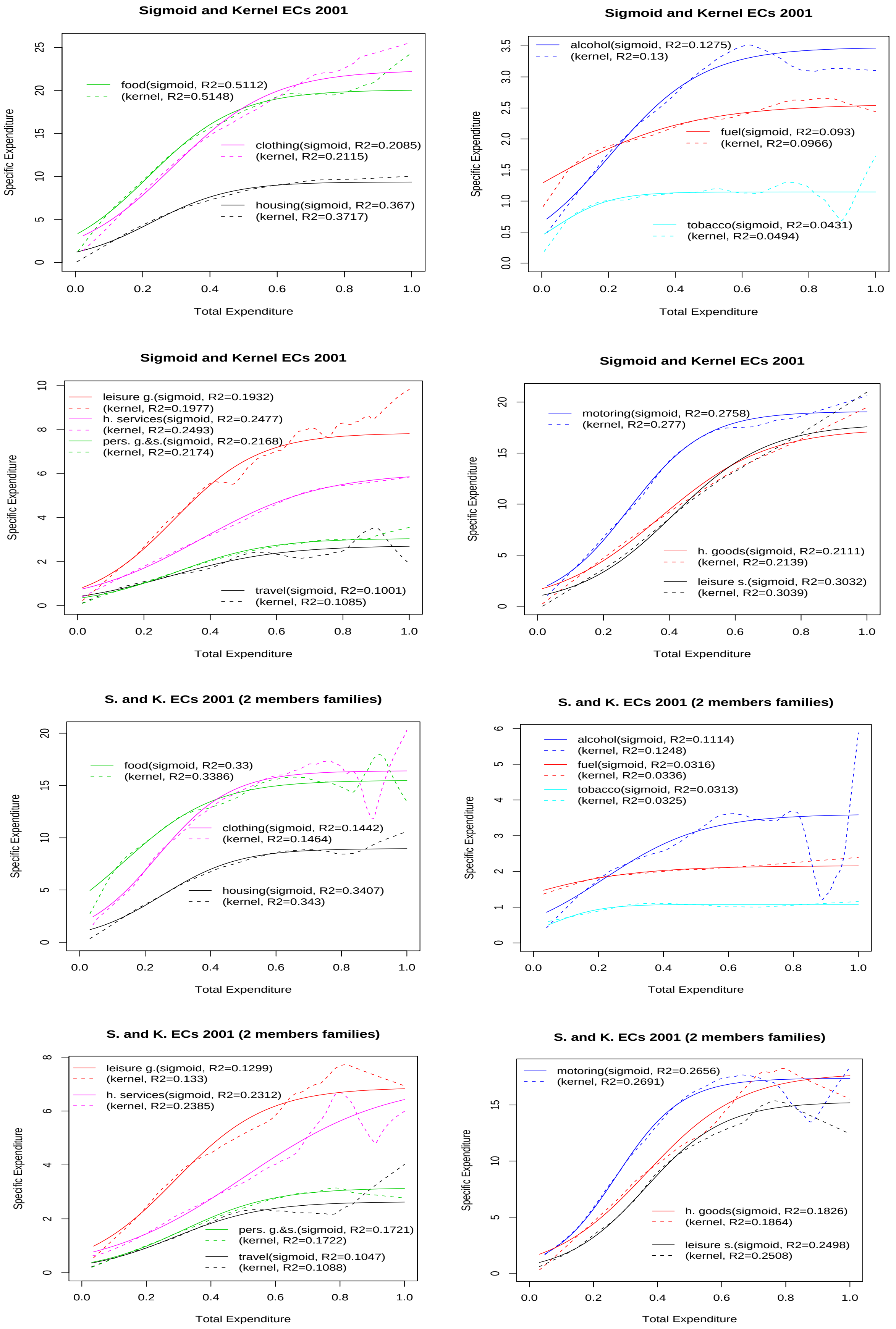

Figure 2: Comparison between sigmoid (parametric) and kernel (nonparametric) Engel curves (UK FES data).

fit of equation 3 for the 13 groups of commodities under investigation across several years.[4] For some sets of goods (housing, household goods, household services, motoring, leisure services) the fit of the sigmoid has improved, for others (fuel, food, tobacco, clothing, personal goods and services, leisure goods) has worsened. The changing fit over time may be due both to a tendency of the "true" EC to get close or deviate from satiation and to a changing variability of the data.

Table 2: Coefficients of determination (R^2) of the fitted sigmoid EC across time

year	**housing**	**fuel**	**food**	**alcohol**	**tobacco**	**clothing**
2001	0.3670	0.0930	0.5112	0.1275	0.0431	0.2085
2000	0.3633	0.1018	0.5244	0.1418	0.0568	0.2157
1999	0.3354	0.1111	0.5157	0.1271	0.0555	0.2275
1993	0.3099	0.1156	0.5312	0.1259	0.0756	0.2327
1987	0.3202	0.1223	0.5481	0.1548	0.0666	0.2752
1981	0.2509	0.1302	0.5282	0.1428	0.0863	0.2469
1975	0.2234	0.1179	0.5621	0.1399	0.1044	0.2729

year	**household goods**	**household services**	**personal goods & s.**	**motoring**	**fares & o. travel**	**leisure goods**	**leisure services**
2001	0.2111	0.2477	0.2168	0.2758	0.1001	0.1932	0.3032
1999	0.2132	0.2045	0.2161	0.2603	0.1124	0.1942	0.2940
1996	0.2087	0.2026	0.1945	0.2248	0.0974	0.2201	0.2997
1991	0.2166	0.1862	0.2144	0.2387	0.1094	0.2144	0.2547
1987	0.1964	0.2102	0.2231	0.2664	0.1207	0.2359	0.2773

Source: UK FES data 1974-2001.

Given this preliminary evidence that satiation is a common property of ECs, we assess the extent to which the shapes of nonparametrically-estimated ECs are similar across different goods. To measure the similarity in shape between estimated regression curves, we use the rank correlation method proposed by Heckman and Zamar (2000).[5] The rank correlation used here is a generalization of the rank correlation between two finite vectors of numbers (cf. Gibbons 1993). If two curves have the same shape our coefficient is equal to one. Two curves $y = m_1(x)$ and $y = m_2(x)$ are said to have the same shape if there exists a strictly increasing function g such that $m_1(x) = g\{m_2(x)\}$, that is the plot of $y = m_1(x)$ is the same of $y = m_2(x)$ after a deformation of the y axis (Heckman and Zamar 2000: 136). The Heckman-Zamar method presupposes the definition of a probability measure μ on the interval in which $m_1(x)$ and $m_2(x)$ are defined. which we standardize for each category to the interval $[0, 1]$. Our proposed measure is $\mu(A) = (\#x \in A)/(\#x \in [0, 1])$ (i.e the proportion of x points that are in A), for any subinterval A of the unit interval. The rationale for using this measure is to give more weight to the portion of the curve for which there are more observations. The

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[4] We display in the table just few years for reasons of space.

