DIET COMPOSITION, SOCIO-ECONOMIC STATUS AND FOOD OUTLETS DEVELOPMENT IN BRITAIN

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ISER Working Paper
2007-09

Acknowledgement:

Email: pdeago@essex.ac.uk This paper is an extract of the first and second chapters of my PhD thesis. It would not have been possible without the outstanding supervision which I have received from Marco Francesconi. Thanks are also due to Stephen P. Jenkins, Federico Perali, Andrew Chesher and seminar participants at various institutions for their helpful comments and suggestions on previous drafts of this work. I am grateful to the data depositors of the NFS (Department for Environment, Food and Rural Affairs), and to the UK Data Archive, University of Essex, for providing access to the data. I am also grateful to McDonald's Head Office for providing access to the data on new outlets opening by Local Authority District. Finally, I gratefully acknowledge the support received for this research from Chimera, Institute for Socio-Technical Innovation and Research at the University of Essex. I alone am responsible for errors and opinions.

Readers wishing to cite this document are asked to use the following form of words:

De Agostini, Paola (May 2007) 'Diet composition, socio-economic status and food outlet development in Britain', ISER Working Paper 2007-09. Colchester: University of Essex.

The on-line version of this working paper can be found at http://www.iser.essex.ac.uk/pubs/workpaps/

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The support of both the Economic and Social Research Council (ESRC) and the University of Essex is gratefully acknowledged. The work reported in this paper is part of the scientific programme of the Institute for Social and Economic Research.

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ABSTRACT

This paper investigates the relationship between nutrition and socio-economic status among the British population. It describes the dynamics of consumption over age and time using data from the British National Food Survey (NFS) covering the period 1975-2000. Daily intakes-age relationships for men and women are estimated by solving a non-linear least square model with a roughness penalty function approach. Focusing on young age groups, trends of consumption over the 25-year period of study and cohorts effect have been explored across three classes of age. Finally, an exploration of specific trend variations in eating habits has been implemented controlling for family income, region of residence, presence of children, eating out and food outlets development.

NON-TECHNICAL SUMMARY

The main concerns about eating habits variation are health and increasing costs of health care services. While in underdeveloped countries poor nutrition is primarily caused by low family income and lack of food resources. In developed countries this is not the case. The causes of malnutrition are more likely to arise from an unbalanced diet structure or lack of physical activities. Many questions regarding the reasons why people are becoming obese remain unanswered. Have diet or physical activity changed over time? Do we eat more?

In this paper I have started to explore how eating habits of people in Britain have changed over the last twenty-five years of the twentieth century. Using data from 1975-2000 from the National Food Survey I report here an extensive descriptive analysis that investigates the relationship between average nutrient intake consumption across ages and over time with the objective to see how they have changed by gender and age over time and by gender and time for all age groups and, in particular, for children 0-17.

I distinguish here four nutrient intakes: total calories, fat intakes, proteins and carbohydrate. Moreover, I also convert these intakes into calories in order to compare their contribution to the total with the estimated requirements for particular groups of the population given by the Committee on Medical Aspect of Food and Nutrition Policy (COMA, 1990). In particular, they recommend the proportion of energy from fats to be no more than 35%, proportion of energy from proteins to be no more that 15% and proportion of energy from carbohydrates to be no more than 50% for the most common lifestyle and activity levels in the UK.

In general nutrition varies over age and by gender. Males consume more food and nutrient intakes than females. Nutrients consumption strongly increase during childhood until puberty, decrease at the beginning of adulthood age and increase later on, decreasing again when people get older. Age distribution of consumption by major food groups show a general increase up to age 50 and decline afterwards.

There is no evidence of strong variation in total calorie consumption; however, I find an increase in the proportion of energy from fat to 35 percent at the middle of the 80s that remains stable from there since, while the proportion of energy from carbohydrates shows exactly the opposite trend decreasing of about 10% along the period of study.

When comparing different generations at the same age, although total calories-in do not change a lot across generations, younger generations consume higher quantity of fats intakes. The consequences of this can be seen in the proportion of energy from fats, which for younger generation results much higher than older generation when they were the same age.

Changes among nutrient intakes consumption due to income variations are relatively low and in general positive. This means that as income rises consumption rises as well but at a lower rate. Moreover, the sensitiveness of consumption to income variation becomes smaller toward time. This is not surprising as the effect of family income variation is expected to be much higher on food groups than on intake nutrients consumption as shown also by previous studies (Subramanian and Deaton, 1996). This means that as households become richer, the substitution between foods is faster than the variation of diet through substitution within nutrient intakes consumption. In other words, for people is easier to change food quantity consumed than quantity of intakes. However, at this moment it is not possible to say whether a positive variation of family income improves nutrition and therefore health status.

Development of supermarkets and fast food has greatly changed supply chains system. Today, supermarkets make many new products available wherever in the world and out of season, while small and local shops are increasingly less present. The analysis presented here finds some little (between 2-6%) positive significant effects on consumption of calories associated with number of food outlets available within the local area of residence.

Finally, I consider the hypothesis that every meal eaten out was taken at the fast food and estimate an upper bound for the intake-age curve distribution. Comparing the results with previous findings and daily recommended energy intakes I show that in average nutrient intake from eating out do not vary by gender, but over age. In general children age 5-16 consume more nutrients outside the household than adults, with the most of their meals out represented by meals at school. However, if this was not the case and every meal out was taken at the fast food, children's daily consumption of intake would highly overcome daily recommended amounts.

1 Introduction

There is now a large concern with overweight and obesity in Britain. The main reason for this is the negative effects that being obese or overweight can have on people's health as they increase the risk of developing a number of health problems including heart disease, diabetes, high blood pressure, and some forms of cancer.

According to the OECD data, in 2000, 300 million adults were obese and 700 million were classified as overweight around the world OECD, 2003. There are however notable differences in obesity rates across countries. In the United Kingdom, the obesity rate among adults has tripled over the last twenty years of the twentieth century to stand at 22% in 2001. This is higher than in nearly all other OECD countries, but lower than in the United States (31% in 1999) and Mexico (24% in 2000), and comparable to Australia (21% in 1999). Researchers predict that if the average rate of increase in the prevalence of obesity between 1980 and 1998 continues, over a quarter of all adults in England will be obese by 2010. This would bring levels of obesity in England up to those experienced now in the United States.

Obesity and overweight are increasing also among children and adolescents. In 2000, 18 million under five and 155 million children between five and seventeen years old were classified as overweight around the world. From the 80s the number of overweight children and adolescents nearly double. The U.S. Department of Health and Human Services reports that in 1999 13% of children aged 6 to 11 years and 14% of adolescents aged 12 to 19 years were overweight. This prevalence has nearly tripled for adolescents in the past two decades. For instance, in 1984, only approximately 5% of British children were overweight.

Apart from the health issue that being obese or overweight can create, a more immediate consequence of being overweight is social discrimination Stunkard and Sobal, 1995. Thus this phenomena can be also associated with poor self-esteem and depression.

The second concern of overweight and obesity is related to the rise of health care costs. As reported by the Summary of Intelligence on Obesity (2004) the cost of obesity in UK is estimated at 3.7 billion pounds per year and 7.4 billion pounds when adding the cost of overweight. Moreover, considering the time lag between the onset of obesity and related chronic diseases, researchers anticipate that the rise in obesity that has been occurring in the last 20 years, will have substantial implications on future health costs.

The third concern is related to the increase of social costs imposed by overweight and obesity to both individual (ill health, reduce quality of life, year of life lost, premature death, discrimination, etc.) and society (loss of productivity due to sick leave and premature pensions).

The main causes of overweight and obesity are commonly identified on excessive consumption (unbalance diet), lack of physical activities, genetic predisposition and disorders that affect the normal bodily functions as metabolism and growth. The modern sedentary life, the growing number of fast food and restaurant, technological changes, lack of resources, lack of information, unhealthy food's advertisements and women participation in the labor market are often popular justifications of the growing consumption of calories and the reduce physical activity (Lakdawalla and Philipson, 2002, Cutler et al., 2003, Chou et al., 2002, Marmot and Wilkinson, 1999, Bhattacharya and Curry, 2001, Case et al., 2002).

Although the possible solution has been easily identified by the UK Department of Health in the promotion of diet changes and physical activities increase[1], it is difficult to be implemented because it would imply changes in people's habits, preferences and behaviors. Consequently, considering that overweight adolescents have a higher probability (70%) of becoming overweight or obese adults than their non overweight counterparts[2], preventing obesity and overweight in childhood has been recognized as being perhaps a more effective approach in the long term.

However, as food choices depend on many social factors such as history, culture, economic status and environment, as well as on energy and nutrient needs, it remains unclear the exact relative responsibility on the obesity growth of an unbalance diet, excessive consumption and reduce exercise. Thus many questions regarding the reasons why people are becoming obese remain unanswered. Have diet and/or physical activity changed over time? Do people eat more today than in the past? How has diet changed across time? Who has been affected more by this changes? (why them? and why was that?) Do we eat "better" today than in the past?

This paper carries on a first exploration of eating habit variation across age, time and cohorts among the British population. Moreover, it presents some evidence on the relationship between nutrition and socio-economic status in Britain using cross sectional data from the National Food Survey covering the period 1975-2000. In doing so, I use the methodology proposed by Chesher's for decomposing the National Food Survey data and identify original regularities for basic demographic subgroups.

The aim of this paper is to extend Chesher's work using data from 1975 to 2000 considering also some nutrient intakes that he has not looked at. In particular this work focus on total calories, fat intakes, carbohydrate, proteins and the proportion of calories produced by each intake separately. It describes how eating habits have changed by

[1]National governments and international organizations, such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), have been working on nutritional guidelines extension, in particular recommending a reduction in total fat and sugar consumption.

[2]This probability rise to 80% if one or both parents are overweight or obese (genetic predisposition)

gender and age, by gender and time for all age groups and particularly for children aged 0-17, and by generations in Britain. Moreover, it tries to shed a light on the importance of social and economic environmental factors to nutrition changes considering the effect of income separately. There might have been many forces that have affected people's (especially children's) eating habits. In the first part this paper will simply describe consumption patterns without testing one explanation against another. It considers some hypotheses such as food outlet development and eating out in the last part in order to see whether there may be a connection between variation of diet composition and food industry development.

This work is organized as follows. Section 2 describes the data. Section 3 introduces the econometric specification using nonparametric techniques for the estimation of average daily nutrition intakes consumption within a household model that adopts a roughness penalty function and controls for income distribution, eating out, presence of visitors, region of residence, presence of children and number of supermarkets and fast food. Section 4 presents the results. Conclusions and extensions for future research are summarized in Section 5.

2 Data

The data used in this study come from the National Food Survey (NFS). This is a cross-sectional survey started in 1940, and it has run continuously since 1942. Its initial aim was to monitor the diet of the urban "working class" during the war years. In 1950 it was extended to the whole population in Britain to collect data on food consumption and expenditures. Since 1992 the NFS collects information also about confectionary, alcohol and soft drinks; and since 1996 it has been extended to Northern Ireland. From 2001 it has been merged with the Family Expenditure Survey (FES) becoming the Expenditure and Food Survey (EFS).

The NFS collects weekly data over one year on household food acquisition for a large nationally representative sample of British adults and children. It collects year and month specific information about all food entering into the household from roughly 7,000 household in the UK every year (corresponding to a response rate of 65 percent). After a short interview, the household's member who does the most of the shopping is asked to keep a diary where reporting expenditures in British pence as well as physical quantities[3] of food purchased among more than 200 food items listed. Each of the other members, age 11 and over, are requested to collect information on personal expenditure on snack,

[3]Physical quantities are reported in imperial measure.

meals, sweets, and drinks consumed outside the home. The data also record the number and type of meals (breakfast, lunch or dinner) offered to guests. In addition, the survey records some demographic characteristics, for example age and sex of each member of the family, number of male and female working, household characteristics, region of residence, and socio-economic variables, such as income and occupation of head of household.

2.1 Sample Characteristics

The time period considered in this paper covers 26 years from 1975 to 2000, in which 201,032 households and 521,000 individuals were observed. In order to make the subsample collected in each year comparable over time, data on North Ireland are not included as the data collection started there only from 1996. Moreover, the sample does not include either people over 91 because their number was not enough to produce significant figures. Finally, after controlling for missing values, the final sample counts 130,789 households and 353,989 individuals. Descriptive statistics for the main sample are reported in Table 1.

The individual average age in the sample is 35 years. Head of household on average is 49 years old and his wife is just one year younger. Children are on average 8 years old and the sample appears roughly equal distributed over age groups.

Information on eating out are summarized from the net balance variable. This variable varies for each person from 0 to 100. It takes value zero if the person always eats out; it takes value 100 if the person eats every meal at home. When a person eats outside the household, his net balance diminishes of a certain amount depending on which of the main three meals he did not took from the household. For example, when somebody has breakfast out from home, his net balance will diminish by 3 points; if he has lunch outside, his net balance will decrease by 4 points, while when he eats dinner outside, his net balance will decrease by 7 points.

