MODELLING UK HOUSEHOLD EXPENDITURE: ECONOMIC VERSUS NON-ECONOMIC DRIVERS

by

Mona Chitnis and Lester C. Hunt

RESOLVE Working Paper 07-09

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Abstract

This paper attempts to quantify the contributions of economic and non-economic factors to driving consumer expenditure for 12 categories of goods and services (COICOP) by applying the Structural Time Series Model (STSM), using UK quarterly time series data for the period of 1964:q1-2006:q1. This approach allows for a stochastic trend and stochastic seasonals (non-economic factors) which might affect household expenditure demand in addition to income and price (economic factors). The results suggest that the contribution of the exogenous non-economic factors on household expenditure is generally higher for 'housing, water, electricity, gas and other fuels', 'health', 'communication' and 'education'. Therefore, non-economic factors have an important role to play. Hence the message for policy makers is that in addition to an economic incentive such as taxes which might be needed if they wish to restrain future expenditure, other policies that attempt to influence lifestyles might also be considered.

Key Words: Household demand, Household expenditure, Structural Time Series Model, Underlying trend, Exogenous non-economic factors

1. Introduction

UK total real household expenditure (at 2003 prices) has increased about three fold from £59046m in 1964:q1 to £174884m in 2006:q1. This emphasizes the need for a better and clearer understanding of household expenditure structure in order to achieve future 'sustainable consumption'. To do this there is arguably a need to quantify, not only the key economic drivers of income and price, but also non-economic factors such as technical progress, consumer taste and preferences, socio-demographic and geographic factors, lifestyle and value changes. Previous econometric work on demand has tended to concentrate only on the economic factors whereas a separate strand of the energy economics literature has focused on the non-economic factors, but there has not been an attempt, as far as is known, to bring these together and try to quantify their relative contributions to driving consumer expenditure. This is therefore the main aim of this paper.

This is achieved by using the Structural Time Series Model (STSM) since it allows for the examination of the relationship between household expenditure, income and prices ***and*** a stochastic underlying trend. The trend captures the systematic non-price and income effects discussed above that are not easily measured, and therefore difficult to obtain any suitable data. In other words, the trend shows the average effect of other (non-price and non-income) variables affecting expenditure.

In this paper, the STSM is therefore employed to estimate UK household expenditure functions for 12 categories of goods and services using quarterly time series data for the period of 1964:q1-2006:q1. Hence, the effect of price, income and trend (other variables) on household demand for each of these 12 categories are estimated and compared in order to determine the main drivers of demand in each group of goods and services. The 12 categories which are used for demand estimation are based on COICOP (Classification of Individual COnsumption by Purpose) headings. COICOP is an internationally agreed classification system for consumer expenditure[1]. It splits total household final consumption expenditure into 12 divisions by purpose as follows:

- Food and non-alcoholic beverages
- Alcoholic beverages, tobacco and narcotics
- Clothing and footwear
- Housing, water, electricity, gas and other fuels
- Furnishings; household equipment and routine maintenance of the house
- Health
- Transport

- Communication
- Recreation and culture
- Education
- Restaurants and hotels
- Miscellaneous goods and services

There have been a number of previous attempts to model UK household demand and expenditure for different categories of goods and services. A selection of these is presented in Table 1. There are only a few studies that have attempted to estimate demand or expenditure functions for all 12 COICOP headings separately. Attfield (2005) applies the AIDS[2] functional form to estimate UK household expenditure functions for each of the 12 COICOP definitions using quarterly data from 1973:q2 to 2003:q2. Although, demographic and income distribution indices are constructed and added to the AIDS model by Attfield (2005) other non-economic factors are not captured. In addition, 'education' demand is omitted from the analysis. Lula and Antille (2007) analysed Swiss consumption data for 12 COICOP headings from 1980 to 2005, although they aggregated some of the categories to give eight estimated functions by applying the LES[3], AIDS and PADS[4] functional forms. The deterministic trend is included in the LES functions but not in the other functional forms. Selvanathan and Selvanathan (2004) aggregated some of the 12 categories and estimated AIDS and CBS[5] functional forms for eight groups using annual time series data from 1960 to 1995 for South Africa. There is no trend or other non-economic components included in their models.

Other studies in Table 1 estimated household expenditure demand mostly as a single equation or sometimes together with some other categories but not necessarily have with data according to COICOP definitions. The data set used in these other studies include various forms i.e. annual/quarterly time series, panel or cross-section. Almost none of the studies have attempted to use a component to capture non-economic factors in the model by using a stochastic trend; the exceptions being Moosa and Baxter (2002), Duffy (2006) and Hunt et al (2003) who estimate UK alcoholic beverages, UK tobacco and UK energy (housing and transportation) demand for households using STSM respectively.

Table 1. Selected studies on household demand for different goods and services

Study	Sector[1]	Region	Functional Form	Data	Trend
Selvanathan, Selvanathan (2006)	'Food', 'Tobacco', 'Soft drinks', 'Alcohol'	43 developed & developing countries	Rotterdam model under preference independence	Annual (different for each country)	Not included
Attfield (2005)	All COICOP categories except 'education'	UK	AIDS	Quarterly time series 1973:q2-2003:q2	Not included
Lula, Antille, (2007)	'Food, beverage and tobacco', 'Clothing and footwear', 'Housing, water, electricity and gas', 'Furnishing, and household equipment', 'Health', 'Transport and communication', 'Leisure, culture and education', 'Other goods and services'	Switzerland	LES, AIDS, PADS	1980-2005	Included in LES only, Deterministic.
Duffy (2006)	'Tobacco'	UK	Rational addiction model	Time series Quarterly 1964:2-2002:3	Included, Stochastic
Lanfranco, Ames, Huang (2002)	'Food'	US Hispanic	Semilogarithmic	Cross-section 1994-1996	Not included
Hunt, Judge, Ninomiya, (2003)	'Energy'	UK	STSM' cointegration	Quarterly time series 1971:q1-1997:q4	Included, Stochastic
Duffy (2003)	'Food', 'Drink', 'Tobacco'	UK	Advertising-Augmented AIDS	Time series Quarterly 1963:1-1996:1	Not included
Xiao, Kinnucan, Kaiser (1999)	'Non-alcoholic beverage'	US	two-stage Rotterdam model logarithmic first-difference	Time series Annual 1970-1994	Included as an intercept.
Williams (2005)	'Alcohol'	US	Structural and reduced form	Survey 1997, 1999	Not included
Moosa, Baxter (2002)	'Alcoholic beverages'	UK	AIDS	Time series Quarterly 1964:1-1995:1	Included, Stochastic
Eakins, Gallagher (2003)	'Alcohol'	Ireland	Dynamic AIDS	Time series Annual 1960-1998	Not included
Jones, Labeaga (2003)	'Tobacco'	Spain	Rational addiction model	Panel Household survey 1986;3-1994:4	Not included

Table 1 (continued). Selected studies on household demand for different goods and services

Study	Sector[1]	Region	Functional Form	Data	Trend
Wagner, Mokhtari (2000)	'Clothing and footwear'	US	Double-logarithmic	Micro panel data Quarterly Households survey 1990-1991	Not included
Selvanathan, Selvanathan (2004)	'Food', 'Clothing', 'Housing', 'Furniture', 'Medical care', 'Transport', 'Recreation', 'Miscellaneous'	South Africa	CBS, AIDS	Time series Annual 1960-1995	Not included
Khaled, Lattimore (2006)	'Clothing and footwear', 'Housing', 'Household operation', 'Transport', 'Other goods and services'	New Zealand	Rotterdam	Time series Annual 1981-2004	Included as intercept
Karagiannis, Velentzas (2004)	'Food, beverages and tobacco', 'Clothing and footwear', 'Settling and housing', 'Others'	Greece	Quadratic AIDS (habit persistence version)	Time series Annual 1950-1993	Not included
Gaudin (2006)	'Water'	USA	Log - log	cross-section 1995	Not included
Mazzanti, Montini (2005)	'Water'	Italy	Log-linear	Annual Panel data 1998-2001	Not included
Jochmann, Leon-Gonzalez (2004)	'Health Care'	Germany	-	Annual Panel data 1997-2001	Not included
Creel, Farell (2005)	'Medical care services'	USA	-	Annual Household panel survey 1996-2000	Not included
Mocan, Tekin, Zax (2003)	'Medical care'	China	-	cross-section household survey 1989	Not included
Dargay, Vythoulkas (1998)	'Transport'	UK	Dynamic	Annual Pseudo-panel (cohorot) Household survey 1983-1993	Not included
Tych, Pedregal, Young, Davies (2002)	'Telephone call'	UK	Logarithmic	1998-1999 (not much clear)	Included, Stochastic

Table 1 (continued). Selected studies on household demand for different goods and services

Study	Sector[1]	Region	Functional Form	Data	Trend
Huh, Kim, Kim (2002)	'Telephone access'	Korea	Asymmetric GEV model	Survey 1998	Not included
Hailu, Boxall, McFarlane (2005)	'Recreation'	Canada	SEM	Survey 1996, 1997	Not included
Chen, Hong, Liu, Zhang, Hou, Raymaond (2004)	'Recreation'	China	Travel cost	On-site survey of visitors (semi-interview) Summer1999	Not included
Cameron, Worswick (2001)	'Education'	Indonesia	-	Household survey 1993	Not included
Canton, Jong (2005)	'Higher education'	Netherlands	ECM , SUR Log-log	Time series Annual 1950-1999	Not included
Showers, Shotick (1994)	'Total insurance'	US	-	Household survey Quarterly 1987	Not included

1 Note the categories in this column are not necessarily according to the COICOP category definitions used for the estimation in this paper.

The next section of this paper, introduces the empirical methodology that is used to estimate household expenditure functions. The data description and estimation results are given in section III with a summary and conclusion in section IV.