[5] A comparative advantage of this method is the ability to capture *qualitative* features of the curves such as kinks and spikes. Methods based on L^2 distance do not perform well in this respect (Marron and Tsybakov 1995).

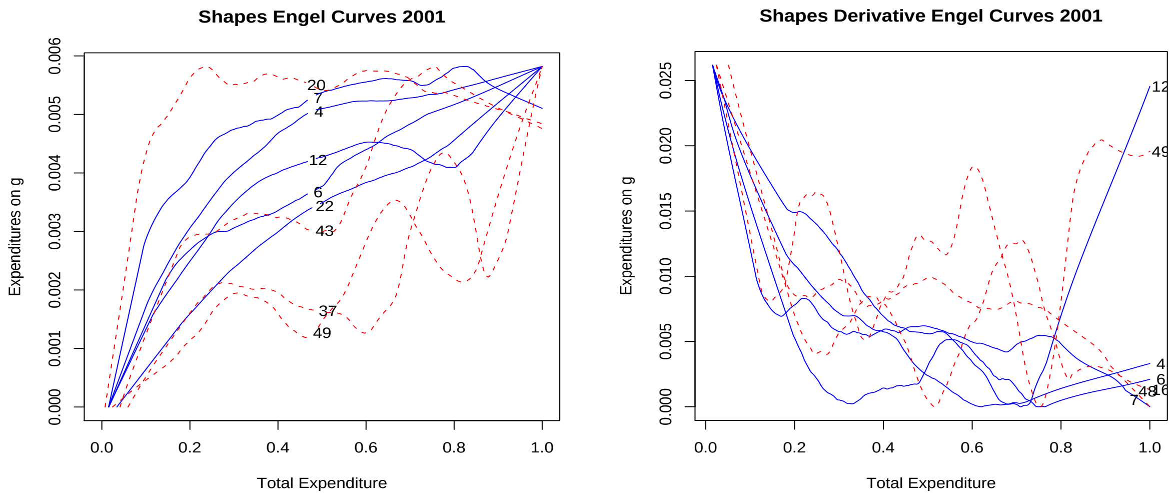

Figure 3: Engel curves (first diagram) and ECs derivatives (second diagram) for (some of) the following expenditures categories: cereals(4), eggs(6), fats(7), sugar(12), food at work & school (16), cigarettes (20), outwear(22), legal costs(37), spectacles(43), driving insurance & lessons (48), non-motor vehicles(49). Solid-line curves belong to the same cluster, dashed-line curves are clustered outside of it.

rank correlation between $m_1(x)$ and $m_2(x)$ is defined as:

$$\rho_\mu(m_1, m_2) = \frac{\int \{r^{m_1}(w) - R^{m_1}\}\{r^{m_2}(w) - R^{m_2}\}d\mu(w)}{\sqrt{\int \{r^{m_1}(w) - R^{m_1}\}^2 d\mu(w) \int \{r^{m_2}(w) - R^{m_2}\}^2 d\mu(w)}}, \tag{4}$$

where $r^{m_1}(x) = \mu\{t : m_1(t) < m_1(x)\} + \frac{1}{2}\mu\{t : m_1(t) = m_1(x)\}$ and $R^{m_1} = \int r^{m_1}(w)d\mu(w)$. $r^{m_2}(x)$ and R^{m_2} are defined analogously. A consistent estimator of ρ_μ is given by Heckman and Zamar (2000: 139).

We also attempt to group the estimated ECs relative to 59 different categories of expenditure (constituting all together the entire household budget) on the basis of the shape. We perform a hierarchical cluster analysis using as distance measure $d = (1 - \rho_\mu)$.[6] We find that ECs do not group in few equinumerous clusters or in clusters corresponding to macro types of expenditures such as, for example, durable goods, nondurable goods and services. For any agglomeration criterion used (average, single, complete linkage, Ward) we find that most curves fall into one very large cluster. The other clusters are composed of one or maximum two elements.

Specifically, with the average linkage criterion, a large cluster of ECs emerges consisting of 54 elements when 5 splits are imposed. This same cluster contains 53 elements when the splits are six, up to 50 when the splits are ten. The first diagram in Figure 3 displays results from the imposition of 10 splits. Five ECs drawn in a solid line all belong to the same large cluster. The curves in dashed lines are ECs that belong to other, smaller clusters. Curves are readjusted in the y axis so that they can be easily compared by shape.

The same analysis is performed for derivatives. Remarkably different results emerge from the analysis of the derivatives. Derivatives exhibit much more heterogeneity in shape, as the

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[6] Since $-1 \leq \rho_\mu \geq 1$ we have $0 \leq d \geq 2$.

second diagram of Figure 3 shows. Although a large cluster still emerges, it is relatively small. When 10 splits are imposed, the largest cluster of derivatives includes 42 expenditure groups possessing an average within distance of $d = 0.3311$. In contrast, the large cluster of simple ECs contained (for the same number of splits) 50 expenditure groups with average within distance $d = 0.0288$. Moreover, in the results pertaining to the derivatives, the size of the smaller clusters has also grown, with one cluster containing 6 expenditure groups and another with 4 expenditure groups.

Hence ECs display a very similar shape across different commodities. Noteworthy differences in shapes are observed for only very few expenditure categories. However, a wider variety of shapes emerges when considering derivatives and higher classes of income. When grouping ECs and their derivatives on the basis of their shape, we do not obtain classifications typically made in consumption research. We do, in particular, find no distinction in terms of goods versus services or durable versus non-durable.

The shapes of the typical EC (see again Figure 3) is strictly increasing up to a certain point of X. Thereafter, we find a class of shapes for which it goes up again, while in others it remains flat or goes down. This confirms Prais' (1952) early hypothesis that the "typical shape" of an EC for a good g reflects that g has an income elasticity greater than unity at low income levels for which g is a luxury.

The observed tendency of ECs to change direction at very high levels of X should be cautiously interpreted. For this range, there is typically a dramatic decrease in the number of observations. This fact, however, does not bias our results on comparison. This is because the measure incorporated in the rank correlation method weighs the sub-intervals of total consumption according to the frequency of observations. Intervals containing few observations thus contribute much less to the overall rank correlation than those which have many observations.

4 Evolution of Satiation

In this section we study how satiation properties evolve over time. An implicit assumption in structural change theory is that ECs are stable, in that they do not change their position or shape over time. As a consequence, industries face a slowdown in the growth of demand, as an increasing number of consumers reach the satiation level of expenditure. Implicit in Pasinetti's (1981) model is an inference about how expenditures will change over time that is based on hypotheses about how expenditures change as income increases. This is equivalent to using estimated ECs for predicting what will happen sectoral demand, provided that income rises over time. This inference assumes that the underlying EC will not change over time. That is, given a rise in income in some time period, newly rich consumers will alter their expenditure such that their consumption patterns is similar to that which the rich exhibited before the rise in income. If ECs are not stable and a change in their position and shape over time is evident, the validity of this inference comes into question.