In the sample considered here, the average individual records a net balance per week of 87.47 points. Thus, in average during one week a person obtains almost 13 percent of his net balance from outside the household. This corresponds almost to one full day eating out (one breakfast (3), one lunch (4) and one dinner (7) per week). Figure 1 shows average net balance per person over time (panel a) and by age comparing 1975 and 2000 (panel b). Panel c represents net balance variation over time by age groups. The lower the net balance line-trend is, the higher is the number of people eating out. Average individual net balance diminished of about 4 percentage points from 1975 to 2000. Thus, the proportion of food taken from home supply decreased whilst the amount of food eaten

Table 1: Descriptive Statistics (1975-2000) - Household obs. 130,789 - Individuals obs. 353,989

	Descriptive Statistics			
	Mean	Std. Dev.	Min	Max
Individual Characteristics				
age	34.88	22.73	0	91
age of wife of hoh	47.69	17.70	16	92
age of children	8.15	5.04	0	17
Head of Household Characteristics				
age	49.34	17.52	16	91
age if male	47.27	16.28	16	91
age if female	55.36	19.50	16	91
Family Characteristics				
number of members	2.61	1.37	1	13
number adult male	0.88	0.55	0	6
number adult female	0.99	0.44	0	7
number children	0.74	1.08	0	10
number adult aged greater than 64	0.35	0.64	0	4
number person aged 0000	0.04	0.19	0	3
number person aged 0104	0.18	0.46	0	5
number person aged 0507	0.13	0.38	0	3
number person aged 0811	0.17	0.45	0	5
number person aged 1215	0.16	0.44	0	6
number person aged 1617	0.06	0.26	0	3
Eating Out				
net balance per person	87.47	14.94	0	100
total net balance per household	238.75	127.22	0	1247
Visitors				
net balance per person	10.13	9.60	0	100

out has increased.

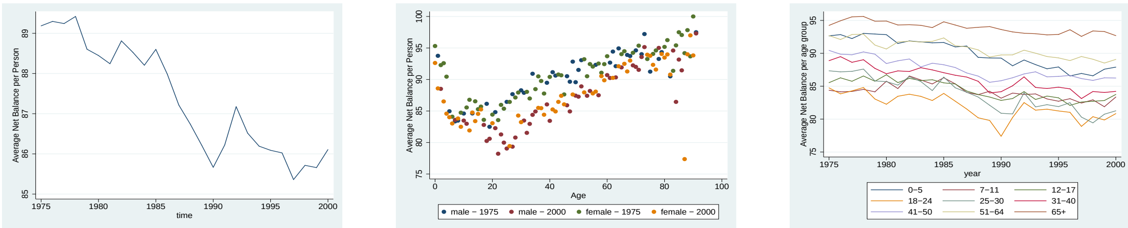
Figure 1 panel b) compares average individual net balance distribution over age between 1975 and 2000. The younger part of the population eats away from home more often than people older than 60 years old. Youths between age 5 and age 23 eat out more often than anybody else in the sample[4]. The comparison over time reveals, maybe not surprising, that in recent years people eat out more than in the past. The difference of 5 percentage point corresponds, in terms of meals, to one lunch more away from home in 2000 respect to 1975.

Figure 1 panel c) compare average individual net balance over time by age groups.

[4]Probably this result is due to the fact that people still in education have at least one meal at school. However, the data available do not allow me to control for this.

People over 65 eat away from home less often than others. Whilst people between 18 and 24 years old are those eating out more often. In general the younger generations (young adults 25-30, adolescent 12-17 and children 7-11) eat out more often. Although the figures shown here can be picking up the fact that many pupils have lunch at school, or that people can benefit from meal on wheels or lunches out during working days, the general decline of the net balance over time indicates that nowadays people tend to take lees food from home supply than in the past.

Figure 1: Describing Average Net Balance per person.



(a) Over time. (b) By age. (c) By age groups.

In average there are about 2 or 3 members per household, with a maximum of 13 members. Approximately 9 percent of the individuals lives alone, 59 percent lives in household without children, while 41 percent lives in household with only adults (Table 2).

The sample is roughly 5 percent from Wales, 9 percent from Scotland, 7 percent from the Northern, 9 percent from York and Humberside, 11 percent from the North West, 7 percent from East Midland, 10 percent from West Midland, 8 percent from South West, 3 percent from East Anglia and 30 percent from South East. For the analysis presented here, regions of residence have been aggregated into four macro-groups as shown from Table 2.

The NFS collects also a set of economic variables such as net family income, total expenditure on food, specific food expenditures on particular items and quantity of food purchased during the period of study.

The main aim of this paper is to study whether and how the composition of the British diet has changed from the past so much to be considered a possible explanation for the rapid growth of obesity observed during the last twenty years. Thus the dependent variables used in this paper are nutrient intakes. They results from the transformation of quantities of food purchased by the household and their allocations among different family members have been computed according to the methodology described in the following section.

To summarize the information on food, I cluster more than 200 food items listed in the

Table 2: Family structure and region of residence - Household obs. 130,789 - Individuals obs. 353,989

Variables	Households		Individuals	
	Freq.	Percent	Freq.	Percent
Presence of Children				
Hhld with children	50,948	38.95	208,893	59.01
Hhld without children	79,841	61.05	145,096	40.99
Region of Residence				
Central, South-West and Wales	39,623	30.29	108,167	30.56
Scotland	11,726	8.97	32,234	9.11
North of England	36,149	27.64	98,127	27.72
London and SE England	43,291	33.10	115,461	32.61
Total	130,789	100.00	353,989	100.00

NFS into 14 big food groups[5]: diary products, meat, fish, eggs, fats and oils, sugar and preservatives, vegetable, fruit, cereals, soft drinks, confectionaries, alcohol, miscellaneous and beverage.

Table 3 reports descriptive statistics on net family income and quantities (in grams[6]) of food purchased on average per household in a week period on each food group.

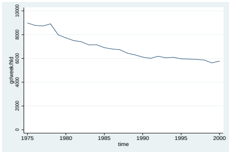
Over the time period, the average household (of 2 or 3 people) buys in one week almost 6 kg (1 kg = 1 liter) of diary products, 3 kg of meat, 12 eggs, almost 1 kg of fats and oils, 1.4 kg of sugars and preservatives, 6 kg of vegetables, 2.7 kg of fruit, 4 kg of cereals, pasta and rise, 4 liters of soft drinks and 3 liters of alcohol.

Figures 2 shows average variation of food groups purchased over time (1975-2000). In the period of study, we can notice a decrement in purchases of diary products, eggs, sugar and preservatives, cereals and vegetable. The figures also show increments in acquisition of fish, fruit, miscellaneous. Acquisition of soft drinks, confectionaries (i.e. chocolate bars, snacks, etc.) and alcohol are recorded in the NFS only from 1992. Between 1992 and 2000 the average quantity purchased of soft drinks and alcohol have increased, whilst quantity of confectionaries remained stable.

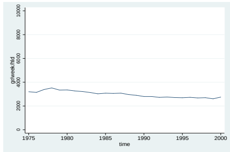
[5]The classification of food into general categories can be slightly different from study to study. Specifically, there are differences between the American and European classification. The US uses a six groups classification, whilst in the UK it is common to distinguish five main food groups. However, some foods listed in the NFS are not easy to classify: data on alcohol, confectionary and soft drinks are available only from 1992, eggs are measured in number of units and cannot be summed up with other food. Therefore the choice to keep more than 6 food groups.

[6]The NFS reports quantities in imperial measures and every quantity have been converted into grams using conversion factors.

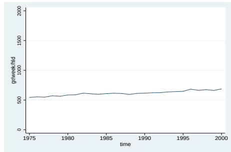
Figure 2: Describing average variation over time of Major food groups.



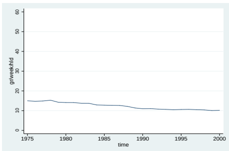
(a) Diary Products.



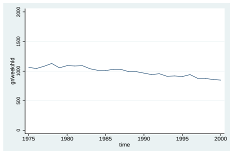
(b) Meat.



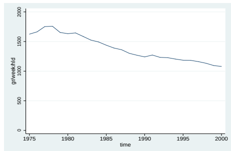
(c) Fish.



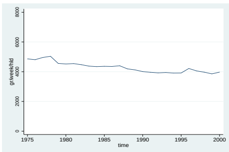
(d) Eggs.



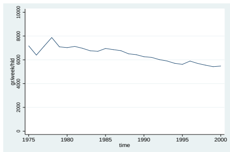
(e) Fat and oils.



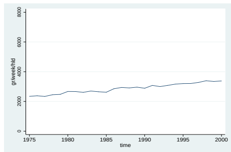
(f) Sugar and Preservatives.



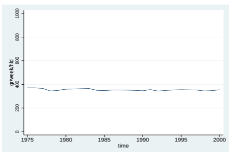
(g) Cereal, pasta, rise and bread.



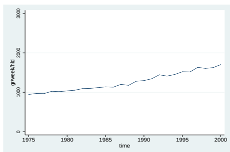
(h) Vegetable.



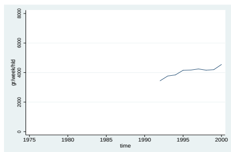
(i) Fruit.



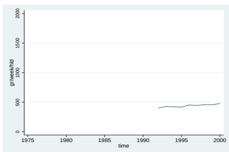
(j) Beverage.



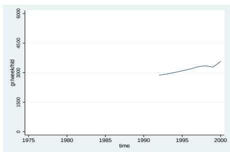
(k) Miscellaneous.



(l) Soft Drinks.



(m) Confectionar-ies.



(n) Alcohol.

Table 3: [Continue] Descriptive Statistics (1975-2000) - Household obs. 130,789 - Individuals obs. 353,989

	Descriptive Statistics			
	Mean	Std. Dev.	Min	Max
Weekly Family Income				
net family income	150.18	156.13	10	2978.00
Quantity of Food purchased (g)				
diary products	6635.38	4464.00	42.00	66640.75
meat	2846.82	2757.96	25.00	140219.1
fish	592.87	567.04	28.00	20723.85
eggs (N. of eggs)	12.19	8.11	0	162
fats and oils	962.35	877.08	11.00	40161.2
sugar and preservatives	1397.65	1078.61	14.00	62511.75
vegetable	6159.51	5846.39	20.00	117907.7
fruit	2783.29	2588.28	9.98	81364.5
cereals	4159.73	3274.51	19.00	303111.1
soft drinks	4034.82	4035.49	74.83	85050.78
confectionaries	437.46	455.75	7.37	8500.32
alcohol	3188.45	3958.58	10.48	123138.2
miscellaneous	1250.97	1584.85	0	61696.84
beverage	344.50	268.06	9.00	10000.17

2.2 Derived Nutrient Intake Variables

Many nutritionists have pointed out that in order to have a healthy diet is important to have the right balance of nutrients needed to be healthy. The definition of balance diet can be either based on combination of food or combination of intakes or both as long as the balance of nutrients is right.

Table 4: [Continue] Descriptive Statistics (1975-2000) - Household obs. 130,789 - Individuals obs. 353,989

	Descriptive Statistics			
	Mean	Std. Dev.	Min	Max
Quantity of Intakes purchased				
calories (Kcal)	37414.10	25811.94	0	1260780
Proteins (g)	769.69	551.56	0	22950.10
Energy from proteins (Kcal)	3078.76	2206.24	0	91800.40
Fat intake (g)	1687.04	1278.57	0	39593.91
Energy from fats (Kcal)	15183.33	11507.13	0	356345.20
Carbohydrates (g)	4559.54	3475.14	0	263892.50
Energy from carbohydrate (Kcal)	17098.27	13031.77	0	989596.87

The analysis that follows will therefore concentrate on consumption of nutrient intakes. The amount of nutrient intakes purchased by each household during the period of study are computed from the basic NFS data using the conversion factor tables provided by the Department for Environmental Food and Rural Affairs (DEFRA, 1999). Apart from alcohol, soft drinks and confectionaries for which data are available only from 1992, the full detail of reported food purchased is used. Weights are converted to intakes using the intake content factors provided by DEFRA. This paper considers 4 nutrient intakes[7]: calories, proteins, fat, carbohydrates. Moreover, as the UK estimated requirements for particular groups of the population are given in terms of proportion of energy from fats, proteins and carbohydrates on Medical Aspects of food and , COMA, in what follows I also convert proteins, fats and carbohydrates into calories in order to be able to compare their proportional contribution to the total calories. The Committee on Medical Aspect of Food And Nutrition Policy specifically set targets[8] for the proportion of energy from fats to be no more than 35%, proportion of energy from proteins to be no more that

[7]The first version of this paper studied 13 nutrient intakes: calories, proteins, fat intake, carbohydrate, calcium, iron, vitamin C, D, E, B6 and B12, potassium, magnesium. However, conversion factor for potassium, magnesium, vitamin B6, vitamin B12 and vitamin E are available only from 1992 and they do not produce significant estimation. I report here the most interesting: total calories, fat intakes, proteins, carbohydrate, proportion of energy from fats, from proteins and from carbohydrates. The other results are available from the author under request.

[8]Although the UK nutritional requirements are now over ten years old, they have not been reviewed yet.

15% and proportion of energy from carbohydrates to be no more than 50%. Estimated Average Requirement (EAR) for energy varies by age, gender, lifestyle and activity levels. The COMA's estimations reflect a sedentary lifestyle (the most common in the UK) with little physical activity at work or in leisure time.

Total amount of energy from fat is obtained multiplying total amount of fats by 9.00. Total amount of energy from carbohydrates derive from the multiplication of total amount of carbohydrates times 3.75. Total amount of energy from proteins is the result of total amount of proteins (animal and vegetable) by 4.00. The proportion of energy is the ratio between the total amount of calories provided by a certain intake and the daily total amount of calories consumed.

Table 4 shows household consumption of nutrient intakes in a week period. In average a household purchases 37,414 calories per week and more than 1.5 kg of fats. This means that almost half of the total calories purchased is derived from fats.

Table 5: Average proportion of energy from different intakes (1975-2000) - Household obs. 130,789 - Individuals obs. 353,989

	Freq.	%	Cum.
Proportion of energy from fats (PEF)	15183.33	40.58	40.58
Proportion of energy from carbohydrate (PEC)	17098.27	46.70	87.28
Proportion of energy from proteins (PEP)	3078.76	8.23	95.51
Proportion of energy from other intakes	2053.74	4.49	100.00
calories (Kcal)	37414.10	100.00	

2.3 Food outlet data

One of the remarkable phenomena of the twentieth century is the spread of restaurant, fast food and supermarket chains. One of the aims of this paper is to examine the effect of this spread on the British population's diet.

