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Why is Consumption so Seasonal?*

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Abstract

U.K. and U.S. data suggest that consumption seasonality is both stochastic and characterized by permanent changes, that is there are seasonal unit roots in consumption. This paper explains the changes in the seasonal pattern of U.K. consumption and in doing so offers new insights into the much studied business cycle characteristics of consumption. We find that changes in consumption seasonality have zero or negative correlation with changes in the income seasonal, an observation which casts doubt on liquidity constraints as an important determinant of consumption fluctuations. Neither is consumption seasonality driven by precautionary saving, rates of return or climatic variables. Instead, seasonality in consumption is induced by the utility function, with the evidence ruling out seasonal habits or periodic effects. The evidence is consistent with seasonality changing due to preference shocks which we interpret, based on econometric evidence and a historical survey, as changes in customs. While these changes are slow moving they generate substantial variation in seasonal fluctuations in the post-war period, with Christmas consumption gaining in importance. Our results suggest that seasonal fluctuations may differ significantly from business cycle fluctuations and suggest that preference shifts should be considered as a possible source of non-seasonal fluctuations in consumption.

1. Introduction

There exists a substantial consensus in macroeconomics that the prime determinant of consumption is income. The main consumption puzzles concern the exact relationship between these variables, and proposed resolutions involve drawing distinctions between different types of income i.e. expected/unexpected, transient/permanent, idiosyncratic/aggregate, etc (see, *inter alia*, Blinder and Deaton (1985), Quah (1991), Pischke (1995)). However, seasonally unadjusted data reveals an additional problem of substantial autonomous seasonal fluctuations ("excess seasonality") in consumption (a feature noted by Miron (1986), Ferson and Harvey (1992) and Heaton (1993) on U.S data and by Osborn (1988) on U.K data). Figs.1 and 2 plot the first difference of UK total consumption and real personal disposable income. Visual inspection reveals a strong seasonal in consumption, but not in income. Regressing the change in the logarithm of consumption (less its sample average) on four seasonal dummies gives an \bar{R}^2 of 0.87 while the same regression for income gives an \bar{R}^2 of 0.48, suggesting consumption is far more seasonal than income.

This paper seeks to establish some robust stylised facts about consumption seasonality and to use these to find out why consumption is so seasonal. At a basic level the answer to this question seems obvious. For instance, end year consumption is high because of Christmas - few parents disappoint their children on December 25th by pointing out that it is utility maximising to smooth consumption intertemporally. An implicit distinction is therefore drawn between the seasonal component of consumption, a product of social and cultural factors, and the non-seasonal component, determined by economic forces. This view is often coupled with the belief that seasonality is a constant; because the timing of the seasons does not vary then neither will the seasonal effects. If this is the case then ignoring seasonality in consumption is justified, aside from econometric issues relating to seasonal adjustment (e.g. Sims (1974), Wallis (1974)).

However, do consumers respond to Christmas the same way each year? In section 2 we provide econometric and historical evidence that the seasonality in U.K consumption has changed significantly over time. A feature of this study is a focus on *changes* to the seasonal pattern of consumption, in contrast to other studies (i.e Miron (1986), Paxson (1993)) which assume constant seasonality. If consumption seasonality is stochastic a number of important issues are raised: (i) how does seasonality evolve over time? does it change in a permanent or a temporary way? does it change slowly or rapidly? (ii) is the changing seasonal related to changes in the seasonal pattern of income/relative prices/climate? (iii) is it caused by changes

to the utility function, and how should we characterise these changes?

There are four reasons why these questions are important. *Firstly*, as seasonality accounts for 90% of fluctuations in detrended consumption any theory which fails to account for seasonality is incomplete. *Secondly*, given the size of seasonal fluctuations it is important to assess their optimality. Whereas the claim that business cycles represent optimal responses to technological shocks has caused considerable controversy i.e. Summers (1986) and Mankiw (1989), the implicit conventional view is that seasonal fluctuations are welfare maximising (see Miron (1994) for an exception). However if, for instance, consumption is seasonal because of a combination of liquidity constraints and seasonal income this is not the case and non-seasonal studies (e.g. Imrohorglu (1989)) will underestimate the welfare losses. *Thirdly*, seasonal fluctuations may be informative regarding non-seasonal phenomena. Barsky and Miron (1989) argue that seasonality is more easily identified than business cycles, and that examining seasonal correlations between variables may help us understand business cycle phenomena. Similarly, any finding that seasonal fluctuations are due to social influences or preference shifts is suggestive that the same forces may operate at non-seasonal frequencies, see Hall (1986) and Scott (1994). The *final* reason for understanding seasonal consumption relates to Sims' (1993) claim that seasonally adjusted data may be the most appropriate way to analyze economic hypotheses. Hansen and Sargent (1993) confirm that in some cases this conjecture is correct, but stress that the model still has to correctly capture seasonal and non-seasonal variation. In other words, even if an econometrician uses seasonally adjusted data the sources of seasonality need to be fully understood.

Explaining why consumption is seasonal requires identifying the seasonal pattern. In section 2 a number of different statistical models of seasonality are examined and tested. We find strong evidence that seasonality is important in explaining a range of consumption measures and that these seasonals are stochastic, evolving slowly over time in a non-stationary way, i.e. changes to the seasonal pattern are permanent. These econometric results are given support by historical examples relating to the English Christmas. Our study focuses only on U.K data as many key U.S variables are not published seasonally unadjusted, although the empirical results of Canova and Hansen (1995) confirm the international relevance of non-stationary seasonality in consumption.

Section 3 examines whether changes in the consumption and income seasonals are related. Using an unobserved components approach we focus on the relationship between

seasonal consumption and income, using a multivariate version of Harvey's (1989) Basic Structural Model. The results suggest that while consumption is high in seasons when income is high, *changes* in the consumption and income seasonal display either a zero or a negative correlation. In other words, there is no evidence that stochastic fluctuations in seasonal consumption are due to income. We discuss in detail the implications of this finding for liquidity constraints as well as ruling out precautionary saving as an explanation for consumption seasonality. Section 4 examines whether rates of return explain consumption seasonality, and whether the seasonality in relative consumption shares is due to seasonality in relative prices. While we find evidence of a seasonal pattern in interest rates this is unable to explain consumption seasonality, although we do find a limited role for relative price variability. Section 5 focuses on climatic influences and finds no relationship between the weather and consumption. All this evidence suggests consumption seasonality is intrinsic to consumption rather than the product of exogenous factors, and Section 6 examines which of seasonal habits, periodic effects or preference shocks is the most appropriate explanation. The evidence is overwhelmingly in favour of the idea of non-stationary seasonal preference shocks which we argue, in the light of our historical evidence, represents the effects of slowly changing customs. The final section concludes by placing these results in a wider context.

2. Stochastic or Deterministic Seasonality?

(i) *Deterministic Seasonality*

Seasonality is usually modelled as being constant by the use of deterministic seasonal dummies. Table 1 lists the result of regressing logarithmic changes¹ of different consumption components and income (all constructed to have zero mean) on deterministic seasonal dummies. The estimated seasonals are mostly plausible : energy consumption is highest in times of cold weather; alcohol expenditure increases in the fourth (Christmas/ New Year's Eve) and second quarter (pre-Budget); clothing has a strong seasonal pattern linked to the fashion seasons; consumer durables rise strongly in the first (January sales) and third quarter (new car registrations). The importance of seasonality is apparent with half the consumption components having \bar{R} s above 90%. A large amount of income fluctuations are seasonal ($\bar{R}=0.48$), but considerably less than for consumption. A number of regularities arise from Table 1 : most

¹ Unless otherwise stated, all empirical results in this paper are for data expressed in logarithmic form.

categories experience a large first quarter decline, nearly all variables have a substantial fourth quarter increase, and for most variables the second and third quarter seasonals are the smallest. However, although the *qualitative* nature of the seasonals are similar, there is substantial *quantitative* variation: Quarter 1 seasonals vary between -0.385 and 0.094, while Quarter 4 estimates vary between -0.128 and 0.261.

Table 1 assumes that seasonal patterns never change. Figs.3-11 examine the plausibility of this assumption by using Buys-Ballot plots in which each variable is separated into four time series, one for each quarter. If seasonality is deterministic, each line should be distinct and vary only due to non-seasonal randomness. If seasonality is stochastic each quarter will show variation in its relative position. The plots for non-durable consumption reveal a variable seasonal, with the fourth quarter effect becoming larger and the second and third quarter seasonals moving together. Fig.4 plots the income quarters and reveals that the significant seasonal pattern of Table 1 is a product of the early years of the sample. Fig.5 plots durable consumption and is a good example of the inadequacy of deterministic seasonal dummies. Table 1 reports low seasonal content for durables, but Fig.5 suggests a strong seasonal pattern which has changed markedly over time. The most notable change is the fall in fourth quarter consumption compared to the first quarter, reflecting the increased importance of January sales. Also evident is the switch in 1967 to a larger third quarter effect when the new car registrations month was changed from January to August. The remaining figures also reveal substantial changes in seasonal structure. In many cases there are increased Christmas effects and larger first quarter declines; there are several cases of seasonals changing in sign (i.e. durables, alcohol, other goods) so that "spring becomes summer", as found in Japanese consumption by Engle, Granger, Hylleberg and Lee (1993).

Simple statistical evidence confirms the impression given by the Buys-Ballot plots of substantial changes in seasonals. In Table 1 we quote Box-Ljung tests for serial correlation at seasonal lags. None of the equations had significant serial correlation at non-seasonal lags, but there is a substantial problem at seasonal lags. This evidence strongly suggests that the simple deterministic seasonal model does not adequately capture seasonality in consumption and income. In the next sub-section we consider different ways of modelling stochastic seasonality and test for whether consumption seasonality is stochastic or not.

(ii) *Stochastic Seasonality*

There are two general approaches to modelling stochastic seasonality. The first is to

assume seasonality is non-stationary. Define the seasonal summation operator $S(L) = 1+L+L^2+\dots+L^{s-1}$ where s is the number of seasons, and let $\{D_t\}$ be a time series of deterministic seasonal effects. With deterministic seasonality $S(L)D_t = \alpha$, where α is the annual trend growth rate, so that seasonality cancels out over the year. The obvious way of making seasonality stochastic while maintaining only intra-year effects (aside from trend considerations) is to assume $S(L)D_t = \alpha + \epsilon_t$, where ϵ_t is a disturbance with moving average order less than $s-1$ (see Bell and Hillmer (1984)). In this case, $\Delta_s x_t (= \Delta S(L)x_t)$ is at most an $MA(s-1)$ process and so is not predictable a year ahead, aside from any trend. For quarterly data $S(L) = 1+L+L^2+L^3 = (1+L)(1+L^2)$, which has unit roots of -1 , $+i$ and $-i$ corresponding to infinite peaks in the spectral density at frequencies π and $\pi/2$ (two unit roots) respectively. As shown by Hylleberg, Engle, Granger and Yoo (1990) (hereafter HEGY) these seasonal unit roots, like their non-seasonal analogues, have shocks which are persistent and variances which increase over time. The advantage of the $S(L)$ operator is that while it allows for changing seasonality, it follows the deterministic seasonal model in forecasting forward an unchanged seasonal pattern. However, it is precisely this feature of the $S(L)$ operator which introduces seasonal unit roots.