If indeed ECs do remain fixed and household income rises, a corollary is that an increasing proportion of households should reach satiation point. Whereas ECs stability will be assessed in the next section, here we examine what evidence exists for this corollary. This is measured by the proportion of households for which the EC is downward sloping. Let n be the number of households having affluence (measured by total consumption) $X_1, \ldots, X_n$ and respectively allocating positive expenditures $Y_1, \ldots, Y_n$ on a good g. We estimate the values that the EC derivative $m'(X_i)$, estimated by the kernel smoothing procedure, take at points $X_1, \ldots, X_n$. The proportion of households for which the EC is downward sloping is:

$$Sat = \frac{\sum_{i=1}^{N} I(\hat{m}'(X_i) < 0))}{N}, \tag{5}$$

where $I(\cdot)$ is the indicator function.[7] Table 3 displays *Sat* for some the years available.[8] No clear trend is found in any expenditure category: in each expenditure category the proportion of households for which the derivative EC is negative moves in an erratic manner. For fuel, tobacco, fares & other travels, household goods, and leisure services some weak tendency can be tracked down. In the first three mentioned categories of commodities the proportion of households subjected to satiation has slightly increased over time. On the contrary, in household goods and fares & other travels, a proportionally increasing number of households tend to deviate from satiation. However, the changes displayed by the other categories are more erratic. Time series analysis reported in section 5 will show that the movements of *Sat* over time are similar to those of a random walk.

Table 3: Proportion of households for which the EC is downward sloping (negative EC derivative).

year	**housing**	**fuel**	**food**	**alcohol**	**tobacco**	**clothing**
2001	0.0193	0.0531	0.0153	0.0360	0.0764	0.0163
2000	0.0000	0.0202	0.0203	0.0231	0.0593	0.0000
1999	0.0167	0.0098	0.0132	0.0518	0.1205	0.0285
1994	0.0164	0.0104	0.0121	0.0000	0.1429	0.0136
1989	0.0316	0.0438	0.0101	0.0170	0.0532	0.0177
1984	0.0145	0.0000	0.0116	0.0362	0.1396	0.0075
1979	0.0041	0.0160	0.0241	0.0213	0.0610	0.0158
1974	0.0000	0.0108	0.0095	0.0000	0.1033	0.0110

year	**household goods**	**household services**	**personal goods & s.**	**motoring**	**fares & o. travel**	**leisure goods**	**leisure services**
2001	0.0000	0.0058	0.0007	0.0447	0.0613	0.0050	0.0000
2000	0.0000	0.0000	0.0026	0.0290	0.0058	0.0000	0.0093
1999	0.0000	0.0000	0.0140	0.0120	0.0136	0.0192	0.0000
1994	0.0092	0.0116	0.0015	0.0531	0.0339	0.0149	0.0044
1989	0.0000	0.0212	0.0265	0.0234	0.0179	0.0099	0.0000
1986	0.0086	0.0000	0.0000	0.0533	0.0097	0.0137	0.0238

Source: UK FES data 1974-2001.

In order to get a more detailed picture of the satiation and escaping satiation phenomenon, we introduce an operational definition of *satiation line* and *satiation point*. The satiation line

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[7] $I(a) = 1$ if a is true, and $I(a) = 0$ if a is false.

[8] We do not display the entire intervals 1974-2001 and 1986-2001 because of limited space.

represents the level of expenditure (relative to a specific group of goods) where the EC has first displayed a tendency to satiate, starting from a specific level of income (satiation point). The satiation line is expressed as $y = y^s$, where y^s is a constant and the line takes values only for income $x \geq x^s$. The point (x^s, y^s) denotes the satiation point. Satiation line and satiation point are obtained in the following way. The EC is estimated through kernel nonparametric smoothing:

$$Y_i = \hat{m}_K(x_i) + \nu_i \tag{6}$$

Let x^s the smallest value of income for which $\hat{m'}_K(x_i) < 0$. That is, x^s is the income of the poorest household for which the derivative of EC is negative. Let us assign to this household the index i_s, among the ordered vector of households $i = 1, \ldots, N$ such that $x_1 < x_2 < \ldots x_n$. The level of expenditure (for each particular good) that the household i_s is expected to allocate, as specified by the EC, determines y^s. That is $y^s = \hat{m}_K(x^s)$.

Our estimation of the satiation point and line for 13 categories of commodities and 8 sub-categories of food suggests that the point of satiation changes considerably across years (see Figure 4). In our analysis, total and specific expenditure are deflated by the consumer price index, so that they are all measured by pounds adjusted to 1974 levels. For some goods, this change is quite erratic. In other cases, displayed in Figure 4, some trends are detectable. For aggregate food, clothing, household goods, household services, leisure goods, and leisure services the point of satiation has moved towards a higher level of both total and specific expenditure. For other goods, like alcohol, tobacco, the satiation point has moved over time towards a lower level of specific consumption. For beef, lamb, and sugar the satiation point has moved towards a lower level of both total and specific consumption.