The data source used for this purpose would have ideally provided information on how many outlet have opened every year within each Local Authority District[9] from 1974 to 2000. However this was not the case. Data on supermarkets opening every year were very difficult to find even by regions. The only information available to my knowledge is provided by the Competition Commission report (2000) and the annual reports of each supermarket chain.

[9]Information on since when supermarkets first entered into the Country seem to be available from the Office of the Deputy Prime Minister. However I have been refereed to their report.

Supermarkets provide "one-stop shopping", meaning that all household's items requiring relatively frequent replacement can all be found there. Thanks to its internal organization[10], supermarket can be a profitable, low-cost form of food retailing providing a wide combination of different items but also an increase in the number of food lines stocks. Thus it is convenient for the person who does the shopping in the household, usually the housewife, to buy all her food (planning meal and menu) together with non-food household requirements, such as cleaning materials McClelland, 1962.

Geographically, development has been most uneven, early moves being almost entirely confined to London (Table 6), probably because of its unique density of population with extremely high traffic of people. Today, the market in the UK is dominated by six big supermarket chains: Tesco, Sainsbury's, ADSA, Coop, Morrisons, Sateway, and some others small companies such as Iceland, Aldi, Lidl, M&S, Netto, Somerfield, Waitrose. Base on their size (sometimes turn over and/or number of checkouts), extent of self-service, stock assortment Smith, 2004 supermarket can be classified into different categories. However here I do not make any particular distinction and I control for the effect on the diet due to one extra supermarket opening in the market.

Data on fast food by Local Authority District have been obtained directly from McDonald's head office. They provides information on store location, including the postcode, and exact opening date and store numbers. Thus each of the 381 outlets can be matched to a Local Authority District information in the National Food Survey, whilst data on supermarkets have been merged to the survey by region.

McDonalds entered into the UK in 1974 and from there since it has grown steadily and consistently. It went from 0 to 381 outlets in 17 years.

Table 6 reports the average number of supermarket and fast food by year of survey from 1975 to 2000 in each macro-region used in the next sections.

Notice that after merging the NFS with the data on fast food and supermarkets opening, I loose the first year for fast foods and the last year for supermarkets. The discrepancy probably arises because not all LADs appear in the data set used here. Instead for supermarkets data are not available for 2000 as can be seen from Table 6.

[10]Self-service system, jobs specialization, rationalization and mechanization

Table 6: Average number of food outlets by region (1975-2000) - std. deviation in parenthesis.

	Scotland		Northern England		Central, SW and Wales		London and SE of England	
year	N. spmkt	N. Fast Food	N. spmkt	N. Fast Food	N. spmkt	N. Fast Food	N. spmkt	N. Fast Food
1975	2.00	0.00	12.42	0.00	8.14	0.00	46.56	0.00
	(0.00)	*(0.00)*	*(6.19)*	*(0.00)*	*(1.16)*	*(0.00)*	*(8.06)*	*(0.00)*
1976	3.00	0.00	13.84	0.00	9.47	0.00	53.98	0.08
	(0.00)	*(0.00)*	*(6.02)*	*(0.00)*	*(0.88)*	*(0.00)*	*(9.67)*	*(0.27)*
1977	6.00	0.00	14.32	0.00	11.10	0.00	57.22	0.00
	(0.00)	*(0.00)*	*(5.87)*	*(0.00)*	*(1.45)*	*(0.00)*	*(9.75)*	*(0.00)*
1978	9.00	0.00	16.34	0.00	13.16	0.00	61.29	0.31
	(0.00)	*(0.00)*	*(7.17)*	*(0.00)*	*(2.16)*	*(0.00)*	*(10.06)*	*(0.60)*
1979	10.00	0.00	16.85	0.00	14.80	0.00	68.40	0.17
	(0.00)	*(0.00)*	*(8.68)*	*(0.00)*	*(2.23)*	*(0.00)*	*(12.07)*	*(0.38)*
1980	14.00	0.00	16.98	0.00	16.45	0.00	77.59	0.27
	(0.00)	*(0.00)*	*(9.43)*	*(0.00)*	*(1.67)*	*(0.00)*	*(10.82)*	*(0.44)*
1981	17.00	0.00	17.43	0.00	19.54	0.08	91.11	0.55
	(0.00)	*(0.00)*	*(10.24)*	*(0.00)*	*(3.68)*	*(0.27)*	*(14.91)*	*(0.78)*
1982	20.00	0.00	18.97	0.00	21.98	0.06	104.33	0.45
	(0.00)	*(0.00)*	*(11.67)*	*(0.00)*	*(5.49)*	*(0.23)*	*(15.24)*	*(0.50)*
1983	22.00	0.00	20.88	0.17	25.46	0.40	113.43	0.74
	(0.00)	*(0.00)*	*(12.11)*	*(0.38)*	*(5.22)*	*(0.49)*	*(17.68)*	*(1.12)*
1984	22.00	0.00	24.09	0.28	26.16	0.34	115.24	0.47
	(0.00)	*(0.00)*	*(11.90)*	*(0.56)*	*(5.37)*	*(0.83)*	*(28.13)*	*(1.19)*
1985	24.00	0.00	29.00	0.39	29.59	0.70	126.42	0.69
	(0.00)	*(0.00)*	*(13.71)*	*(0.66)*	*(5.02)*	*(1.16)*	*(22.28)*	*(0.78)*
1986	24.00	0.00	31.47	0.61	31.96	0.75	131.42	0.56
	(0.00)	*(0.00)*	*(16.10)*	*(0.77)*	*(3.88)*	*(1.41)*	*(28.63)*	*(0.79)*
1987	26.00	0.00	33.22	0.51	36.29	0.83	143.70	0.69
	(0.00)	*(0.00)*	*(15.12)*	*(0.81)*	*(4.87)*	*(1.39)*	*(33.57)*	*(1.03)*
1988	27.00	0.60	43.87	1.00	40.89	0.81	158.35	1.22
	(0.00)	*(0.83)*	*(16.47)*	*(0.82)*	*(5.38)*	*(1.15)*	*(35.33)*	*(1.22)*
1989	30.00	0.89	47.74	1.09	45.14	1.06	174.11	1.11
	(0.00)	*(1.26)*	*(18.04)*	*(0.82)*	*(6.87)*	*(1.64)*	*(37.30)*	*(1.02)*
1990	33.00	0.87	54.47	1.18	50.30	1.16	187.62	1.17
	(0.00)	*(1.57)*	*(19.93)*	*(1.06)*	*(8.22)*	*(1.74)*	*(38.61)*	*(0.98)*
1991	36.00	0.78	57.73	1.23	52.55	0.94	202.55	1.43
	(0.00)	*(0.82)*	*(24.96)*	*(1.31)*	*(10.99)*	*(1.16)*	*(39.09)*	*(1.33)*
1992	39.00	1.26	64.42	1.65	57.67	1.00	216.24	1.38
	(0.00)	*(1.90)*	*(27.14)*	*(1.65)*	*(11.92)*	*(1.22)*	*(39.02)*	*(1.45)*
1993	39.00	1.56	66.49	1.52	61.03	1.45	233.29	1.43
	(0.00)	*(2.36)*	*(27.16)*	*(1.53)*	*(12.67)*	*(2.74)*	*(51.56)*	*(1.64)*
1994	41.00	1.59	67.29	1.73	63.20	1.48	257.88	1.50
	(0.00)	*(2.08)*	*(26.86)*	*(1.51)*	*(14.26)*	*(3.15)*	*(53.82)*	*(1.46)*
1995	82.00	1.76	73.44	1.93	67.43	1.45	274.32	1.93
	(0.00)	*(2.25)*	*(29.22)*	*(1.39)*	*(15.26)*	*(3.24)*	*(56.72)*	*(1.51)*
1996	88.00	2.21	75.04	2.16	70.03	2.14	291.69	2.39
	(0.00)	*(2.92)*	*(32.18)*	*(1.74)*	*(15.95)*	*(3.57)*	*(58.90)*	*(1.76)*
1997	96.00	2.05	77.52	3.21	75.22	2.55	302.84	2.50
	(0.00)	*(3.36)*	*(33.41)*	*(2.25)*	*(17.57)*	*(3.73)*	*(60.82)*	*(2.27)*
1998	101.00	2.22	80.22	3.67	81.83	2.82	308.34	2.75
	(0.00)	*(3.73)*	*(36.95)*	*(2.63)*	*(19.56)*	*(3.78)*	*(62.94)*	*(2.17)*
1999	108.00	2.47	87.58	3.98	86.70	3.07	318.24	2.89
	(0.00)	*(4.53)*	*(38.67)*	*(2.66)*	*(19.96)*	*(3.82)*	*(65.32)*	*(2.24)*
2000	–	2.50	–	4.46	–	3.30	–	3.02
	–	*(4.67)*	–	*(3.15)*	–	*(4.55)*	–	*(2.39)*
All sample	39.45	0.93	42.48	1.24	40.68	1.09	166.85	1.24
	(33.16)	*(2.32)*	*(33.85)*	*(1.91)*	*(28.08)*	*(2.53)*	*(103.17)*	*(1.67)*

3 Modeling Demand for food and nutrients

The NFS collects information about total food acquisition and expenditure per household. There is no information on individual consumption. In order to take into account consumption variation with respect to age and sex of different household members I use the model proposed by Chesher in 1997 and 1998 with the aim of disaggregate household food acquisition into individual consumption.

So if one considers a household h with P total household members, expected consumption of individual p is assumed to be function of his individual characteristics x_p (e.g. sex and age) and household characteristics z:

$$E[c_p|x, z] = f(x_p, z)$$

Thus average household consumption results from the sum of average household members consumptions:

$$E[c|x, z] = \sum_{p=1}^{P} f(x_p, z)$$

If a household consumes q_i^c, quantity of food i, and therefore the amount of nutrient contained in each unit of food i, ν_i, the total quantity of nutrient consumed by the household can be expressed as $c = \sum \nu_i q_i^c$. The total quantity of nutrient entering the household is the total amount of nutrient contained into total food purchased[11], $y = \sum \nu_i q_i$. In the long term it is probably reasonable to assume that total amount of food entering the household is equal to the total amount of food consumed by the household. Therefore the expected value of total food acquisition is assumed to be equal to expected value of total food consumed $E[y|x, z] = E[c|x, z] = \sum_{p=1}^{P} f(x_p, z)$. Where y represents the total quantity of food entering into the household and c the total quantity of food consumed.

Assuming that f is a separable function with respect to x_p and z allows f to be written as product of two functions:

$$f(x_p, z) = g(x_p) \cdot u(z)$$

The amount of food consumed by a person p still depends from her own characteristics, such as age and sex, and from her family characteristics. The model proposed here allows to estimate the average consumption of nutrient for a person p of age a and sex s. Thus when one considers two persons of the same age and sex, living in two different households, their consumption of nutrient will be the same independently from their family structure

[11] The NFS records amount of food i entering the household h: $q_i^c \neq q_i$.

u_z. This assumption also implies that diet of children and adults are not affected by family structure. In order to take that into account and presence of children are introduced in z.

It is known that consumption differs over age among male and female, even in early ages. So, let $g_S(a_p)$ be the function representing the relationship between consumption and age for each sex $S = M, F$. The total distribution of consumption over age can be express as follows:

$$g(x_p) = g(age, sex) = s_p g_M(a_p) + (1 - s_p) g_F(a_p)$$

where $g_S(a_p)$ are complex and non-linear functions and s_p is a dummy variable taking value 1 if the individual observed is male, and 0 otherwise.

The demand for food and nutrient changes through lifetime with level of activity and preferences. Using a non-parametric approach one can define the relationship between food consumption and age for each gender $g_S(a_p)$ and add household characteristics in parametric form $u(z) = exp(z'\gamma)$.

For each individual p, define a vector of dummy variables $w_p = [w_{p,0}, w_{p,1}, w_{p,2}, \ldots, w_{p,99}]$ allocating value 1 to the dummy corresponding to the class of age to which the individual p belongs. That is:

$$w_{p,a} = \begin{cases} 1 & \text{if } a \leq a_p \leq a + 1 \\ 0 & \text{otherwise} \end{cases}$$

So, for example, if three individuals belong to family 1 each respectively of aged 50, 2 and 0 years old, the matrix of vectors w_p, where in our example $p = 1, 2, 3$, identifies person p (second column) in household h (first column) as follows:

$$\mathbf{X} = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & \ldots & 1 & \ldots & 0 \\ 1 & 2 & 0 & 0 & 1 & \ldots & 0 & \ldots & 0 \\ 1 & 3 & 1 & 0 & 0 & \ldots & 0 & \ldots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{pmatrix}$$

Given the assumptions above, the relationship between age and intake for males and females can be approximated by the discrete form:

$$\mathbf{g_S(a_p)} = w_p^{'}\beta^S = \begin{pmatrix} w_{p,0} \\ w_{p,1} \\ w_{p,2} \\ \vdots \\ w_{p,99} \end{pmatrix} \begin{pmatrix} \beta_0^S & \beta_1^S & \beta_2^S & \dots & \beta_{99}^S \end{pmatrix}$$

Where β_a^S are the coefficients estimated at each age for $S = M, F$. They represent the average amount of nutrient consumed by a person p of age a and sex S.

Hence we can formalize the expected value of household consumption[12] as follows:

$$E[y|x,z] = \sum_{p=1}^{P}[s_p \cdot g_M(a_p) + (1 - s_p) \cdot g_F(a_p)] \cdot exp(z^{'}\gamma)$$

$$E[y|x,z] = \sum_{p=1}^{P}[s_p w_p^{'}\beta^M + (1 - s_p) w_p^{'}\beta^F] \cdot exp(z^{'}\gamma)$$

Noticed that $\sum_p s_p w_p^{'}$ represents the number of males of age a living in the household and $\sum_p (1 - s_p) w_p^{'}$ represents the number of females of age a living in the household. Thus, for each household, the expected nutrient consumption is going to be:

$$E[y|x,z] = \sum_{p=1}^{P}\sum_{a=0}^{A}[n_{pa}^M \beta_a^M + n_{pa}^F \beta_a^F] \cdot exp(z^{'}\gamma)$$

where A is the maximum value taken by the variable age and β_a^S represents the average amount of nutrient consumed by any individual of age a and gender S.