2. Estimation method

To estimate the household expenditure functions for 12 COICOP categories, the Structural Time Series Model (STSM) is applied (see Harvey 1989). This allows for the estimation of a stochastic, rather than a deterministic, underlying trend that arguably is important when estimating the elasticities of demand as discussed by Hunt and Ninomiya (2003). In addition to technological advance, the underlying trends could be strongly affected by changes in tastes, consumer preferences, socio-demographic and geographic factors which are not easily measured, and therefore difficult to obtain any suitable data. Also, the STSM allows for stochastic or evolving seasonals over the estimation period. Therefore, deterministic seasonal dummies which are normally used when using quarterly data are encompassed within the stochastic seasonals and could be admissible if they are statistically accepted by the data. Hence the stochastic trend and stochastic seasonality are included in the following long-run expenditure model:

$$exp_t = \mu_t + \lambda_t + \pi p_t + \tau y_t + \upsilon_t \qquad \upsilon_t \sim NID(0,\sigma_\upsilon^2) \qquad \textbf{(1)}$$

where $\exp_t$ is the households expenditure for each category of COICOP 12, μ_t represents the trend component, λ_t represents the seasonal component, p_t is the real price of each category of COICOP 12, y_t is the real households disposable income, π and τ are unknown parameters and υ_t is a random white noise disturbance term. All variables are in natural logarithm.

The trend component μ_t is assumed to have the following stochastic process:

$$\mu_t = \mu_{t-1} + \rho_{t-1} + \eta_t \qquad \eta_t \sim NID(0,\sigma_\eta^2) \qquad \textbf{(2)}$$

$$\rho_t = \rho_{t-1} + \xi_t \qquad \xi_t \sim NID(0,\sigma_\xi^2) \qquad \textbf{(3)}$$

The trend includes a level Equation (2) and a slope which is ρ Equation (3). η_t and ξ_t are random white noise disturbance terms. The nature of the trend depends on the variances σ_η^2 and σ_ξ^2, known as hyperparameters. In practice, to evaluate the estimated models, the equation residuals (similar to ordinary regression residuals) and a set of auxiliary residuals are estimated. The auxiliary residuals include smoothed residuals of the error terms for Equation (1), (2) and (3) (known as the irregular, level and slope residuals respectively).

At the extreme, if σ_η^2 and σ_ξ^2 are equal to zero, the model will collapse to the model with a conventional deterministic linear trend model as follow:

$$exp_t = a + \lambda_t + bt + \pi p_t + \tau y_t + \upsilon_t \qquad \textbf{(4)}$$

The seasonal component λ_t has the following stochastic process:

$$S(L)\lambda_t = \omega_t \qquad \textbf{(5)}$$

where $\omega_t \sim NID(0,\sigma_\omega^2)$, S(L) = 1 + L + L^2 + L^3 and L = the lag operator. The conventional case is a restricted version of this when $\sigma_\omega^2 = 0$, with λ_t, reducing to the familiar deterministic seasonal dummy variable model.

The Maximum Likelihood (ML) procedure in conjunction with the Kalman filter is used to estimate the following Autoregressive Distributed Lag (ARDL) form of

Equation (1), starting with lags of eight quarters of the expenditure, price and income variables, using the software STAMP 6.3 (Koopmans, et al., 2000);

$$A(L)exp_t = \mu_t + \lambda_t + B(L)p_t + C(L)y_t + \upsilon_t \quad \textbf{(6)}$$

where $A(L)$, $B(L)$ and $C(L)$ are polynomial lag operators equal to $1-\alpha_1 L-\alpha_2 L^2 - ... - \alpha_8 L^8$, $1+\beta_1 L+\beta_2 L^2 + ... + \beta_8 L^8$ and $1+\gamma_1 L+\gamma_2 L^2 + ... + \gamma_8 L^8$ respectively. $B(L)/A(L)$ and $C(L)/A(L)$ represent the long-run price and income elasticities respectively. Other variables and parameters are as defined above. This general function is considered initially and the preferred model found by testing down from the over parameterised ARDL model subject to a battery of diagnostic tests.[6]

The following equation presents the estimated version of Equation (6):

$$exp_t = \hat{\mu}_t + \hat{\lambda}_t + \hat{B}(L)p_t + \hat{C}(L)y_t + \hat{A}'(L)exp_t + \hat{\upsilon}_t \quad \textbf{(7)}$$

where $\hat{A}'(L) = \hat{\alpha}_1 L - \hat{\alpha}_2 L^2 - ... - \hat{\alpha}_8 L^8$. To estimate the contribution of the trend, seasonality, price and income to demand, $\hat{A}'(L)\exp_t$ for lags of demand is replaced by Equation (7) until the coefficient of lagged expenditure which appears in right hand side of the equation after replacements approaches zero, so ignorable:

$$exp_t = D'(L)\hat{\mu}_t + E'(L)\hat{\lambda}_t + \hat{B}'(L)p_t + \hat{C}'(L)y_t + F'(L)\hat{\upsilon}_t \quad \textbf{(8)}$$

where $D'(L) = 1+\delta_1' L + ... + \delta_n' L^n$, $E'(L) = 1+\varepsilon_1' L + ... + \varepsilon_n' L^n$, $\hat{B}'(L)=1+\beta_1' L+...+\beta_n' L^n$, $\hat{C}'(L)=1+\gamma_1' L+...+\gamma_n' L^n$ and $F'(L) = 1+\zeta_1' L + ... + \zeta_n' L^n$. The annual change of Equation (8) is then constructed as follows:

$$\begin{aligned} exp_t - exp_{t-4} &= D'(L)(\hat{\mu}_t - \hat{\mu}_{t-4}) + E'(L)(\hat{\lambda}_t - \hat{\lambda}_{t-4}) + \hat{B}'(L)(p_t - p_{t-4}) \\ &\quad + \hat{C}'(L)(y_t - y_{t-4}) + F'(\hat{L})(\hat{\upsilon}_t - \hat{\upsilon}_{t-4}) \end{aligned} \quad \textbf{(9)}$$

where $D'(L)(\hat{\mu}_t - \hat{\mu}_{t-4})$, $E'(L)(\hat{\lambda}_t - \hat{\lambda}_{t-4})$, $\hat{B}'(L)(p_t - p_{t-4})$, $\hat{C}'(L)(y_t - y_{t-4})$, $F'(\hat{L})(\hat{\upsilon}_t - \hat{\upsilon}_{t-4})$ are contributions of trend, seasonality, price, income and residuals respectively to the changes in expenditure.[7]

As mentioned in the introduction, an attempt is made to quantify the contributions of the economic drivers (income and price) and exogenous non-economic factors (hereafter ExNEF for short) for household expenditure.[8] Indeed, what is called ExNEF here will incorporate all the issues related to annual change in the underlying expenditure trend[9] explained earlier in this section. Therefore, $D'(L)(\hat{\mu}_t - \hat{\mu}_{t-4})$, $E'(L)(\hat{\lambda}_t - \hat{\lambda}_{t-4})$, $\hat{B}'(L)(p_t - p_{t-4})$ and $\hat{C}'(L)(y_t - y_{t-4})$ are the contributions of ExNEF, seasonality, price and income respectively to annual changes in expenditure $\exp_t - \exp_{t-4}$.

3. Data and Estimation Results

Data

The initial general ARDL demand relationships as outlined above are estimated for the UK using quarterly time series data over the period 1964:q1 to 2006:q1. Data for household expenditure, household real disposable income and real prices (implied deflators) are collected from the UK Office for National Statistics (ONS) online database.[10] All data are ***not*** seasonally adjusted and in terms of chained volume measures (reference year 2003). Real household disposable income data, which are used, include non-profit institutions serving households (NPISH) expenditures. There is no separate time series data for household disposable income in national statistics. Implied deflators for each COICOP category are deflated by total implied deflator to produce relative prices for the same category.

Results

The models are estimated for the UK household expenditure for each of COICOP 12 categories of goods and services separately, using data from 1966q1 to 2004:q1; saving 2 years (eight observations) for post sample prediction tests. By testing down from Equation (6) with a two year lag (eight quarters) a suitable restricted model for each category of COICOP 12 expenditure is selected by eliminating statistically insignificant variables in order to determine the number of lags, included variables and the nature of the trend, but ensuring a range of diagnostics tests are passed. The preferred models for each category are shown in Tables 2a, 2b and 2c. Furthermore, three charts relating to each preferred model are presented representing: a) the underlying expenditure trend, b) seasonality, and c) the contributions of price, income, ExNEF and seasonality.[11]

Table 2a: Estimated STSM expenditure functions for the UK 1964q1-2004q1

Dependent variable: expenditure (in logs) - exp				
Independent Variables / **Category**	**'food and non-alcoholic beverages'**	**'alcoholic beverages, tobacco and narcotics'**	**'clothing and footwear'**	**'housing, water, electricity, gas and other fuels'**
y	0.20 (2.90)	0.35 (4.22)	0.34 (3.78)	0.05 (0.88)
y(-1)	-	-	0.20 (2.27)	-
p	-0.49 (-4.41)	-0.49 (-6.14)	-	-0.09 (-1.29)
p(-1)	-	-	-	-
p(-2)	0.24 (2.13)	-	-	-
p(-6)	-	-	-0.71 (-4.64)	-
exp(-1)	-	-	-	0.15 (2.32)
exp(-4)	-	-	0.19 (2.92)	-
exp(-6)	-	-	-	-
Long run Elasticities				
Price	-0.25	-0.49	-0.88	-0.11
Income	0.20	0.35	0.67	0.06
Estimated Variance of Hyperparameters				
Irr (10^{-5})	14.09	0	4.70	$5.62*10^{-1}$
Lvl(10^{-5})	4.47	12.63	18.69	3.02
Slp(10^{-5})	-	-	-	-
Sea(10^{-5})	$9.93*10^{-1}$	6	1.91	6.43
Trend				
Nature of Trend	Local level with drift	Local level with drift (Irr for 1994.4 included)	Local level with drift (Irr for 1973.1, 1979.1 included)	Local level with drift (Irr for 1979.1, 1987.4, 1989.1, 1990.1 included)
Growth rate at end of period (% p.a.)	0.32	-0.65	-0.13	1.37
Diagnostics				
Equation Residuals				
Std. Error	0.02	0.02	0.02	0.01
Normality	0.48	1.38	1.33	3.33
H(n)	H(51)=2.02	H(52)=0.94	H(50)=0.84	H(51)=0.36
$r_{(1)}$	0.05	0.06	0.01	0.0005
$r_{(4)}$	-0.01	0.08	0.01	-0.03
$r_{(8)}$	-0.05	-0.12	0.004	-0.0002
D.W.	1.86	1.86	1.94	1.92
$Q_{(8,n)}$	$Q_{(8,5)}$=5.28	$Q_{(8,5)}$=10.44	$Q_{(8,5)}$=5.66	$Q_{(8,5)}$=6.82
Rs^2	0.47	0.70	0.58	0.75
Auxiliary Residuals				
Irregular Normality	0.18	4.82	0.50	4.87
Level Normality	0.66	1.44	2.10	0.10
Slope Normality	-	-	-	-
Predictive Failure Tests (2004q2-2006q1)				
$\chi^2_{(8)}$	4.57	2.50	4.69	2.01
Cusum $t_{(8)}$	0.79	-0.92	0.01	-0.50
Likelihood Ratio Tests				
Test (a)	122.75	211.38	102.18	37.92
Test (b)	-	-	-	-
Test (c)	23.09	141.98	24.13	133.08

Notes for Table 2a:

exp, y and p represent expenditure, income and the real price of each category (all in logs). Irr represent intervention dummies.

t-statistics are given in parenthesis.