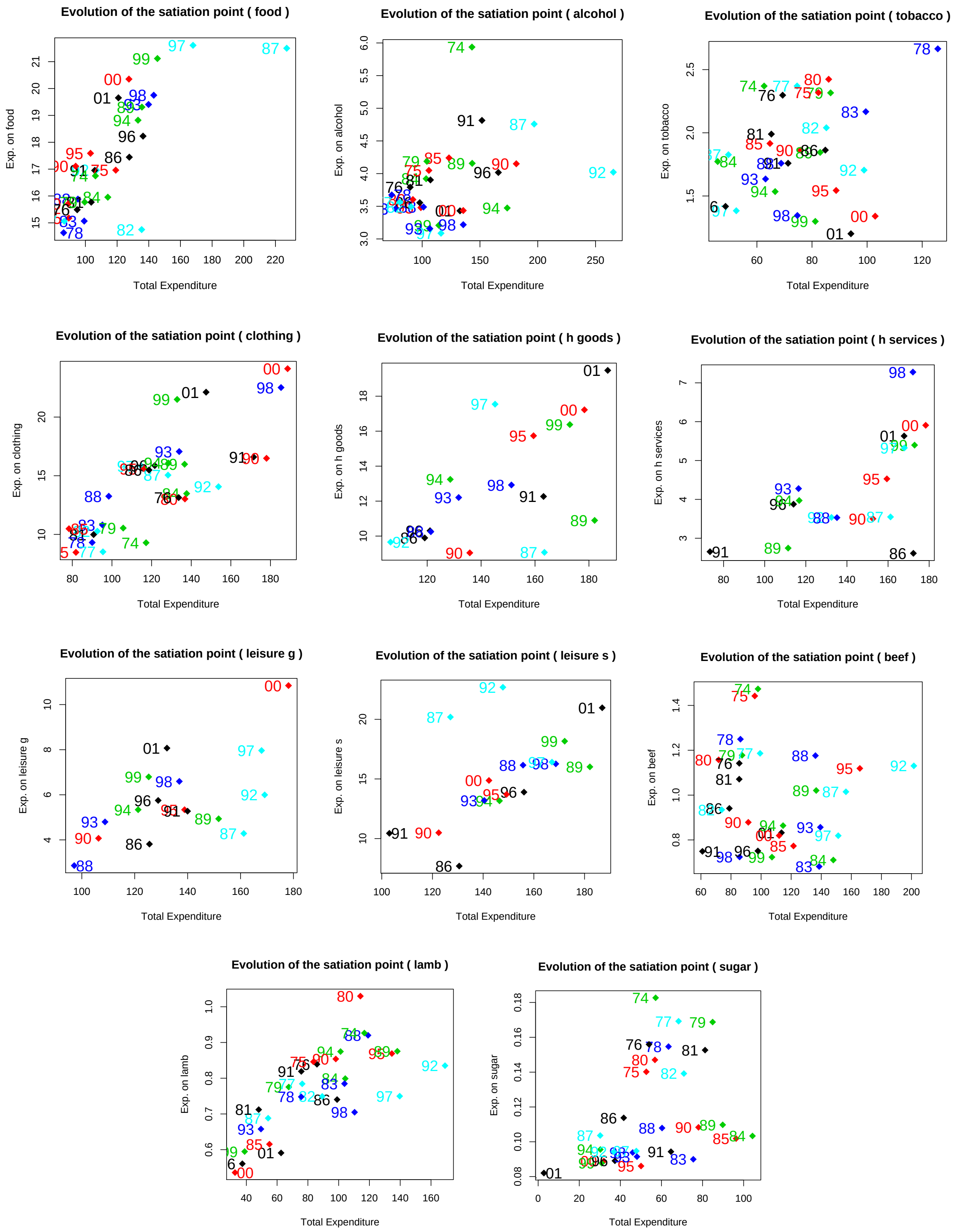
We now develop some indicators of *deviation from satiation*, which measure the tendency for households to spend beyond the observed satiation level of expenditure (the opposite to satiation). Some evidence for this tendency has already emerged in the above analysis. First, we introduce a *distance from satiation*, which is the distance between the kernel estimated EC and the satiation line defined above, measured for those points of total consumption greater than x^s. More specifically, let $y_i = \hat{m}(x_i) + \epsilon_i$ be the kernel estimated EC and $y = y^s$ the satiation line. The distance from satiation is defined as:

$$Dsat = \frac{\sum_{i=i_s}^{N} (\hat{m}_K(x_i) - y^s)}{N_s}, \tag{7}$$

where i_s is the index of the household which has income x^s. That is, being $x_1 < x_2 < \ldots < x_n$ the ordered income of the households $i = 1, \ldots, n$, we have that $x_{i_s} = x^s$. N_s is the number of households with total consumption greater than x^s. Second, we measure the proportion of households that are *beyond* satiation in the following way.

$$Esc = \frac{\#\text{households richer than } x^s \text{ and spending more than } y^s}{N}. \tag{8}$$

Tables 4 and 5 display how *Dsat* and *Esc* have changed over years 1974-2001 for household expenditure on housing, fuel, food, alcohol, tobacco, clothing, and eight sub-categories of food (see Table 5), as well as over years 1986-2001 for expenditure on household goods, household services, personal goods & services, motoring, fares & other travels, leisure goods, and leisure


Evolution of the satiation point (food)

Evolution of the satiation point (alcohol)

Evolution of the satiation point (tobacco)

Evolution of the satiation point (clothing)

Evolution of the satiation point (h goods)

Evolution of the satiation point (h services)

Evolution of the satiation point (leisure g)

Evolution of the satiation point (leisure s)

Evolution of the satiation point (beef)

Evolution of the satiation point (lamb)

Evolution of the satiation point (sugar)

Figure 4: Evolution of the satiation point over time.

services. We do not report the entire time series because of limited space (these variables are used in the time series analysis in the next section).

In each expenditure category considered, the index $Dsat$ tends to oscillate, across years, around a fixed mean, which is typically very close to zero.[9] This is confirmed, by the time series analysis reported in the next section, in which the hypothesis that $Dsat_t$ is stationary ($\sim I(0)$) is not rejected in any expenditure category considered here. This result has implications for the hypothesis of the satiation as a general property of EC: there are deviations from satiation across years, but these tend to be on average null across time.

On the other hand, when we examine the proportion of households "beyond" the satiation point a quite different dynamics emerge. Esc_t, as the next section will show, is a non-stationary time series (in particular $\sim I(1)$) for most expenditure categories. In most of the cases, Esc_t tends to increase over time. Thus, although the tendency to satiate is persistent over time, an increasing (in proportion over the population) number of (rich) households allocate their expenditure, on some commodities, beyond the line where average expenditure satiate. There are only two types of household expenditure in which this phenomenon does not occur, namely alcohol and tobacco.

5 Stability and Time Series Analysis

In this section we examine whether the tendency to satiate and to deviate from satiation, along with other relevant variables, display some common dynamics or *co-movements*. To measure EC *stability*, we examine how distant an EC at time t is from the EC at time $t-1$, in the space spanned by total and specific expenditure. In a companion paper (Chai and Moneta 2007) we have found that the ECs for most goods and services taken into consideration (at different level of aggregation) have changed significantly shape and position between 1974 and 2001. Here we investigate whether shifts in position and shape display any co-movements with changes in satiation, deviation from satiation, distribution of consumers, and inflation.

In order to measure shifts in shape and position of EC we use the following average distance:

$$d(t, t-h) = \frac{1}{n}\sum_{i=1}^{n} \hat{m}(x_{(i,t)}) - \hat{m}(x_{(i,t-h)}), \tag{9}$$

where $x_{(i,t)}, \ldots, x_{(n,t)}$ is a number of equidistand points on the x-axis.

Figures 5 and 6 display together 17 different ECs at five different years, together with their average distance (as defined in equation 9). There are several categories of expenditure in which ECs have, for each time interval considered, moved upwards: clothing, household services, leisure goods, and leisure services. Food, motoring, and travel have also showed the tendency to move upwards - although this occurrence is interrupted by the downward movements.