The alternative approach is to assume seasonality is stationary so that, for example, $D_t = D_0 + \pi D_{t-s} + \epsilon_t$ where $|\pi| < 1$. Under this formulation seasonality changes only temporarily and is eventually mean reverting, where seasonality in the mean relies upon D_0 being seasonal. Unlike the non-stationary formulation, stationary seasonality forecasts forward a non-constant seasonal pattern. As emphasised by Miron (1994), a stationary seasonal variable has spectral power at all frequencies and is not qualitatively different from other stationary processes.

(iii) *Testing Deterministic vs Non-stationary Seasonality*

To examine whether U.K consumption and income seasonals are deterministic or non-stationary we use the test statistic of Canova and Hansen (CH) (1995). This is a test for the stability of the parameters associated with deterministic seasonal dummies, the alternative being that they change in a non-stationary manner. Several versions exist, the most straightforward being a joint test for the constancy of all s seasonals which can also be applied to each individual quarter. Another version focuses not on individual seasons, but different parts of the spectral density - testing for seasonal unit roots at the frequencies π and $\pi/2$. The exact form of the test and its distribution is shown in Canova and Hansen (1995).

Table 2 shows the results of applying the CH test to our dataset. The evidence against deterministic seasonality is overwhelming with every series rejecting the joint hypothesis that

all quarters are deterministic. In summary, the CH tests confirm our earlier graphical analysis that seasonality is stochastic. Table 2 relates only to U.K consumption, but Table 7 of Canova and Hansen (1995) suggests that seasonal unit roots are also present in U.S non-durable and services consumption.

(iv) *Testing Stationary vs Non-Stationary Seasonality*

It may be that Table 2 reflects the inadequacies of deterministic seasonality rather than the relevance of non-stationarity. Our other test is due to HEGY and focuses on the stochastic nature of seasonality, the null being non-stationarity and the alternative is stationary seasonality. Following the recommendations of Ghysels, Lee and Noh (1994) we only quote the HEGY test for when the auxiliary equation contains an intercept and seasonal dummies, although the results are largely unchanged with other specifications.

Table 3 shows the results of applying HEGY tests to our data. We report t-tests for whether there are unit roots at the π frequency, t-tests and an F-test for the two unit roots at $\pi/2$ frequency and an overall F-test for seasonal unit roots at both the π and $\pi/2$ frequencies. The vast majority of consumption seasonals are well described as non-stationary (as also found by Osborn (1990) using a different test statistic), with only energy and other services (marginally) showing any signs of seasonal unit roots. Given (a) the vast majority (92%) of tests do not reject seasonal unit roots (b) those that do conflict with the CH test and (c) the results of Ghysels, Lee and Noh (1994) and Harvey and Scott (1994) show that the autoregressive nature of the HEGY test sometimes leads it to be inaccurate we interpret Tables 2 and 3 as very strong evidence that consumption seasonality is both stochastic and non-stationary. However, the HEGY tests on income are more ambiguous regarding the presence of seasonal unit roots.

(v) *Can Seasonality Really be Non-Stationary?*

Non-stationary seasonality is viewed controversially by economists as it implies that the seasonals for each quarter can move in any direction, so that, for instance, Christmas consumption could become negative. Although Figs.3 to 11 show a number of cases where seasonals swap position in no case do we find significant declines in the Christmas seasonal. However, although non-stationary seasonality allows for radical seasonal changes, these may occur at a glacial pace. HEGY (1990) pp.218-9 shows each seasonal unit root defines a stochastic difference equation which has a solution consisting of the starting values of the seasonal plus cumulated sums of past disturbances. The larger the initial conditions relative to the variance of seasonal innovations, the slower the change in the seasonals and the less likely

are Christmas effects to disappear in the near future. For most consumption categories the seasonal variances are indeed very small relative to their current level.

The second point of defense for non-stationary seasonality is historical evidence, which reveals considerable variation in the economic impact of Christmas. As emphasised in Miller (1993), Christmas is now a truly global festival which has led to distinct changes in the social habits/consumption of a variety of non-Christian cultures (e.g Japan (see Moeran and Skov (1993))). Such effects are also noticeable amongst Christian countries. As the following shows, the timing, duration and relative importance of the English Christmas has experienced significant variation as has its economic impact, showing periods of decline as well as increase. These changes have been slow acting but long lasting, precisely what a model of non-stationary seasonality implies. Our discussion will focus on Christmas, although evidence for non-stationary changes in other quarters is also well documented.

Christmas, as a Christian festival, first appeared in the East with a festival on Epiphany (6th January, or Twelfth Night) which celebrated the baptism of Christ, believed to be the beginning of His divine nature. By the fourth century, January 5th was being celebrated as the Nativity and January 6th as Epiphany with doctrinal debates occurring over whether Christ was divine at birth. Between 325 and 336 A.D the Nativity was being celebrated separately in the West on December 25th. This dating of Christmas is widely seen, e.g Miles (1912), as superimposing a Christian festival on the older pagan celebrations of Saturnalia and Kalends, from which Christmas inherited its tradition of feasting and over-indulgence. Thus the origins of Christmas did not in themselves alter the seasonal nature of the calendar. In 567 A.D the Council of Tours decreed that the twelve days between December 25th and January 6th was a sacred and festive season and over the centuries Christmas became one of the major festivals of the English year, comprising a mixture of pagan and religious activities. However, while the Nativity was traditionally dated December 25th the timing of celebrations varied regionally, beginning as early as All Saints Day (November 1st) and finishing on Candlemas (February 2nd). Further, as documented by Cressy (1989), the English calendar was full of feast days and holy days and while Christmas was important it was not preeminent - Easter and Whitsuntide being more significant.

The most extreme change in Christmas festivities came about under Puritan rule. Repugnance at the mix of heathen Yule festival and "popish Christ-mass" that Christmas

represented led to a parliamentary ordinance in June 1647² banning the honouring of Christmas³. In an attempt to purge the pagan aspects of the Nativity, serious debate occurred over the Messiah's true birth date (e.g Heming (1648), Palmer (1649), Skinner (1649a and b)). While the ordinance proved unpopular and no alternative date was suggested, these events substantially changed the nature of the English Christmas. In 1660, with the return of the monarchy, Christmas could again be legally celebrated, but until Victorian days it was a festival in abeyance. Pimlott (1978) quotes Old Robin's Almanack of 1709 "Christmas scarcely should we know, did not the almanacks it show". Golby (1981) reports an analysis of *The Times* between 1790 and 1836 and finds that in 20 of these 47 years, Christmas receives no mention, and in the remaining 27 it receives only a brief uninformative report. Belk (1993) states "Christmas celebrations were dying out in Europe and America before Charles Dicken's 1843 publication of *A Christmas Carol*".

The origin of the modern Christmas can be seen in the early 1840s, with the Prince Consort and Charles Dickens widely seen as the main creators/innovators. It is at this point that Christmas becomes the main festival of the year and where Christmas cards, trees, crackers and presents and the role of the family are perceived as central, causing a transformation in the economic significance of Christmas. In the early 19th century presents were dying out, confined to New Year and given only to children. However, by the end of the 19th century Christmas presents to adults were standard which, as noted by Pimlott (1978), brought about a major change in the seasonal nature of consumption⁴.

"Previously the benefits of the Christmas trade had been mainly confined to suppliers of food and drink and to those who provided the services - entertainments, transport and so on - for which the season increased the demand. The market for Christmas presents - once at least they had become common among adults - was potentially open to almost every branch of retail

² In Scotland, Presbyterians banned Christmas celebrations in 1583. Christmas has played a less significant role in the Scottish calendar, the more prominent date being New Year's Day. As recorded by Pimlott (1978), Christmas only became more important after the Second World War, he quotes a Scottish store manager "Millions are now being spent at Christmas in Scotland where before the war the figure was paltry by comparison".

³ Early Puritan emigrants to America also condemned Christmas as "a wanton Bachanaellian feast " (Barnett (1954)) and the Massachusetts Bay Colony passed an ordinance in 1659 making Christmas just like any other day, with fines payable by anyone refusing to work or found celebrating. In the twentieth century several totalitarian societies have also banned Christmas e.g the Soviet Union under Lenin.

⁴ Pimlott (1978) offers fascinating detail on how consumption of particular goods has changed over the years. He offers evidence on the "revolution" whereby plum pudding took over from plum porridge as the traditional Christmas dish, and how in 1955 more chicken was eaten than turkey in the UK at Christmas, yet by 1977 less chicken was eaten at Christmas than in a *normal* week of the year.

trade and most of the industries producing consumer goods".

This dramatic period of change also brought refinement to the preeminence and duration of Christmas celebrations. By the 1860s, Twelfth Night, traditionally a huge climax to the festive season, was dead. Other festival days also withered as Christmas became increasingly important. In 1761 the Bank of England granted 47 special days holiday, in 1825, 40. By 1830 this had fallen to 18, reaching 4 by 1834. As Christmas became more important it also began to extend in time, the 1871 Bank Holiday Act finally recognising Boxing Day as a public holiday. The economic effects of Christmas also spread out, in 1887 the first advert for Christmas presents in *The Times* was 12th December, by 1898 they were being advertised by 30th November.

These examples relate to the very distant past and it may be argued that such changes are unlikely to occur now. However, Figs.3-11 show that as the twentieth century has progressed the economic impact of Christmas has increased yet further. This is strong evidence that seasonality is non-stationary - the rise in quarter four consumption is inconsistent with deterministic or mean-reverting seasonality. However, using seasonal unit roots to explain this upward trend involves accepting the possibility that at some point in the future Christmas effects may go negative. However, as Pimlott says "It is part of the tradition that Christmas is never as it used to be" - given the dramatic changes of the past 150 years, the increased number of different religions in the U.K as well as increasing concern over the commercialism of Christmas it seems not unreasonable to accept as a *possibility* zero Christmas effects in the distant future.

3. The Relationship between Seasonal Consumption and Income⁵

Having established that consumption seasonality is stochastic and non-stationary we now turn to explaining the evolution in consumption seasonality. In this section our focus is on the seasonal pattern of consumption and income. Following Campbell and Mankiw (1989) assume that a proportion, θ , of consumers set consumption equal to permanent income and the remainder ("rules of thumb" consumers) set consumption equal to current income. Therefore $c_t = (1 - \theta)y_t + \theta y_t^p + b_t$, where y_t^p denotes permanent income and we have included an additional term, b_t , which denotes fluctuations in consumption due to non-income factors. The b_t term should be interpreted broadly, either as reflecting shifts in the utility function e.g Miron (1986) or Scott

⁵ I am indebted to Siem Koopman and Andrew Harvey for providing me with a Beta version of their STAMP software which was extensively used in this section.

(1994), or the influence of omitted variables. Under Rational Expectations, the expected change in permanent income is by definition zero and so cannot contain a seasonal component. Therefore, using this hybrid model, seasonality in consumption must reflect either seasonality in current income or in b_t , an issue to which we now turn.