3.1 Penalized least square regression

In its simplest form the roughness penalty approach is a method for relaxing the model assumptions in classical linear regression in a slightly different way from polynomial regression (Green and Silverman, 1995). In order to estimate β^M, β^F and γ, and given the discontinuity of age, I use non-linear least squares with a roughness penalty function methodology and minimize the following object:

$$min_{\beta^M \beta^F \gamma} \left[\sum_{h=1}^{H} (y_h - \left(\beta_0 + \sum_{a=0}^{99} (n_{ha}^M \beta_a^M + n_{ha}^F \beta_a^F) \right) exp(z_h^{'}\gamma)) \right]^2 +$$

[12] Thus food acquisition in the long term - see first assumption above.

$$+\lambda_M^2 \sum_{a=0}^{99} (\beta_a^M - 2\beta_{a+1}^M + \beta_{a+2}^M)^2 + \lambda_F^2 \sum_{a=0}^{99} (\beta_a^F - 2\beta_{a+1}^F + \beta_{a+2}^F)^2$$

where β_0 captures flows of nutrients into households that are unrelated to the number of household members (e.g. food for pets or wasted food) and the last term is the discrete version of the roughness penalty function capturing the smoothness of the relationship between age and consumption. The same object is representable in matrix form as follows:

$$min(\mathbf{Y} - \mathbf{X}\beta)^{'}(\mathbf{Y} - \mathbf{X}\beta) + \lambda^2\beta^{'}\mathbf{W}^{'}\mathbf{W}\beta$$

where $\lambda > 0$.

Using matrix the data structure can be summarized as follows. Let

$$\mathcal{D} = \begin{pmatrix} y_h & \mathbf{i} & N^M & N^F & Z \\ 0 & 0 & \lambda \cdot A & 0 & 0 \\ 0 & 0 & 0 & \lambda \cdot A & 0 \end{pmatrix} = \begin{pmatrix} Y & X & Z \\ 0 & \lambda \cdot W & 0 \end{pmatrix}$$

where: $\left[i, N^M, N^F\right] = X$, and

$$\begin{pmatrix} 0 & \lambda \cdot A & 0 \\ 0 & 0 & \lambda \cdot A \end{pmatrix} = \lambda \cdot W$$

The final sum of squared model without considering Z is[13]:

$$minS = (Y - X\beta)^{'}(Y - X\beta) + \lambda^2\beta^{'}W^{'}W\beta$$

so the β estimator turns out to be biased and the bias depends on λ:

$$\widehat{\beta}(\lambda) = (X^{'}X + \lambda^2 W^{'}W)^{-1}X^{'}Y$$

with expected value given by:

$$\begin{aligned} & E\left[\widehat{\beta}(\lambda)\right] = (X^{'}X + \lambda^2 W^{'}W)^{-1}X^{'}E(Y|X) \\ & = (X^{'}X + \lambda^2 W^{'}W)^{-1}X^{'}(X\beta + \epsilon) \\ & = (X^{'}X + \lambda^2 W^{'}W)^{-1}X^{'}X\beta + 0 \\ & \implies E\left[\widehat{\beta}(\lambda)\right] = (X^{'}X + \lambda^2 W^{'}W)^{-1}X^{'}X\beta \end{aligned}$$

[13] The vector Z will be introduced later on in this chapter.

and variance:

$$V\left[\widehat{\beta}(\lambda)\right] = \sigma^2(X'X + \lambda^2 W'W)^{-1}X'X(X'X + \lambda^2 W'W)^{-1}$$

3.2 How to choose the degree of smoothness λ

As indicated by Green and Silverman, the most common method used to identify λ is *Cross Validation* (CV). This methodology requires to omit arbitrarily an observation i and estimate the curve from the remaining data. This new object, denoted $\widehat{g}^{-i}(t_j, \lambda)$, is the minimizer of:

$$\sum_{j \neq i}\{y_j - g\left(t_j\right)\}^2 + \lambda \int \left(g''\right)^2$$

The value of λ derives from minimizing the sum of square differences between observed and estimated values, this time considering also observation i omitted before:

$$minCV(\lambda) = n^{-1}\sum_{k=1}^{n}\{y_k - \widehat{g}^{-i}(t_k, \lambda)\}^2$$

Following Chesher (1997, 1998), this paper considers three possible values of the degree of smoothness: no smoothness ($\lambda = 0$), $\lambda = 57.3$, that it is the value that minimizes Wahba's (1975) generalized cross-validation criterion, and $\lambda = 100$.

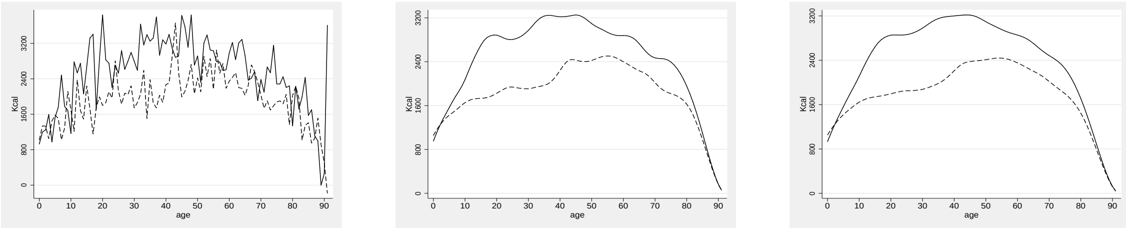
Calories distribution over age for men and women using data from 1975 are shown in Figure 3 for each value of λ specified above. The same model has been run for every year of the NFS considered.

For each year, estimate using $\lambda = 0$ show high variability across ages, and all the models show that the trend of consumption of calories increases during early ages and decreasing after 60, with two main local maximum at age 15 and 50. Considering that the main aim of this work is to describe variations of eating habits over age, and that the differences between using $\lambda = 57.3$ or $\lambda = 100$ are not very large, all the results that follow will use $\lambda = 100$.

3.3 Introducing information on eating out and visitors

The NFS provides some information about food eaten out and visitors. Although it does not record the amount of food obtained from no household supplies, for each person a measure of the number of meals taken from the household during the survey week is available. This information, as already said above, is given by the "net balance" and it

Figure 3: Estimated energy-age curves for male and female using data from 1975 with roughness penalty λ=0, λ=57.3 and λ=100.



(a) λ=0. (b) λ=57.3. (c) λ=100.

varies from 0 to 100. This measure has also been collected for each visitor of the household who stayed over for at least one meal.

The analysis that follows controls also for eating out interpreting the net balance b_p as the proportion of food obtained by each person from the household supply. If the estimated coefficients β_a^M and β_a^F are interpreted as general total food consumed by person p, then the total amount of food obtained from the household is $b_p\beta_a^S$ and the initial model can be written as follows:

$$E[y|x,z,b] = \beta_0 + \sum_{p=1}^{P}\sum_{a=0}^{A}[n_{pa}^M b_p \beta_a^M + n_{pa}^F b_p \beta_a^F] \cdot exp(z^{'}\gamma)$$

$$= \beta_0 + \sum_{p=1}^{P}\sum_{a=0}^{A}[b^{'}_M \beta_a^M + b^{'}_F \beta_a^F] \cdot exp(z^{'}\gamma)$$

where for each household b_S is a vector containing the net balance for each individual at each year of age.

Similarly, using visitors' net balance information, the model takes into account each visitor as an additional member of the household, by age and sex, who takes from the household the proportion of food indicated by his net balance.

3.4 Introducing information on food outlet development

Information on food outlets density are introduced in the model distinguishing between supermarkets and fast foods. I consider the number of supermarkets and fast food present in Britain in each year of survey. This information enter into the model as an additional regressor in the vector z representing household characteristics.

$$E[y|x,z,b] = \beta_0 + \sum_{p=1}^{P}\sum_{a=0}^{A}[n_{pa}^M b_p \beta_a^M + n_{pa}^F b_p \beta_a^F] \cdot \exp(z^{'}\gamma)$$

$$= \beta_0 + \sum_{p=1}^{P} \sum_{a=0}^{A} [b_M^{'} \beta_a^M + b_F^{'} \beta_a^F] \cdot \exp(z^{'} \gamma)$$

where

$$\exp(z^{'}\gamma) = \exp(\gamma \ln finc + \sum_{i=1}^{3} \delta_i r_i + + \varrho \cdot child + \xi \cdot Nspmkt + \varphi \cdot Nfstfd)$$

The model controls for net family income ($finc$), dummies for region of residence, presence of children (dummy child), number of supermarkets and number of fast food present in a particular year within the region of residence or the Local Authority District of a certain household.

Coefficients ξ and φ are interpreted as the variation of diet (calories, fats, proteins, carbohydrate) due to one extra food outlet respectively in the region or the Local Authority District of residence.

Information on the effects of the number of food store and the number of fast food is important because the difference in eating behavior may depend from the local food supply that might either affect people motivation to adopt a healthy diet or the decision of changing their diets. For instance, some nutritionists (Morland et al., 2002) argued that the continues growth of supermarkets since the 70s has made available to the consumers a larger amount of food from everywhere in the world. Thus while before the British diet was mainly based on local products, now one can find any kind of vegetable and fruits at any time of the year. The rise in the variety of food supply (i.e. vegetable and fruits) might have cause a rise in consumption of these foods and therefore a change in the British diet composition.

3.5 Effect of having all meals out at the fast food

The NFS provides detail records of food purchased and obtained from household supply. It also records data on few main categories of meals eaten out such as "school meals", "meal on wheel", "other meals", "midday meals" and "meals out".

Here I propose the application of Chesher's method for inferring the effect of fast food products on the British diet between 1975 and 2000 if every meal eaten outside the house would have been eaten at the fast food.

This is obviously a very strong assumption, but it will allow to draw an upper-bound of the intake-age and intake-year curves and shed a light on the possible effect of British's changing habits such as increasing in eating out.

Although the NFS does not record in detail the type and quantity of food eaten out, it provides the total meals out and the net balance measure for each household member indicating the proportion of meals taken from the household.

Some fast food provide detail nutritional information of their menu per meal and serving on their website. Using information on the average calorie, fat and carbohydrate intake per meal at the fast food, I estimate the total household consumption of intake k eaten out as $Mo_h\varphi_k$, where Mo_h is the number of meals out of household h and φ_k represents the average amount of nutrient k per each serving at the fast food.

If, as above, the estimated coefficients from the model presented in section 3.3. β_a^M and β_a^F are interpreted as general total amount of nutrient consumed by person p, and the difference to 100 of the net balance is interpreted as the proportion of nutrient obtained by each person from outside the household, the total amount of intake obtained from person p from eating out is $(100 - b_p)\%\beta_a^S$. Therefore I can rewrite the initial model for home supply in terms of eating out as follows:

$$E[c_{out}|x, z, b] = \beta_0 + \sum_{p=1}^{P}\sum_{a=0}^{A}[n_{pa}^M(1 - b_p)\beta_a^M + n_{pa}^F(1 - b_p)\beta_a^F] \cdot exp(z^{'}\gamma)$$

where for each household $(1-b_S)$ is a vector containing the proportion of meals eaten out (1-net balance) for each individual at each year of age. These new estimates represent the average consumption of intake k for a person of age a and gender S. When added with the average consumption of intake k of the same person taken from home supply it provides the total average individual consumption of intake k at age a separate by gender.

4 Results

With the aim of providing a through decomposition of the NFS data and identify original regularities for basic demographic subgroups, this section describes the estimates of the Roughness Penalty Function Model obtained from non-linear ordinary least squares (NL-OLS) method to account for function smoothness. The paper investigates nutrition curves - using nutrient intakes - with the objective to see how they have changed by gender and age over the recent time period and by gender and time for all age groups and, particularly, for children aged 0-17. I will also consider the effect of income, other household characteristics, number of supermarkets and fast food separately.

4.1 Age

The relationship between nutrient intake and age have been estimated separately by each sample year in two steps: in a first stage, this paper deals only with the results from the non parametric analysis (nutrient intake in relation to gender and age), while in the second stage, I also control for other household characteristics such as income, region of residence, presence of children, number of supermarkets and fast food.

The analysis will consider here four nutrient intakes[14]: calories, fat intake, protein and carbohydrate. As all fat, protein and carbohydrate transform into calories, I will also report age curves, time variations and cohort differences in term of proportion of energy produced by each of these three nutrients.

4.1.1 Age curves estimation

At the first stage, I estimate nutrient consumption only in relation to household members characteristics (i.e. age and gender). Coefficients are estimated separately for each year and they have been averaged up over the whole sample period 1975-2000. The findings for each nutrient intake for males and females separately, by each completed year of age from 0 to 91, are reported graphically in Figure 4.

Both for male and female the distribution of consumption over the life cycle show an inverse U shape, increasing rapidly until age 14 for girls and 16 for boys, then it declines until around age 25, and it increases again showing a peak at the age 55 for females and 60 for males. After that there is a steady decline.

The estimates show that on average males consume more then females at any age. This picture is quite similar along all the period for all nutrients[15] considered, with some exceptions such as calcium and vitamin C. The findings show that on average females consume more calcium than males after 40 years old, and more vitamin C along all the life cycle[16].

The peak at puberty is consistent with consolidation of body height and weight during the adolescence period. The peak occurs 2 years earlier in girls than in boys, as puberty itself does. Similarly, the fall in consumption after middle age can be explained by the

[14] Other nutrient intakes and foods have been analyzed using the same methodology. Within food groups I have considered 1) diary products, 2) meat and fish products, 3) fat, oils, sugar and preservatives, 4) cereal, pasta, rise and bread, 5) vegetable and fruit. Other intakes analyzed are: calcium, iron, vitamin C. The results are available by the author on request. Other foods, as for example, beverage, miscellaneous, soft drink, confectionaries and alcohol, but the NFS data are collected only from 1992 onwards. Consumption distributions over age for these food groups appear very unstable and irregular with numerous peaks, so they have been left out from the rest of the analysis.