Concerning the average distance divided by the residuals standard deviations (numbers within brackets in each diagram of Figures 5 and 6), we see that the ECs related to household expenditure on housing, fuel, and personal goods & services have remained relatively stable

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[9] This phenomenon compares also when we divide $Dsat$ by the residual standard deviation of the EC (see Tables 4 and 5)

Table 4: Indicators of tendency to deviate from satiation

year	**housing**			**fuel light power**			**food**		
	Dsat	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*
2001	0.4068	0.0761	0.0271	0.1258	0.1130	0.0601	0.5073	0.0697	0.0244
1998	N.S.	N.S.	N.S.	0.0252	0.0215	0.0025	0.2841	0.0447	0.0054
1992	-0.4395	-0.0639	0.0119	0.0067	0.0050	0.0014	0.0476	0.0074	0.0271
1986	-0.0488	-0.0075	0.0079	0.0492	0.0424	0.0323	0.2632	0.0410	0.0078
1980	N.S.	N.S.	N.S.	-0.1033	-0.0779	0.0066	0.1306	0.0234	0.0219
1974	N.S.	N.S.	N.S.	0.1642	0.1073	0.0186	0.0530	0.0085	0.0089

year	**alcoholic drink**			**tobacco**			**clothing-footwear**		
	Dsat	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*
2001	-0.2228	-0.0803	0.0173	-0.0397	-0.0428	0.0501	1.2741	0.0760	0.0130
1998	-0.0367	-0.0149	0.0105	-0.0264	-0.0283	0.0794	N.S.	N.S.	N.S.
1992	N.S.	N.S.	N.S.	-0.1357	-0.1122	0.0222	-1.2118	-0.1191	0.0088
1986	0.2062	0.0710	0.0302	-0.1583	-0.1243	0.0345	0.6097	0.0553	0.0146
1980	0.2787	0.1024	0.0228	-0.0766	-0.0497	0.0263	N.S.	N.S.	N.S.
1974	N.S.	N.S.	N.S.	-0.0108	-0.0069	0.0732	-0.7317	-0.1054	0.0038

year	**household goods**			**household services**			**personal gds & services**		
	Dsat	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*
2001	N.S.	N.S.	N.S.	0.0966	0.0234	0.0019	N.S.	N.S.	N.S.
1996	-0.2971	-0.0351	0.0089	0.0413	0.0146	0.0127	-0.1787	-0.0625	0.0059
1991	N.S.	N.S.	N.S.	0.4997	0.1738	0.0606	0.3211	0.1338	0.0156
1986	0.6637	0.0587	0.0085	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

year	**motoring**			**fares & other travel**		
	Dsat	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*
2001	1.1570	0.0958	0.0587	-0.0064	-0.0022	0.0338
1996	0.5592	0.0514	0.0297	0.2023	0.0853	0.0053
1991	0.0305	0.0017	0.0198	0.1251	0.0582	0.0137
1986	-0.4589	-0.0557	0.0301	0.0908	0.0393	0.0031

year	**leisure goods**			**leisure services**		
	Dsat	*Dsat*/σ	*Esc*	*Dsat*	*Dsat*/σ	*Esc*
2001	0.1850	0.0254	0.0132	N.S.	N.S.	N.S.
1996	0.1669	0.0319	0.0058	N.S.	N.S.	N.S.
1991	-0.1063	-0.0226	0.0037	0.6419	0.0655	0.0201
1986	-0.1425	-0.0457	0.0066	-0.9585	-0.0897	0.0062

Note: N.S. denotes "no satiation"; *Dsat* is the average distance of the estimated EC from the saturation line calculated for all the households richer than x^s; σ is the residual standard deviation (relative to the estimated EC for $x_i \geq x^s$); and *Esc* is the proportion of households which are located "above" and "rightwards" of the point of satiation.

Table 5: Indicators of tendency to deviate from satiation

year	beef			lamb			pork		
	Dsat	$Dsat/\sigma$	*Esc*	*Dsat*	$Dsat/\sigma$	*Esc*	*Dsat*	$Dsat/\sigma$	*Esc*
2001	-0.0245	-0.0434	0.0297	0.0247	0.0614	0.1437	0.0103	0.0268	0.0284
1998	-0.0110	-0.0216	0.0572	0.0344	0.0809	0.0350	0.0334	0.0948	0.2736
1992	-0.2347	-0.3505	0.0021	-0.0489	-0.0889	0.0076	-0.0055	-0.0136	0.0113
1986	0.0222	0.0315	0.0515	0.0191	0.0417	0.0263	-0.0664	-0.1326	0.0057
1980	0.0670	0.0775	0.0229	-0.1127	-0.1499	0.0016	-0.1385	-0.1955	0.0022
1974	-0.1686	-0.1662	0.0045	-0.0016	-0.0026	0.0015	-0.0501	-0.0923	0.0143

year	fish			eggs			milk		
	Dsat	$Dsat/\sigma$	*Esc*	*Dsat*	$Dsat/\sigma$	*Esc*	*Dsat*	$Dsat/\sigma$	*Esc*
2001	0.0563	0.1374	0.1358	N.S.	N.S.	N.S.	0.0032	0.0118	0.0480
1998	-0.0159	-0.0334	0.0094	-0.0229	-0.1630	0.0134	-0.0200	-0.0732	0.0604
1992	N.S.	N.S.	N.S.	0.0069	0.0369	0.0853	-0.0200	-0.0564	0.0444
1986	0.0014	0.0032	0.0321	0.0050	0.0246	0.0239	-0.0014	-0.0032	0.0379
1980	-0.0038	-0.0076	0.0212	0.0012	0.0041	0.0178	0.0130	0.0271	0.0260
1974	0.0181	0.0495	0.0122	-0.0101	-0.0313	0.0390	-0.1195	-0.2002	0.0032

year	drinks			sugar		
	Dsat	$Dsat/\sigma$	*Esc*	*Dsat*	$Dsat/\sigma$	*Esc*
2001	0.0103	0.0428	0.0278	0.0004	0.0077	0.3265
1998	0.0059	0.0232	0.0123	-0.0003	-0.0061	0.1773
1992	-0.0333	-0.1065	0.0034	-0.0022	-0.0416	0.2003
1986	N.S.	N.S.	N.S.	0.0046	0.0631	0.1556
1980	0.0013	0.0048	0.0036	0.0079	0.0841	0.0522
1974	-0.0680	-0.2530	0.0025	0.0112	0.0789	0.0441

Note: N.S. denotes “no satiation”; *Dsat* is the average distance of the estimated EC from the saturation line calculated for all the households richer than x^s; σ is the residual standard deviation (relative to the estimated EC for $x_i \geq x^s$); and *Esc* is the proportion of households which are located “above” and “rightwards” of the point of satiation.

over time. In other expenditure categories, the tendency to move downwards is evident: in alcohol, tobacco, and in several sub-categories of food. In particular, the downward tendency is most evident for eggs, milk, and sugar.