(i) *Multivariate Estimates*

Because our focus is on the relationship between consumption and income at seasonal frequencies we use an unobserved components model in which consumption and income are assumed to consist of a trend, seasonal and irregular (white noise) component. We follow the approach of Harvey (1989) and specify the law of motion for each component. Let μ_t^i denote the trend component for variable i , we assume that $\mu_t^i = \mu_{t-1}^i + \beta^i + \eta_t^i$, where β^i is a constant and η_t^i is a normally distributed zero mean disturbance. In other words, the trend component of each variable is a random walk with drift. We denote the seasonal component of variable i by γ_t^i , which we assume is the sum of two terms, γ_t^{i1} and γ_t^{i2} . A number of possible specifications exist but we choose Harvey's (1989) trigonometric form so that $\gamma_t^{i1} = \gamma_{t-1}^{i1\circ} + \omega_t^{i1}$, where $\gamma_t^{i1\circ} = -\gamma_{t-1}^{i1} + \omega_t^{i1\circ}$, and $\gamma_t^{i2} = -\gamma_{t-1}^{i2} + \omega_t^{i2}$, where all of the ω_t^i 's are normally distributed i.i.d disturbances with the same variance, σ_ω^2 . Therefore $\gamma_t^{i1} = -\gamma_{t-2}^{i1} + \omega_t^{i1} + \omega_{t-1}^{i1\circ}$ and $\gamma_t^{i2} = -\gamma_{t-1}^{i2} + \omega_t^{i2}$, so that the γ_t^{i1} term models the one cycle a year seasonal component (seasonal unit root at π frequency) and γ_t^{i2} models the two complex unit roots at the $\pi/2$ frequency (cycle twice a year). The smaller is σ_ω^2 the slower the evolution of the seasonal pattern, when $\sigma_\omega^2 = 0$ the model collapses to that of deterministic seasonal dummies. Otherwise, the presence of the disturbance term adds an MA component to the seasonal dynamics which has the advantage of allowing for smoothly changing seasonal patterns. Harvey and Scott (1994) find that allowing for such effects is important for consumption.

Our particular interest is in the correlation between the innovations to γ_t^y and γ_t^c e.g are changes in the seasonal components related, and so we estimate our components model using a multivariate approach. More specifically, let \mathbf{x}_t be the vector $\{c_t, y_t\}'$, $\mu_t = \{\mu_t^c, \mu_t^y\}'$, $\gamma_t = \{\gamma_t^c, \gamma_t^y\}'$ and $\epsilon_t = \{\epsilon_t^c, \epsilon_t^y\}'$, where ϵ_t^i denotes the irregular disturbance to variable i . We allow the innovations to each component to be correlated across variables but not between components. In other words, we allow $E(\eta_t^y \eta_t^c)$ to be non-zero but not $E(\eta_t^y \epsilon_t^y)$ or $E(\eta_t^y \epsilon_t^c)$. Economically, this means we rule out the possibility that changes in the seasonal pattern of consumption are linked to increases in permanent income or trend income. Because of the requirement that in expectation seasonal effects sum to zero over the next year this amounts to ruling out seasonal

consumption in any one quarter being a Giffen good. We therefore estimate the following system by maximum likelihood utilising the Kalman filter:

$$\begin{aligned}
x_t &= \mu_t + \gamma_t + \epsilon_t \\
\mu_t &= \mu_{t-1} + \beta + \eta_t \\
\gamma_t &= \gamma_{1t} + \gamma_{2t} \\
\gamma_{1t} &= \gamma_{1t-1} + \omega_{1t} \\
\dot{\gamma}_{1t} &= -\gamma_{1t-1} + \omega_{1t} \\
\gamma_{2t} &= -\gamma_{2t-1} + \omega_{2t} \\
\epsilon_t &\sim N(0, \Sigma_\epsilon) \quad \eta_t \sim N(0, \Sigma_\eta) \\
\omega_{1t}, \omega_{2t}, \omega_{1t}^{\dot{}} &\sim N(0, \Sigma_\omega)
\end{aligned} \tag{1}$$

The extent to which variables have common components is revealed by the covariance matrices, Σ_ϵ , Σ_η and Σ_ω . Return to our hybrid model, where $c_t = (1-\theta)y_t + \theta y_t^p + b_t$, and assume (consistent with Rational Expectations) that $y_t^p = \mu_t^p = \mu_{t-1}^p + \eta_t^p$ (i.e permanent income is a random walk without drift). In addition, because our focus is on seasonal fluctuations, assume that b_t is purely seasonal and equal to $\gamma_t^{b1} + \gamma_t^{b2}$. Denoting the correlation coefficient between η_t^y and η_t^c i.e. the innovations to the trend in consumption and income, by ρ_η and the correlation coefficient between the seasonal innovations of consumption and income by ρ_ω , the hybrid model implies

$$\begin{aligned}
\rho_\eta &= \frac{\theta \sigma_{yp} + (1-\theta) \sigma_y^2}{\sigma_y \sqrt{(\theta^2 \sigma_p^2 + (1-\theta)^2 \sigma_y^2 + 2\theta(1-\theta) \sigma_{yp})}} \\
\rho_\omega &= \frac{(1-\theta) \sigma_\omega^2 + \sigma_{b\omega}}{\sigma_\omega \sqrt{(1-\theta)^2 \sigma_\omega^2 + \sigma_b^2}}
\end{aligned} \tag{2}$$

where σ_{yp} denotes $E(\eta_t^y \eta_t^p)$, $\sigma_i^2 = E(\eta_t^i)$, $i=y,p$, σ_ω^2 is the variance of the seasonal innovations to income, σ_b^2 the variance of seasonal shocks to $\{b_t\}$ and $\sigma_{b\omega}$ is the covariance between the seasonal innovations to b_t and income. Examination of (2) reveals that $\rho_\eta = 1$ (in which case consumption and income share a common trend and are cointegrated at the zero frequency, see Stock and Watson (1988)) if: (i) $\theta=0$ e.g everyone is a rule of thumb consumer (ii) y_t, y_t^p are perfectly correlated ($\sigma_{yp} = \sigma_y \sigma_p$). The first link is obvious, if everyone sets consumption equal to income then the two variables must share the same trend. The second case occurs if consumers only use observed current income to form their estimate of permanent income so that innovations

to y_t^p and y_t are perfectly correlated. Examining the seasonal correlation coefficient we find $\rho_\omega = 1$ if : (i) $\sigma_b^2 = 0$ and $\theta < 1$ (i.e there exist some rules of thumb consumers) or (ii) b_t is perfectly correlated with the income seasonal ($\sigma_{b\omega} = \sigma_b \sigma_\omega$). In both cases, consumption and income share a common seasonal component which, as noted by Harvey (1989) p.455, equates to seasonal cointegration. Note that condition (i) for a common seasonal component is weaker than the corresponding condition for a common trend, seasonal cointegration only requires $\theta < 1$ due to the absence of a seasonal pattern in y_t^p and the absence of seasonality in $\{b_t\}$. More generally (2) suggests that the relationship between consumption and income should be similar at seasonal and non-seasonal frequencies if $\theta < 1$.

Table 4 shows maximum likelihood estimates of (1)⁶. All equations have high explanatory power compared to a model with four deterministic seasonal dummies and most display no evidence of misspecification. The estimates suggest that in most cases the relative size of the seasonal variances is between 7-10 times smaller than the trend variance, confirming our earlier comments that seasonality evolves relatively slowly. At the zero frequency, there is evidence of high correlation between consumption and income, as shown by ρ_n . However, in contrast, only two consumption series have a positive seasonal correlation with income. Further, the Engle et al (1993) test for seasonal cointegration/common seasonal component reveals little evidence in favour of a common seasonal. This and the fact that the estimated seasonal variance of consumption was considerably larger than for income shows that the important feature driving consumption seasonality is not income. Table 4 is also important in revealing the differences in the seasonal and non-seasonal relationships between consumption and income. The main business cycle fact for consumption is a strong positive dependence on income (e.g Davidson, Hendry, Srba and Yeo (1978), Flavin (1981)) whereas at seasonal frequencies there is a negative correlation. This estimated negative correlation between the seasonal innovation to consumption and income is consistent with consumption and leisure being complements within the season. As a consequence, higher consumption is associated with more leisure and lower income. Unfortunately the lack of a seasonally unadjusted time series on hours worked and wages prohibits any econometric investigation of this hypothesis.

This finding of a negative seasonal correlation between consumption and income

⁶ For alcohol, other goods and other services we augment (1) by assuming $\beta_t = \beta_{t-1} + u_t$ to remove residual serial correlation, although estimates of ρ_ω were little changed compared to estimates of (1). Maravall (1993) argues for the validity of this specification for many I(1) variables.

conflicts with the findings of Barsky and Miron (1989) that the seasonal cycle is similar to the business cycle. Figure 12 helps shed light on the difference between our results and those of Barsky and Miron by illustrating a cross plot of the non-durable consumption seasonal against the income seasonal. The chart shows a clustering of points, with each cluster associated with a particular quarter. Within each quarter there is a small negative correlation between observations, across clusters there is an upward sloping positive relationship. As explained above, the current value of each seasonal depends on an initial condition plus the sum of cumulated seasonal shocks. Figure 12 suggests that consumption and income seasonality are correlated in their initial conditions but not in their innovations. Barsky and Miron's (1989) use of deterministic seasonal dummies emphasises the deterministic components, whereas our focus is on the stochastic element of seasonality.

(ii) *Implications for Liquidity Constraints*

A common interpretation of "rule of thumb" consumers who set consumption equal to current income is that they are liquidity constrained. In this case our finding above of a negative relationship between seasonal innovations to consumption and income echoes the results of Paxson (1993) in questioning the empirical relevance of liquidity constraints. However, Deaton (1991) shows that optimal behaviour in the presence of liquidity constraints is invariably more complex than simply setting consumption equal to income, although he does not consider the case of seasonal income. In this subsection we consider what implications liquidity constraints have for the seasonal pattern of consumption and income and use these results to interpret the estimates of Table 4.

Deaton (1991) stresses that a key aspect of liquidity constraints is an asymmetry whereby consumption can be prevented from being too high but not from being too low. This asymmetry is captured in the consumer's Euler equation which is $\lambda(c_t) = \max[\lambda(x_t), \beta E_t \lambda(c_{t+1})]$, where λ is the marginal utility of money, β is the consumer's discount factor, E_t is the expectations operator conditional on the t period information set and x_t denotes cash in hand (income plus assets). This asymmetry implies that if income possesses a seasonal pattern then in high income periods consumers can use the seasonality in income to partly overcome liquidity constraints. However, a consequence of doing so is that cash in hand is then lower than it otherwise would have been in low income seasons. As a consequence, consumption is more likely to be tied to income in future periods and display a seasonal pattern. In other words, income seasonality has two

offsetting influences on consumption behaviour. On the one hand, income seasonality can help smooth consumption by easing liquidity constraints when non-seasonal income is low in a high seasonal income period. However, doing so implies that unless non-seasonal income is abnormally high when there is a low seasonal income period, consumption will in part track the seasonal pattern of income.

Figure 13 shows the relationship between consumption and cash in hand for the simple case where $y_t \sim N(100,10)$, the utility function is of the CRRA form with a risk aversion coefficient of 2, the real interest rate is 2% and the rate of time preference is 5%. This is exactly the case of Deaton's Table 1 except that we superimpose onto income a deterministic seasonal of $\{+10,-10,+10,-10,\dots\}$ ⁷. The relationship between consumption and cash in hand is seasonally dependent. For both seasons there is a significant range for which the consumer simply spends all cash in hand, even in the high income quarter. In this range, liquidity constraints are so binding that agents are prepared to use all available cash in hand to alleviate the situation even though this leaves them exposed to seasonally low income next period. However, the point at which the consumer begins to save assets is lower for the high income period. Beyond this point the average propensity to consume is always higher in the low income season. Consumers know in this case that low cash in hand represents low seasonal income rather than a bad draw of non-seasonal income. Because this situation will be reversed next period they are prepared to spend more out of their current cash in hand. Simulating a time series for consumption and income from Figure 13 (and for alternative model specifications) we found that the standard deviation of consumption when income was seasonal was essentially the same as for the non-seasonal case (although income is much more variable with the seasonal pattern). In other words, the consumption smoothing possibilities of high income seasons are offset by the increased sensitivity of consumption to income in low income seasons. Comparing the seasonal patterns we found that (i) consumption seasonals were much smaller than income seasonals i.e there is some consumption smoothing going on over the seasons (ii) even when the income seasonal was deterministic, consumption seasonality was stochastic. The reason for this is the asymmetry intrinsic to liquidity constraints. High income seasons are useful only when non-seasonal income is low and they in turn only impart seasonality in consumption next period if non-seasonal

⁷To calculate these decision rules we used the Parameterised Expectations approach of den Haan and Marcet (1990). A third order polynomial in cash in hand multiplied by the seasonal dummies was sufficient to replicate the results of Deaton's Table 1.

income is not abnormally high in the low income season. As a consequence, consumption does not inherit the seasonality of income in every period and is not well described by deterministic seasonality.