[15] And foods

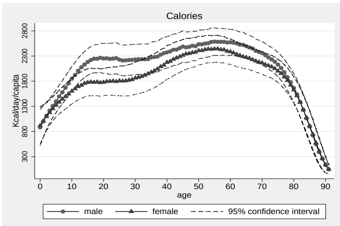
[16] The reason of that is probably the higher consumption of food estimated for females, like diary products (after age 35), vegetable and fruits as it is shown in my thesis.

fact that elderly people spend less energy and lose weight. It is also important to note the general steady rise in all nutrients consumption after 30. This usually coincides with a period in life when people exercise less and increase weight, but these are not necessarily the only explanations.

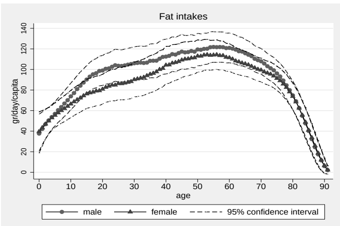
The age patterns of fats intake and carbohydrates (Figure 4, panel b)and d) respectively) are very similar to those of calories intake. For both men and women, they increase during childhood, slightly decrease between age 15 and 30, and then increase again, but more rapidly for women than for men.

Consumption of proteins across age shows less differences among genders (Figure 4, panel c), with the largest difference between age 10 and 40.

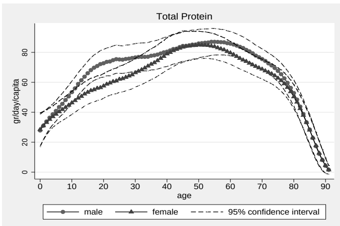
Figure 4: Estimated intake-age curves using linear model with roughness penalty λ =100 - weighted average over 1975-2000.



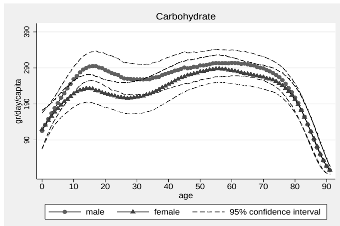
(a) Calories.



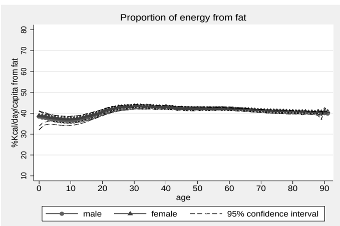
(b) Fat Intake.



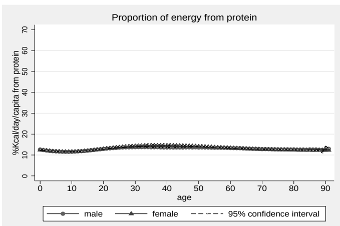
(c) Proteins.



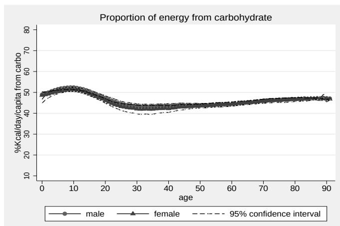
(d) Carbohydrate.



(e) Proportion of energy from fat.



(f) Proportion of energy from proteins.



(g) Proportion of energy from carbohydrate.

Fat intakes converts to calories at the rate of 9 kcal per gram. Therefore, multiplying the average per capita fat consumption by 9 and dividing it by total calories at each age I could plot the distribution of proportion of energy from fat (PEF) shown in Figure 4, panel e). Over the life cycle, in average PEF does not differ between men and women and it varies between 30 and 40 percent until age 25. Afterwards it is stable at around 40 percent of total daily calories. The WHO recommended that the proportion of energy from fat and saturated fats should be reduced by 2005 to 35%. I will add some more on this point in the next sections when studying whether and how PEF has changed over the period 1975-2000 and how its trend had moved over time.

Also protein and carbohydrate convert into calories, respectively at 3.75 and 4.00 Kcal per gram. Their estimated age distributions are shown in Figure 4, panel f) and g). In average carbohydrates provide between 40 and 50 percent of the daily calorie intake. Children consume more energy from carbohydrate than the rest of the population, whilst after age 20 the share of calorie from carbohydrate declines under 50% of the daily total amount and it remains stable at this level thereafter.

The proportion of energy from protein (PEP) is much lower than that obtained from fats and carbohydrates. In average it stands around 11 percent of the total daily amount of calories consumed. For both adult men and women age 30-50, PEP is in general a little higher than for the rest of the population.

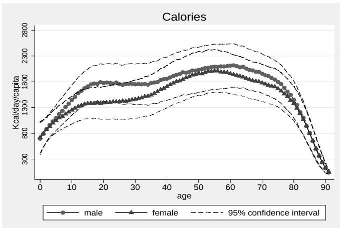
4.1.2 Estimate Non-linear model controlling for income, eating out and visitors

This section presents the estimated intake-age curves obtained introducing also other variables in the model previously estimated. Controlling for eating out and food consumed by visitors, and other household characteristics such as income, region of residence, presence of children makes the model non-linear. While household characteristics enter into the model as extra regressors in the vector z. Information on eating out and number of visitors modify the matrix X through the net balance information and the modification of the household size as visitors are considered *extra* household members taking from the household supply only the amount of food represented by their net balance. Here I will focus on the comparison between new and old nutritional-age curves, while in a following section I will present the estimates on the other variables.

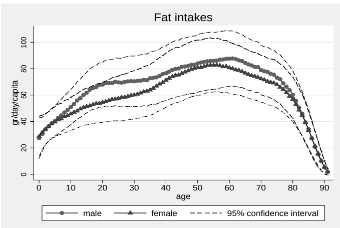
The model has been estimated separately for each year and for each nutrient intake considered. Figure 5 represents graphically estimated coefficients using roughness penalty $\lambda = 100$ averaged up for the period 1975-2000.

Introducing information on the net balance reduces the amount of food allocated in average to each person in the household. This is because the net balance takes into account only the proportion of food obtained from the household's supply. While the effect of controlling for the presence of visitors redistributes food purchased by the household

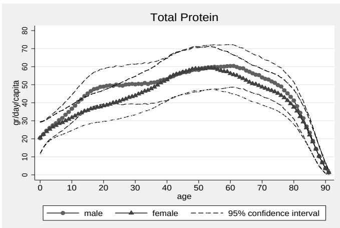
Figure 5: Estimated intake-age curves using non-linear model with roughness penalty λ =100 - weighted average over 1975-2000.



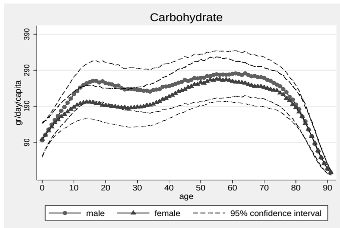
(a) Calories.



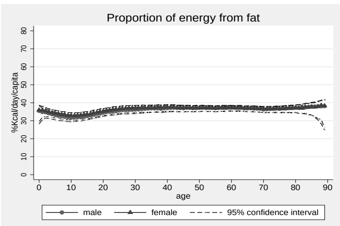
(b) Fat Intake.



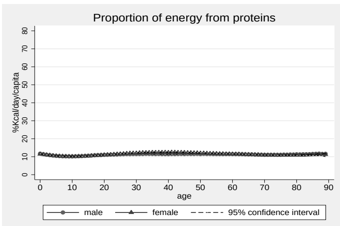
(c) Proteins.



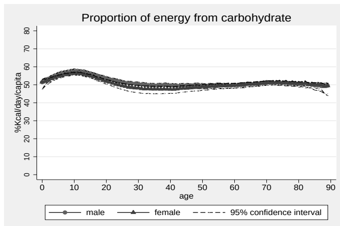
(d) Carbohydrate.



(e) Proportion of energy from fat.



(f) Proportion of energy from proteins.



(g) Proportion of energy from carbohydrate.

among more people, as we assume that some of the food bought from the household is consumed by visitors not by household members. The effect on the age curve is that it appears flatter than it did in the previous section. Although we observe a shift downward of the intake-age curves and a flatter shape, the new intake-age curves show a similar shape to Figure 4. However, at this point, it is difficult to say which of the two effects (eating out or visitors) is driving the individual consumption estimation.

Nevertheless men still consume more intakes than women (Figure 5). Proportion of energy from fat are now constantly around 30 percent, proteins provide more than 10 percent of total energy, while proportion of energy from carbohydrates remains as before between 60 and 50 percent.

It is also to notice that part of the steep rise seen earlier after age 30 disappears especially for men. This might be the effect of having guests. In fact if people after age 30 receive visitors in their home and invite them for a meal, then the age dependence relation estimated here will take it into account assigning a lower amount of nutrients from household supply to each individual.

The decrement in quantity consumed at home, might be also caused by the use of net balance information to take into account eating out. If a member of the family has net balance equal to 86, it means that in average he eats out one day per week. For that day what before was allocated to his consumption given age and gender, now it will be redistributed among the other household members with the effect of increasing their consumption. The higher decrement observable compare to previous estimates is for people age 30 plus. If people at this age range tend to eat outside rather than take food from household supply, part of the change in the shape of the curve might be due to the incidence of eating out.

4.2 Time

The focus of this section is on changes in nutrient intakes over time. I, first, analyze nutritional trends first for the whole population and then, I draw particular attention to young people distinguishing three age groups (0-6, 7-12, 13-17) by gender. The aim of this section is to chart patterns of consumption over time. There might be many forces that have affected people's (especially children's) food habits. Common examples of such drivers are, home technology improvements, changes of parental costs of time and preferences, information and type of food available, junk food eaten out (Cutler et al., 2003). In this section I simply describe patterns without testing one explanation against another. I will consider some of these hypotheses in a later section.

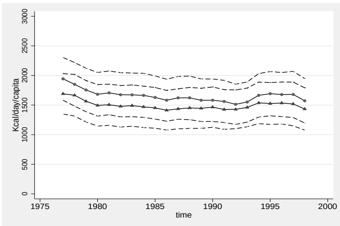
Figure 6 illustrates how eating habits have changed over the 26 years period between

1975 and 2000 in term of intakes among the whole British population.

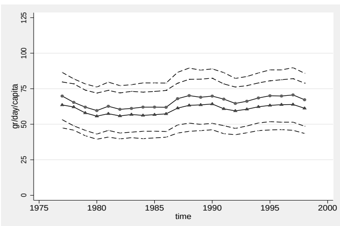
On the opposite of what is commonly believed, total daily calorie consumption (Figure 6 panel a)) remains quite stable over time for both men and women. Fat intakes (panel b) and proteins (panel c) are slightly increasing along all the period, while consumption of carbohydrates (panel d) slowly decreases until 1994, returning to similar level as at the beginning of the period afterwards.

The largest variation is shown in the contribution of energy provided by each intake. Proportion of energy from fats is very different from the beginning to the end of the time period. Panel e) in Figure 6 shows a steady increase of consumption that pass from 25 percent at the end of the 70s to 35 percent of total calories by the end of the 90s. The opposite findings are shown by panel g) on proportion of energy from carbohydrates. PEC decreases from 60 to 50 percent up to 1990 and it remains stable from thereafter.

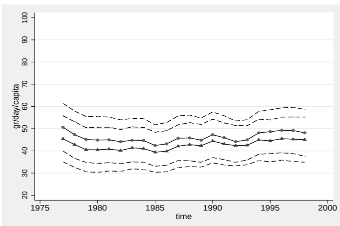
Figure 6: Estimated intakes-year curves using non-linear model with roughness penalty λ =100 - weighted average over age (male and female).



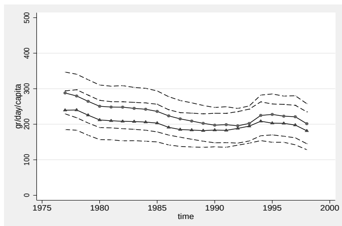
(a) Calories.



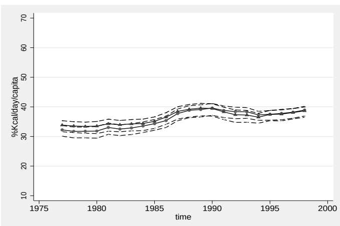
(b) Fat Intake.



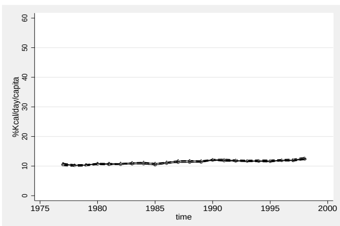
(c) Proteins.



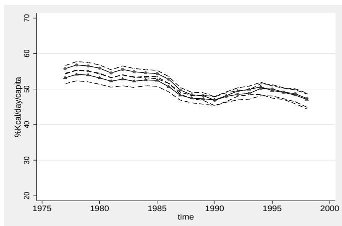
(d) Carbohydrate.



(e) Proportion of energy from fat.



(f) Proportion of energy from proteins.

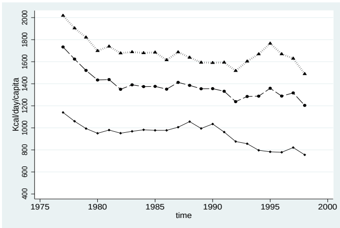


(g) Proportion of energy from carbohydrate.

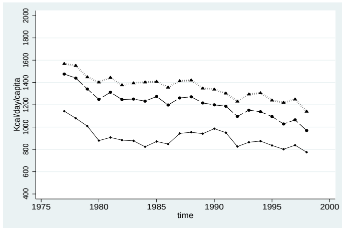
Panel f) in Figure 6 represents proportion of energy from proteins (PEP). Its trend appears quite flat around 10 percent with a tendency to increase slowly toward the end of the period.