The restrictions imposed for the LR test are: a) fixed level, b) fixed slope, c) fixed seasonal.

Normality is the Bowman-Shenton and Doornik-Hansen statistics approximately distributed as $X^2_{(2)}$.

Skewness and Kurtosis statistics are approximately distributed as $X^2_{(1)}$.

H(n) is the test for heteroscedasticity, approximately distributed as $F_{(n,n)}$.

$r_{(1)}$, $r_{(4)}$ and $r_{(8)}$ are the serial correlation coefficients at the 1st, 4th and 8th lags respectively, approximately distributed at N(0,1/T).

DW is the Durbin Watson statistic.

$Q_{(8,n)}$ is the Box-Ljung Q-statistic based on the first n residuals autocorrelation; distributed as $X^2_{(n)}$.

R^2 is the coefficient of determination.

$X^2_{(8)}$ is the post-sample predictive failure test. The *Cusum t* is the test of parameter consistency, approximately distributed as the t-distribution.

5% probability level is considered for significance.

Following Harvey and Koopman (1992), where necessary, appropriate dummies are included in the models for outliers and structural breaks.

Table 2b: Estimated STSM expenditure functions for the UK 1964q1-2004q1

Dependent variable: expenditure (in logs) - exp				
Independent Variables / **Category**	**'furnishings, household equipment and routine maintenance of the house'**	**'health'**	**'transport'**	**'communication'**
y	0.67 (6.18)	0.08 (0.59)	-	-
y(-1)	-	-	0.67 (4.42)	0.12 (2.02))
p	-0.79 (-3.54)	-0.16 (-1.01)	-0.97 (-4.15)	-0.13 (-3.48)
p(-1)	-	-	0.80 (3.59)	-
p(-2)	-	-	-	-
p(-6)	-	-	-	-
exp(-1)	0.19 (3.24)	-	-	-
exp(-4)	-	-	-	0.29 (5.31)
exp(-6)	-	0.18 (2.29)	-	-
Long run Elasticities				
Price	-0.98	-0.20	-0.17	-0.18
Income	0.83	0.10	0.67	0.17
Estimated Variance of Hyperparameters				
Irr (10^{-5})	2.30	17.78	8.34	5.50
Lvl(10^{-5})	19.96	29.80	42.55	29.21
Slp(10^{-5})	-	-	-	-
Sea(10^{-5})	9.98	4.61	15.00	-
Trend				
Nature of Trend	Local level with drift (Irr 1968.1, 1973.1, 1973.2, 1979.2 included)	Local level with drift	Local level with drift (Irr 1968.1, 1974.1, 1979.2 included)	Local level with drift (Irr 1971.1, 1982.4, 1986.2 included)
Growth rate at end of period (% p.a.)	-0.14	1.98	1.56	3.98
Diagnostics				
Equation Residuals				
Std. Error	0.03	0.03	0.04	0.02
Normality	1.75	3.02	5.39	2.81
H(n)	H(51)=0.71	H(50)=0.62	H(51)=0.37	H(51)=0.98
$r_{(1)}$	0.02	0.02	0.01	0.02
$r_{(4)}$	0.07	0.05	0.07	0.06
$r_{(8)}$	-0.03	-0.01	0.01	-0.05
D.W.	1.94	1.97	1.97	1.94
$Q_{(8,n)}$	$Q_{(8,5)}$=5.82	$Q_{(8,5)}$=2.49	$Q_{(8,5)}$=5.55	$Q_{(8,6)}$= 3.57
Rs^2	0.63	0.59	0.71	0.58
Auxiliary Residuals				
Irregular Normality	4.10	0.05	3.05	0.71
Level Normality	4.80	1.17	2.01	1.63
Slope Normality	-	-	-	-
Predictive Failure Tests (2004q2-2006q1)				
$\chi^2_{(8)}$	14.46	3.36	1.53	8.25
Cusum $t_{(8)}$	-1.00	-0.38	-0.55	-1.20
Likelihood Ratio Tests				
Test (a)	67.64	160.10	211.89	170.22
Test (b)	-	-	-	-
Test (c)	95.01	61.60	104.66	-

Notes for Table 2b: see notes to Table 2a.

Table 2c: Estimated STSM expenditure functions for the UK 1964q1-2004q1

Dependent variable: expenditure (in logs) - exp				
Independent Variables \ Category	'recreation and culture'	'education'	'restaurants and hotels'	'miscellaneous goods and services'
y	0.27	-0.12	0.34	0.37
	(3.17)	(-2.28)	(3.48)	(4.40)
y(-1)	0.19	-	0.28	-
	(2.20)		(2.78)	
p	-0.51	-0.45	-0.71	-0.69
	(-2.81)	(-7.63)	(-4.17)	(-3.24)
p(-1)	-	0.37	-	-
		(5.78)		
p(-2)	-	-	-	-
p(-6)	0.45	-	-	0.46
	(2.61)			(2.28)
exp(-1)	0.25	0.74	0.22	0.25
	(3.45)	(13.74)	(3.08)	(4.49)
exp(-4)	-	-	-	-
exp(-6)	-	-	-	-
Long run Elasticities				
Price	-0.24	-0.11	-0.91	-0.23
Income	1.84	-0.16	0.79	0.49
Estimated Variance of Hyperparameters				
Irr (10^{-5})	2.72	9.37	4.69	11.40
Lvl(10^{-5})	13.74	11.67	17.87	-
Slp(10^{-5})	-	-	-	1.39
Sea(10^{-5})	3.42	-	5.44	2.14
Trend				
Nature of Trend	Local level with drift (Irr 1990.1 included)	Local level with drift (Irr 1970.4, 1971.2, 1972.1 included)	Local level with drift (Irr 1993.1 included)	Smooth trend (Irr 1986.1, 1987.4, 1990.1 included)
Growth rate at end of period (% p.a.)	2.85	1.14	0.63	-0.73
DIAGNOSTICS				
Equation Residuals				
Std. Error	0.02	0.02	0.02	0.02
Normality	4.73	5.72	4.48	2.41
H(n)	H(50)=1.09	H(52)=0.88	H(51)=0.89	H(50)=1.49
$r_{(1)}$	0.03	-0.007	-0.004	-0.01
$r_{(4)}$	0.10	0.006	0.01	0.03
$r_{(8)}$	-0.11	0.04	-0.04	-0.16
D.W.	1.92	1.99	2.00	2.02
$Q_{(8,n)}$	$Q_{(8,5)}$=15.85	$Q_{(8,6)}$=1.69	$Q_{(8,5)}$=5.05	$Q_{(8,5)}$= 5.46
Rs^2	0.56	0.57	0.61	0.64
Auxiliary Residuals				
Irregular Normality	5.45	5.69	5.38	2.29
Level Normality	1.07	2.12	3.03	-
Slope Normality	-	-	-	1.12
Predictive Failure Tests (2004q2-2006q1)				
$\chi^2_{(8)}$	12.15	1.20	4.24	6.87
Cusum $t_{(8)}$	0.17	-0.55	-0.13	0.11
Likelihood Ratio Tests				
Test (a)	44.65	59.55	41.13	-
Test (b)	-	-	-	67.68
Test (c)	96.41	-	101.69	84.40

Notes for Table 2c: see notes to Table 2a.

The preferred equations in Tables 2a to 2c show that all models (except for 'recreation and culture' which suffers from a problem with autocorrelation[12]) fit the data well passing all diagnostic tests indicating that there are no problems with residual serial correlation, non-normality or heteroscedasticity. Furthermore, the auxiliary residuals are found to be normal and the model is stable as indicated by the post sample predictive failure tests.

The results show that elasticities with respect to the price and income are inelastic in both the short and the long run - except for 'recreation and culture' where the income elasticity is greater than one in the long run. Furthermore, there is no general pattern for the relationship between the estimated short run and long run elasticities – some being greater, some being smaller and some being equal for both price and income.

There are some models where the estimated income or price coefficients are not as expected *a priori*. For 'housing, water, electricity, gas and other fuels' and 'health' expenditure, both the income and price coefficients are insignificant. 'Education' expenditure has a negative income coefficient (giving negative income elasticities in both the short and long run). 'Communication' and 'transport' expenditure have no immediate significant response to income but a significant response to the income lag. In addition, for 'clothing and footwear' expenditure, there is no immediate response to price but a significant response to the price lag.

Likelihood Ratio (LR) tests for all preferred equations find that imposing the restriction of a deterministic trend[13] is rejected. Therefore, the estimated underlying expenditure trends presented in part a) of Figures 1-12, are the local level with drift specifications[14] for all household expenditure categories other than 'miscellaneous goods and services' where it is the smooth trend specification.[15] It can be seen that the underlying expenditure trends are clearly non-linear, generally increasing for most of the categories over estimation period hence shifting the expenditure demand curve to the right if price and income are held constant. However, the underlying expenditure trends are generally decreasing for 'alcoholic beverages and tobacco, narcotics' and very stochastic for 'clothing and footwear' and 'furnishings; household equipment & routine maintenance of the house', shifting the expenditure demand curve upwards and downwards at different times *(ceteris paribus)*. LR tests also indicate that imposing the restriction of deterministic seasonality (where seasonal dummies are fixed such as the conventional model) is rejected for all categories except for 'communication' and 'education'; illustrated in part b) of Figures 1 to 12.