We also repeated this simulation exercise for the case in which income was characterised by non-stationary seasonality (setting the variance of seasonal shocks to 0.25) and for each simulation estimated the correlation between seasonal innovations to consumption and income. For 100 simulations we found the mean value for the correlation coefficient was 0.43, with a range of 0.22 to 0.62. These results clearly suggest that while liquidity constraints do not predict that the seasonal pattern of consumption equals that of income, they do predict a positive correlation between consumption and income seasonality. While consumer's optimal response to liquidity constraints lessens the "rule of thumb" emphasis on the similarity of consumption and income at seasonal frequencies it gives no justification for a negative relationship. Therefore, the results of Table 4 tell against both the "rule of thumb" consumption model and more sophisticated liquidity constraint models⁸.

(iii) *Precautionary Savings*

A number of authors (Skinner (1988), Caballero (1990), Acemoglu and Scott (1994)) have suggested that precautionary saving may account for observed consumption puzzles. This implies that if the variance of income has a pronounced seasonal pattern, then precautionary saving can also account for excess seasonality. However, an LM test cannot reject at even the 1% level the hypothesis that the variance of income residuals in (1) is uncorrelated with deterministic seasonal dummies. Unlike the case of liquidity constraints however this finding does not tell against precautionary saving explaining the non-seasonal behaviour of consumption. Our results only suggest that income uncertainty does not contribute to seasonal consumption fluctuations, not that these effects are unimportant at non-seasonal frequencies.

Having established that consumption seasonality is not related to that in income, in the next section we investigate whether the seasonality captured by b_t in our hybrid model reflects seasonality in an omitted variable.

⁸ Neither can an appeal to heterogeneity rescue liquidity constraints. Unemployment displays a strong seasonal pattern which is liable to provide a seasonal pattern in the income of liquidity constrained individuals.

4. Interest Rates and Relative Prices

(i) *Intertemporal Relative Prices*

The standard intertemporal model of consumption has consumption growth responding to anticipated rates of return. Under certain distributional assumptions, Hansen and Singleton (1983) show

$$\Delta \ln C_t = \alpha + \frac{1}{\sigma} r_t + \epsilon_t \quad (3)$$

where r_t is the real interest rate, ϵ_t is a white noise disturbance and $1/\sigma$ is the intertemporal elasticity of substitution. Therefore, seasonality in rates of return could explain seasonal consumption.

Modelling the nominal base rate as an AR(1) plus four seasonal dummies (other AR terms were insignificant) there are significant seasonal effects in quarters 3 and 4, when on average base rates are higher. There is no evidence of any seasonal serial correlation, and a LR test for the exclusion of the seasonals was comfortably rejected at the 1% level. The CH test nowhere rejected the null of deterministic seasonality. Testing inflation (the quarterly change in the logarithm of the CPI) leads to similarly strong conclusions with inflation on average higher by 0.45% in quarter 2, and lower by 0.45% in quarter 3. These results suggest interest rates cannot be the cause of consumption seasonality, as the latter has non-stationary seasonality while seasonality in interest rates is stationary. The failure of interest rates to explain the seasonal dynamics in consumption is readily seen by estimating (3): the estimate of $1/\sigma$ is negative and there is significant residual seasonal serial correlation, the Box-Ljung statistic for fourth order serial correlation is 155.6 (distributed χ^2_4), rising to 704.1 at lag twenty. Thus at both seasonal and non-seasonal frequencies the serial correlation properties of consumption are very dissimilar to rates of return.

(ii) *Intratemporal Relative Prices*

A feature of the consumption data is large seasonal fluctuations in both aggregate consumption and relative consumption shares. In this sub-section we examine whether the latter are caused by fluctuations in intratemporal relative prices. Consider the case where the consumer's utility function is:

$$U(C_t) = \frac{1}{1-\sigma} C_t^{1-\sigma} \tag{4}$$

$$C_t = \left(\sum_{i=1}^n C_{it}^{\frac{\delta-1}{\delta}} \right)^{\frac{\delta}{\delta-1}}$$

where δ is the elasticity of substitution between categories of the n consumption goods. Optimal consumption shares are determined by equating the ratio of marginal utilities to relative prices e.g

$$\frac{C_i}{C_j} = \left(\frac{P_j}{P_i} \right)^{-\delta} \tag{5}$$

If P_j is a mark up over marginal costs i.e. $\Gamma_j MC_j$, then seasonal variations in marginal costs may cause seasonality in both prices and relative consumption shares.

Regressing relative consumption shares on relative prices (all shares are relative to durable consumption) explains little seasonal variation. However, this assumes that demand responds to seasonal and non-seasonal variations in price in the same way. To overcome this Table 6 shows the results of estimating a multivariate BSM for the bivariate system of relative consumption and relative prices. With the exception of food, all seasonal correlations are negative so that higher seasonal prices are associated with lower seasonal consumption. However, with the exception of energy and alcohol/tobacco none of these correlations are significant at the 1% level and there is little evidence of seasonal cointegration. Thus, while some seasonal fluctuations in consumption are related to seasonal changes in relative prices⁹ there is no evidence of common seasonal components and so seasonality in consumption shares cannot be accounted for by relative prices.

5. Seasonality and Climate

To the extent economists are prepared to deviate from deterministic seasonality it is often assumed that seasonality in consumption is a response to climatic conditions (e.g. Miron (1986)). In this section we argue that the changing seasonal pattern in consumption is unrelated to fluctuations in the weather.

Figs. 14-16 show Buys-Ballot plots of three summary variables of the weather in England

⁹ These results do not imply relative prices **cause** the consumption seasonal. If $P_j = \Gamma_j MC_j$, where Γ_j is decreasing in the elasticity of demand, then a negative covariance between demand and Γ_j , as suggested by Rotemberg and Saloner (1986), could explain these findings even in the absence of any seasonality in MC_j .

and Wales. Figs.14 and 15 show that temperature and sunshine have a clear seasonal pattern, being lowest in the first quarter and highest in the third. Each series shows considerable variation but no alteration in the relative seasonal position. Fig. 16, showing rainfall, is more confused with considerable volatility associated with each quarter. These figures suggest that while there are particularly cold winters and warm summers these do not reflect randomness in the seasonal component but just the general unpredictability of the weather. Estimating univariate BSMs on these weather series confirms this conjecture: the seasonal components are estimated to have zero variance and all series have large irregular variances. Table 5 shows that the CH test never rejects the null of deterministic seasonality. Therefore consumption seasonality cannot be explained by the weather: seasonal consumption changes are non-stationary while climatic seasonals are not. Estimating multivariate BSMs for consumption and the weather we find zero correlations for seasonal innovations but non-zero correlations for the irregular disturbance. These results are consistent with the idea that exceptionally hot weather does boost consumption of, for instance, ice cream but that it alters the non-seasonal rather than seasonal component of ice cream consumption.

6. Endogenous Sources of Seasonality

The preceding sections have ruled out a number of plausible variables as explanations for the changing seasonality in consumption¹⁰, suggesting that seasonality is inherent to consumption and reflects agents preferences. In this section we examine which aspects of agents' preferences might explain this consumption seasonality. Following Hansen and Sargent (1993), we distinguish three different types of seasonal influences: (a) seasonal habits (b) periodic changes in preference parameters (c) seasonal preference shocks.

(a) *Seasonal habits* - these have been successfully used by Ferson and Harvey (1992) and Osborn (1988) (the latter in conjunction with periodic effects) to explain U.S and U.K consumption respectively. However, our finding of seasonal unit roots rules out habits as a sufficient explanation of consumption seasonality. Under habit formation, agents gain utility not from C_t but from $C_t - g(L)C_{t-1}$, or in the simplest seasonal case, $C_t - g_4 C_{t-4}$, where $g_4 < 1$. The case where $g_4 = 1$ is ruled out by assumption as it implies utility is derived only from the annual change

¹⁰ For presentational reasons we have considered each variable sequentially. However, a simultaneous analysis of consumption, income, interest rates and the weather yields the same conclusions.

in consumption, and not its level. If $g_4 < 1$ habits only introduce stationary autoregressive behaviour. To see this consider the quadratic utility function:

$$-\frac{1}{2}(C_t - g_4 C_{t-4} - b)^2 \quad (6)$$

where b represents a deterministic bliss point. Letting $\beta (< 1)$ denote the discount factor, assumed equal to $1/(1+r)$, the consumer's Euler equation is

$$E_t[C_{t+1}(1-L)(1-g_4L^4)(1-g_4\beta^4L^{-4})] = 0 \quad (7)$$

Only if $g_4 = 1$ does consumption possess seasonal unit roots as in that case the first order condition involves the lag polynomial $(1-L^4) = (1-L)S(L)$. However, when $g_4 < 1$ the first order condition only involves zero frequency unit roots through $(1-L)$, the standard Hall (1978) martingale result. Therefore evidence for seasonal unit roots rules out the possibility of explaining consumption fluctuations by seasonal habits alone.

(b) *Periodic models* - Osborn et al (1988) argue that findings of seasonal unit roots may reflect a periodic structure (e.g the coefficients vary with the seasons). Osborn (1988) examines a model where the first order conditions for utility maximisation are such that $c_t = \sum \psi_i D_i^i c_{t-i} + e_t$, so that the autoregressive coefficient is seasonal. Under the restriction $\psi_1 \psi_2 \psi_3 \psi_4 = 1$, $\Delta_4 c_t = (1-L)S(L)c_t = u_t$, where u_t is an MA(3) process. The fact that u_t is a MA(3) process means that while quarterly changes in consumption are predictable because of seasonality, annual changes are unpredictable a year ahead. This represents a natural extension of Hall's (1978) martingale result to seasonal data, although it is only satisfied by periodic processes with the restriction $\psi_1 \psi_2 \psi_3 \psi_4 = 1$. Moreover, Osborn (1988) finds that periodic effects alone are not sufficient to explain U.K consumption seasonality.

(c) *Seasonal Preference Shocks* - assume utility is of the CRRA form but subject to a stochastic preference shock ξ_t (i.e $u(C_t) = (\xi_t C_t)^{1-\sigma}/(1-\sigma)$) then (setting $\beta(1+r)=1$) the Euler equation gives $\Delta \ln C_t = \Delta \ln \xi_t + e_t$ where $E_{t-1} e_t = 0$, and consumption will automatically reflect any seasonality in preference shocks. When ξ_t is deterministic we have the model of Miron (1986) and consumption seasonality is explained by fixed seasonal dummies, while if $\ln \xi_t$ has non-stationary seasonality then so has consumption. In both cases, as with the pure periodic model, preference shocks imply that consumption is a seasonal martingale. As stressed in Section 2, autoregressive

based models such as seasonal habits do not imply this annual unpredictability. Unlike the periodic or seasonal habit model, if seasonality arises from preference shifts a clear separation can be made of the seasonal and non-seasonal features of the optimisation problem due to the separability in the Euler equation. This separation of seasonal and non-seasonal factors in turn offers simple and tractable solutions to the fact that consumption is seasonal but rates of return are not (contrary to the CAPM) and to the fact that there is significant seasonal variation in relative consumption shares independent of relative prices. This separability also means that seasonal anomalies can be explained without modifying the non-seasonal aspects of the theory.