4.2.1 Children

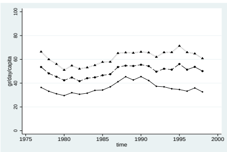
Figure 7: Estimated intakes-year curves for children using non-linear model with roughness penalty λ =100 - weighted average by class of age (boys and girls).



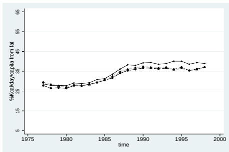
(a) Calories - boys.



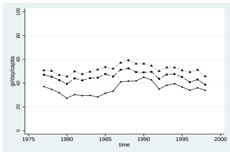
(b) Calories - girls.



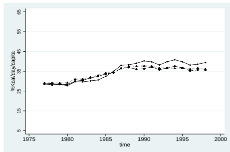
(c) Fat Intake - boys.



(d) Proportion of energy from fat - boys.

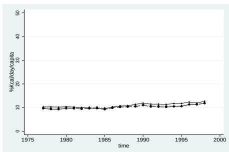


(e) Fat Intake - girls.

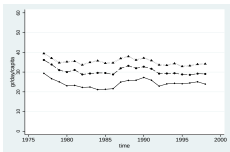


(f) Proportion of energy from fat - girls.

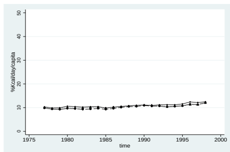
(g) Proteins - boys.



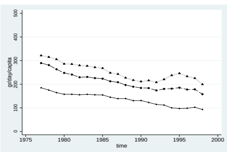
(h) Proportion of energy from proteins - boys.



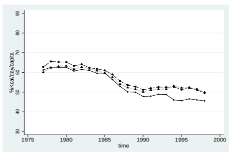
(i) Proteins - girls.



(j) Proportion of energy from proteins - girls.

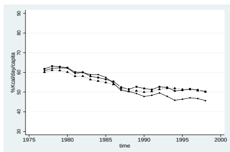


(k) Carbohydrates - boys.



(l) Proportion of energy from carbohydrate - boys.

(m) Carbohydrates - girls.



(n) Proportion of energy from carbohydrate - girls.

Trends of nutrient intakes consumption for children are shown in Figure 7 separately for boys and girls by age groups. The first two columns in Figure 7 show average daily intakes consumption for males, while the last two columns show estimates for females.

Each line corresponds to a different age group. I consider three classes of age here: 0-6, 7-12 and 13-17. In general younger children consume less than older children. The variation of consumption across age groups results from the distance between the curves and respects the intake-age distribution shown in previous sections.

Opposite from the results shown for the whole British population, consumption of total calorie for boys and girls decreases along the time period considered of about 300-400 calories per day per person (Figure 7, panels a) and b)). Increase in eating out could be a possible explanation for this finding. In fact as shown in Figure 1, adolescents eat out more often than almost everybody else and considering the increase in eating out observable from the data, the decrease in demand of total calorie from home supply could be the result of a higher rate of eating out. On the other hand this could also be the result of education programme aiming at changing children's eating habits toward a more healthy diet.

The remaining results do not emphasize huge differences in trends between children and adult's diet. Fat intake and protein trends (Figure 7, panels c), e), g) and i)) for both genders at all ages tend to increase slightly from 1978 until 2000. The difference between ages is larger for boys than girls, in line with the results found above (females eat less than male in general).

The consumption trend of carbohydrate is decreasing (similarly to that of the whole population), and the proportion of energy produced decreases as well from 65 to 45 percent of total daily calories. The difference across ages for both males and females is larger at the end of the period than at the beginning, but the results do not show relevant differences among gender.

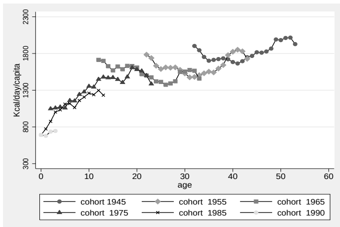
Proportion of energy from fat has increased along the time period (Figure 7, panels d) and f)). Although it does not change a lot across age groups, it is larger at the end of the period than in the 70s. The rise was slightly steeper for girls than for boys and it is quite flat (around 36 percent) from the 90s onwards.

As for the whole British population, proportion of energy from proteins for children shows a stable trend along all the study period (around 10 percent of total daily energy).

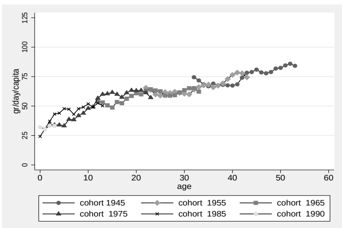
4.3 Cohorts

The focus of this section is on differences in nutrient intake consumption among generations. The NFS is a series of household cross sectional data and, thus, it does not follow the same individuals over time. In order to see whether there exist some generation's effect on differences between people born at different times, I consider five cohorts (1945, 1955, 1965, 1975, 1985 and 1990).

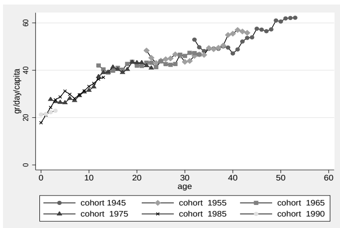
Figure 8: Estimated intakes-cohort curves using non-liner model with roughness penalty λ =100.



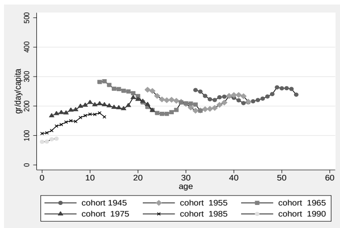
(a) Calories.



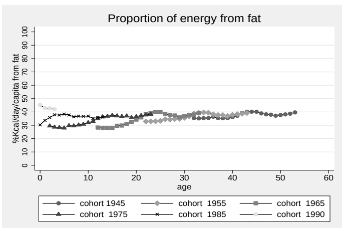
(b) Fat Intake.



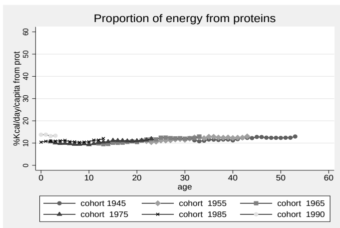
(c) Proteins.



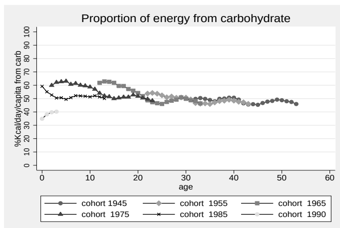
(d) Carbohydrate.



(e) Proportion of energy from fat.



(f) Proportion of energy from proteins.



(g) Proportion of energy from carbohydrate.

Cohorts are constructed by year of birth of each individual. For each survey I average estimate nutrient intake consumption by age and then track the sample from the same cohort one year older in the next survey. The analysis reported here does not distinguish by gender. For example, people who were born in 1945 are observed from age 30 (in 1975) to age 55 (in 2000), while cohort 1975 is observed from age 0 to age 25. The last two cohorts (those born in 1985 and 1990) are the youngest cohorts in the sample who were born after the beginning of the survey, therefore they are observed only for a short period of time: fifteen and ten years, respectively. Results on nutrient intakes and food groups are shown in Figure 8.

Figure 8 shows the cohort intake consumption curves beginning with those born in 1990. In panel a) of Figure 8, the first line segment connects the average consumption of calories of those who were zero years old in 1975 to the average consumption of calories of 1 year old in 1976, until the last observation of the cohort in 2000, when they were 10 years old. The second line segment repeats the exercise for those who were five years older until the last cohort considered in this graph of those born in 1945.

There is a visible life-cycle pattern rising with age as we saw from the previous sections. With few exceptions at older ages, the lines for the younger cohorts are very often but not always above the lines for the older cohorts, even when they are observed at the same age, that is when the cohorts overlap.

Comparing nutritional habits of different generations at the same age, calorie consumption is slightly different for different cohorts at different ages. Between age 0 and 10 younger generation consumed less than older ones, while between age 10 and 18 they consume slightly more calories than their older counterparts.

Figure 8 panels b), c) and d) plot fat intake, protein and carbohydrate patterns by cohorts. Also here one can notice a life-cycle pattern with consumption rising as age increases and younger generations consuming higher amount of intakes at all ages. In particular looking at children between 0 and 10 years old I compare the 1975, 1985 and 1990 cohorts. Children born in 1990 eat more fats than those born earlier since when they are age 4. Consumption of fat intake maintains the same structure, with younger generation eating more fats than older ones, at all ages. Similar patterns are shown for consumption of proteins (Figure 8, panel c)). For all generations the rise in consumption of proteins is mainly due to age effect rather than differences between generations.

The opposite results arise from panel d) of Figure 8 on consumption of carbohydrates. In this case one can notice some differences among generations. Until age 20, younger generations consume less carbohydrates than their older counterparts when they were the same age. On the opposite, within adults, younger generations eat more carbohydrates than older ones.

The final effect on the diet's composition is shown by panel e), f) and g) in Figure 8. Calories from proteins is still similar among all cohorts (10 percent of total energy). On the other hand, younger generations obtain more calories from fat and less from carbohydrates than older generations used to. In particular, the proportion of energy from carbohydrate shows a slightly decreasing life-cycle trend as we saw above with share of calories declining as age rises and with the youngest generation obtaining about 10 percent more of their daily energy from carbohydrates until age 20.

4.4 Income

The previous sections confirmed that in general nutrition varies over age. It has also been shown that children consumption have changed over time. In particular, the findings show a common change in the proportion of energy obtained from fats and carbohydrates among all the aspects analyzed in the previous sections. I turn now to examine whether the accumulation of household income has played a role in the way people eat. Poorer people may be more likely to malnutrition that leads to poorer health status. In addition, their families may be less able to provide the investment necessary to maintain good diet in the presence of low income. In doing so I explore the relationship between intake consumption and net family income and I analyze the time trends of such a relationship.

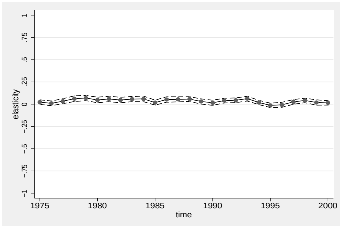
I use the estimates on the log of net family income from the non-linear least square model with Roughness Penalty Function of nutrient intakes consumed by the whole household in one week period. The estimated coefficients on log net family income, which represent elasticities of consumption with respect to income for each nutrient, are reported in Tables 7. This provides alternative evidence on the health-income gradient discussed by a number of analysts (Case et al., 2002).

The income elasticity reported here measures the proportionate rate of change in quantity of a nutrient consumed from household supply due to a unit proportionate change in household income per capita, other individual and household characteristics held constant.

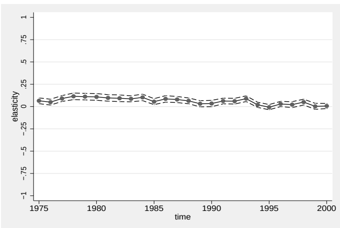
Table 7: Elasticity of intake consumption respect to family income per capita [γ from NL-OLS].

	Intakes γ coefficients.							
Year	Calorie	s.e.	fat intake	s.e.	proteins	s.e.	carbohydrates	s.e.
1975	0.02	*(0.01)*	0.06	*(0.02)*	0.04	*(0.01)*	-0.01	*(0.01)*
1976	0.01	*(0.01)*	0.05	*(0.02)*	0.04	*(0.02)*	-0.02	*(0.02)*
1977	0.03	*(0.01)*	0.09	*(0.02)*	0.09	*(0.01)*	-0.02	*(0.02)*
1978	0.06	*(0.02)*	0.12	*(0.02)*	0.10	*(0.02)*	0.02	*(0.02)*
1979	0.07	*(0.01)*	0.11	*(0.02)*	0.11	*(0.02)*	0.03	*(0.02)*
1980	0.05	*(0.02)*	0.11	*(0.02)*	0.10	*(0.02)*	-0.01	*(0.02)*
1981	0.06	*(0.02)*	0.10	*(0.02)*	0.08	*(0.02)*	0.04	*(0.02)*
1982	0.05	*(0.02)*	0.09	*(0.02)*	0.07	*(0.02)*	0.01	*(0.02)*
1983	0.06	*(0.01)*	0.09	*(0.02)*	0.10	*(0.01)*	0.03	*(0.02)*
1984	0.06	*(0.02)*	0.10	*(0.02)*	0.09	*(0.01)*	0.02	*(0.02)*
1985	0.02	*(0.01)*	0.06	*(0.02)*	0.06	*(0.01)*	-0.02	*(0.02)*
1986	0.05	*(0.02)*	0.09	*(0.02)*	0.07	*(0.01)*	0.03	*(0.02)*
1987	0.05	*(0.01)*	0.08	*(0.02)*	0.11	*(0.01)*	0.03	*(0.02)*
1988	0.06	*(0.01)*	0.06	*(0.02)*	0.06	*(0.01)*	0.05	*(0.01)*
1989	0.03	*(0.01)*	0.03	*(0.02)*	0.04	*(0.01)*	0.03	*(0.02)*
1990	0.02	*(0.01)*	0.03	*(0.02)*	0.05	*(0.01)*	0.00	*(0.02)*
1991	0.04	*(0.01)*	0.06	*(0.02)*	0.07	*(0.01)*	0.02	*(0.02)*
1992	0.04	*(0.01)*	0.06	*(0.02)*	0.05	*(0.01)*	0.03	*(0.02)*
1993	0.06	*(0.01)*	0.09	*(0.02)*	0.08	*(0.01)*	0.04	*(0.02)*
1994	0.02	*(0.01)*	0.02	*(0.01)*	0.05	*(0.01)*	0.01	*(0.01)*
1995	-0.01	*(0.01)*	-0.01	*(0.01)*	0.03	*(0.01)*	-0.03	*(0.01)*
1996	-0.01	*(0.01)*	0.03	*(0.01)*	0.02	*(0.01)*	-0.04	*(0.02)*
1997	0.03	*(0.01)*	0.02	*(0.02)*	0.05	*(0.01)*	0.03	*(0.01)*
1998	0.04	*(0.01)*	0.05	*(0.02)*	0.05	*(0.01)*	0.04	*(0.01)*
1999	0.02	*(0.02)*	0.00	*(0.02)*	0.04	*(0.01)*	0.03	*(0.02)*
2000	0.01	*(0.01)*	0.01	*(0.01)*	0.03	*(0.01)*	0.02	*(0.01)*

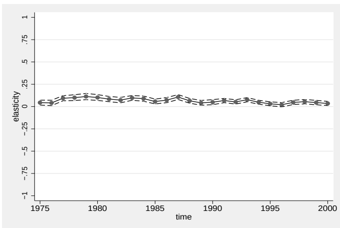
Figure 9: Estimated nutrient intakes elasticity trend, λ =100.