Moving to time series analysis, we examine the time series AD_t, which is constructed by dividing the average distance between ECs relative to two consecutive years for the average standard deviation of the estimation in the two years: $AD_t = d(t, t-1)/\sigma$. The Dickey-Fuller test confirms that AD_t is stationary. This means that these shifts in ECs tend to be quite regular in that they have a stable mean and do not have a tendency to increase or decrease over time. In other words, for most goods an EC shifts every year by the same average amount, so that, for example, the expected distance between EC in 2001 and EC in 2000 is equal to the expected distance between EC in 1975 and 1974.

For each expenditure category, we now proceed to examine the co-movements amongst the variables described in table 6. First, we test whether these nine variables show a unit root. For

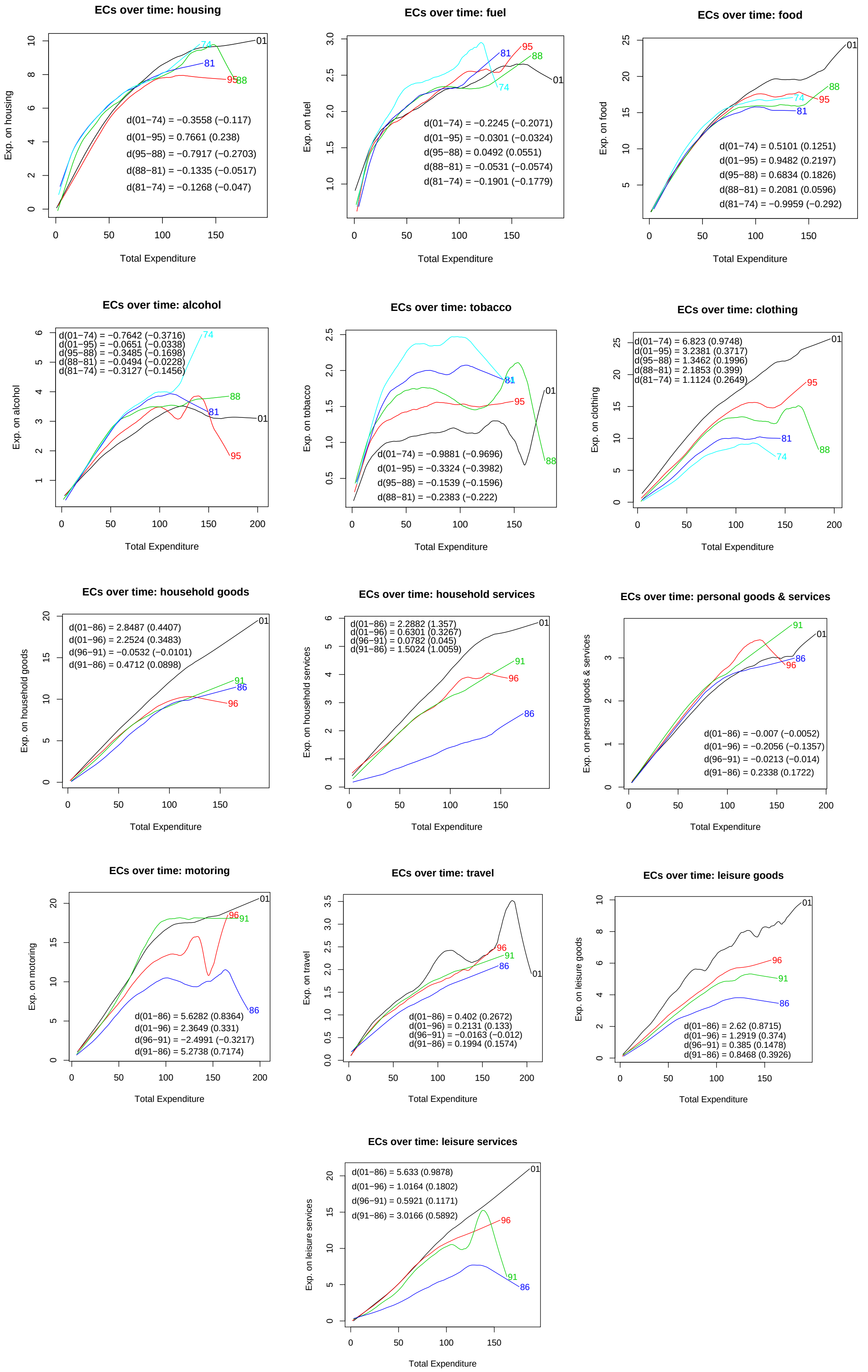

Figure 5: Evolution of ECs over time. The values of total and specific expenditures are measured in pounds deflated to 1974 levels. Legends in each diagram report distances as defined in equation 9, and (within brackets) the same distance divided by the residuals standard deviation (averaged between years).