While our inability to reject the null of non-stationarity in Section 2 is damaging to the seasonal habits model, we have not so far allowed for periodic effects in consumption. To test periodic versus non-stationary seasonality it is necessary to exploit the fact that periodic seasonality implies certain cointegrating relationships between each of the quarters of a time series but that seasonal unit roots do not. For instance, letting ΔC_{iT} denote the annual change in the logarithm of consumption in quarter i of year T , Osborn's (1988) periodic model implies :

$$\begin{bmatrix} \Delta C_{1T} \\ \Delta C_{2T} \\ \Delta C_{3T} \\ \Delta C_{4T} \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 & \Psi_1 \\ 0 & -1 & 0 & \Psi_1 \Psi_2 \\ 0 & 0 & -1 & \Psi_1 \Psi_2 \Psi_3 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} C_{1T-1} \\ C_{2T-1} \\ C_{3T-1} \\ C_{4T-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1T} \\ \epsilon_{2T} \\ \epsilon_{3T} \\ \epsilon_{4T} \end{bmatrix} \quad (8)$$

or

$$\Delta C_T = \Pi C_{T-1} + \epsilon_t$$

so that Π has rank 3, whereas if consumption possesses seasonal unit roots Π is a null matrix as none of the quarters cointegrate. Therefore equation (8) is a VAR where the rank of Π is informative about the nature of seasonality. Franses (1994), using the results of Johansen (1988), shows how to estimate (8) (suitably augmented to remove any serial correlation) and test for the rank of Π and the exact nature of the cointegrating relationships between quarters. Testing the validity of seasonal unit roots (and therefore the appropriateness of the $\Delta_4 (= (1-L)S(L))$ filter) involves testing whether $\text{Rank}(\Pi) = 0$. Table 7 shows the results of testing this hypothesis on various consumption categories using Johansen's trace statistic, significant values reject the Δ_4 filter as being appropriate. With one exception the results overwhelmingly support the notion of

non-stationary preference shocks rather than periodic effects. This suggests that it is not seasonal preference parameters which induces consumption seasonality, instead it is shifts in the utility function.

However, as emphasised by Summers (1986), results which rely significantly on unobserved shocks to account for economic phenomena require strong independent corroborating evidence. Examination of Figures 3-12 and the historical/social analysis of Section 2 help provide this supporting evidence. The Buys-Ballot plots reveal significant increases in quarter four consumption. This is confirmed in Table 8 which lists the value of the fourth quarter consumption seasonal (estimated in Table 4 and expressed here as a percentage of consumption) at the beginning of each of the last four decades. The Christmas effect on non-durable consumption has risen from 4.2% in 1960 to 6% in 1990. It is noticeable that the most pronounced increases in fourth quarter consumption are closely associated with Christmas : alcohol and tobacco, and other goods (which includes jewellery, toys and books). This post-war increase in Christmas consumption is also consistent with the longer run historical examples of Section 2. In other words, we should interpret the evidence in favour of slowly changing non-stationary seasonal taste shocks as reflecting the importance of social customs which alter over the decades in response to a combination of new goods, fashion and technology all of which provide considerable flux to our seasonal conventions¹¹. Emphasising the importance of social customs also offers additional support to the notion of seasonality being non-stationary. When a custom becomes established it exerts a permanent and not temporary influence on future consumption behaviour.

7. Conclusion

This paper has used changes in consumption seasonality to try and infer what determines the seasonal nature of consumption. The first step was to characterise the seasonal nature of consumption. We found strong evidence that consumption seasonality is non-stationary, subject to slow but permanent changes. The plausibility of this formulation was confirmed by historical examples. This non-stationary formulation places considerable emphasis on the innovations to the

¹¹ We have not attempted to distinguish between consumption and consumption expenditure. Both consumption of alcohol and other goods contains an element of durability about them. However, even if one took the extreme position that the increased seasonality is entirely expenditure based it seems that changes in social customs would still be needed to explain the increase in Christmas expenditure.

seasonal pattern, a different perspective to more standard ways of viewing seasonality. We found little evidence that the consumption seasonal was inherited from income. Neither could we detect a significant role for interest rates or climatic variations. By far the most plausible candidate is that seasonality is endogenous to consumption, and within this category of explanations non-stationary preference shocks seem the most compelling answer. Historical and sociological evidence suggests that these preference shocks should be interpreted as slowly changing social customs/conventions. Therefore this study supports the notion that consumption is seasonal because of social influences, but denies that this means that consumption seasonality is either economically unimportant or statistically uninteresting.

These results have a number of implications. The first is that, at least for consumption, the propagation mechanism involved in the seasonal cycle is very different from that associated with the business cycle, there being either a zero or a negative relationship between seasonal consumption and income. This finding throws significant doubt on the empirical and welfare importance of liquidity constraints. Further, the existence of seasonal preference shocks raises the issue of how these filter through into the rest of the economy and how they interact with productive technology. Although Chatterjee and Ravikumar (1992) analyze a Real Business Cycle model with seasonality they do not consider the case of stochastic preferences. Further work should also examine whether seasonality in production is non-stationary and if not whether this is informative regarding the convexity or otherwise of productive technology. The relative roles of seasonality in technology (e.g. Todd (1990) and Cooper and Haltiwanger (1993)) and seasonality in preferences in explaining the seasonal cycle should also be examined.

Finally, the issue of whether preference shocks/social customs only affect the seasonal component of consumption needs to be examined. Hall (1986) suggests that there are significant autonomous fluctuations in consumption, and Scott (1994) argues that taste shocks may explain a significant amount of non-seasonal consumption fluctuations. Shiller (1984) also argues for the importance of social influences in determining stock prices. Not only does this possibility have significant implications for the way economists model consumption, it also has wider relevance to the issue of what causes cyclical fluctuations and the importance of "animal spirits".

Data Appendix

All data is quarterly and seasonally unadjusted. The U.K consumption series are drawn from *Economic Trends Annual Supplement* 1994 Edition Table 1.7 and the associated consumption price indices are derived by dividing the nominal series by the 1990 price series. Most of the categories are self-explanatory, aside from other goods, which includes, as its largest component, home furnishings, jewellery, sports and toys, and other services, which includes, *inter alia*, laundry, insurance, cinema, gambling, and miscellaneous services. We exclude rents, rates and water from our analysis because this is an annual series which is interpolated. Real Personal Disposable Income is taken from Table 1.6 and is in 1990 prices (CSO mnemonic CECO). The base rate series is taken from the Bank of England's Quarterly economic database. The real interest rate series is calculated as the base rate divided by 400 less the quarterly inflation rate. The climate variables were taken from the CSO's *Annual Abstract of Statistics* Tables 1.2, 1.3 and 1.4 in the years when these were published, the latest year being 1992.

Table 1 : Deterministic Measures of Seasonality

Variable	\bar{R}^2	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Q(4)	Q(16)
Total Consumption	0.865	-0.086 (-23.845)	0.032 (3.276)	0.023 (2.863)	0.032 (11.646)	31.0	187.6
Real Personal Disposable Income	0.476	-0.031 (-5.824)	0.023 (3.361)	-0.006 (-0.297)	0.009 (4.971)	47.8	82.5
Non-durable Consumption	0.946	-0.100 (-37.560)	0.040 (5.710)	0.020 (5.025)	0.042 (9.100)	57.3	173.6
Durable Consumption	0.167	0.083 (1.173)	-0.043 (-0.819)	0.029 (0.431)	-0.071 (-1.109)	163.5	471.3
Consumption of Alcohol and Tobacco	0.939	-0.281 (-16.301)	0.134 (11.997)	0.037 (7.382)	0.115 (4.971)	96.2	218.5
Food Consumption	0.712	-0.059 (-9.856)	0.035 (4.239)	0.006 (0.063)	0.024 (2.767)	65.4	152.5
Clothing and Footwear Consumption	0.972	-0.385 (-65.436)	0.136 (6.625)	-0.006 (-0.297)	0.261 (61.471)	106.0	211.0
Consumption Energy Products	0.857	0.094 (2.673)	-0.227 (-15.096)	-0.105 (-4.113)	0.241 (12.477)	139.7	294.1
Consumption Other Goods	0.938	-0.223 (-19.440)	0.046 (5.243)	0.028 (3.534)	0.154 (6.488)	107.2	263.9
Consumption Other Services	0.926	-0.022 (-2.389)	0.073 (9.218)	0.075 (11.338)	-0.128 (-12.901)	96.9	261.3

Sample Period : 1957q1-1993q2. Columns 3 to 6 report the coefficients from regressing the change in the logarithm (demeaned) of the variable in the first column on four deterministic seasonal dummies. T-statistics in parentheses calculated using Newey-West standard errors and Bartlett weights. Q(k) is the Box-Ljung test for serial correlation over first k lags - distributed under the null of no serial correlation as χ_k^2 .

Table 2 : Test of Deterministic vs Non-Stationary Stochastic Seasonality

Variable	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Joint	π	$\pi/2$
Total Consumption	1.426 ^a	1.468 ^a	0.241	0.325	1.970 ^a	2.021 ^a	2.321 ^a
Real Personal Disposable Income	0.650 ^b	0.213	0.064	0.688 ^b	0.963	1.174 ^a	1.650 ^a
Non-Durable Consumption	1.259 ^a	1.155 ^a	0.995 ^a	0.234	1.813 ^a	1.201 ^a	1.901 ^a
Durable Consumption	1.290 ^a	1.534 ^a	1.256 ^a	1.084 ^a	2.200 ^a	4.193 ^a	2.277 ^a
Alcohol and Tobacco	0.492 ^c	0.810 ^a	1.835 ^a	1.223 ^a	2.078 ^a	2.663 ^a	10.013 ^a
Food	0.864 ^a	0.958 ^a	1.213 ^a	0.886 ^a	2.008 ^a	1.527 ^a	3.521 ^a
Clothing and Footwear	1.465 ^a	1.678 ^a	0.103	0.126	1.928 ^a	4.245 ^a	11.396 ^a
Energy	0.152	1.181 ^a	0.346	1.196 ^a	1.784 ^a	1.588 ^a	2.010 ^a
Other Goods	0.463	1.074 ^a	1.884 ^a	1.443 ^a	2.093 ^a	5.875 ^a	12.675 ^a
Other Services	0.791 ^a	0.785 ^a	1.225 ^a	1.054 ^a	1.875 ^a	0.037	5.097 ^a
5% Critical Value	0.470	0.470	0.470	0.470	1.010	0.470	0.749

Sample period is 57q1:93q2. Column headings reveal hypothesis being tested i.e. quarter 1 is a test for deterministic seasonality in the first quarter against an alternative of non-stationary seasonality. The column headed "joint" is a test for all quarters simultaneously. The final columns test deterministic vs non-stationary seasonality at frequencies π and $\pi/2$. A ^a denotes significant at 1% level, ^b at 2.5% level, ^c at 5% level. Critical values from Canova and Hansen (1995).