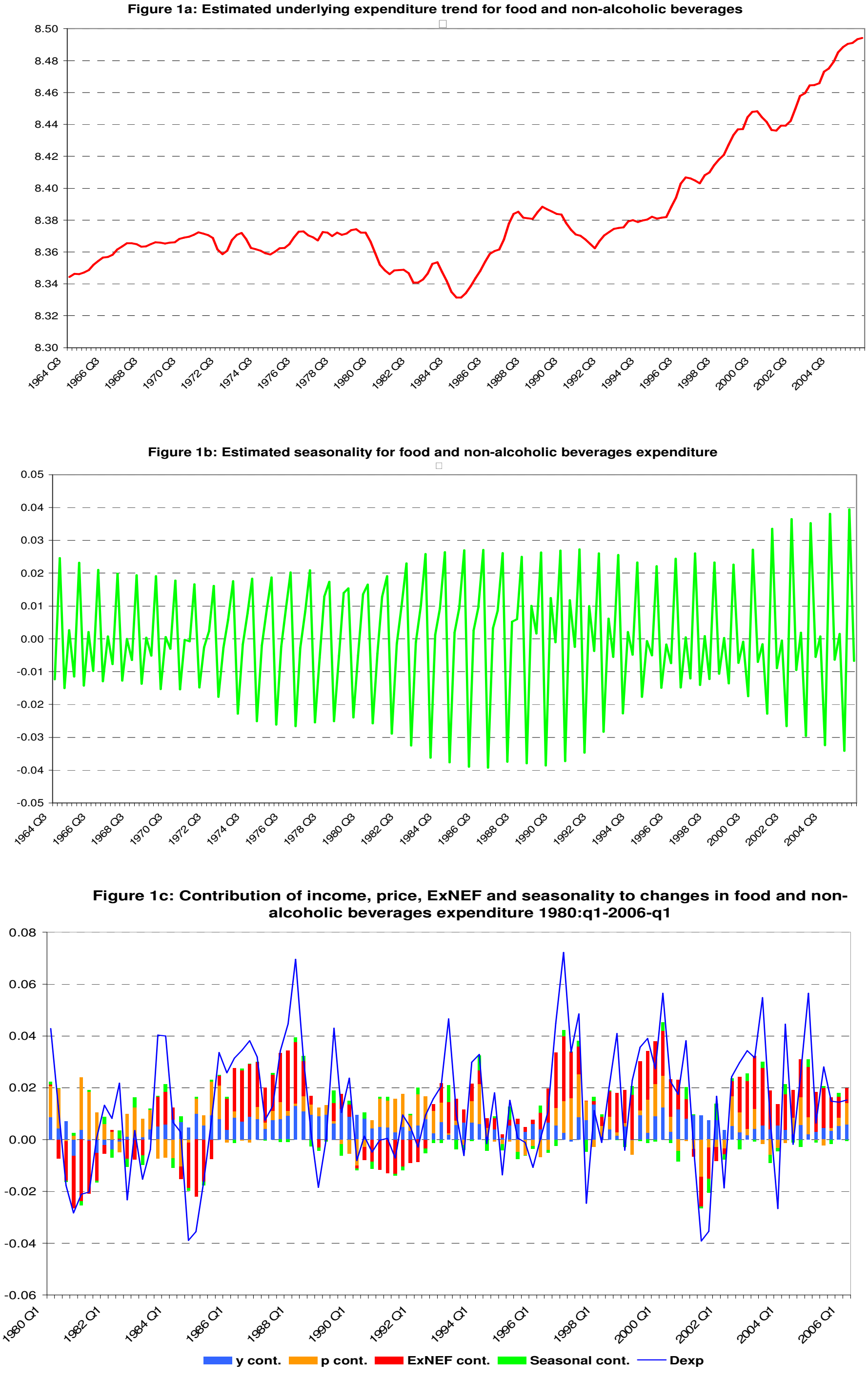


Figure 1: 'Food and non-alcoholic

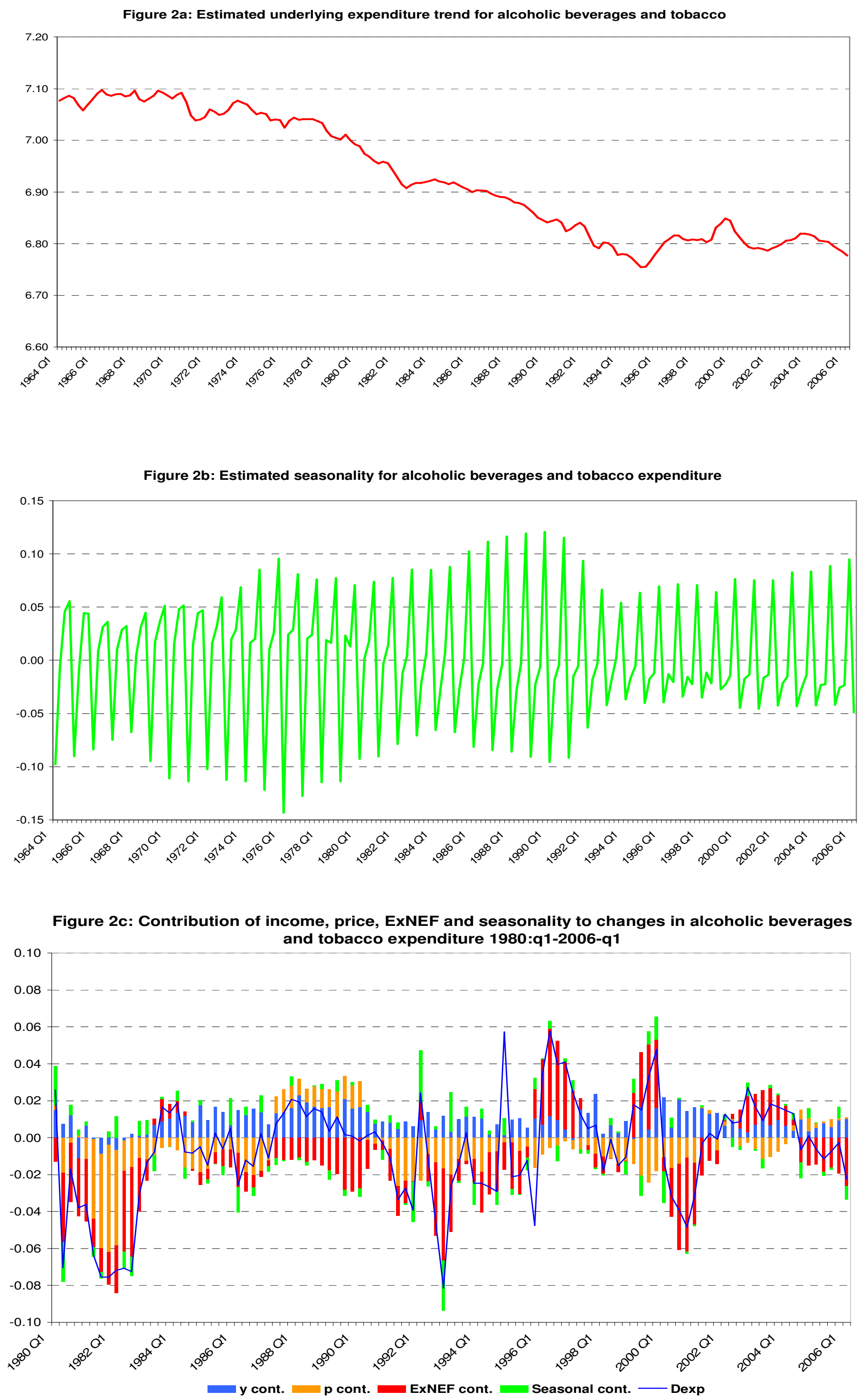


Figure 2: 'Alcoholic beverages, tobacco and narcotics'