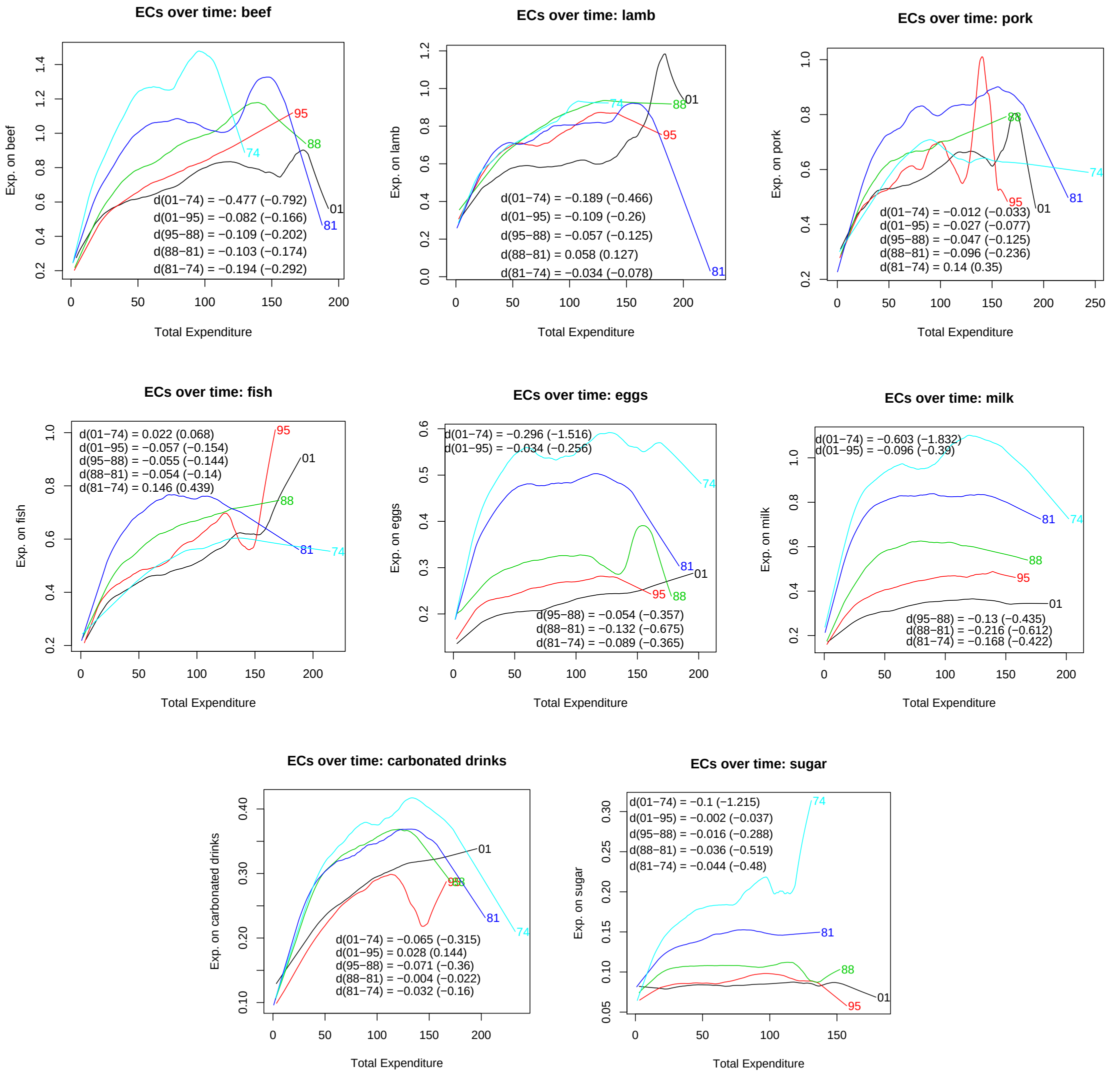

Figure 6: Evolution of ECs over time. The values of total and specific expenditures are measured in pounds 1974. Legends in each diagram report distances as defined in equation 9, and (within brackets) the same distance divided by the residuals standard deviation (averaged between years).

each expenditure category shown in the first column of tables 7 and 8, we run an augmented Dickey-Fuller test on the nine variables. As Tables 7 and 8 show, in most of the expenditure categories, all variables display a unit root (i.e. they are integrated of order one: $\sim I(1)$), except for $Dsat_t$ and AD_t, which are, as already mentioned, integrated of order zero ($\sim I(0)$), i.e. stationary time series. For example, the non-stationary variables that determine the coordinates of the satiation point, $Xsat_t$ and $Ysat_t$, possess a stochastic trend so that at each year they tend to shift rightwards and upwards respectively. However, $Ysat_t$ is $\sim I(0)$ with respect to tobacco and milk expenditure. Esc_t, which measures the deviation from satiation, is $\sim I(0)$ in several subcategories of food (i.e. pork, fish, eggs, and carbonated drinks). Here, the proportion of families which are beyond the satiation point tends to increase over time, as evident in Table 5.

We have tested for the existence of cointegrating relationships, using Johansen's test for cointegration rank (see Johansen 1995), among all possible combinations of the nine variables described in Table 6. Results are displayed in Tables 7 and 8. Concerning those variables that are $\sim I(0)$ (to which the notion of cointegration does not, by definition, apply), we tested whether they are correlated with the first differences of the variables that are $\sim I(1)$. From these results, we draw three conclusions:

1. Price (P_t) plays an important role in influencing other variables in most categories of commodities, and in particular both Sat_t and Esc_t. The only categories in which this is not the case is alcohol and sugar, in which no cointegrating relationships emerge at all.

2. The income distribution, as captured by its moments Mtc_t and Vtc_t, has an important influence on the movements of the point of satiation. As expected, shifts in the mean or variance of total consumption move together with (and probably directly influence) shifts in the satiation point. There are also co-movements between shifts in income distribution and changes in the tendency to satiate, or, even more often, in the tendency to deviate from satiation, as demonstrated by the fact that in many cases $Xsat_t$ and $Ysat_t$ enter in cointegrating relationships with Sat_t or Esc_t. However, this does not occur for all the categories. In particular, Sat_t co-moves with Mtc_t or Vtc_t only in tobacco, beef, lamb, pork and eggs. Co-movements between Mtc_t or Vtc_t and Esc_t emerge, on the other hand, in housing, food, tobacco, clothing, beef, lamb, milk, and carbonated drinks.

3. The measure of stability co-moves often with changes in the mean, as demonstrated by the significative correlations, emerging in many expenditure categories between AD_t and ΔMtc_t. Similar phenomenon emerges between $Dsat_t$ and ΔMtc_t or ΔVtc_t.

6 Conclusions

To summarize, we point out both 'general' and 'specific' features of consumption behaviour that have emerged in the results. The former refers to properties refers to aspects of expenditure patterns that are common across different individuals and consumption activities. Specific features, on the other hand, are aspects of consumption that are unique to specific individuals and consumption activities.

Table 6: Variables used for time series analysis

Variables	Description
Sat_t	proportion of families for which EC is downward sloping (negative EC derivative)
$Xsat_t$	level of total consumption (on the X axis) at which the EC derivative starts to be negative (satiation point)
$Ysat_t$	level of specific consumption (on the Y axis) at which the EC derivative starts to be negative (satiation point)
Esc_t	proportion of families which have a level of total consumption (X) and specific consumption (Y) greater than the satiation point
$Dsat_t$	average distance of EC from the horizontal line $y = y^s$ for values of X grater than x^s, where (x^s, y^s) is the satiation point.
P_t	price index
Mtc_t	per capita (average) total consumption
Vtc_t	variance of total consumption
AD_t	average distance among EC (divided by standard error of EC estimation): $d(t, t-1)/\sigma$.

Satiation emerges as general feature of ECs. This means that different consumers, in different years, and engaged in different consumption activities share a common tendency: as income rises, the tendency to persist in the same consumption activity slows down until it reaches a level of satiation. The point (in the space spanned by total and specific expenditure) in which satiation tends to occur is a specific feature, depending on the kind of consumption activity in which an individual is engaged and on past expenditure patterns. We showed, through cointegration analysis, that the point of satiation is further determined by the income distribution across household population, in particular by its first two moments.

A second general feature is the rate of change in consumption patterns over time, as shown by the shifts in shape of position of ECs. Given any group of commodities, ECs shift by the same average magnitude each year. However, across commodities, shifts are quite heterogeneous, in some categories of expenditure one should expect to experience more intense movements than in others.

The tendency to deviate from satiation is also a general property, in the sense that it emerges for different categories of commodities and in different years, but its nature is much more specific than the tendency to satiate. In some years and for some commodities, for example, it does not emerge at all. Whereas satiation seems to characterize the consumers as possessing homogenous physiological traits, deviation from satiation is a property of consumers as engaged in an evolving society where learning and discovery plays a major role in determining expenditure patterns. This activity of learning and discovery is contemporaneously pursued by the supply side (firm and industries), perhaps as a result of a need to escape the satiation tendency which is evident in household expenditure patterns.