Table 3 : HEGY tests for Seasonal Unit Roots

Variable	π	$\pi/2$	$\pi/2$	$F_{\pi/2}$	$F_{\pi,\pi/2}$
Total Consumption	-1.912	-2.117	-1.043	2.750	2.968
Real Personal Disposable Income	-2.648	-3.597 ^c	-4.092 ^a	13.365 ^a	9.917 ^a
Non-Durable Consumption	-2.070	-1.894	-1.511	2.785	2.885
Durable Consumption	-1.173	-3.340	-0.917	5.957	4.139
Alcohol and Tobacco	-1.139	-2.314	-0.186	2.707	2.031
Food	-2.145	-2.880	-0.742	4.320	4.060
Clothing and Footwear	-1.669	-2.667	-1.402	4.500	3.756
Energy	-3.933 ^a	-2.694	-1.171	4.332	7.922 ^a
Other Goods	-1.324	-2.039	-0.831	2.403	2.080
Other Services	-2.577	-3.473 ^c	-0.363	6.219	5.904
5% Critical Value	-2.900	-3.440	-1.960	6.570	6.040

Sample period : 1957q1 to 1993q2. Column headed π shows test for seasonal unit root at π frequency, $\pi/2$ show t-tests for the two unit roots at frequency $\pi/2$, $F_{\pi/2}$ is an F test for both unit roots at the $\pi/2$ frequency, and $F_{\pi,\pi/2}$ is a joint F test for seasonal unit roots at both π and $\pi/2$ frequency. 5% critical values are taken from HEGY (1990) for π , $\pi/2$ and $F_{\pi/2}$ and from Ghysels, Lee and Noh (1994) for $F_{\pi,\pi/2}$. All auxiliary regressions are augmented by including an intercept and seasonal dummies and just enough lags to ensure white noise residuals i.e "holes" were allowed in the augmentation.

Table 4 : Multivariate BSM Estimates

Variable	σ_ω	σ_η	σ_ϵ	ρ_ω	ρ_η	Prediction Error Variance	R^2_s	H(47)	Q(4)	Q(8)	EGHL π	EGHL $\pi/2$
Total Consumption	0.0018	0.0122	0.0001	-0.168 ^c (2.073)	0.790 ^a (15.676)	2.3×10^{-4}	0.388	0.916	4.207	7.596	-2.651	6.544
Non-Durable Consumption	0.0111	0.0075	0.0026	-0.200 ^b (2.483)	0.981 ^a (61.515)	1.2×10^{-6}	0.409	0.757	3.200	3.911	-3.207	4.862
Durable Consumption	0.0018	0.0145	0.0414	-0.164 ^c (2.022)	0.583 ^a (8.730)	6.9×10^{-3}	0.566	0.357	2.809	5.010	-1.440	8.705
Alcohol and Tobacco	0.0031	0.0164	0.0105	0 (0)	0.601 ^a (9.148)	7.1×10^{-4}	0.599	0.436	5.618 ^c	8.083	-1.877	1.569
Food	0.0016	0.0066	0.0096	-0.195 ^b (2.419)	0.588 ^a (8.844)	2.4×10^{-4}	0.535	2.557	5.009	7.596	-2.622	3.240
Clothing	0.0031	0.0179	0.0096	0.633 ^a (9.947)	0.696 ^a (11.792)	7.4×10^{-4}	0.557	1.114	2.803	10.504	-2.442	7.546
Energy	0.0081	0.0125	0.0113	0 (0)	0.436 ^a (5.894)	1.17×10^{-3}	0.626	0.785	5.789	8.276	-3.045	6.122
Other Goods	0.0383	0.0989	0	-0.306 ^a (3.910)	0.691 ^a (11.629)	4.6×10^{-4}	0.628	0.361	1.000	7.1994	-1.568	3.064
Other Services	0.0038	0.0095	0.0044	0.387 ^a (5.106)	0.763 ^a (14.360)	2.7×10^{-4}	0.471	1.716	2.755	4.340	- 4.097 ^a	7.778

Sample Period : 1958q1:1993q2. Because of a change in data definition all statistics for energy consumption are for 1964q1:1993q2. H(47) is a heteroscedasticity statistic equal to the sum of the last third of squared residuals over the sum of the first third, distributed approximately $\chi^2_{47,47}$. Significant values reject the null of homoscedasticity. R^2_s is the R^2 relative to a model with four deterministic seasonal dummies. σ_i is the standard deviation attached to innovation i for consumption and ρ_i denotes the correlation coefficient between the innovation i of consumption and income. The figure in parentheses is a test for independence of the components (see Stuart and Ord (1991) section 26.20) which has a Student's t-distribution with 140 degrees of freedom. Significant values reject independence. Q(k) is the Box-Ljung test for kth order serial correlation, distributed asymptotically as χ^2_{k-p+1} where p is the number of variance terms estimated. EHGL denotes the seasonal cointegration test of Engle et al (1993), significant values reject the null of no seasonal cointegration between consumption and income.

Table 5 : Seasonal Unit Root Tests : Interest Rates, Inflation, Climate

Test	Base Rates	Inflation	Real Base Rates	Sunshine	Rainfall	Mean Air Temperature
CH Joint	0.402	1.126	1.191	0.581	0.088	0.107
CH π	0.390	0.639	0.419	0.365	0.176	0.655
CH Joint $\pi/2$	0.435	0.573	0.414	0.421	0.401	0.620

Sample period for interest rates and inflation 1957q3 to 1993q2, for weather variables 1950q1 to 1990q4.

Table 6 : Correlation Coefficients Between Relative Prices and Consumption Share

Consumption Good/Durable Consumption	Non-Durables	Alcohol and Tobacco	Food	Clothing and Footwear	Energy	Other Goods	Other Services
Correlation Coefficient	0.000 (0)	-0.679 ^a (10.94)	0.039 (0.460)	0.205 ^b (2.478)	-0.575 ^a (8.316)	-0.177 ^c (2.129)	0.146 (1.746)
EGHL π	-1.779	-0.928	-1.229	-0.964	-0.977	-1.795	-1.693
EGHL F_{-1}	5.309	9.474 ^c	7.413	5.508	13.010 ^a	3.598	3.794

Correlation coefficient is between the innovation to the seasonal component of the variable named in the first column and the innovation to the seasonal component of the relevant relative price. Figure in parantheses is test for independence of correlation coefficient, see Table 5.

Table 7 : Testing for Seasonal Cointegration between Quarters

	Total Consumption	Non-Durable	Durable	Alcohol and Tobacco	Food	Clothing and Footwear	Energy	Other Goods	Other Services
Rank=0	49.61 (2)	37.62 (2)	48.88 (1)	51.29 (2)	55.09 (1)	65.74 ^c (1)	54.53 (1)	45.05 (3)	36.95 (2)

Table shows Johansen's (1988) trace test for cointegrating relationships between the quarters of each consumption category. Significant values reject the null of no cointegration. 95% critical value is 55.92 (Franses (1994), Table A.1). The VAR was augmented until there was no evidence of serial correlation up to order 4 (4 years, order of augmentation given in parentheses) and of no vector serial correlation of up to lag 2. For consumer durables the test statistic reported is for the sub-sample 1970q1 to 1992q2.

Table 8 : Changing Fourth Quarter Seasonal Effects

Year	Non-durable	Alcohol and Tobacco	Food	Clothing and Footwear	Energy	Other Goods	Other Services
1960	4.2	9.2	2.8	21.8	6.1	10.3	-4.0
1970	5.0	12.3	2.4	22.3	7.2	12.8	-4.3
1980	5.2	14.0	2.0	23.6	11.3	15.4	-4.7
1990	6.0	19.4	2.6	22.4	11.6	17.8	-2.8

Table reports estimated fourth quarter seasonal effect (expressed as a percentage of consumption) estimated from Table 4.

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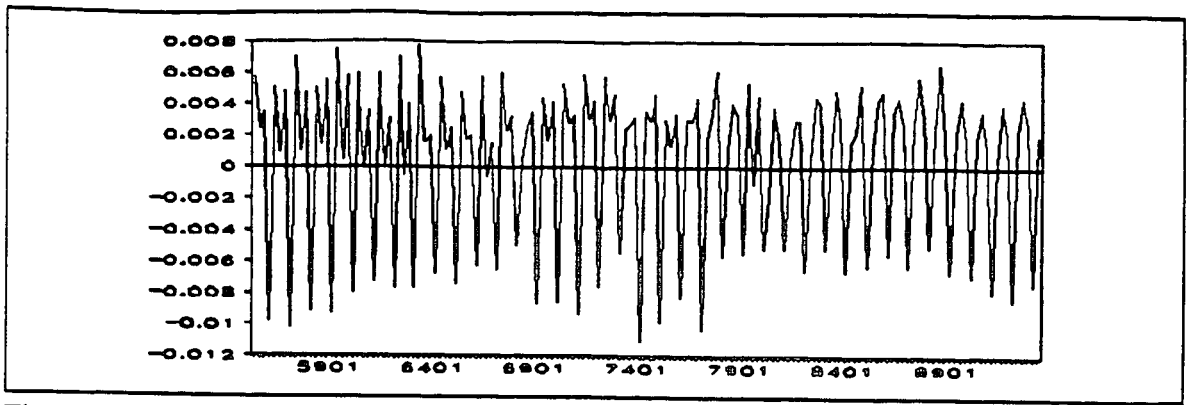