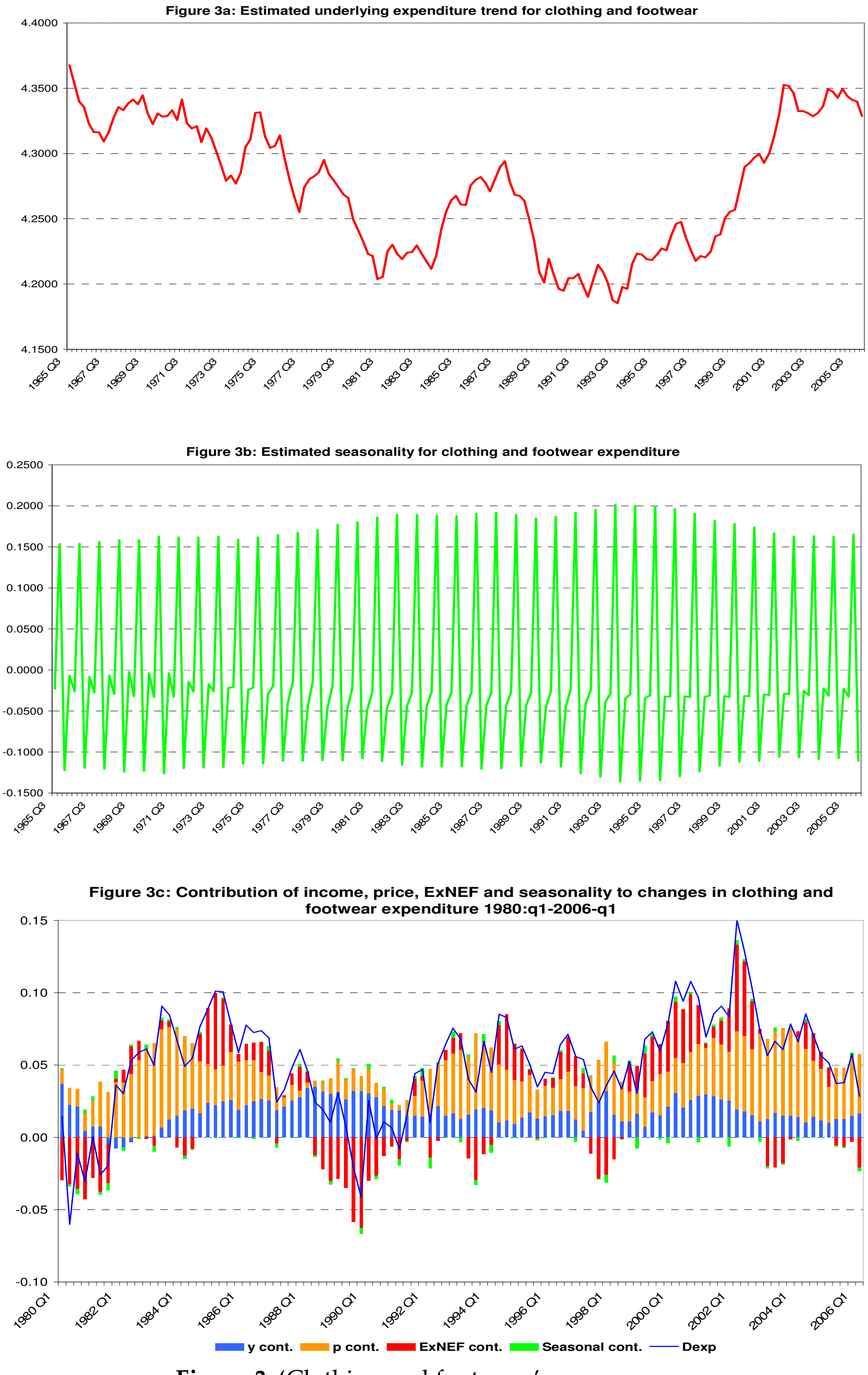


Figure 3: 'Clothing and footwear'

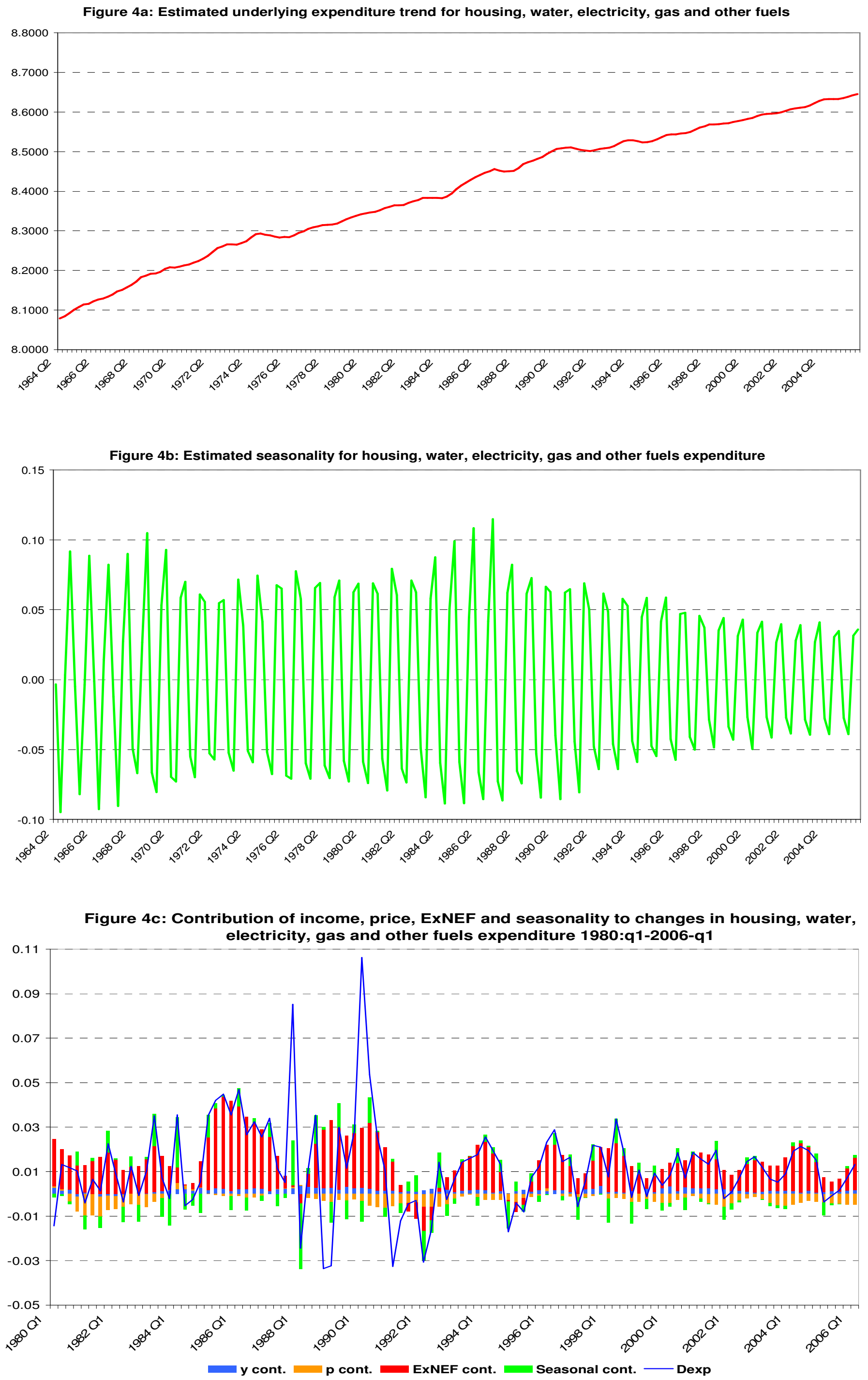


Figure 4: 'Housing, water, electricity, gas and other fuels'

Part c) of Figures 1 to 12 gives the estimated contribution to the annual change in total expenditure for each category from the various components: price, income, ExNEF and seasonality from 1980:q1 to 2006:q1. It can be seen that seasonality generally has a relatively small effect on expenditure.

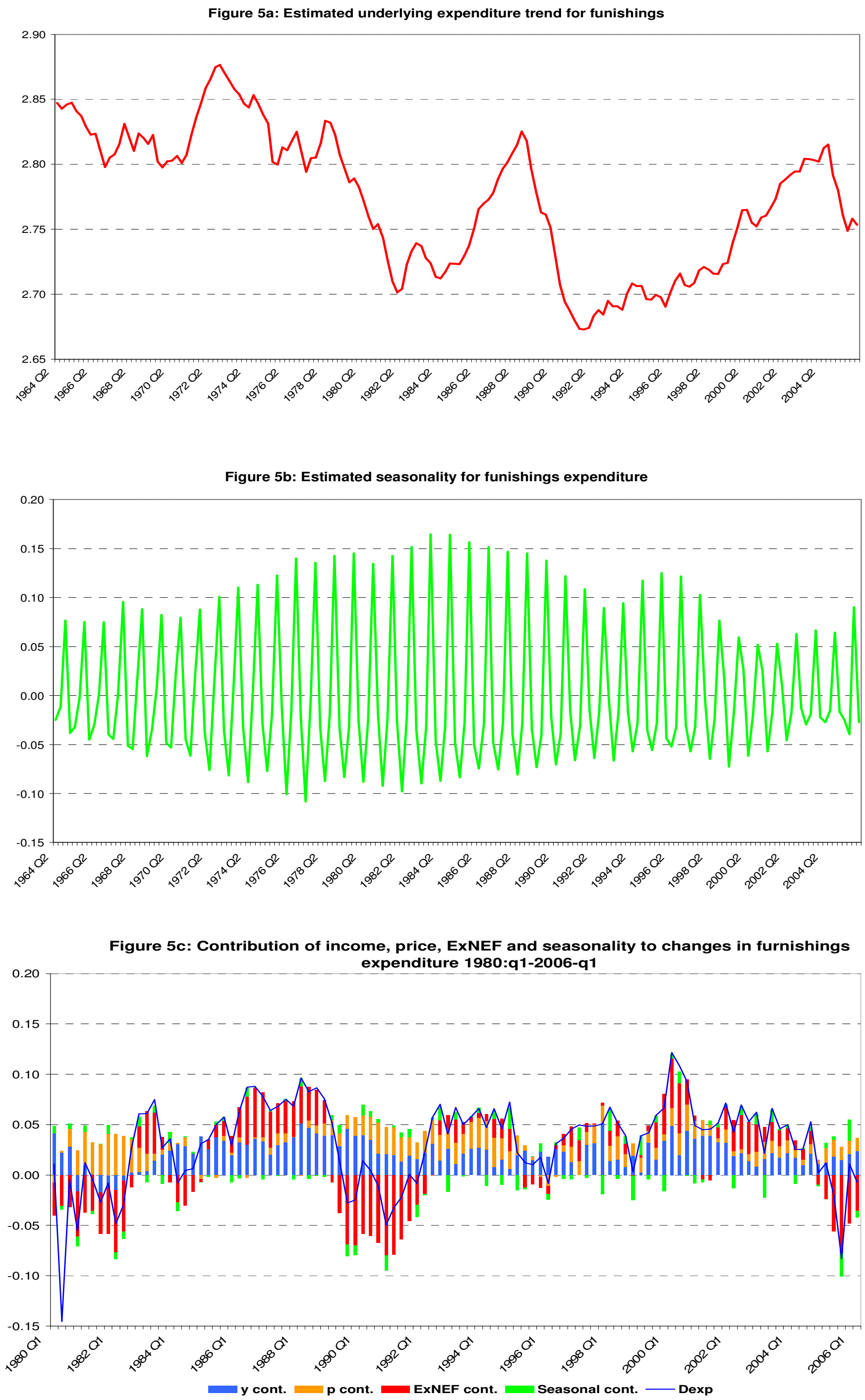


Figure 5: 'Furnishings'