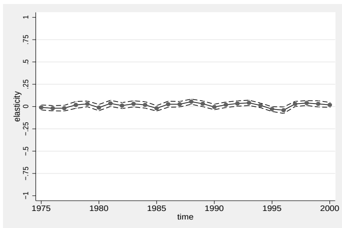
(a) Calories.



(b) Fat Intakes.



(c) Proteins.



(d) Carbohydrates.

Table 7 shows the estimated income elasticities for each year obtained using NFS data together with estimated standard errors. In all cases the results indicate that nutrient intakes, with some exception in some years, are "normal" goods: quantity purchased increases as income rises at a lower rate (elasticity less than 1) than the rate at which income increases.

For example, the first column in Table 7 reports income elasticity of calorie consumption for each year of the sample (γ) and panel a) in Figure 9 describes its trend graphically over the whole period of study. Elasticity of calories with respect to income varies in a range between -0.01 and 0.07, being negative only in 1995 and 1996. Therefore, apart from '95 and '96, an increase in family income would result in an increase of daily calorie consumption.

Nutrient intakes show relatively low income elasticities. In fact, most of the elasticities are close to zero (i.e. calorie and carbohydrate). Fat intakes and proteins show to have been more sensitive to income variation than other nutrients in the past. However their sensitiveness to income variations decreases with time.

Finally, there is some evidence of changes through time in income elasticities for nutrient intakes. However effects of variation in income are expected to be slightly stronger on food[17] than on nutrients consumption. This may reflect the fact that consumers, at different income level, substitute between food groups in a way that substitution within nutrients results very little (**?**). Possible drivers of such effects might be sought in changes through time in the nature of food and in the way they are presented to households, changes in the technology available for preparing foods, changes in household circumstances including increased labor market participation and cost of time. However, although during the period of study increments of income have implied little positive changes in quantity of intakes consumed, at this point it is not possible to say whether consuming more nutrient intakes implies a better diet and therefore a better health status.

[17]Estimates of elasticity of food groups using the same methodology are reported in my thesis and results are available upon request. The results show a general positive relationship between quantity of food consumed and increment of per capita family income. There are, however, some exceptions. Elasticity of cereal, pasta, rice and bread consumption are sometimes negative or very close to zero. Thus, cereals elasticity of consumption has floated around zero along most of the period considered revealing a general insensitiveness of cereals consumption to income variations. Different trends are observable for meat and fish products. In this case income elasticity is positive, slightly higher than 0.5 at the beginning of the time period with a trend downwards starting from 1985. Income elasticities for diary products, fats from oils, sugars and preservatives, and vegetable and fruit are in average very similar (range $0-0.25$). In particular trend of elasticity of oils and sugars has been stable since the middle of the 70s until the beginning of the 90s varying between 0.03 and 0.17. Between 1992 and 1998 income elasticities of those products show a wider variability (range -0.07 to 0.42).

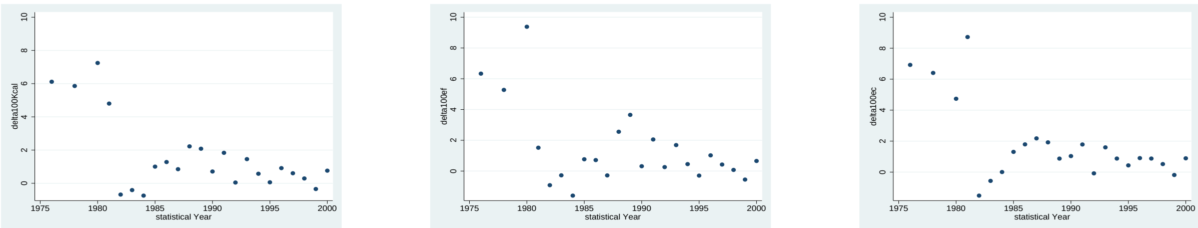
4.5 Effects on diet of developing of supermarkets and fast food

A common explanation given for the rapid increase observed in the obesity rate in industrialized Countries is the wide variety of ready food made available by fast food and supermarkets. Ready meals from fast food and supermarkets are often classified as unhealthy food. This section uses the model proposed above to explore the relation between diet composition and number of food outlet available within the local area of residence.

Indeed if in one region the develop of food outlet has increased over the average, it could be possible to observed a different pattern of intake consumption than in regions where instead the food choice is much lower. The main question that this section tries to address is whether supermarkets and fast food have effectively had an impact on changing consumption of certain nutrient intakes.

For each year, data on the number of fast food per LAD and number of supermarkets per region were available. They were introduced in the model within the regressors in the vector z. Estimated coefficients for total calories, energy from fats and carbohydrates are reported in Appendix (Tables 8 and 9), while here I report them graphically over time in Figures 10 and 11 respectively for fast food and supermarkets.

Figure 10: The effect of one extra fast food on intakes consumption (only statistically significant years).

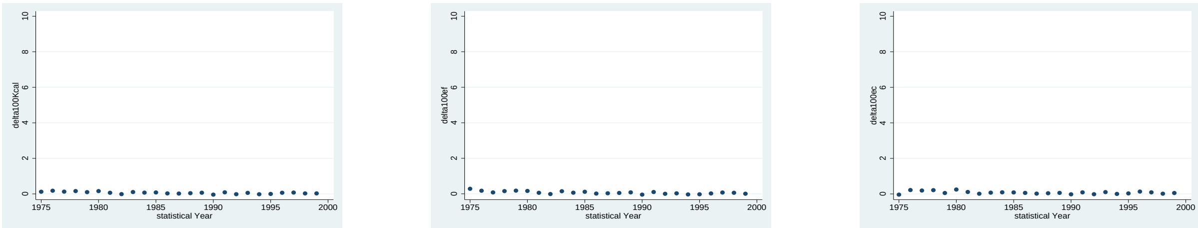


(a) Calories. (b) Energy from fats. (c) Energy from carbohydrates.

These graphs plot the effect of one extra fast food and one extra supermarket as weekly percentage variation of calories, energy from fat and carbohydrate on average by year only for those years where the effect results significantly different from zero.

Although the magnitude of the coefficients is small, the effect of an extra outlet on calories, energy from fats and carbohydrates is mostly positive (only exception are 1977 1979 where the small variation of the data observed do not produce significant values) with a maximum variation of 8% of total calories (400 Kcal) and energy from carbohydrate, and almost 10% of energy from fat per week in an average household. The graphs highlight a stronger effect of fast food on diet at the beginning of the survey period and a much lower effect from the middle of the 80s onwards (between 0 and 2% of total calories). Most of this variation derives from positive variation of energy from fat after 1985 (around 2% for each new fast food opened) while the effect on energy from carbohydrate attributable to one more fast food on the average of total fast food is around 1% (Figure 10, panel c).

Figure 11: The effect of one more supermarket within the local region on intakes consumption (only statistically significant years).



(a) Calories.

(b) Energy from fats.

(c) Energy from carbohydrates.

On the opposite, the effect of adding one extra supermarket to the average number of outlets within the region of residence is much smaller in term of total energy (between 2 and 10% in terms of total calories, between 1 and 7% in term of energy from fat and from zero to 6% in term of energy from carbohydrate).

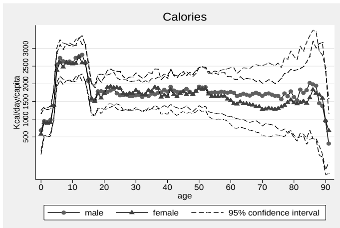
Thus, although the data available are not very detailed there appears to be some association between food outlets with an increase in energy from fats. However, as the effects becomes smaller over time, as observed by Sturm and Datar (2005), it also appears quite difficult to associate food outlets with the increase in energy from fats and/or decline of energy from carbohydrates noticed above.

4.6 Eating out at the fast food

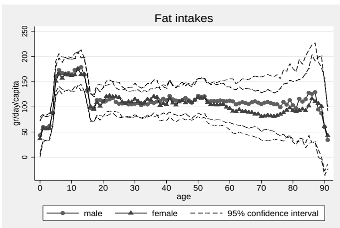
The last section of this long discussion considers another common explanation and possible driver of the rise in the obesity rate in Britain: eating out at the fast food.

The NFS records each year the number of meals eaten out. They are classified by meals on wheels, school meals, midday meals and other meals. Assuming that school meals and meals on wheels are balanced meals in term of intakes, the rest of the meals eaten out could be taken from everywhere else: pubs, fast food, restaurants or packed-lunches, etc. Data collected by the Institute of Grocery Distribution established that the share of meals eaten away from home in pubs and quick services in 2000-01 was between 13% and 22%.

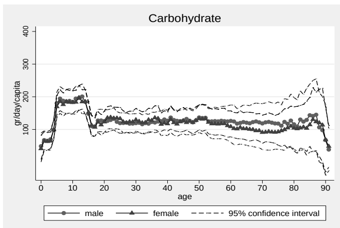
Figure 12: Estimated only eaten out intake-age curves using non-linear model with roughness penalty λ =100 - weighted average over 1975-2000.



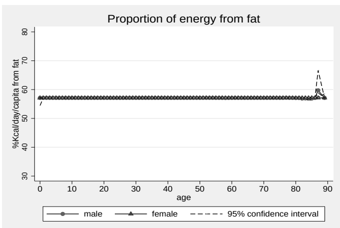
(a) Calories.



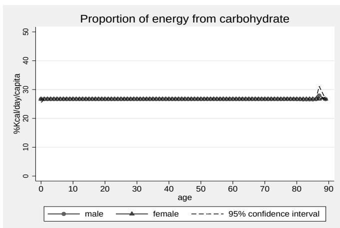
(b) Fat Intake.



(c) Carbohydrate.



(d) Proportion of energy from fat.



(e) Proportion of energy from carbohydrate.

Following the procedure explained in section 3.5 and the model proposed above, I again estimate intake-age and intake-year curves distribution under the hypothesis that all meals out are eaten at the fast food[18]. The intake-age curves estimated are shown graphically in Figure 12. The first panel represents average consumption of calories eaten out across age and by gender. The findings do not show difference between males and females. However, they underline high consumption for children at school age. This is probably due to the fact that children between 5 and 16 years old very often have lunch at school and this cannot be distinguish by the model. Therefore the results presented here should be interpreted only as an extreme case under the hypothesis that meals at school were also taken from the fast food.

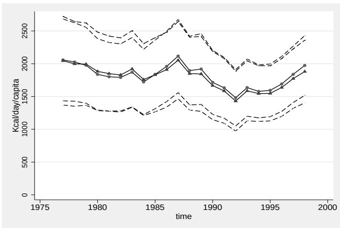
The second and third panels plot variation in daily grams per capita of fat intake and carbohydrate. The variation for adults is stable over age around 100 grams of fat intake and 150 grams of carbohydrate. Again for children the variation would be higher than for adults (because they eat out more often), respectively 170 grams of fat intake and 200 grams more of carbohydrate.

The fourth and fifth panels represent variation in terms of caloires due respectively to variation of fat and carbohydrate. They are stable by age and represent respectively 57% and 27% of energy from food eaten out.

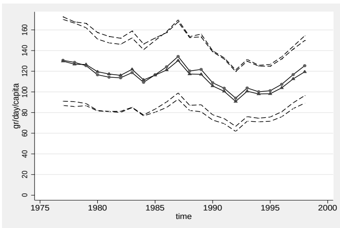
Figure 13 represents average individual variation of intake from eating out over time by gender. In average total calorie eaten out do not differ by gender and it results quite stable towards the middle of the 80s, while it decreases to about 1000 calories per day by 1995. Afterward it starts increasing again.

[18]Using data from the menus available online, the average meal provides 571.77 kilo-calories

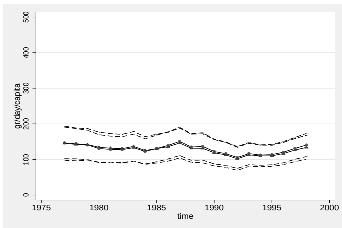
Figure 13: Estimated only eaten out intake-time curves using non-linear model with roughness penalty λ =100 - weighted average over 1975-2000.



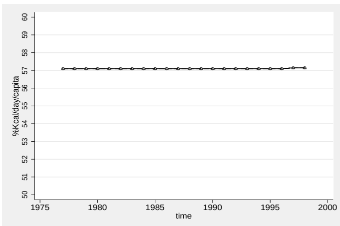
(a) Calories.



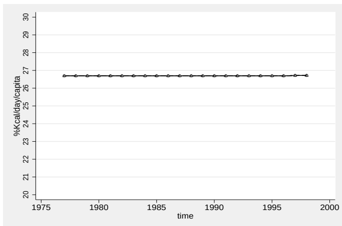
(b) Fat Intake.



(c) Carbohydrate.