Figure 1 : Logarithmic Change Real Total Consumption

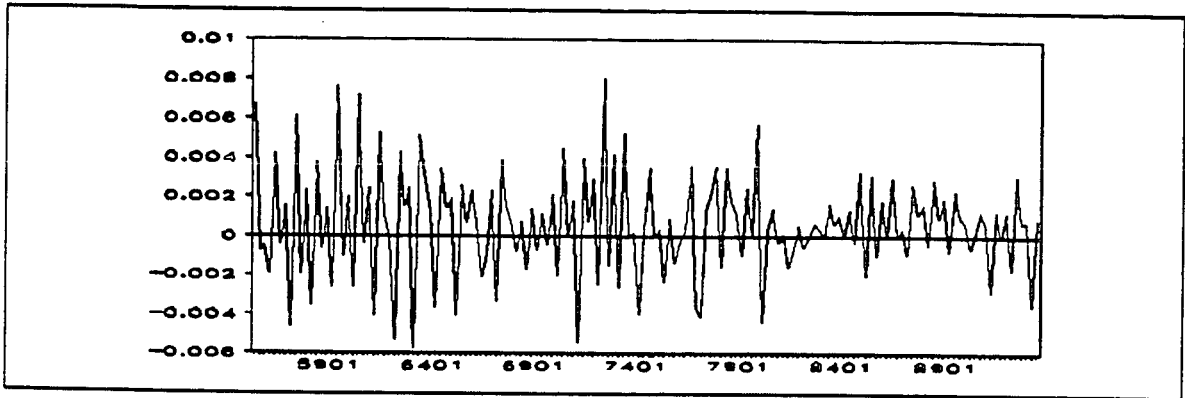


Figure 2: Logarithmic Change Real Personal Disposable Income

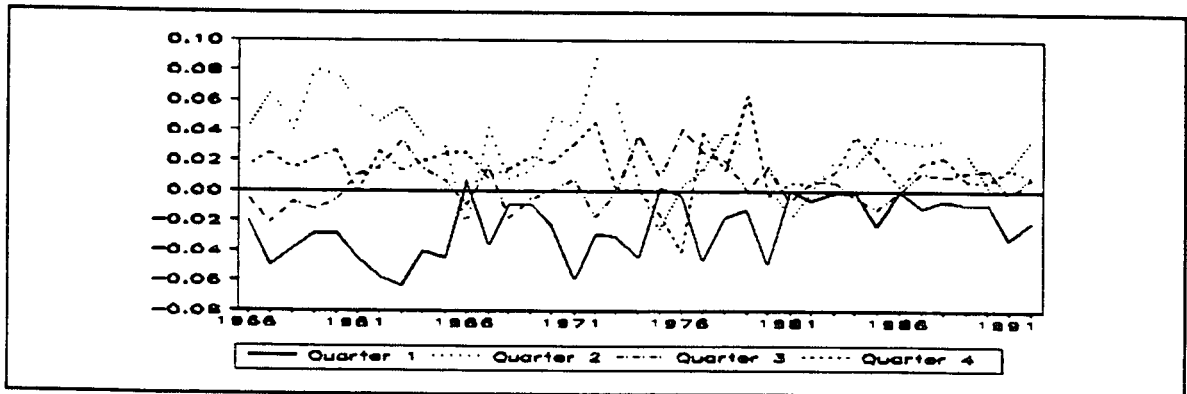


Figure 3 : Buys-Ballot Plot Real Personal Disposable Income

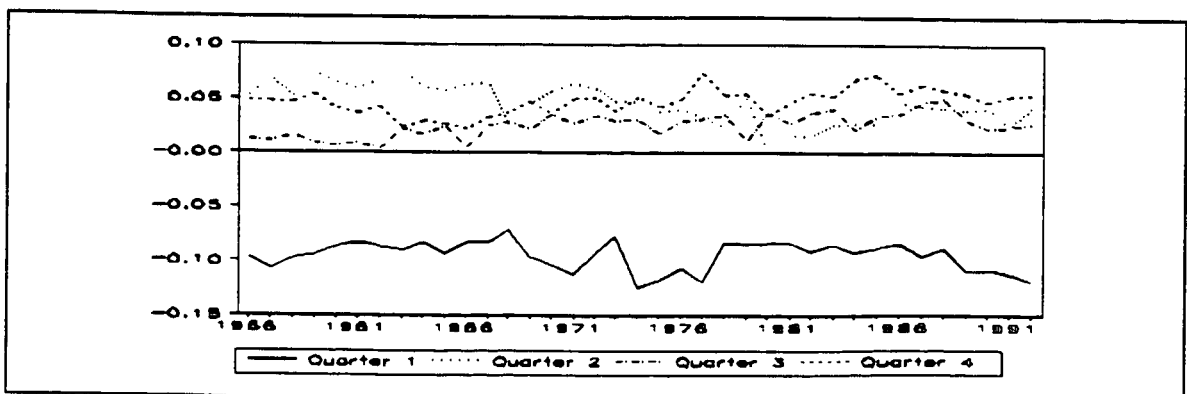


Figure 4 : Buys-Ballot Plot Non-Durable Consumption

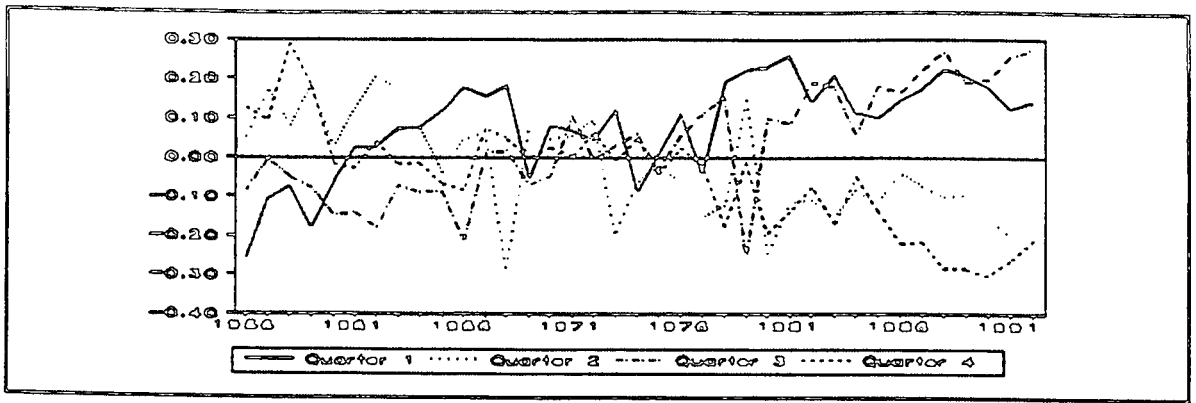


Figure 5 : Buys-Ballot Plot for Durable Consumption

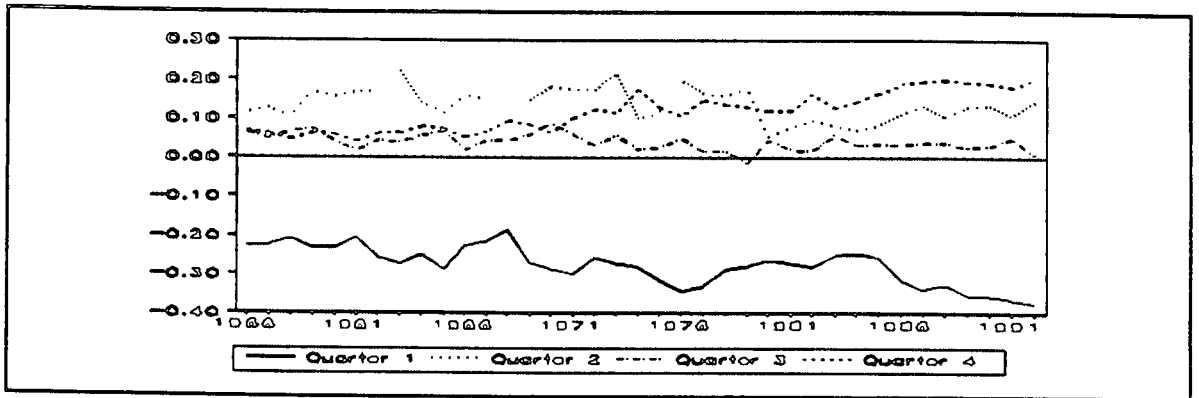


Figure 6 : Buys-Ballot Plot for Alcoholic Drinks and Tobacco

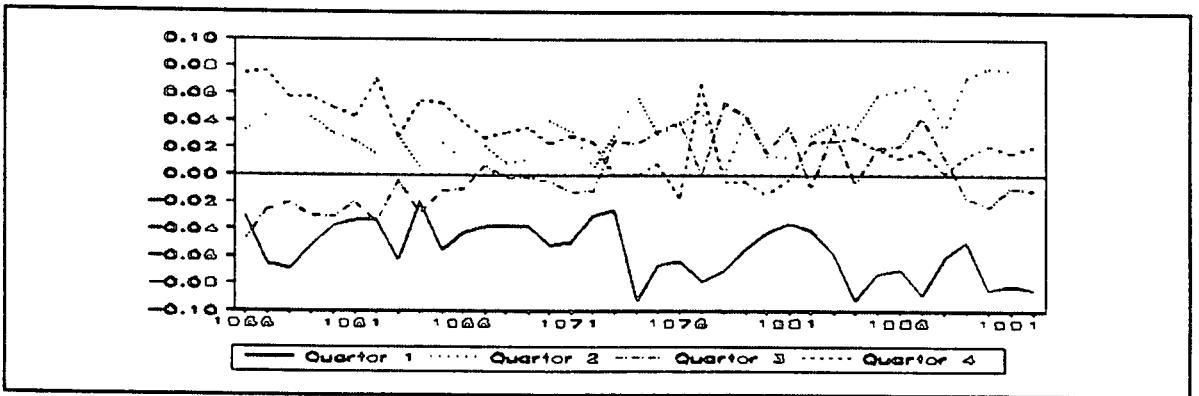


Figure 7 : Buys-Ballot Plot for Food Consumption

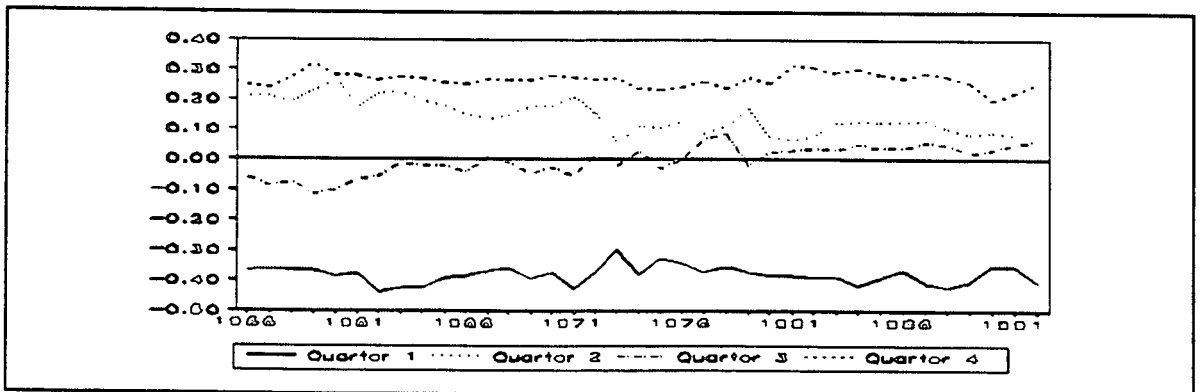


Figure 8 : Buys-Ballot Plot for Clothing and Footwear Consumption

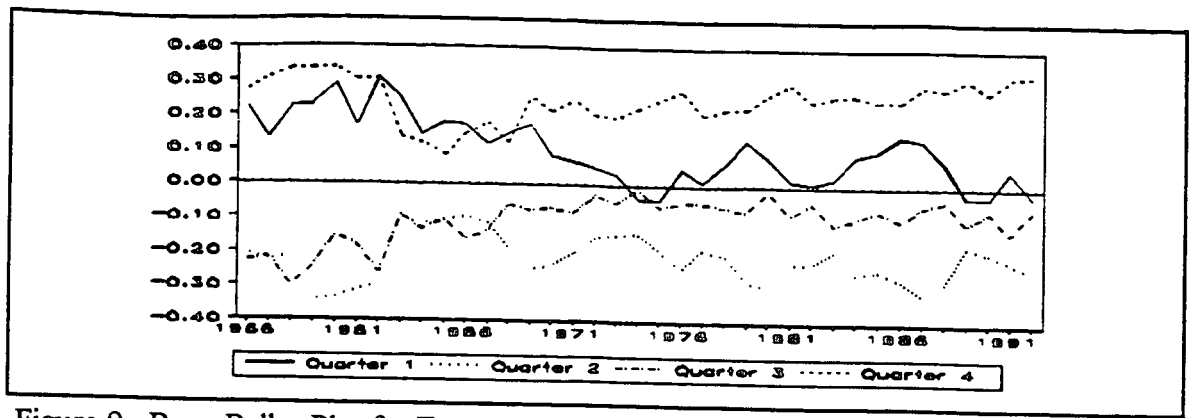


Figure 9 : Buys-Ballot Plot for Energy Consumption