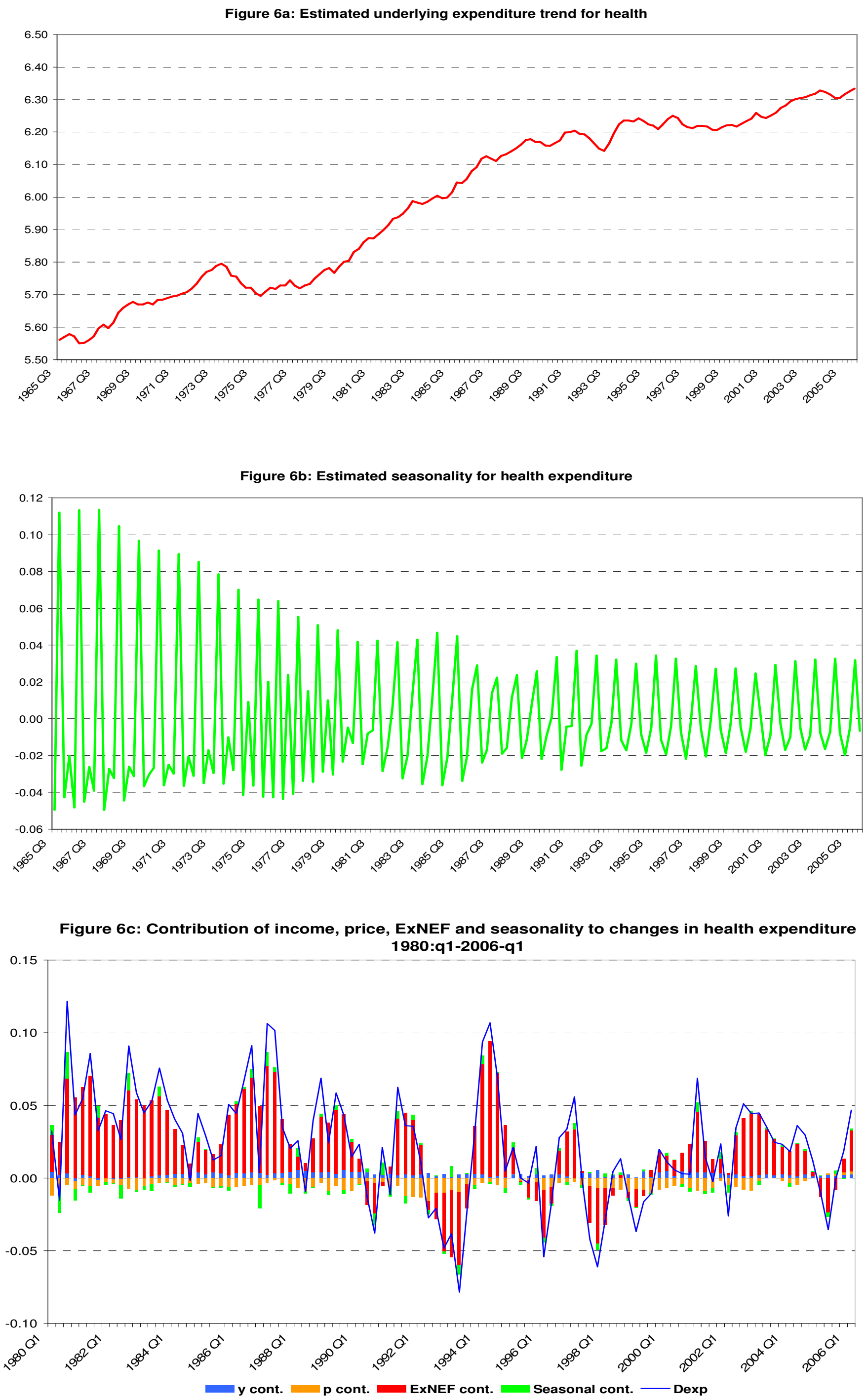
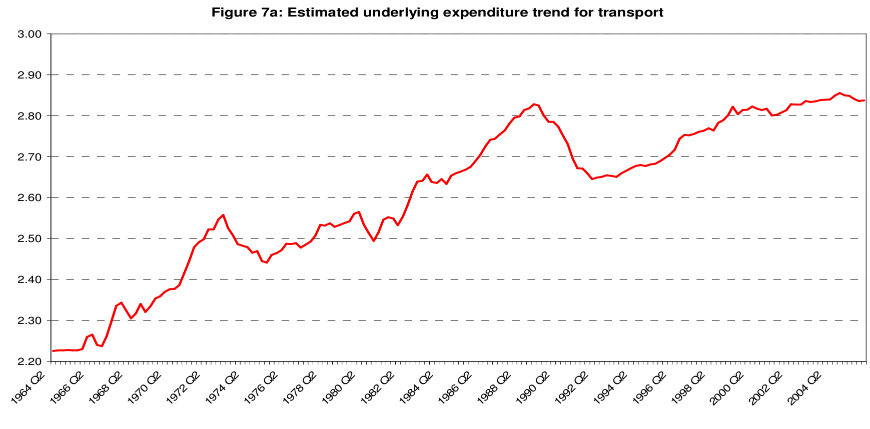
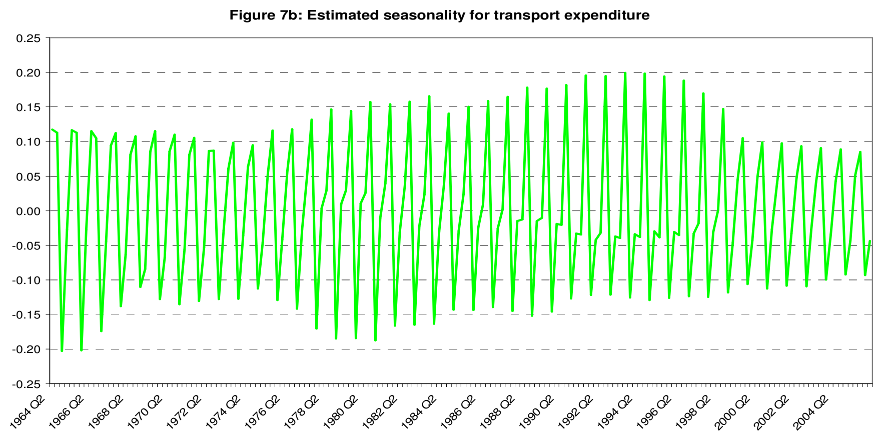


Figure 6: 'Health'





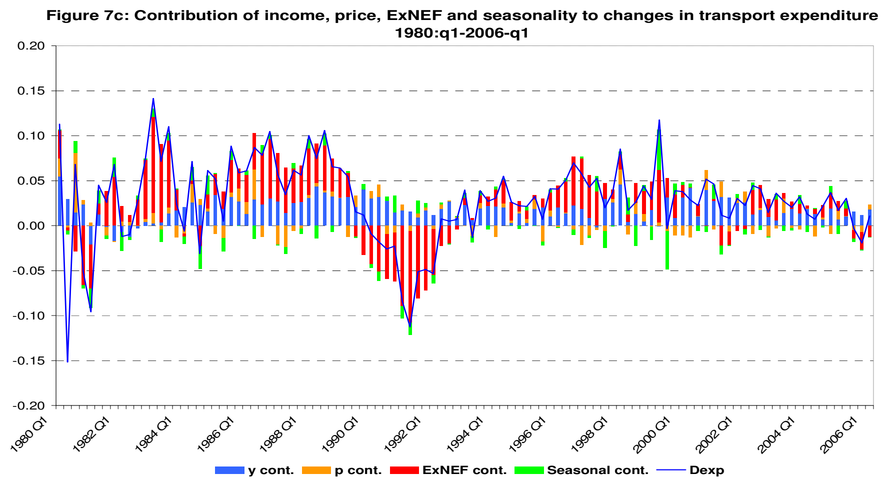
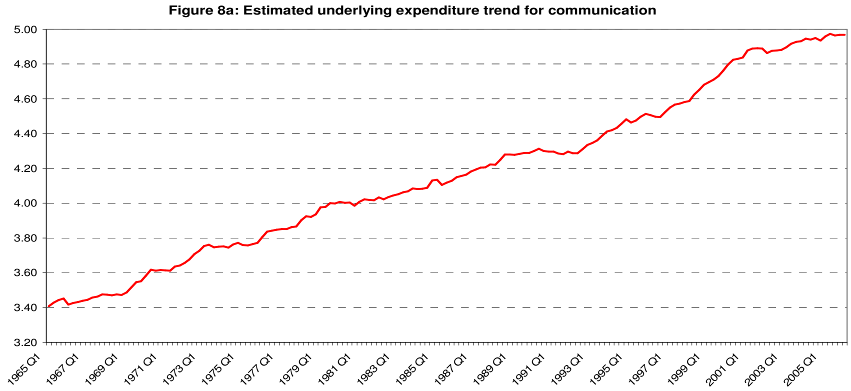
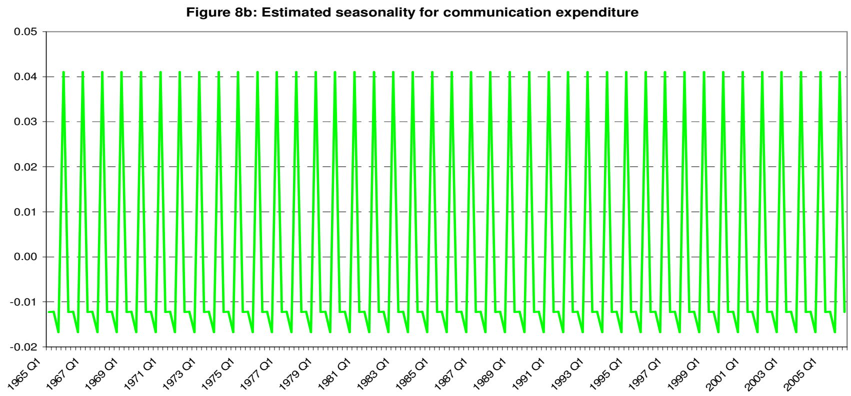


Figure 7: 'Transport'





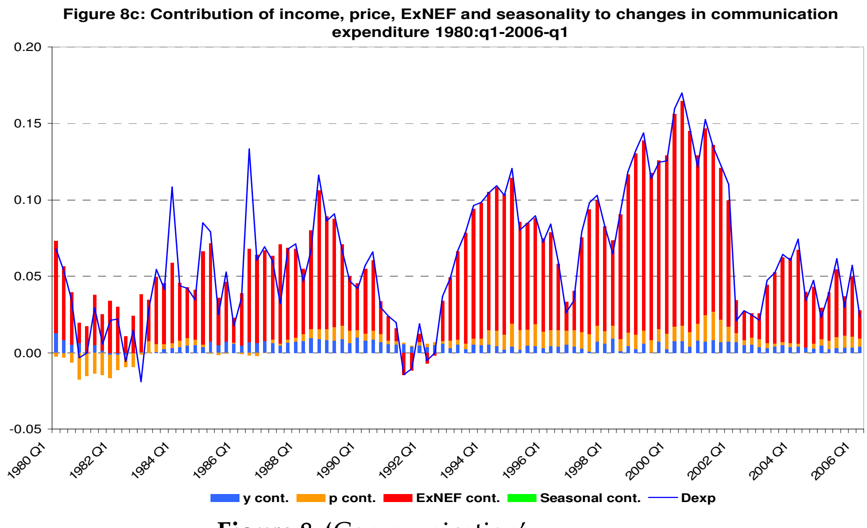


Figure 8: 'Communication'

For 'food and non-alcoholic beverages', 'alcoholic beverages, tobacco and narcotics', 'clothing and footwear', 'furnishings; household equipment & routine maintenance of the house', 'transport', 'recreation and culture', 'restaurants and hotels' and' miscellaneous goods and services' ExNEF contributes considerably to the change in expenditure relative to price and income. This reflects the stochastic nature of the underlying expenditure trend and implies that the effect of ExNEF should not be ignored, in particular for 'food and non-alcoholic beverages' expenditure.