In sum, these results strongly support the notion that economies undergo periodic structural change as they grow and the consumption patterns of households evolve. At the same

Table 7: Results of time series analysis (aggregate categories)

Housing	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Xsat_t, P_t >$; $< Esc_t,\ P_t >$; $< Xsat_t,\ Mtc_t >$; $< Esc_t,\ Mtc_t >$; $< Xsat_t,\ Vtc_t >$; $< Ysat_t, P_t, Mtc_t >$; $< Esc_t, P_t, Mtc_t >$; $< Ysat_t, P_t, Vtc_t >$
	Correlation	$corr(\Delta Mtc_t, AD_t) = 0.3830$; $corr(\Delta Vtc_t, AD_t) = 0.4182$
Fuel	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Ysat_t, Mtc_t >$; $< Ysat_t, Vtc_t >$; $< Ysat_t, P_t, Vtc_t >$
Food	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Sat_t, P_t >$; $< Xsat_t, P_t >$; $< Esc_t, P_t >$; $< Esc_t, P_t, Vtc_t >$
Alcohol	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Dsat_t, AD_t \sim I(0)$
	Cointegration	no cointegrating relationships
	Correlation	$corr(Dsat_t, \Delta Mtc_t) = -0.3885$;
Tobacco	Unit roots	$Sat_t, Xsat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Ysat_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Xsat_t, P_t >$; $< Esc_t, P_t >$; $< Sat_t, Vtc_t >$; $< Esc_t, Vtc_t >$; $< Sat_t,\ P_t,\ Mtc_t, Vtc_t >$.
	Correlation	$corr(Ysat_t, \Delta P_t) = -0.7272$
Clothing	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1)$; $Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Sat_t, P_t >$; $< Ysat_t, Mtc_t >$; $< Ysat_t, P_t, Mtc_t >$; $< Esc_t, P_t, Mtc_t >$

Note: For each expenditure category (first column), the cell rights of "Unit roots" shows the variables (among those described in Table 6) for which the Augmented Dickey Fuller test rejects the null hypothesis of no unit root (indicated as $\sim I(1)$) and the variables (indicated as $\sim I(0)$) for which the same test does not reject the same null hypothesis. The cell right of "Cointegration" shows the n-uples of variables, among those that have a unit root, for which the Johansen trace test does not reject the presence of a cointegrating relationship. The cell rights of "Correlation", when present, shows the couples of variables, between one of the variables that are $\sim I(0)$ and a first difference of one of the variables that are $\sim I(1)$, for which the hypothesis of zero correlation is rejected. All tests are conducted here at the 0.05 level of significance.

Table 8: Results of time series analysis (some sub-categories of food)

Beef	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Ysat_t, Mtc_t >; < Esc_t, Mtc_t >; < Sat_t, Vtc_t >; < Esc_t, Vtc_t >; < Xsat_t, P_t >; < Ysat_t, P_t >; < Esc_t, P_t >; < Ysat_t, P_t, Mtc_t >; < Sat_t, P_t, Vtc_t >; < Ysat_t, P_t, Vtc_t >$
	Correlation	$corr(Dsat_t, \Delta Vtc_t) = -0.4842$
Lamb	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Ysat_t, P_t >; < P_t, Vtc_t >; < Sat_t, P_t, Mtc_t >; < Ysat_t, P_t, Mtc_t >; < Sat_t, P_t, Vtc_t >; < Esc_t, P_t, Vtc_t >; < Esc_t, P_t, Mtc_t, Vtc_t >$
	Correlation	$corr(Dsat_t, \Delta Mtc_t) = -0.3964$
Pork	Unit roots	$Sat_t, Xsat_t, Ysat_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Esc_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Sat_t, P_t >; < Sat_t, Mtc_t >; < Sat_t, Vtc_t >; < Xsat_t, Mtc_t >; < Xsat_t, Vtc_t >; < Sat_t, P_t, Mtc_t >; < Sat_t, P_t, Vtc_t >; < Xsat_t, P_t, Vtc_t >; < Sat_t, P_t, Mtc_t, Mtc_t >$
	Correlation	$corr(Esc_t, \Delta P_t) = -0.5020$
Fish	Unit roots	$Sat_t, Xsat_t, Ysat_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Esc_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Ysat_t, Mtc_t >; < P_t, Vtc_t >$
	Correlation	$corr(AD_t, \Delta Mtc_t) = -0.6040$
Eggs	Unit roots	$Sat_t, Xsat_t, Ysat_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Esc_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Sat_t, P_t >; < Sat_t, Mtc_t >; < Sat_t, Vtc_t >; < Xsat_t, P_t >; < Xsat_t, Mtc_t >; < Xsat_t, Vtc_t >; < Ysat_t, Mtc_t >; < Ysat_t, Vtc_t >; < P_t, Mtc_t >; < P_t, Vtc_t >; < Sat_t, P_t, Mtc_t >; < Sat_t, P_t, Vtc_t >; < Xsat_t, P_t, Mtc_t >; < Xsat_t, P_t, Vtc_t >; < Ysat_t, P_t, Mtc_t >; < Ysat_t, P_t, Vtc_t >; < P_t, Mtc_t, Vtc_t >; < Sat_t, P_t, Mtc_t, Vtc_t >$
	Correlation	$corr(AD_t, \Delta Mtc_t) = -0.5609$
Milk	Unit roots	$Sat_t, Xsat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Ysat_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< P_t, Vtc_t >; < Esc_t, P_t, Vtc_t >; < Xsat_t, P_t, Vtc_t >$
	Correlation	$corr(Ysat_t, \Delta Vtc_t) = -0.4259;\ corr(Dsat_t, \Delta Vtc_t) = 0.4229;\ corr(AD_t, \Delta Vtc_t) = -0.4284$
C. drinks	Unit roots	$Xsat_t, Ysat_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Sat_t, Esc_t, Dsat_t, AD_t \sim I(0)$
	Cointegration	$< Xsat_t, P_t >; < Xsat_t, Mtc_t >; < Xsat_t, Vtc_t >; < Xsat_t, P_tMtc_t >; < Xsat_t, P_t Vtc_t >$
	Correlation	$corr(Esc_t, \Delta Mtc_t) = 0.5378;\ corr(Dsat_t, \Delta Mtc_t) = 0.7544;\ corr(AD_t, \Delta Mtc_t) = 0.5975$
Sugar	Unit roots	$Sat_t, Xsat_t, Ysat_t, Esc_t, P_t, Mtc_t, Vtc_t \sim I(1);\ Dsat_t, AD_t \sim I(0)$
	Cointegration	no cointegrating relationships

See note at the bottom of Table 7.

time, any model of such structural change that makes projections about the growth rate of sectoral demand should not only be based on cross sectional ECs, but also need to take into account how the ECs themselves tend to change over time. Such extra information improves our understanding of the theoretical link between evolving consumption patterns and structural economic change.

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