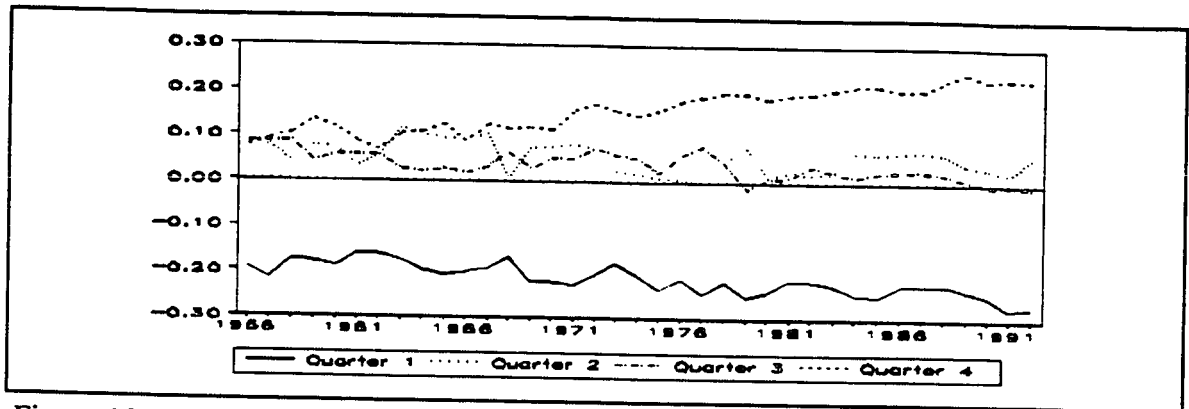


Figure 10 : Buys-Ballot Plot for Consumption Other Goods

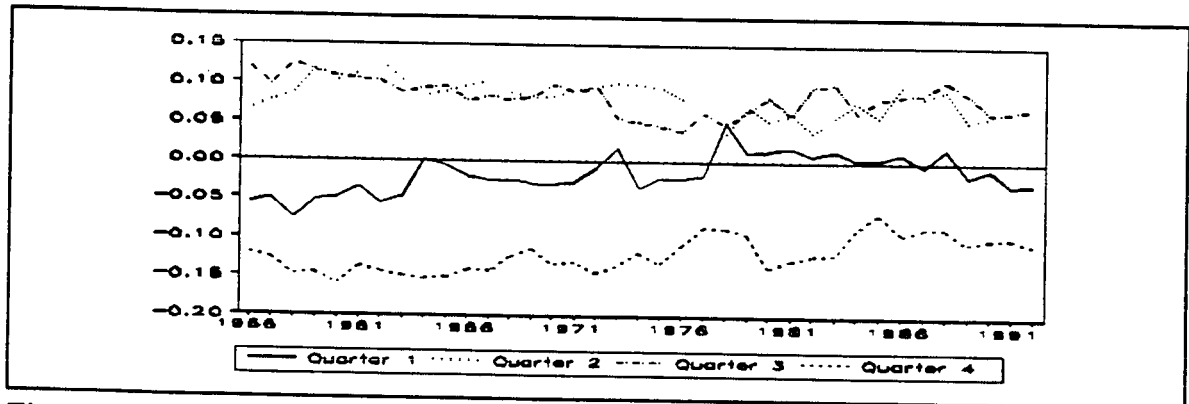


Figure 11 : Buys-Ballot Plot for Consumption Other Services

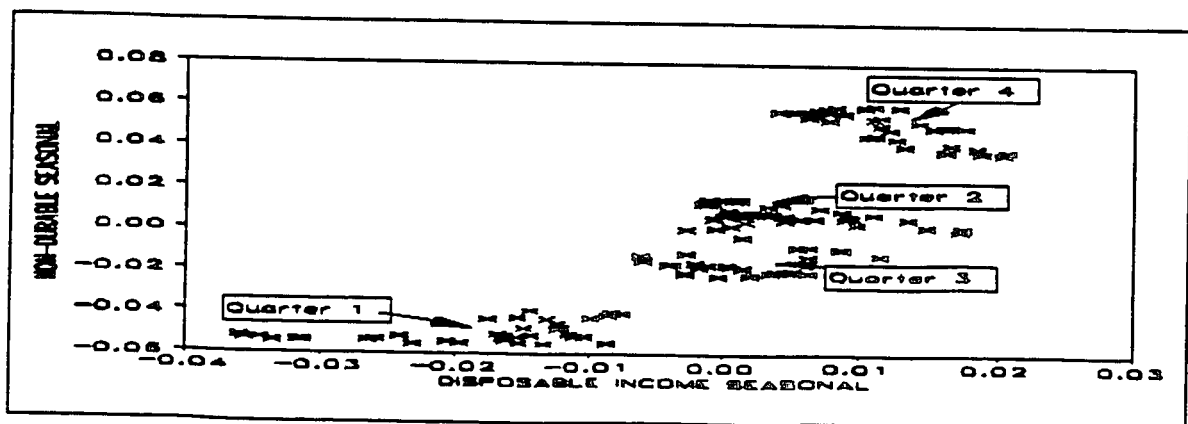


Figure 12 : Seasonal Components of Non-Durable Consumption and Disposable Income

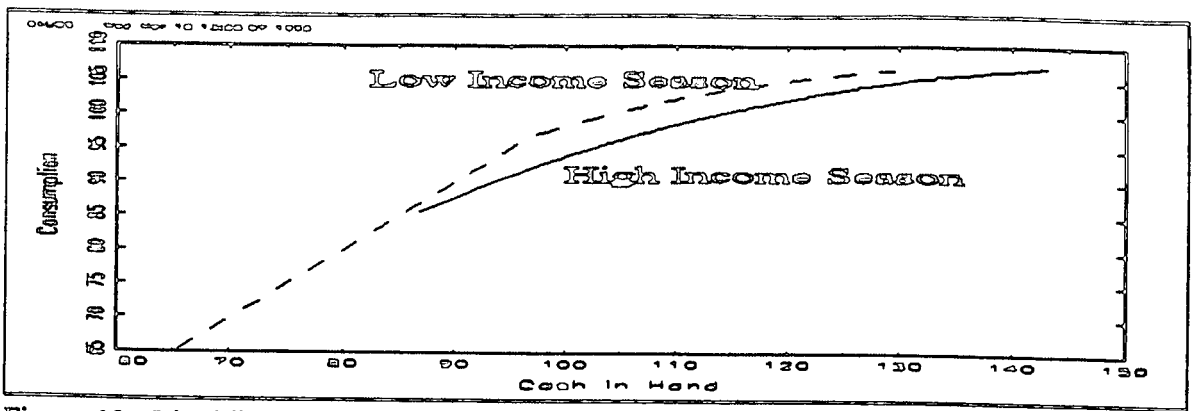


Figure 13 : Liquidity Constraints and Seasonal Income

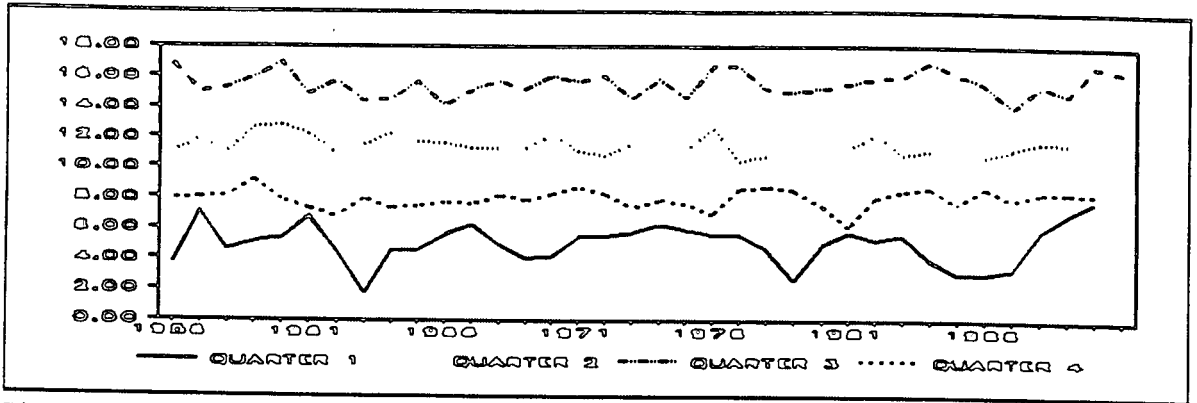


Figure 14 : Buys-Ballot Plot Mean Average Air Temperature England and Wales

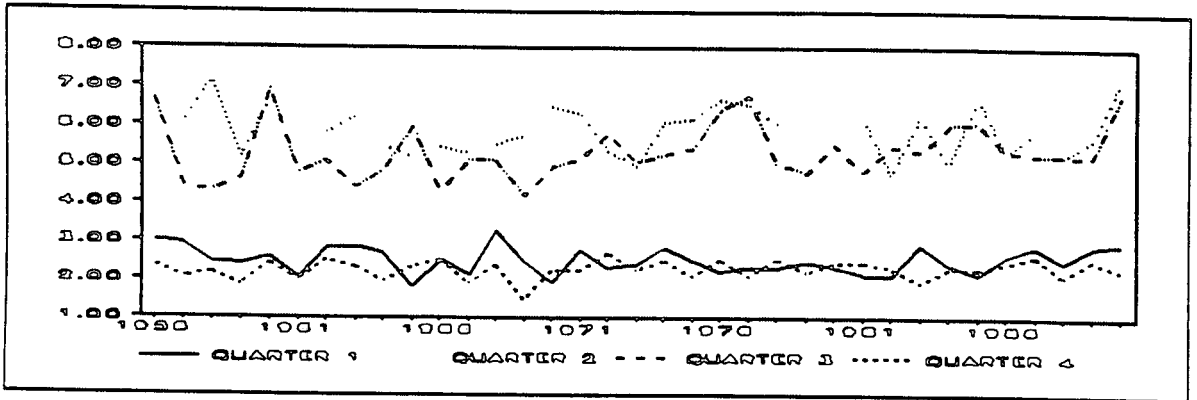


Figure 15 : Buys-Ballot Plot for Mean Hours of Sunshine England and Wales

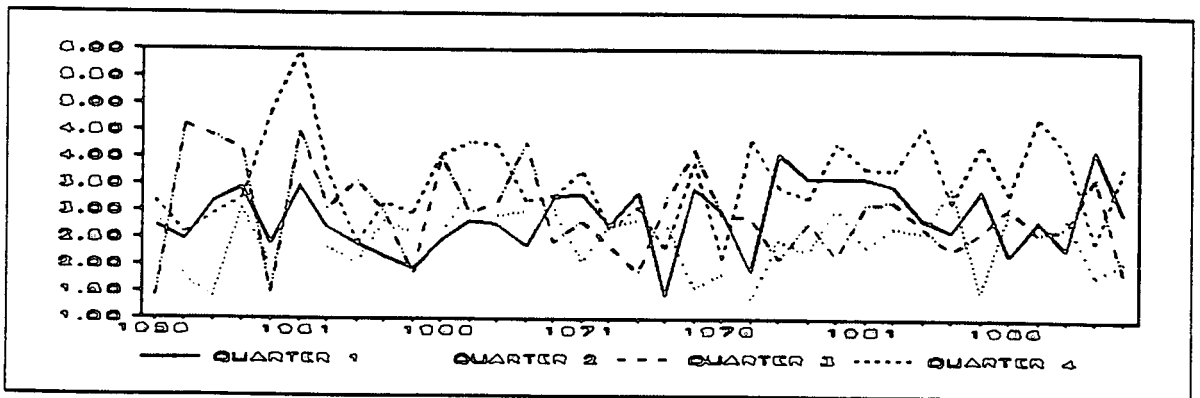


Figure 16 : Buys-Ballot Plot Mean Average Rainfall, England and Wales

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