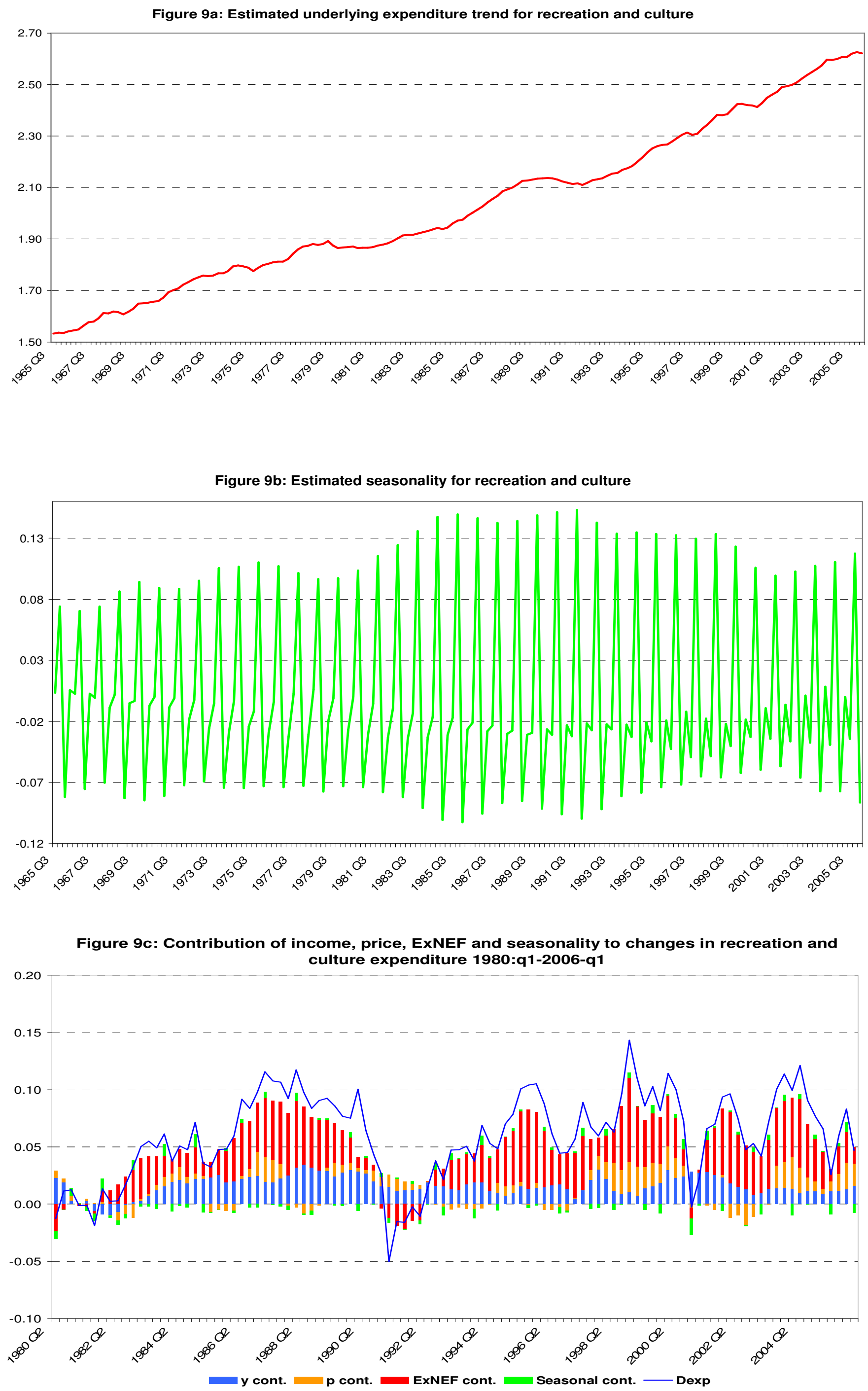
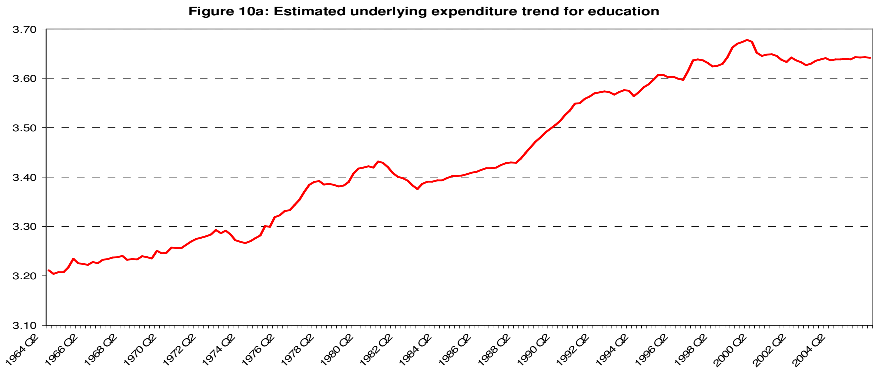
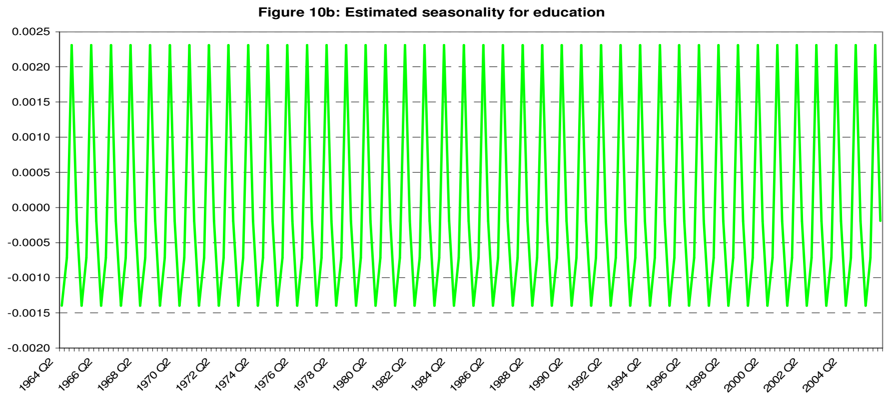


Figure 9: 'Recreation and culture'





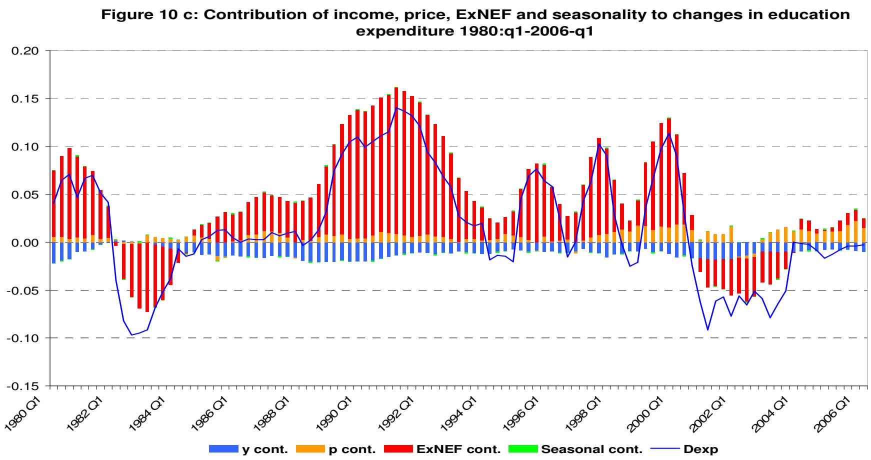


Figure 10: 'Education'

Figure 11a: Estimated underlying expenditure trend for restaurants and hotels

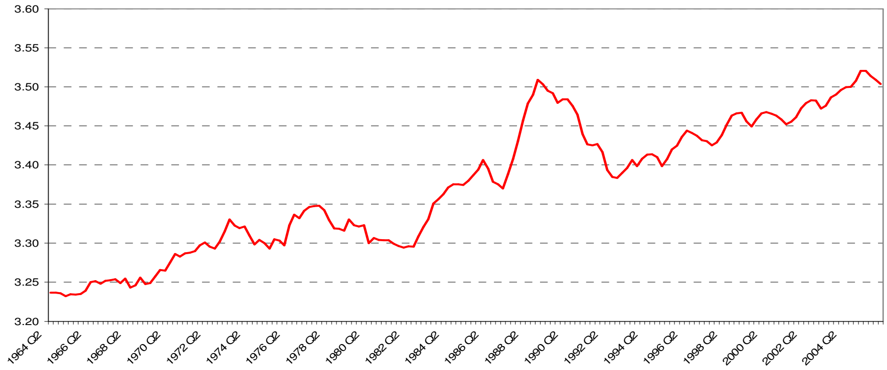


Figure 11b: Estimated seasonality for restaurants and hotels

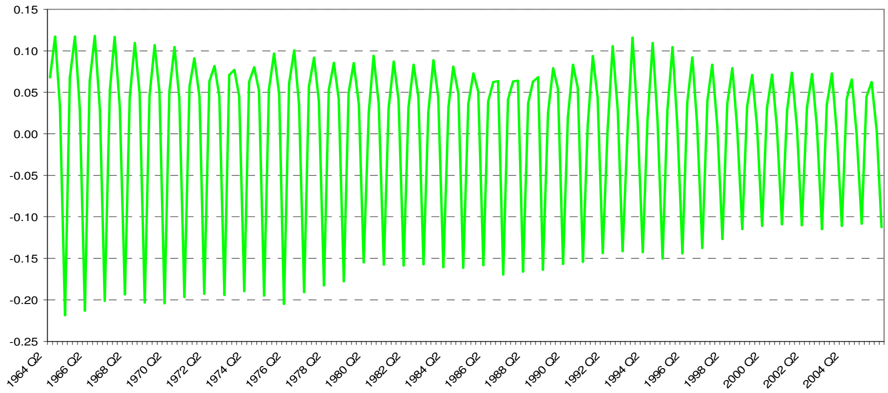


Figure 11 c: Contribution of income, price, ExNEF and seasonality to changes in restaurant and hotels expenditure 1980:q1-2006-q1