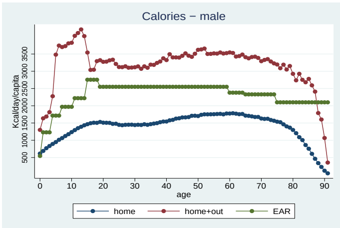


(d) Proportion of energy from fat.

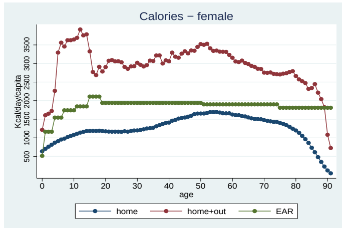


(e) Proportion of energy from carbohydrate.

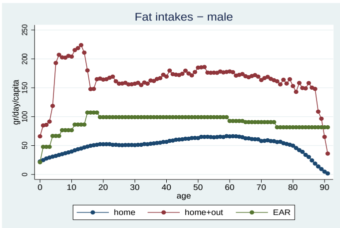
Figure 14: Estimated bounds intake-age curves using non-linear model with roughness penalty λ =100 - weighted average over 1975-2000.



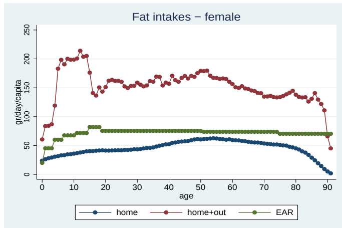
(a) Calories.



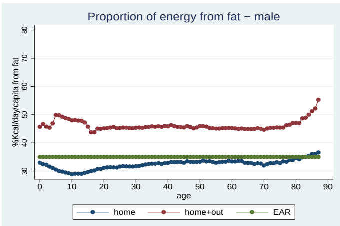
(b) Calories.



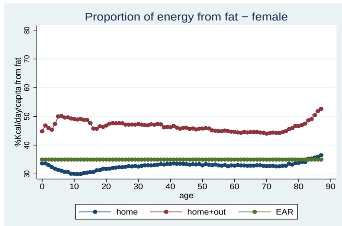
(c) Fat Intake.



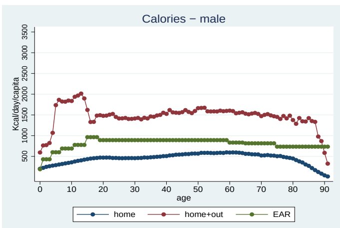
(d) Fat Intake.



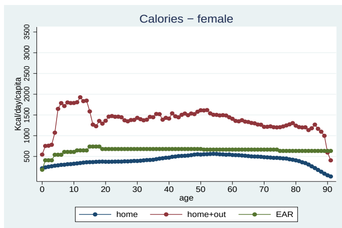
(e) Proportion of energy from fat.



(f) Proportion of energy from fat.

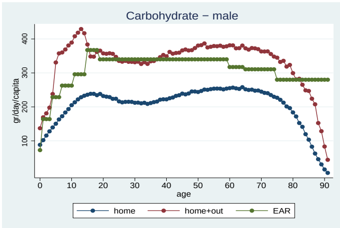


(g) Energy from fat.

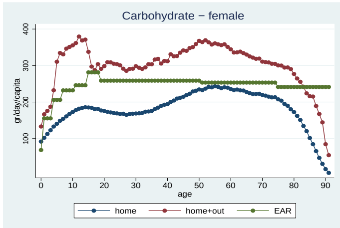


(h) Energy from fat.

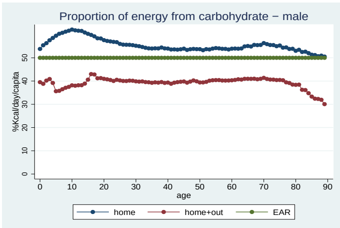
Figure 15: [Cnts.] Estimated bounds intake-age curves using non-linear model with roughness penalty λ =100 - weighted average over 1975-2000.



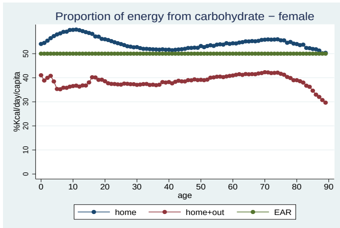
(a) Carbohydrate.



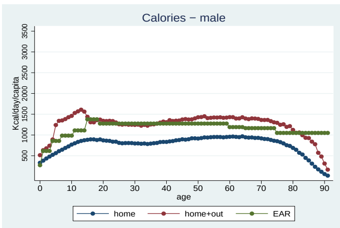
(b) Carbohydrate.



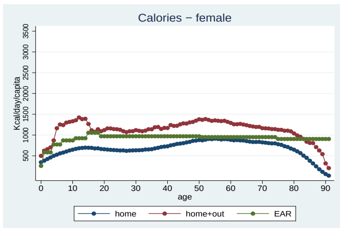
(c) Proportion of energy from carbo.



(d) Proportion of energy from carbo.



(e) Energy from carbo.



(f) Energy from carbo.

Figure 14 summarizes the findings of this paper. The blue lines represent average consumption from home supply for male (left panels) and female (right panels). The red lines represent the total amount of intakes consumed in a day under the hypothesis that every meal eaten out was taken at the fast food. The green lines represent Average Recommended Energy by age and gender suggested by the UK government (on Medical Aspects of food and , COMA).

The findings show that the British's diet eaten at home is in general in line with what is recommended by the nutritionist guidelines. However, food eaten outside the household under the extreme hypothesis that every meal out would be at the fast food, can rise the total daily intake of energy, fat intake and carbohydrate over the recommended limits. If consumer's preferences for fast food products increase to the point that every meal out is taken at the fast food, the rise in obesity rate could probably be explained by the overcoming of the recommended daily intake.

5 Discussion and Outline for future work

This paper has started to explore how eating habits of people in Britain have changed over the last twenty-five years of the twentieth century. Using data from 1975-2000 from the National Food Survey this paper reports an extensive descriptive analysis that investigates the relationship between average nutrient intake consumption across ages and over time. In doing so I estimates a Roughness Penalty Function model obtained from ordinary least squares method to account for function smoothness (Chesher, 1997, 1998). I investigate nutrition curves - using nutrient intakes - with the objective to see how they have changed by gender and age over time and by gender and time for all age groups and, in particular, for children 0-17.

The paper stresses six main results. First findings demonstrated that in general nutrition varies over age and by gender. In general males consume more nutrient intakes than females. Nutrients consumption strongly increases during childhood until puberty, decrease at the beginning of adulthood age and increase later on, decreasing again when people get older.

The second finding focuses on changes on nutrient intakes over time and in particular among British youth by three age groups. The results show a change in trend for some nutrient intakes such as proportion of energy from fat intake, protein and carbohydrate. Fat intake and protein increase very slowly along all the time period of study. In particular the proportion of energy from fat increased at the end of the 80s to 35 percent and it is stable from there since, while the proportion of energy from carbohydrates shows exactly the opposite trend decreasing of about 10% along the period of study. The variations emerged in nutrient intakes might be due to variation in food consumption and to some variation of the data collection process[19].

The third finding focuses on cohort analysis in order to see whether different generations eat differently. I compare five birth-cohorts and present results for four nutrient intakes. The most interest findings regard total calories and fat intakes. While calorie-in do not change a lot across generations, younger generations consume higher quantity of fat intakes. The consequences of this can be seen in the proportion of energy from fats, that for younger generations results larger than for older generations when they were the same age[20].

In the fourth part I consider the effect of income on eating habits. Focusing on the relation between eating habits and income distribution, trends of elasticity of intakes

[19]In particular the data show an increases in diary products, meat and fish products, fat from oils and sugars and cereals since the beginning of the 90s.

[20]Younger generations consume also more diary products, fat from oil and sugars, and less vegetable and fruit than their parents when they were the same age.

consumption with respect to income have been computed. The findings highlight that changes among nutrient intakes consumption due to income variations are relatively low (all less than 1) and in general positive, meaning that as income rises consumption rises as well but at a lower rate. In general the sensitiveness of consumption to income variation becomes smaller with most of the trends tending to zero. Finally, there are some evidence of changes through time in income elasticities for nutrient intakes. However, the effect of family income variation is expected to be much higher on food groups than on intake nutrients consumption. This means that as households become richer, the substitution between foods is much quicker than the variation of diet through substitution of nutrient intakes. In other words, for people is easier to change food quantity consumed than quantity of intakes. However, at this moment it is not possible to say whether a positive variation of family income improves nutrition and therefore health status.

The fifth part of the paper investigates the relation between intake consumption and food outlets. Development of supermarkets and fast food has greatly changed supply chains system. Today, supermarkets make many new products available wherever and whenever in the world, while small and local shops are increasingly less present. The analysis presented here finds some very small positive significant effects on consumption of calories associated with number of food outlets available within the local area of residence.

Finally, applying Chesher's model to meals out under the hypothesis that every meal eaten out was taken at the fast food, I estimate an upper bound for the intake-age curve distribution and compare it with previous findings and daily recommended energy intakes. The findings showed that in average nutrient intake from eating out do not vary by gender, but over age. In general children age 5-16 eat outside the household more often than adults, with the most of their meals out taken from meals at school. If this was not the case, and one assumes that every meal eaten out was taken at the fast food, then the daily consumption of intake would highly overcome the daily recommended amounts for an healthy diet.

Observing these results, some extension should be considered for future research. Many might be the causes of eating habits changes resulting from the analysis carried on in this paper. For example technical change, income growth, lifestyle changes, mass media and advertising, and changes in relative prices. In fact, technical changes have provided food supply system with mechanisms that increase productivity and improve food conservation and its distribution system.

Further studies would be needed in order to explore the effect of prices on household food demand also in relation to fast food and supermarkets, the effect of food quality (i.e. healthy and unhealthy) and, not least, the role of physical activities (life-style) on the rise of obesity.

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6 Appendix

Table 8: Estimated coefficients on the effect of fast food by LADs (s.e. values in brackets).

	Calories		Fat intake		Carbohydrate	
year	coeff.	s.e.	coeff.	s.e	coeff.	s.e
1975						
1976	0.059	*0.029*	0.061	*0.036*	0.067	*0.033*
1977	-21.376	*0.000*	0.000	*0.000*	0.000	*0.000*
1978	0.057	*0.020*	0.051	*0.023*	0.062	*0.025*
1979	-0.063	*0.031*	-0.023	*0.036*	-0.114	*0.037*
1980	0.070	*0.024*	0.090	*0.028*	0.046	*0.028*
1981	0.047	*0.013*	0.015	*0.015*	0.084	*0.014*
1982	-0.007	*0.021*	-0.009	*0.024*	-0.015	*0.023*
1983	-0.004	*0.009*	-0.003	*0.010*	-0.006	*0.011*
1984	-0.007	*0.009*	-0.016	*0.011*	0.000	*0.011*
1985	0.010	*0.007*	0.008	*0.008*	0.013	*0.008*
1986	0.013	*0.007*	0.007	*0.008*	0.018	*0.008*
1987	0.008	*0.006*	-0.003	*0.008*	0.022	*0.006*
1988	0.022	*0.006*	0.025	*0.007*	0.019	*0.007*
1989	0.021	*0.006*	0.036	*0.006*	0.009	*0.006*
1990	0.007	*0.005*	0.003	*0.007*	0.010	*0.005*
1991	0.018	*0.006*	0.020	*0.007*	0.018	*0.007*
1992	0.000	*0.005*	0.003	*0.006*	-0.001	*0.006*
1993	0.014	*0.003*	0.017	*0.003*	0.016	*0.003*
1994	0.006	*0.003*	0.005	*0.004*	0.009	*0.003*
1995	0.001	*0.003*	-0.003	*0.004*	0.004	*0.003*
1996	0.009	*0.003*	0.010	*0.003*	0.009	*0.004*
1997	0.006	*0.002*	0.004	*0.003*	0.009	*0.003*
1998	0.003	*0.002*	0.001	*0.003*	0.005	*0.003*
1999	-0.003	*0.003*	-0.006	*0.003*	-0.002	*0.003*
2000	0.008	*0.002*	0.007	*0.002*	0.009	*0.002*

Table 9: Estimated coefficients on the effect of supermarket by region (s.e. values in brackets).

	Calories		Fat intake		Carbohydrate	
year	coeff.	s.e.	coeff.	s.e	coeff.	s.e
1975	0.001	*0.001*	0.003	*0.001*	0.000	*0.001*
1976	0.002	*0.001*	0.002	*0.001*	0.002	*0.001*
1977	0.001	*0.001*	0.001	*0.001*	0.002	*0.001*
1978	0.002	*0.001*	0.002	*0.001*	0.002	*0.001*
1979	0.001	*0.001*	0.002	*0.001*	0.001	*0.001*
1980	0.002	*0.001*	0.002	*0.001*	0.002	*0.001*
1981	0.001	*0.001*	0.001	*0.001*	0.001	*0.001*
1982	0.000	*0.001*	0.000	*0.001*	0.000	*0.001*
1983	0.001	*0.001*	0.001	*0.001*	0.001	*0.001*
1984	0.001	*0.000*	0.001	*0.000*	0.001	*0.000*
1985	0.001	*0.000*	0.001	*0.001*	0.001	*0.000*
1986	0.000	*0.000*	0.000	*0.000*	0.001	*0.000*
1987	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1988	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1989	0.001	*0.000*	0.001	*0.000*	0.001	*0.000*
1990	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1991	0.001	*0.000*	0.001	*0.000*	0.001	*0.000*
1992	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1993	0.001	*0.000*	0.000	*0.000*	0.001	*0.000*
1994	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1995	0.000	*0.000*	0.000	*0.000*	0.000	*0.000*
1996	0.001	*0.000*	0.000	*0.000*	0.001	*0.000*
1997	0.001	*0.000*	0.001	*0.000*	0.001	*0.000*
1998	0.000	*0.000*	0.001	*0.000*	0.000	*0.000*
1999	0.000	*0.000*	0.000	*0.000*	0.001	*0.000*
2000						