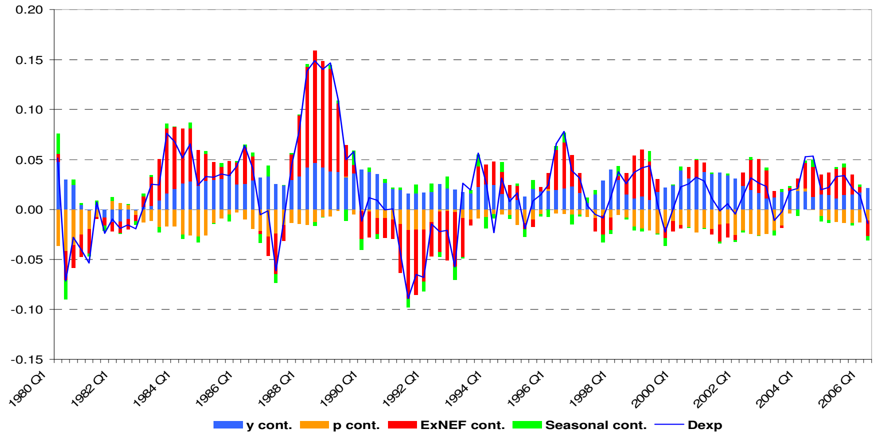
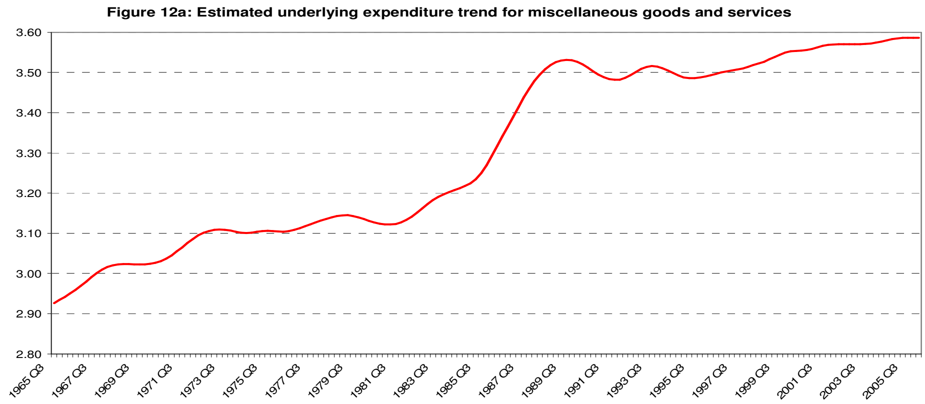
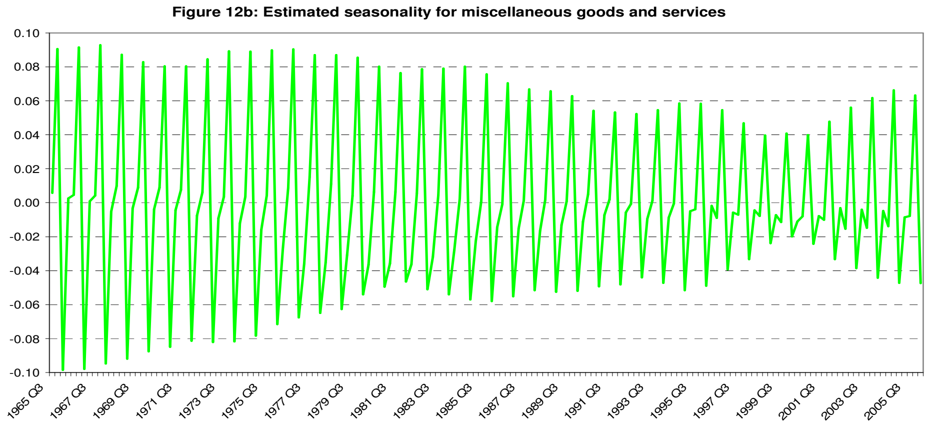


Figure 11: 'Restaurant and hotels'





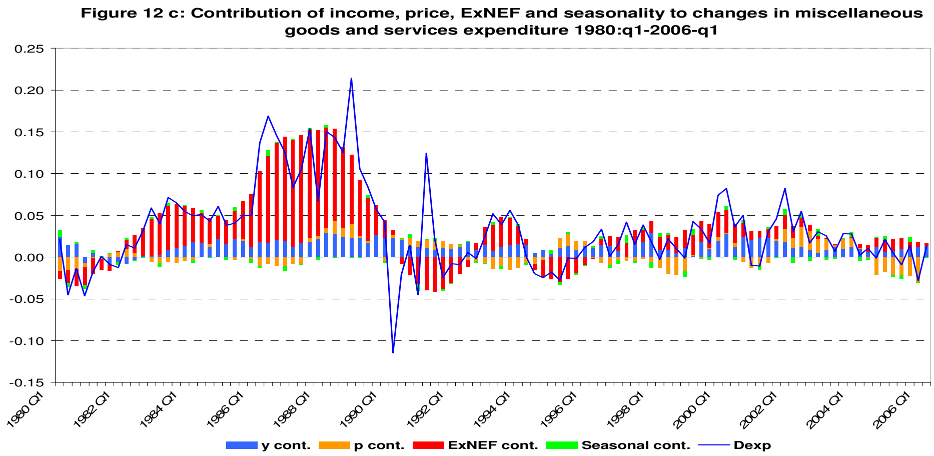


Figure 12: 'Miscellaneous goods and services'

In the case of 'housing, water, electricity, gas and other fuels', 'health', 'communication' and 'education' categories, the ExNEF has a large impact on expenditure changes; much higher than the contribution from price and income. This highlights again, the importance of considering the non-economic factors when considering what drives expenditure in these groups.

4. Summary and conclusion

Household expenditure has continued to grow over time. Therefore, from a sustainability perspective, it is important to better understand the drivers of household expenditure to aid policy makers attempting to encourage and incentivise more sustainable consumption. Economic theory suggests that price and income are the two key economic drivers of demand, plus other exogenous factors. This study attempts, as far as is known, to quantify the not only the economic drivers of price and income but also the important exogenous non-economic factors that affect and drive expenditure.

Using the STSM it is shown that the contribution from the exogenous non-economic factors ExNEF[xvi] to annual changes in expenditure is important relative to the contribution from the economic drivers price and income. For the majority of the 12 COICOP categories the contribution from ExNEF is estimated to be very relatively high; in particular for 'housing, water, electricity, gas and other fuels', 'health', 'communication' and 'education'. Therefore, assuming policy makers do not wish to reduce the rate of economic growth as a way to curtail the growth in expenditure the message for policy makers is clear. For categories with larger ExNEF contribution to changes in expenditure, in addition to an economic incentive, such as taxes, other policies that attempt to influence lifestyles might need to be used and hence considered if they wish to restrain future expenditure in order to achieve sustainable consumption. For categories with low or no contribution of ExNEF to changes in expenditure, the primary policy option to reduce expenditure, given that expenditure demand functions are price inelastic, is to increase significantly prices. However, such a policy needs careful consideration given its side effects for households. Therefore, a challenge remains for government on how to bring about significant behaviour change in such categories of expenditure.

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Notes:

[1] COICOP is used to classify both the individual consumption expenditure of households, non-profit institutions serving households and general government and the actual individual consumption of households. For more information see: **http://esa.un.org/unsd/cr/registry**

[2] Almost Ideal Demand System

[3] Linear Expenditure System

[4] Perhaps Adequate Demand system

[5] Differential consumer demand systems known as CBS (Central Bureau of Statistics)

[6] This includes normality, heteroscedasticity, autocorrelation and predictive failure tests. In addition, LR tests are carried for restrictions of deterministic time trend and deterministic seasonal dummies. For further details refer to Hunt and Ninomiya (2003).

[7] Note that the contributions/changes are in terms of percentages (logs) so the shares of contributions to changes in total expenditure are indeterminate.

[8] This work is part of on-going research attempting to quantify the impact of ExNEF on consumer demand and expenditure; see, for example, Chitnis and Hunt (2009) and Broadstock and Hunt (2009).

[9] Previously known as Underlying Energy Demand Trend (UEDT); f. For instance, see: Hunt and Ninomiya (2003).

[10] http://www.statistics.gov.uk/statbase/TSDTimezone.asp.
See "Consumer Trends" for time series data on expenditure and implied deflators and for more information http://www.statistics.gov.uk/downloads/theme_economy/CT2007Q4.pdf.
See "Economic Trends Annual Supplement" for time series data on real household disposable income and for more information http://www.statistics.gov.uk/downloads/theme_economy/ETSupp2006.pdf.

[11] The underlying expenditure trend, seasonality and contributions for the preferred models re-estimated over the whole period, up to and including 2006:q1, are actually presented.
[12] Even after some experimentation with different specifications and/or dummy variables, autocorrelation still exists.
[13] By restricting the variance of the level and/or the slope to be zero.
[14] Where the level is stochastic but the slope fixed.
[15] Where the level is fixed but the slope stochastic.
[xvi] Estimated by the annual change in the stochastic underlying expenditure trend.